

Mechanical line sowing with two-wheeled tractors for maize, wheat, legumes and direct seeded rice

*Experiential learning modules for sustainable
intensification and agricultural service provision*

BOOK V



Timothy J. Krupnik, Kamrun Naher, Kh. Shafiq Islam,
Md. Abdul Matin, Syed Mahmudul Huq, Shamim Ara Begum,
Muhammad Arshadul Hoque, Sheikh Md. Nazim Uddin,
Scott Justice, Khondker Murshed-E-Jahan, Israil Hossain



Mechanical line sowing with two-wheeled tractors for maize, wheat, legumes and direct seeded rice

*Experiential learning modules for sustainable
intensification and agricultural service provision*

BOOK V

Timothy J. Krupnik
Kamrun Naher
Kh. Shafiq Islam
Md. Abdul Matin
Syed Mahmudul Huq
Shamim Ara Begum
Muhammad Arshadul Hoque
Sheikh Md. Nazim Uddin
Scott Justice
Khondker Murshed-E-Jahan
Md. Israil Hossain



Cereal Systems Initiative for South Asia

MECHANICAL LINE SOWING WITH TWO-WHEELED TRACTORS FOR MAIZE, WHEAT, LEGUMES AND DIRECT SEEDED RICE

Experiential learning modules for sustainable intensification and agricultural service provision (Book V)

Timothy J. Krupnik¹, Kamrun Naher², Kh. Shafiq Islam¹, Md. Abdul Matin³, Syed Mahmudul Huq¹, Shamim Ara Begum¹, Muhammad Arshadul Hoque³, Sheikh Md. Nazim Uddin⁴, Scott Justice^{5,6}, Khondker Murshed-E-Jahan⁷, and Md. Israil Hossain⁸

- ¹ International Maize and Wheat Improvement Center (CIMMYT), House 10/B, Road 53, Gulshan 2, Dhaka 1213, Bangladesh
- ² Food and Agriculture Organization (FAO) of the United Nations, House 37, Road 8, Dhanmondi R/A, Dhaka 1205, Bangladesh
- ³ Farm Machinery and Postharvest Engineering (FMPE) Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur 1701, Bangladesh
- ⁴ Department of Agricultural Extension, Khamarbari, Farmgate, Dhaka 1215, Bangladesh
- ⁵ International Maize and Wheat Improvement Center (CIMMYT). Botany Division, 1st Floor, NARC, Khumaltar, Lalitpur, Nepal
- ⁶ Independent farm mechanization consultant. Yangon, Myanmar.
- ⁷ Winrock International. House 13/B, Road 54, Gulshan 2, Dhaka, Bangladesh
- ⁸ Bangladesh Wheat and Maize Research Institute. Nashipur, Dinajpur, Bangladesh.

CIMMYT – the International Maize and Wheat Improvement Center – is the global leader in publicly-funded maize and wheat research and related farming systems. Headquartered near Mexico City, CIMMYT works with hundreds of partners throughout the developing world to sustainably increase the productivity of maize and wheat cropping systems, thus improving global food security and reducing poverty. CIMMYT is a member of the CGIAR System and leads the CGIAR Research Programs on Maize and Wheat and the Excellence in Breeding Platform. The Center receives support from national governments, foundations, development banks and other public and private agencies.

This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA. The designations employed in the presentation of materials in this publication do not imply the expression of any opinion whatsoever on the part of CIMMYT or its contributory organizations concerning the legal status of any country, territory, city, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. The opinions expressed are those of the author(s), and are not necessarily those of CIMMYT or its partners. CIMMYT encourages fair use of this material with proper citation.



Correct citation: Krupnik, T. J., Naher, K., Islam, Kh. S., Matin, Md. A., Huq, S. M., Begum, S. A., Hoque, M. A., Uddin, S. M. N., Justice, S., Murshed-E-Jahan, K., Hossain, Md. I. 2020. Mechanical line sowing with two-wheeled tractors for maize, wheat, legumes and direct seeded rice: *Experiential learning modules for sustainable intensification and agricultural service provision* (Book V). Cereal Systems Initiative for South Asia, Dhaka, Bangladesh: CIMMYT.

Cover and back cover photos: Saikat Mojumder

Drawings: S. M. Shaha Alam

Publication design: M. Shahidul Haque Khan, Md. Nazmul Islam Dulal

Editor: Frances Hunt

Published by:

CIMMYT Bangladesh, House 10/B, Road 53, Gulshan 2, Dhaka 1212

Tel. (landline/fax): +880 2 989 6676, +880 2 989 4278

Postal address: PO Box 6057, Gulshan, Dhaka 1212, Bangladesh

For more information by email: t.krupnik@cgiar.org

Printed in Bangladesh. Published in 2020.

This publication was developed by the International Maize and Wheat Improvement Center (CIMMYT) as part of the Cereal Systems Initiative for South Asia (CSISA) project, which is made possible with generous support from the United States Agency for International Development Mission in Bangladesh and the Bill & Melinda Gates Foundation.

CSISA was established in 2009 with the goal of benefiting more than eight million farmers by the end of 2020. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI). Operating in rural 'innovation hubs' in Bangladesh, India and Nepal, CSISA works to increase the adoption of various resource-conserving and climate-resilient technologies, and improve farmers' access to market information and enterprise development. CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills. CSISA works in synergy with regional and national efforts, collaborating with myriad public, civil society and private sector partners.

CSISA's goals are to:

- Promote widespread adoption of resource-conserving practices, technologies and services which increase yields with lower water, labor and input costs.
- Support mainstreaming innovations in national-, state- and district-level government programs to improve long-term impacts achieved through investments in the agricultural sector.
- Generate and disseminate new knowledge on cropping system management practices that can withstand the impacts of climate change in South Asia.
- Improve the policy environment to facilitate the adoption of sustainable intensification technologies.
- Build strategic partnerships that can sustain and enhance the scale of benefits accrued through improving cereal system productivity.

CSISA-MI emerged out of CSISA's ongoing efforts in the USAID/Bangladesh Mission-funded CSISA expansion project (2010-2015), and during CSISA Phase II. It continues to be strategically aligned with the broader CSISA Phase III program in Bangladesh, and is led by CIMMYT in partnership with International Development Enterprises (iDE). CSISA-MI is a five-year project (July 2013 – September 2018) that focuses on unlocking agricultural productivity through increased adoption of agricultural mechanization technologies and services.



USAID
FROM THE AMERICAN PEOPLE

BILL & MELINDA
GATES *foundation*

This publication was made possible through the support provided by the United States of Agency for International Development (USAID) and the Bill & Melinda Gates Foundation. The contents and opinions expressed herein are those of the author(s) and do not necessarily reflect the views of USAID, the United States government or the Bill & Melinda Gates Foundation, and shall not be used for advertising or product endorsement purposes.

Table of Contents

Introduction

Session 1	Introduction, training objectives and pre-training evaluation	1
Session 2	Introduction to the two-wheeled tractor	9
Session 3	Introduction to the Power Tiller – Operated Seeder (PTOS)	11
Session 4	Major parts of the PTOS and their functions	13
Session 5	Calibration of the PTOS (practical exercise)	15
Session 6	How to use a PTOS safely and effectively	17
Session 7	Troubleshooting and maintenance	20
Session 8	Starting a PTOS business	22
Session 9	Review of key messages, post-training evaluation and close of training	24

Flipcharts and handout materials

Session 1	Introduction, training objectives and pre-training evaluation	29
Session 2	Introduction to the two-wheeled tractor	31
Session 3	Introduction to the PTOS	36
Session 4	Major parts of the PTOS and their functions	40
Session 5	Calibration of the PTOS	46
Session 6	How to use a PTOS safely and effectively	60
Session 7	Troubleshooting and maintenance	74
Session 8	Starting a PTOS business	79
Session 9	Review of key messages, post-training evaluation and close of training	97

Annexes

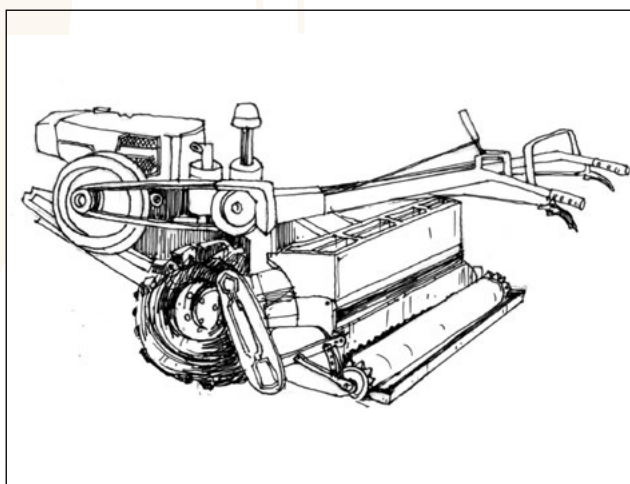
Annex 1	Evaluation questionnaires and answers	113
Annex 2	Video resources	114
Annex 3	Common tools required for maintenance of the PTOS	118
Annex 4	Accurate procedure for fuel consumption measurement by two-wheeled tractors and the PTOS	119

* PowerPoint files of the flip charts in 'ready to present' format can be downloaded from here (for English language: <https://bit.ly/2FR5SYY>) or here (for Bangla language: https://csisa.org/wp-content/uploads/sites/2/2019/12/191204_PTOS-SP-AM-smh.pdf).

Introduction

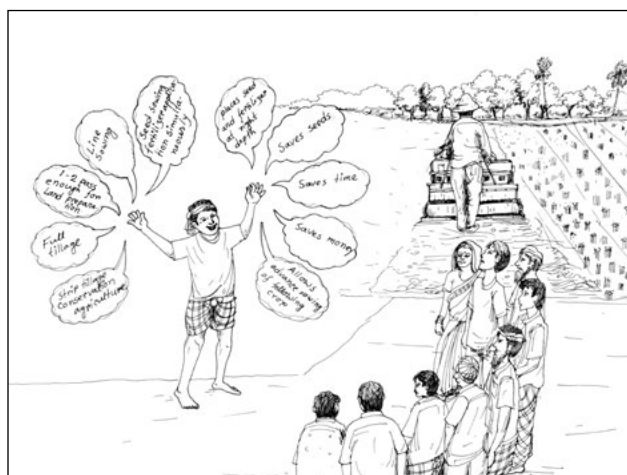
Mechanical sowing refers to the placement of seeds into the soil by an agricultural machine or a manually operated (but mechanical) device. Mechanical sowing, also referred to as mechanical seeding, is generally practiced in areas where there are constraints to labor availability or where farmers want to reduce the drudgery of planting seed by hand. It is typically utilized for cereal crops, but can also be applied to legumes and many other crops, including rice. When farmers or agricultural machinery service providers – people who own seeding machinery and rent out its use on an affordable fee-for-service basis – practice such seeding, the geometry of crop placement tends to be precise, as long as the machine is well calibrated, and correctly used and maintained (topics that are covered in this learning module). While mechanical seeding may not always result in increased yields, it does save labor costs for farmers, and thus profit increases where yields are maintained compared to hand-sown seed. Further savings may result when farmers use mechanical seeding equipment that tills or prepares the soil as it sows seed, or where tillage is foregone, as in zero-till and conservation agriculture systems. Where the sowing date is critically important – for example, for wheat or maize grown in the tropics and sub-tropics – mechanical seeding can advance sowing dates, leading to potential yield increases compared to more time-consuming conventional planting involving multiple tillage passes and hand sowing.

This book focuses on seeding machinery (sometimes called a power tiller-operated seeder, or PTOS), that can be attached to a two-wheeled tractor. It typically has a rotovator to till the soil, and seed and fertilizer boxes with mechanisms to meter and place the seed and fertilizer into the soil in rows as the tractor



A typical power tiller-operated seeder (PTOS), sometimes referred to by its commercial name as a 2BFG (or its derivatives), used for direct seeding. In the above picture, only the seed box (and no fertilizer box) is visible.

moves forward. Other configurations exist, but we focus on the above because they tend to be the most commonly and commercially available machines in South Asia, Southeast Asia and parts of Africa. In doing so, our focus is on two-wheeled 'hand' tractors (sometimes also called single-axle tractors) because of their wide suitability for smallholder farming conditions in both Asia and Africa, although they are also found in parts of Central and South America. The 'scale-appropriate' nature of this equipment for resource-constrained smallholder farmers is particularly appealing for agricultural development projects concerned with advancing appropriate technologies¹.



When some of the rotary blades are removed from the rotovator of a PTOS, the same machinery (often termed "2BG-6A" and usually made in China) for two-wheeled tractors can be used to practice strip tillage. Strip tillage is a conservation agriculture practice, which permits the machine operator to place seeds into the soil while tilling the field only in small strips (also referred to as furrows or slots), leaving in place a mulch of the previous crops' residue on the untilled area between strips. The residue acts as a soil moisture-conserving mulch. When practiced in the context of diversified crop rotation, this conservation agriculture practice can provide cost-saving benefits to farmers. Other two-wheeled tractor-attachable equipment suitable for zero tillage and direct seeding applications is also available in a number of other countries, although in this book we focus on the most common makes and models, similar to the 2BG-6A and originally developed in China.

¹ See: Krupnik, T.J., Santos Valle, S., Hossain, I., Gathala, M.K., Justice, S., Gathala, M.K., McDonald, A.J. 2013. Made in Bangladesh: Scale-appropriate machinery for agricultural resource conservation. International Maize and Wheat Improvement Center. Mexico, D.F. (Book available online: <http://repository.cimmyt.org/xmlui/handle/10883/3381> and Baudron F., Blackwell J., Sims B., Justice S., Kahan D., Rosee R., Mkomwa S., Kaumbutho P., Sariah J., Gérard B., 2015: Re-examining appropriate mechanization in Africa: Two-wheel tractors, conservation agriculture, and private sector involvement. Food Security. DOI 10.1007/s12571-015-0476-3.

This book covers critical topics for the principles and practice of mechanical seeding by two-wheeled tractors in the context of smallholder farming in the tropics, with emphasis on experiential and hands-on learning. The materials within provide a guide for training facilitators to conduct rapid one-day training on mechanical seeding and crop establishment, with emphasis on maize, wheat, rice and legume crops, and including detailed instructions on how to facilitate training, training material requirements, flipcharts to facilitate discussions, and pre- and post-training evaluations for training participants. These practices are better learned through multiple training sessions or as part of a farmer field school as opposed to individual one-day training. Hence while this book details several modular training sessions that can be conducted consecutively during a single day; the sessions can also be broken up and applied as individual modules during a season-long farmer field school, or for more targeted training sessions.

Note also that training on both mechanical seeding (this book) and on integrated weed management practices (the IWM training module in this series) is needed prior to training farmers, machinery service providers or others, on aspects of direct seeding or the practicalities of direct seeding or conservation agriculture.

Direct seeding of rice, strip tillage, or conservation agriculture all require very precise weed control before and after sowing the crop.

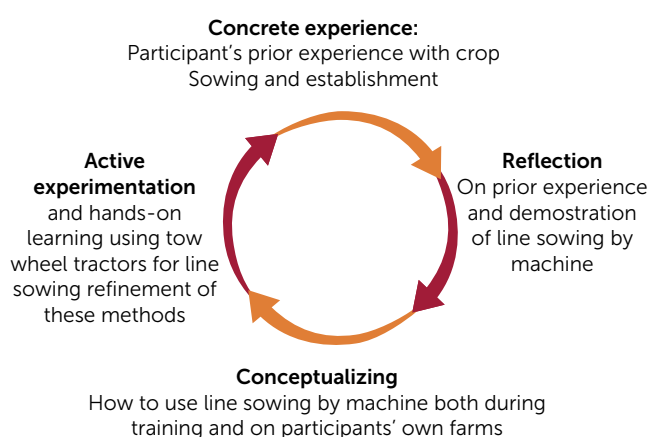
For this reason, training facilitators are encouraged to use these IWM modules prior to attempting to train farmers or service providers on more advanced crop establishment techniques such as conservation agriculture or direct seeding. When practiced together, mechanical seeding, conservation agriculture, and IWM techniques can be incorporated into the packages of services which agricultural service providers make available for farmer-clients, thereby improving both their skillset and business case, and thus improving income generation while supplying needed services to farmers.

Experiential education: The basis for adult learning

This training is meant to be discussion-based and experiential, and to encourage critical reflection and learning among participants. This means that while the facilitator will have to present materials, the format in which this should be done should be horizontal and participatory. We also underscore that farmers and agricultural machinery service providers, who are the target of these training modules, are experts – they work daily in their fields and have considerably more experience than most university educated technicians,

researchers or extension agents. Listening to their opinions and working with them to facilitate learning will enhance the quality of any training. In this sense, it is the responsibility of a training facilitator to elicit training participants' input, opinions and ideas, and to use them interactively to shape discussion and learning. The technical materials included in this document are therefore a guide to supplement farmers' and agricultural machinery service providers' already in-depth knowledge.

The training format used here is based loosely on the experiential learning cycle described by Kolb (1984)², who proposed that adults learn differently than children, with learning based on having a concrete experience, reflecting on this experience, conceptualizing this experience, and then experimenting with the main ideas generated from this experience, after which the cycle of learning is repeated. He further hypothesized that there are generally four types of adult learners and learning styles that should be accommodated, including people who learn by watching demonstrations (whom he called divergers), those who learn by thinking, reading and watching (assimilators), those who learn by hands-on thinking and doing (convergers) and those who learn by doing (accommodators). Well-designed training should accommodate each participant's individual learning style by providing a mixture of lecture and discussion, reading or visual materials, hands-on experiential and experimental opportunities, and opportunities to watch demonstrations and to learn. Kolb's theories have been widely researched and validated in a number of contexts, and provide a solid foundation for educational programs aimed at experienced farmers and agricultural service providers. They are also most popularly used in farmer field schools. In this training, we loosely attempt to formulate Kolb's learning styles, as shown below.



Kolb's (1984) experiential learning cycle as loosely applied in the mechanical seeding by two-wheeled tractors training sessions described in this book.

² Kolb, D.A. 1984. *Experiential Learning: Experience as the Source of Learning and Development*. Prentice-Hall, Englewood Cliffs, NJ.

Facilitators should therefore at every step of the process work to generate discussion and hands-on learning through activities, to provide opportunities to demonstrate and show how to use mechanical seeding approaches, and to encourage critical but constructive reflection among the training participants. There is a certain art to this process, and facilitators should practice with their peers beforehand how to implement different techniques for eliciting discussion among trainees.

Here are some examples of how to ask questions of the training participants in a way that will encourage them to think and critically reflect on the training material:

1. **Arrange seating in a circle, not like in a classroom.** Circular seating arrangements encourage participants and facilitators to interact as equals, and improve the potential for discussion.
2. **Rather than ask closed questions, ask open ones.** For example, rather than ask "How does a furrow opener place seed in the ground?" ask "What is the significance of the depth at which a furrow opener places seed?" Participants may require some additional encouragement to discuss this question, but gently push them towards realizing the answer.
3. **Prompt questions that have open and multiple answers.** For example, rather than ask training participants "What happens if one fluted roller (used for seeding) is not calibrated?" ask "If not all the seeding mechanisms are calibrated, what are the implications for crop establishment, yield and farmers' profits?"
4. **Pick a particular participant to give an answer.** Rotate among students, choosing different ones and asking individuals or a group to answer a question. It may take time for them to come up with an answer, but allow them to work through the process of reflection and coming up with their response. Engage with them and discuss their response, and ask other participants for their thoughts on it. However, if a particular participant is naturally quiet or reserved, avoid asking them too many questions. The goal is to encourage an active learning atmosphere, but without making participants feel uncomfortable.
5. **Most importantly, ask logical questions based on the training materials.** This seems like a simple point, but it is important to stay on topic and ensure that participants are equipped to respond to questions. The ultimate goal is not to make training participants identify what they do not know; rather, our goal is to engage training participants with the training materials so they can succeed at mastering mechanical sowing by applying a combination of what they already know and what they will learn.

6. **Provide space for under-represented students to speak.** In many training programs, men speak over women or dominate the conversation. Members of a particular religious group or caste may also speak over those who are not part of their group. Facilitators should recognize this, and work to give space to under-represented groups to learn and speak. This may require giving them an opportunity to contribute by specifically asking other participants to wait to reply.

The field is the best classroom for farmers and service providers!

The training sessions described in this book are to be held primarily outside and in the field, where participants are encouraged to learn with their own hands how to work with two-wheeled tractors and mechanical seeding equipment. It is only by actually attempting to calibrate machinery and use it to directly place seed that participants will develop sufficient and satisfactory knowledge. To facilitate this, the flipchart material provided in this book can be printed on large paper and taken to farmers' fields, where electricity for PowerPoint presentations or other formats may not be available.

These participatory activities should be emphasized throughout the training. Last but not least, training and education does not end at the conclusion of the day. Participants should be encouraged to experiment with, learn from, modify and adapt mechanical seeding techniques and machinery on their own farm, emulating the cycle of continual learning articulated by Kolb. For this reason, training facilitators should share their contact information with training participants so they can backstop and assist with technical matters when needed. Similarly, trainers may wish to supply contact information of experienced extension agents with knowledge of the PTOS.



The field as the classroom. Farmers and service providers learn about mechanical seeding using power tiller-operated seeders in Bangladesh. Photo: Ranik Martin.

Organization of this book

This book is organized as follows: after a general introductory session to the training format and style, and materials needed for one-day's training, eight independent learning sessions are presented. Each session covers a different topic:

1. Introduction, training objectives, and pre-training evaluation
2. Introduction to the two-wheeled tractor
3. Introduction to the PTOS
4. Main parts of the PTOS and their functions
5. Calibration of the PTOS (practical exercise)
6. How to use a PTOS safely and effectively
7. Troubleshooting and maintenance
8. Starting a PTOS business
9. Review of key messages, post-training evaluation and close of training

Instructions are then given to training facilitators on how to implement each session. This includes a review of the learning objectives, key messages, required materials and step-by-step instructions on how to conduct the training sessions from start to finish, while working to encourage experiential learning as articulated above. Most sessions include a component during which the facilitator is expected to give a brief presentation on the topic. Presentations are intended to be discussion-oriented, so the facilitator should allow time for participants to ask questions, and in turn elicit questions and feedback if few participants are speaking.

Flipchart materials are provided to guide the technical content for each of these presentations. Facilitators should simply follow the flipcharts and use the material presented to initiate discussion and ensure that all technical points are covered. Care should be taken to allow all participants to speak, and to make space for under-represented participants, specifically women, to speak and ask questions.

The pages of this book can be printed out on large poster-sized paper and used for the flipcharts. Flipchart sessions should be conducted in the field and not in a classroom. The same flipcharts are also intended to be printed on normal-sized paper, stapled together, and provided as handouts and reference material for participants at the beginning of each session.

Lastly, training is to begin with a pre-training evaluation of participants' knowledge, and end with a post-training evaluation of their knowledge after the training. The change in participants' scores gives an indication of their progress in learning. Ready-made pre- and post-training evaluation questionnaires are included in this book. Simply print them on regular-sized paper for use.

Training aims and objectives: Mechanical seeding with two-wheeled tractors

This training is aimed at improving farmers' and agricultural machinery service providers' awareness and knowledge about mechanical seeding using power tiller-operated seeders (using two-wheeled tractors), and to improve their skills so that they can ensure safe, effective and economic, profitable crop establishment. This module is designed to cover the major principles of mechanical seeding machinery, correct seed placement, and two-wheeled tractor use, using 2BFG-6A equipment as a model platform for learning.

By the end of the training, participants should be able to:

- understand and explain the convenience of using power-tiller operated seeders for mechanical seeding;
- identify the major mechanical parts of power tiller-operated seeders and their functions as related to mechanical seeding;
- operate the power tiller-operated seeders efficiently and safely;
- understand major failures and breakdowns associated with power tiller-operated seeders and find solutions to fix them; and
- provide tillage and mechanical seeding services to farmers efficiently and profitably.

Whom is this training designed for?

This training is designed for rural agricultural service providers, farmers and future training facilitators interested in understanding and/or practicing mechanical seeding of rice, maize, wheat or legumes using a two-wheeled tractor, and those interested in conservation agriculture. If owners of two-wheeled tractors or mechanical seeders are present, their hired machinery operators should also attend to improve learning and apply the lessons in this book in farmers' fields. The training, however, is designed to some extent for those who have at least a basic familiarity with two-wheeled tractors, although those who do not can still successfully participate and learn. Note that this module builds on the 'integrated weed management' modules also available in this series. We recommend that participants taking the integrated weed management (IWM) training complete the one-day conservation agriculture module before enrolling in the current module. In addition, this module

provides advice that is important for the management of weeds in mechanically sown rice, a topic covered in the next module on two-wheeled tractor-driven seed and fertilizer drills. Completion of the IWM sessions is therefore a prerequisite for moving on to this material.

Key considerations for training

Key considerations for planning, preparing and organizing training events are given below. The facilitator(s) should read each section carefully to ensure effective and efficient implementation of the training. The information presented here can be generalized for each training in this series of books. More specific information pertaining to individual training is presented at the beginning of each module. Be sure that you also review this material.

Participants

The number of participants per batch should be limited to a maximum of around 10-15 people. Ideally, it is good to have at least one two-wheeled tractor-operated mechanical seeder per three to five participants so the opportunity for hands-on learning is increased. Ideally, at least 25% of the participants should be women. Trainees should be targeted who have leadership capability, at least a primary level of education, ideally business experience, and the capability to work outside the household and run a rural business. These points are important as they may increase the probability that the participants will transfer their knowledge to other farmers or service providers. Participants should be contacted well ahead of the training date (at least one week) to allow them to prepare for the training.

Venue

The training venue should be selected carefully. There should be a covered outdoor area, or similar facility having sufficient light, air, and adequate space for the number of participants in each session, and a large bare field/crop land (with adequate space to experiment with equipment). This outdoor area should be no more than a 5-minute walk away from the place where participants will meet. The space should be free from outside distractions. Fields should be available for running mechanical seeding equipment and for participants to learn how to operate machinery successfully (see 'Planning and preparation', below).

Training aids

Please review the detailed list of training aids included at the beginning of each module and make sure that all the required materials are available.

Facilitator(s)

Experienced field technicians and/or extension agents should be selected to facilitate the training. They should have passed a training course or learning session to familiarize them with the principles of experiential learning, and each training module and set of sessions.

Facilitators' preparation

Well ahead of the training start date, the facilitator(s) should go through the module. They should practice the implementation techniques as per allocated time. Each session contains different topics, implementation techniques and time allocation, and facilitators need to read these notes minutely, and practice how to present each session, using the PowerPoint presentation or flipcharts for a timely and lively presentation.

Date of training

The date of the training should be decided following discussion and agreement with participants to ensure their attendance (preferably, it should be during their weekly day off to avoid any financial loss to their business).

Registration

Participants should reach the training venue on time. Immediately after arrival, they should register their name and then take a seat in the classroom. Participant registration should be completed before the training session starts; no registration should be carried out after training begins.

Group formation

Before starting the pre-evaluation exercises which begin each training module, divide participants into three small groups of about five participants each (the number of groups or participants per group may vary according to the total number of participants and machinery availability). Working in smaller groups ensures a more action-oriented, hands-on approach to learning. Generally, four to five people should be assigned to work on each available machine. Set up any seating arrangements so these small groups can sit with one another. Participants will take part in discussions, question and answer sessions, demonstrations and exercises in this small group throughout all the sessions. Do not set up seats in classroom style; use circular seating, as this increases horizontal learning.

Participatory, experiential, and hands-on learning

The training approach should be participatory, with emphasis on hands-on and experiential learning. The

facilitator should utilize techniques that aim to get participants interested and involved in the training, for example, question-and answer-sessions, experience sharing, group exercises, group discussions and group presentations.

Effective and enjoyable training

The training should be facilitated in such a way that the participants find it useful and valuable, rather than a waste of their time. To achieve this, the facilitator should work to ensure that the training is enjoyable (using games, quizzes, sing-along sessions and other techniques to get participants involved). One-way lecture formats are not acceptable and are discouraged as they reduce participants' potential to learn effectively through discussion and experience. The facilitator should arrange a short break (about two minutes) after each ten minutes of presentation, discussion and/or exercise, during which they should ask questions to check whether participants are understanding the training well, and if necessary, adapt their teaching style.

Mobile phone use

Use of mobile phones causes distractions and reduces the effectiveness of the learning experience. All participants including the facilitator should keep their mobile phones switched off during the training session. If anyone needs to take an emergency call, they should excuse themselves from the group and conduct their conversation out of earshot.

Evaluation of participant progress

A pre-training evaluation questionnaire at the start of the day and a post-training evaluation questionnaire at its conclusion are important and essential to judge effective learning. Pre- and post-evaluation questionnaires are provided in Annex 1.

Course preparation, duration, materials, and setting

The course is designed for a one-day training session lasting approximately 10 hours and 15 minutes including demonstrations and practical exercises. This intensive course should be held in the field and not in a classroom. Training facilitators can decide on the best time to take tea and lunch breaks (these are not included in the time estimates above and should be taken into account when planning the training). Times

should be kept flexible depending on the needs of the participants – some sessions may be faster than reported above, others may be slower. This is why it is important to remain flexible.

The content is divided into an introductory session plus eight instructional sessions, as follows:

Session	Topic	Approximate duration (minutes)
1	Introduction, training objectives and pre-training evaluation	60
2	Introduction to the two-wheeled tractor	25
3	Introduction to the PTOS	100
4	Main parts of the PTOS and their functions	55
5	Calibration of the PTOS (practical exercise)	60
6	How to use a PTOS safely and effectively	90
7	Troubleshooting and maintenance	70
8	Starting a PTOS business	90
9	Review of key points, post-training evaluation and close of training	65

Planning and preparing for the training

Please review the 'Key considerations for training' section at the front of this book. Note that you may wish to establish demonstration learning field plots before the start of this training (detailed below in different sessions), so advanced preparation of several weeks is required. In addition to the items listed there, prepare for the training by considering the following:

Training venue

Provide adequate space outside with cover from the sun for at most 10-15 participants, and an empty field/ crop land nearby for practical session. If mechanical seeding is to be practiced using strop tillage, make sure that the nearby field contains the residue of the previous crop as a mulch (preferably about 15 cm tall and still anchored in the soil). The venue should be free from outside distractions.

Required training aids

- ✓ an empty field/crop land nearby for a practice session. If mechanical seeding is to be practiced using strip tillage, make sure that the nearby field has residue of the previous crop as a mulch (preferably about 15 cm long and still anchored to the soil)
- ✓ at least 1 copy of the participant registration form for each participant
- ✓ at least 1 printout of the pre- and post-training evaluation questionnaires for each participant
- ✓ a notebook, pencil and spare pencil for each participant
- ✓ an electrical connection, multi-media projector with sound projection capabilities and screen, or television with DVD player for showing the DVD
- ✓ DVD of Power tiller operated seeder (see Annex 2, "Video resources")
- ✓ printed flipcharts for each session (see Flipcharts and handouts, page 29)
- ✓ printed and stapled A4-sized printouts of the flipcharts, as handouts for participants (see Flipcharts)
- ✓ whiteboard or blank flipchart paper and dry erase markers
- ✓ flipchart stand, whiteboard and stand, white board pens
- ✓ at least three two-wheeled tractors (typically Dongfeng or Sifeng), one for each group of five participants
- ✓ at least three 2BFG-6A (or a similar model) PTOS machines (one for each group of five participants) to attach to the Dongfeng or Sifeng two-wheeled tractors
- ✓ faulty or broken PTOS parts (if available) for display and discussion
- ✓ if possible, one successful service provider who is already providing farmers with mechanical seeding services profitably, using two-wheeled tractor seeding attachments
- ✓ at least two sets of hand tools (see Annex 3)
- ✓ at least 2 L of diesel
- ✓ at least 1 L of motor oil
- ✓ at least 3 kg of rice or wheat seed, 2 kg of mungbean seed or 1 kg of maize seed, depending on which crop the training session is focusing on



Session 1

Introduction, training objectives and pre-training evaluation

Learning objectives

At the end of this introductory session, participants should be able to:

- state the names of the trainers and the other participants
- state the anticipated objectives and content of the training
- understand the training guidelines for learning and cooperation
- assess their own knowledge level regarding the content of the training

Key messages to convey to participants throughout the introductory session

1. This training is composed of nine sessions and will take about 10 hours and 15 minutes excluding lunch, tea or other breaks. Get ready to learn plenty of new things – and please be patient: there is a lot of material to complete.
2. This training is participatory and fun – trainers and trainees will learn from each other.
3. The training is mostly hands-on. Participants should learn by working with the principles of mechanical seeding and associated equipment, rather than just listening. Active participation is best.
4. Participants should be attentive during the training and participate actively – either individually or in groups for each task/assignment/exercise given to them.
5. All participants and facilitators should keep their mobile phone switched off, or on silence. If they receive an urgent call, they should excuse themselves from the group and go elsewhere to answer the call.

How to conduct the session on *Introduction, training objectives and pre-training evaluation*

For this session, you need the participant registration form, the flipchart *Session 1: Introduction, training objectives and pre-training evaluation* designed to introduce the training and its objectives, a notebook, pen and pre-training evaluation questionnaire for each participant, and several sheets of poster paper or a whiteboard and whiteboard pen.

Step 1 – Form groups (15 minutes)

Most adults learn best when they can work in groups. Participants in a small group can interact and can share ideas with each other, which allows peer-to-peer learning and stimulates more entertaining and rich learning experiences.

An ideal size is 10-15 participants for the entire training, divided into smaller groups.

Divide the participants into groups of four or five people by asking them to number themselves 1, 2, 3, 4 and 5 recurring and asking those with the same number to rearrange their seats and sit together (all the 1s in one group, 2s in another and so on). This splits up participants who are sitting with people they already know.

Next, ask each group to select a leader and choose a fun name for their group. It is helpful if the group leader can read and write, which is something the training facilitator can assess during the registration period. Also, try to ensure that someone in each group is competent in basic mathematics and calculations. This will be important later on when learning about machine calibration and business models.

Ask each group to find five things they have in common with every other person in the group, and that have nothing to do with work. Please, no body parts, as we all have legs and arms! Also, no clothing, as we all wear clothes. Focus on more interesting commonalities, such as where they were born and how many children they have, or how many years of

experience in farming they have, and so on. This helps the group explore shared interests more broadly. Ask the group leaders to take notes and be ready to read their list to the whole group at the end of the session. This should generate discussion and a lot of laughter and fun, while encouraging each group to think more like a team.

Step 2 – What are participants' expectations? (10 minutes)

This is one of the most effective tools for breaking the ice and enabling new groups of participants to get to know each other. Each group member is an important source of knowledge. Each participant also has his or her own style of thinking and learning. For this reason, for effective learning it is important for the trainers to understand each participant's expectations of the training module. It will also help the facilitator(s) be better equipped to deliver a successful learning experience throughout the training.



Use an icebreaker approach, during which participants can state what their learning expectations are at the beginning of the day. This will provide feedback from each participant regarding what they expect and also want to get out of the training.

During the introduction of the training module, when it is time for participants to introduce themselves following group formation, the facilitator should explain that participants' expectations are very

important, and that understanding them will be crucial for ensuring quality outcomes from the training. These expectations can later be compared with the module outline, and modifications and changes can be made where necessary.

Ask participants to:

- introduce themselves individually
- share their expectations of the training course (which should be summarized and presented by the group leader after 2-3 minutes of discussion)

Here's an example:

"Hi, my name is Apurba. Our group is expecting to learn how to calibrate a machine to seed crops, and our expectation is that if we knew how to do that we would be able to sow different types of crops efficiently. If we can do that, then each of us can start a business sowing farmers' fields for them."

At the end of the training, the training coordinator should review the list of expectations the groups made, and discuss/explain points not covered in the course and explain whether, and why (if not), their expectations won't be covered in the course.

Step 3 – Introduce the training (10 minutes)

Use flipchart Session 1: Introduction, training objectives and pre-training evaluation to present a brief overview of the training course, the training methods used, the rules, and the participants' responsibilities. Allow time for both the trainer(s) and participants to ask questions.

Step 4 – Pre-training evaluation questionnaire (25 minutes)

Distribute a 'pre-evaluation questionnaire' (see Annex 1) to each participant and allow 20 minutes or so to complete it. If necessary, help any less literate participants to understand and answer the questions. The questionnaire can also be printed out and put up on flipchart paper. Collect the answers; they will be compared with the post-training evaluation answers at the end of the training. They should be corrected before the end of the day, prior to the closing session, during which the evaluation scores will be given to all participants.

Session 2

Introduction to the two-wheeled tractor

Learning objectives³

At the end of this session, participants should be able to:

- check that main parts of the two-wheeled tractor have been correctly prepared for use in the field
- understand how to safely start the two-wheeled tractor's engine

Key messages to convey to participants during this session

1. Carefully inspect the two-wheeled tractor before starting and correct any problems identified.
2. Before starting the engine, make sure there are no children or other people within 5 m of the tractor.
3. Follow the correct process for starting the engine.

How to conduct the session *Introduction to the two-wheeled tractor*

For this session, you will need the following resources and materials:

- the flipchart *Session 2: Introduction to the two-wheeled tractor*
- A4 printed copies of the flipchart as a handout for each participant
- the tools described in Annex 3
- at least one two-wheeled tractor for each group of participants

Step 1 – Generate reflection and discussion (5 minutes)

Initiate the session in a field beside a demonstration plot where the two-wheeled tractors are parked, with a question-and-answer session. **Ask:**

- How do you know if the two-wheeled tractor is ready to start and operate?
- What safety precautions do you take when starting your two-wheeled tractor?

Allow one or two participants to answer the questions, and note important points on poster paper or white board for later discussion.

Step 2 – Hands on-learning: Inspecting the two-wheeled tractor and starting it (20 minutes)

Before beginning Step 2, distribute the *Session 2: Introduction to the two-wheeled tractor* handout to participants. Explain that it can be used as a reminder and guide for starting the two-wheeled tractor. Next, make use of the two-wheeled tractors to explain or review their basic maintenance with the participants. Pick one tractor, and carefully walk the participants through each step of the handout, beginning with starting the engine. Before starting the engine, check that nobody is within five meters of the tractor. This is because while starting the engine, the crank handle could fly off and injure someone.

The two-wheeled tractors should be parked outside in a line, with at least six meters between them so each group can comfortably work on them. After describing the process of inspecting and starting the two-wheeled tractor, ask each group to correct any problems identified during inspection and start their tractor. After successful starting, the machine can be turned off.

³ This session was designed based on the leaflet "Some tips on servicing and using two-wheel tractors" compiled by Jeff Esdaile.

Here are the main messages to convey during Step 2:

Before starting the tractor:

1. Carefully inspect the two-wheeled tractor.
2. Check the radiator has sufficient water.
3. Make sure there is enough fuel to complete the task, and that the fuel is good quality.
4. Check the V-belt tension and adjust if necessary.
5. Check the tension of the fan belt and adjust if necessary.
6. Check the engine oil and add more if needed.
7. Check the transmission oil and add more if needed.
8. After inspection, add quality engine oil if needed.
9. Check that the air filter and exhaust tube are free from obstructions and operating normally.
10. Verify the tire pressure is correct.
11. Make sure there are no children or adults within two meters of the tractor.
12. To start the engine, first press down on the decompression lever. At the same time, turn the crank handle as quickly as possible in a clockwise motion until the engine starts, at which time you can release the decompression lever and remove the crank.

Session 3

Introduction to the Power Tiller-Operated Seeder (PTOS)

Learning objectives

At the end of this session, participants should be able to:

- demonstrate awareness of the different types of two-wheeled tractor mechanical seeders available on the market
- understand and state the function and usefulness of the of two-wheeled tractor mechanical seeders for sowing cereal and legume crops, and for alternative uses
- understand and explain the advantages of line sowing cereal crops, legumes, and other crops using two-wheeled tractor mechanical seeders

Key messages to convey to participants during this session

1. The two-wheeled tractor mechanical seeder (often called a power tiller-operated seeder, or PTOS) is a power tiller-operated machine which enables land preparation using a rotovator, seed sowing and fertilizer application to be done at the same time.
2. Compared to conventional seeding and manual sowing of seed, the PTOS can reduce fuel use, land preparation time and labor costs, thereby minimizing production costs by up to 30%.
3. For crops that are typically broadcast by hand, the PTOS use can reduce the seed requirements per unit of land area.
4. When used for strip tillage (covered in Book 5 of this series), the PTOS can conserve soil moisture and advance sowing dates, which can be beneficial for yields.
5. Compared to broadcast seeding, line sowing ensures better and more even crop stands, and makes it easier to weed crops, either by hand or mechanically.
6. Yields of wheat and other dry season crops can be improved by up to 15% just by line sowing alone, largely because this improves the density and evenness of the plant stand.

7. Line sowing can be done using the PTOS for wheat, maize, rice, pulses, jute, mustard, sesame and many other crops.



How to conduct the *Introduction to the PTOS* session

For this session, you will need the following resources and materials:

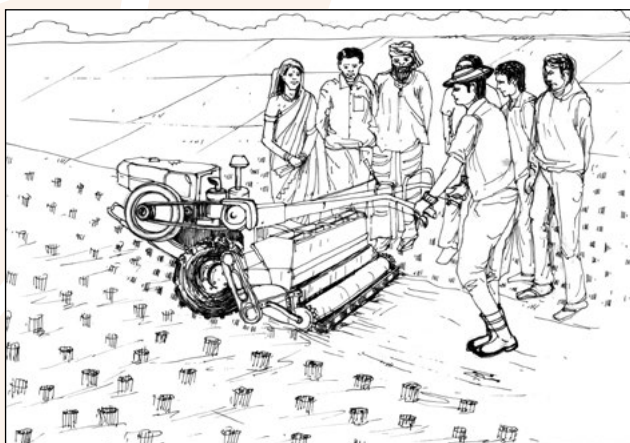
- the flipchart Session 3: Introduction to the PTOS
- A4 printed copies of the flipchart as a handout for each participant
- DVD of the films "Save More, Grow More, Earn More" and "Power Tiller Operated Seeder"
- electrical connection and multi-media facilities for showing the DVD, including speakers or small sound system (see Annex 2, "Video resources")
- several sheets of blank poster paper/whiteboard, whiteboard stand, dry marker/whiteboard pens

Step 1 – Generate reflection and discussion on land preparation and different types of sowing (20 minutes)

Initiate the session by exploring participants' experience about spraying herbicide or insecticide. Ask the following questions:

- When you prepare land for sowing, how do you do it? How many tillage passes does it take?
- When you plant rice, wheat, maize, or legumes, how do you do it?
- What do you think the advantages of sowing a crop in lines might be?
- What might the advantages and disadvantages of sowing rice seed by hand be?
- What do you understand about two-wheeled tractor mechanical seeding?

Encourage one or two participants to answer each question, and make a note of any important points on the whiteboard or flipchart for further discussion.



Step 2 – Power tiller-operated seeder video (50 minutes)

Using a television or multi-media projection and sound facilities, show the 20-minute video "Save more, Grow More, Earn More" and then the 21-minute video "Power tiller-operated seeder".

Following the video, allow about ten minutes for participants to ask any questions and make any comments. Encourage participation and discussion, and allow time for any necessary clarifications.

Also clarify that rice can be directly sown by two-wheeled tractor mechanical seeding, a topic that will be discussed later in these sessions.

If any major technical questions arise, do not get caught up in detailed discussions, as these topics are likely to be addressed later in the day's training. Simply refer to the coming sessions.

Step 3 – Use flipcharts to generate discussion and learning of the basics of two-wheeled tractor mechanical seeding (30 minutes)

Using the flipcharts, review these key items:

1. This training focuses on mechanical seeders that can be attached to Dongfeng and Sifeng two-wheeled Chinese tractors, which are the two most common types of two-wheeled tractors globally.
2. Two-wheeled tractor mechanical seeders are also commonly called power tiller-operated seeders (or PTOS) because Dongfeng and Sifeng two-wheeled tractors come with power tillers (without seeding capability) when they are sold.
3. The PTOS tills the soil and plants seed and places fertilizer at the same time.
4. The PTOS has 48 high-speed blades used for tilling the soil.

Session 4

Main parts of the PTOS and their functions

Learning objectives

At the end of this session, participants should:

- understand how a PTOS works
- be able to identify the major parts of a PTOS
- understand and state the key functions of the main parts of the PTOS

Key message to convey to participants during this session

The main parts of a PTOS include:

- rotovator, typically with 48 blades
- hitching gear
- rotovator chain-sprocket
- seed/fertilizer box
- seed/fertilizer meter
- seed/fertilizer rate adjustment lever
- seed/fertilizer metering shaft
- seed/fertilizer on-off clutch
- furrow opener

- leveling and compaction roller
- tillage depth control lever

How to conduct the session on *Main parts of a PTOS and their functions*

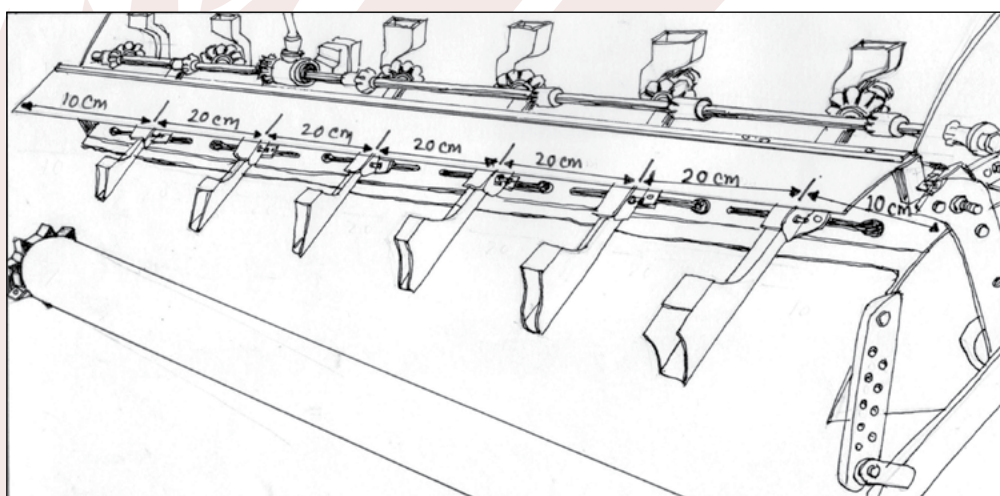
For this session, you will need the following resources and materials:

- flipchart *Session 4: Major parts of the PTOS and their functions*
- A4 printed copies of the flipchart as a handout for each participant
- blank poster paper/whiteboard, whiteboard stand, dry marker/whiteboard pens

Step 1 – Raising participants' awareness (5 minutes)

Take participants to a nearby field (selected before the trainings) where PTOS machines have been placed to demonstrate their use.

Initiate the session using ice-breaking questions and answers.



Rear view of a PTOS showing the roller bar, furrow openers and seed metering system, set to sow mungbean using inclined plates.

Ask: Can anyone name the main parts of a PTOS?

Encourage one or two participants to answer the questions. Listen carefully and list the parts they mention on blank poster paper or the whiteboard.

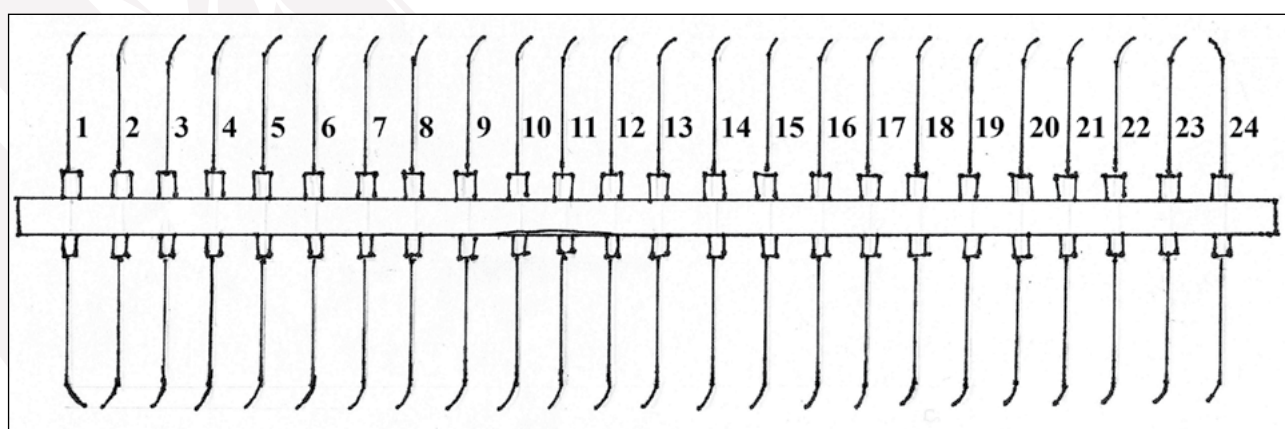
Step 2 – Generate discussion and learning (30 minutes)

Lead the discussion using the flipchart *Session 4: Major parts of the PTOS and their functions*, identifying the main parts of the PTOS, pointing to them on the machine. Pay attention to those not identified correctly (or at all) by participants.

Step 3 – Quick review (20 minutes)

At the end of Session 4, ask participants to get together in their group, with the three groups side by side. Ask each group five to ten questions. If a participant can't answer a question, invite other members of their group to answer. If no one in the group can answer, pass the question on to the next group.

Name of part	Function
Rotovator	Tills the soil by rapid rotation
Hitching gear	Transmits power from the 2WT gearbox to the PTOS gearbox
Rotovator chain cover and sprocket	The chain cover protects the chain, sprocket and oil in the rotovator chain housing from dust, straw and refuse; the sprocket transmits power from the SFD gearbox to the rotovator
Seed fertilizer box	Contains the seed/fertilizer and the seed/fertilizer meter
Seed fertilizer meter	Delivers the seed or fertilizer from the seed fertilizer box to the delivery pipe/chute
Seed fertilizer rate adjustment knob	Adjusts the seed/fertilizer rate
Seed fertilizer on-off lever/clutch	Engages/disengages power to seed/fertilizer meters
Seed/fertilizer metering shaft or bevel gear shaft	Powers the rotating seed/fertilizer meters
Power transmission chain	Transmits power to the bevel gear shaft from front wheel spindle
Furrow openers	Places metered seed/fertilizer at the desired depth in the tilled soil
Leveling and compaction roller	Levels and compacts the tilled soil after seeding
Tillage depth control bar	Helps set the tillage depth



PTOS rotovator showing the arrangement of the 24 holders for blades. Although not visible in this picture, another 24 blades can be found on the rotovator axis in a perpendicular arrangement, giving a total of 48 blades.

Session 5

Calibration of the PTOS (practical exercise)

Learning objectives

At the end of this session, participants should be able to:

- understand and perform the basic mathematics needed to calibrate the seed and fertilizer meter, as appropriate for different crop seeds and fertilizers.
- calibrate the seed and fertilizer meter properly.

Key messages to convey to participants during this session

1. Calibration means fixing the length of the metering roller to get a specific and appropriate seed or fertilizer rate before starting to operate the machine. For example, if 120 kg of seed or 240 kg of urea are to be applied per hectare, it will be necessary to set up the machine to ensure the exact amounts are applied.
2. Calibration of the seed meter should be done by considering: (1) the type of seed metering plate (whether fluted or inclined), and (2) the type and size of the seed.
3. Calibration should be done once at the beginning of each season, each time marking the settings on the machine.
4. Calibrations differ for each crop and fertilizer.
5. Calculate the metering length using the mathematics and formulas given in this module.
6. Set the metering roller length for each crop. This changes the amounts of seed or fertilizer picked up and rotated by the fluted rollers before they are dropped into the soil.

How to conduct the session on *Calibration of the PTOS (practical exercise)*

For this session, you will need the following resources and materials:

- the flipchart *Session 5: Calibration of the PTOS (practical exercise)*.
- A4 printed copies of the flipchart as a handout for each participant.
- blank poster paper/whiteboard and whiteboard stand, dry erase/whiteboard pens.
- an area of uncultivated land around 25-30 m long, and at least several meters wide.
- a seed-fertilizer machine.
- the required amount of seed/fertilizer for the crop you wish to sow (see below and/or consult local extension services for recommendations).
- polythene bag.
- rubber band.
- a digital balance for measuring seed and fertilizer, with at least two or three units after the decimal.
- an experienced mechanic/operator.

Step 1: Questions about calibrating a PTOS (5 minutes)

Begin Session 5 in the field immediately after Session 4, assisted by an experienced PTOS operator or mechanic. Initiate the session with questions and answers.

Ask: Can anybody describe how to calibrate a PTOS, and why it is important?

Encourage one or two participants to answer each question. Write answers on the flipchart if it helps facilitate discussion.

Step 2: Discussion and group exercise (25 minutes)

Lead the discussion using the *Session 5: Calibration of the PTOS (practical exercise)* flipchart, and explain the following:

- the principles of seed meter calibration
- the basic mathematics needed for (1) the fluted roller, and (2) the inclined plate style of seed metering mechanisms

Work with the example calculation procedure as shown on the flipchart. Lead a group exercise on the basic mathematics, following the example calculation in the flipchart. Make sure the group has enough time to ask any questions if they find the procedure complicated.

The steps for calibration are:

1. According to the line-to-line distance required, set the number of furrow openers, starting from the middle point of the machine. For example, the line-to-line distance for wheat is 20 cm (0.2 m), so the six furrow openers should be set 20 cm from each other, measured from the middle of the machine.
2. Extra furrow openers can be removed from the machine or set so they do not touch the soil. It is best to cover the openings to their seed tubes (on the bottom of the seed/fertilizer box) with tape.
3. Use rubber bands to attach plastic bag to the end of the seed delivery tube (by removing the tube from the furrow openers used – you can replace it later when needed). Make sure there is sufficient space at the bottom of the bag for it to collect the seed/fertilizer.
4. Select a specific size of land (20 m to 30 m long and at least 4 m wide is usually sufficient) as a trial plot to run a test calibration.
5. Before running the PTOS in the field, it is essential to meter seed at the right rate by knowing how much seed is needed in each line's plastic bag. This can be determined through a generic and simple calculation, as follows:

$$\text{Required seed quantity in plastic bag (kg)} = \frac{\text{Desired seed rate (kg/ha)} \times \text{line to line distance (m)} \times \text{length of trial plot}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

For example, for wheat sown at a rate of 120 kg per

hectare on a trial plot 20 m long, with a line-to-line distance of 20 cm, the resulting calculation will be:

$$\text{Required wheat seed quantity in plastic bag} = \frac{120 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

This gives the following result:

$$\frac{120 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}} = \frac{0.048 \text{ kg (or 48 grams)}}{\text{per plastic bag for each line}}$$

For crops such as maize, where the number of seeds per unit of land area is more important than their weight, the calculation is different. Irrigated maize is often seeded at a rate of 83,333 plants per hectare and at 60 cm line-to-line spacing. To calibrate for this rate using the same 20-m long trial plot, do not use plastic bags. Instead, simply allow seed to fall onto the ground, and count the number of seeds per 1 m length (do this along several 1 m lengths to ensure consistency).

Here is the formula for maize using this seed rate:

$$\text{Number of seeds per 20 m length for 1 line} = \frac{83,333 \text{ (seeds/ha)} \times 0.6 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

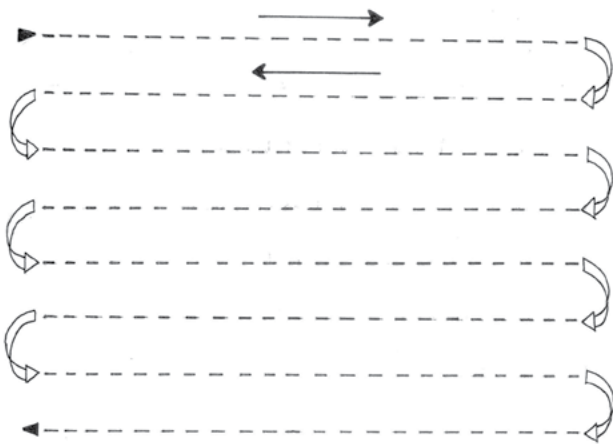
This formula gives the following result:

$$\frac{83,333 \text{ (seeds/ha)} \times 0.6 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}} = \frac{100 \text{ seeds (per 20 m line) or 5 seeds for 1 m length}}$$

1. Now, it is important to test how much seed the PTOS is metering. Put seed in the seed boxes and run the machine for 20 meters.
2. Next, weigh the seed from each plastic bag separately using a digital balance (or count the number of seeds, depending on what crop you are seeding) and observe whether an equal amount/number of seeds were dropped in each line. If the lines are not equal or the seed rate is not correct, it will be necessary to adjust the PTOS.
3. If you are using a fluted roller and the quantity of seed is found to be more (or less) than the required amount, turn the knob to the right (or left) to reduce (or increase) the size of the fluted roller (which is visible from the top of the seed box). This changes how much seed is metered. Repeat the process until you have achieved the correct seed rate.
4. Use a permanent marker to indicate on the machine where to set the knobs for each crop (it is essential to check this calibration at the beginning of each season).

A PTOS that uses an inclined plate seed meter does not require much adjustment, as each plate is made specifically for the type of seed you want to meter, at the correct rate. For these seed meters, the seed rate depends on (1) the number of cells around the periphery of the plate, and (2) the number of revolutions per minute of the plate.

1. Lastly, hold a discussion on how to use the PTOS in the field. When first sowing, it is best to cross the field in parallel lines, turning 180 degrees at the end of the field, as shown below:



Above: Travel pattern for the first step of sowing crops.

This method works very well for maize. For other crops (such as rice, wheat and legumes) it is also good practice to sow two perpendicular lines at each end of the field, after this first step:



Above: Travel pattern for the second step of sowing crops.

Step 3: Demonstration of calibration by an experienced operator and participant practice (30 minutes)

An experienced operator or mechanic should demonstrate the total procedure of seed and fertilizer calibration in the field. Participants should practice this method of calibration.

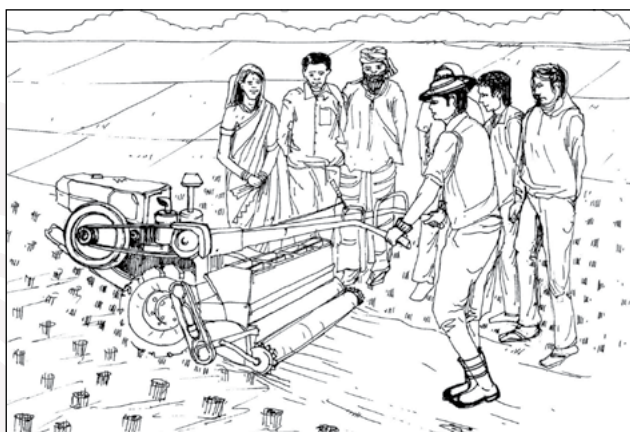
Session 6

How to use a PTOS safely and effectively

Learning objectives

At the end of the session, participants should be able to:

- check the engine oil and fuel, water, lubricant, belt pressure, tine setting and other components
- set the tines correctly for full tillage (48 tines) and strip tillage (24 tines)
- join the machine to the power tiller
- start the machine and operate in the field, and
- maintain safety and operate the PTOS safely



Above: Demonstrating safe operation of the PTOS.

Key messages to convey to participants during this session

1. Wear tight-fitting clothing when operating a PTOS machine to prevent entanglement in its moving parts.
2. Keep any onlookers at least two meters away from the PTOS and never allow children to play near or on it.
3. Be sure there is sufficient fuel and engine oil to complete the job before starting.
4. Check nuts and bolts, belt pressure and tine setting.
5. Be sure the seed-fertilizer box contains enough seed and fertilizer.
6. Check the calibration of the seed and fertilizer meter has been done.
7. Check the tine settings have been made correctly according to the type of tillage (i.e., 48 tines for full tillage and 24 tines for strip tillage)
8. Keep the rotovator 'on-off' lever in the 'off' position before starting the machine.
9. Select the appropriate furrow opener and set at the correct seeding depth for the type of seed (e.g., maize, wheat, mungbean).
10. One furrow opener is required for each line of seed and fertilizer sowing. It should be set out from the mid-point of the machine, based on the crop's line-to-line distance. For example, rice and wheat require 6 furrow openers set at a line-to-line distance of 20 cm (0.2 m); mungbean needs 4 furrow openers (at a line-to-line distance of 30 cm) (0.3 m), and maize requires 2 furrow openers (at a line-to-line distance of 60 cm) (0.6 m).
11. If the PTOS jams, stop the engine and rotovator immediately. Remove/clear away any grass, straw or other materials from the tines.
12. Care should be taken so that clods of earth or straw do not get into the seed-fertilizer tube – this can cause blockages.

How to conduct the session on *How to use a PTOS safely and effectively*

For this session, you need the following resources and materials:

- a PTOS machine
- the flipchart *Session 6: How to use a PTOS safely and effectively*
- A4 printed copies of the flipchart as a handout for each participant
- a piece of crop land to demonstrate the PTOS in operation
- an experienced PTOS operator
- blank poster paper/whiteboard, whiteboard stand, dry erase/marker pens

Step 1: Introduction to a practice session on operating a PTOS safely (10 minutes)

Begin Session 6 in the field immediately after closing Session 5, assisted by an experienced operator/mechanic. Initiate the session through a question-and-answer session and short discussion.

Ask: How many of you can operate a PTOS machine? Make a note the answers on poster paper/whiteboard as a prompt to remember which participants are skilled and which unskilled.

Then ask: What are important considerations for starting and running a PTOS?

Encourage one or two participants to answer. Note responses on the poster paper/whiteboard if it will help facilitate discussion.

Step 2: Demonstration of PTOS operation (30 minutes)

The experienced operator describes and demonstrates the procedures for starting the machine and safely operating it, focusing on the following:

- Before starting the machine:
- Wear tight-fitting clothing.
- Check the engine fuel and oil to make sure there is enough.
- Check the belt tension – make sure it is not loose.
- Check lubricant in the chain, shaft and blade – make sure there is enough.
- Check lubricants in the transmission gearbox and bevel gearbox – make sure everything is well-lubricated.
- Check and clear away any grass or straw which has jammed the tines or rotary shaft.

The experienced operator then starts the PTOS and runs it to demonstrate the following:

- starting the PTOS
- running the PTOS for full tillage
- running the PTOS for strip tillage
- clearing away any grass, straw or soil jam from the tines or other parts

Step 3: Operating a PTOS (practice) (50 minutes)

One participant from each group should operate the machine on uncultivated land for at least one pass each for (1) full tillage and (2) strip tillage. The experienced operator/mechanic should guide them. Monitor the activity, making sure that any unskilled participants practice operating the machine (tillage and seeding) successfully, and point out areas for improvement.

Session 7

Troubleshooting and maintenance

Learning objectives

At the end of the session, participants should be able to:

- understand and explain common failures/breakdowns of the PTOS
- make basic repairs and adjustments, and solve different operational problems
- ensure good maintenance of the machine
- A4 printed copies of the flipchart as a handout for each participant
- blank poster paper/whiteboard, whiteboard stand, dry marker/whiteboard pens
- faulty/broken PTOS parts (if available)
- spare PTOS parts (if available),
- an experienced mechanic

Key messages to convey to participants during this session

- Overloading the PTOS can cause the horizontal transmission shaft to break, resulting in complete machine failure.
- The seed metering shaft may bend due to jams in the metering system, causing non-uniform seed metering.
- Overloading the gear pinions (by tilling hard soil or tilling too deeply) and lack of gear oil causes hitching gears; this may reduce engine power.
- The seed/fertilizer on-off clutch might stop working due to wearing/breaking, wearing of clutch ball, or loosening/wearing of the spring inside the clutch.
- The rotary shaft can stop rotating and produce noise because of lack of gear oil, overloading or the wearing of the bearings.
- The leveling roller bearings can jam or become faulty due to rusting or damage of the bearing seal (a result of the gathering of soil on it) or the roller shaft bending.
- Mishandling or excessive wear and tear can cause the casing on the vertical transmission chain-sprocket box to break.

How to conduct this session

For this session, you will need the following resources and materials:

- the flipchart *Session 7: Troubleshooting and maintenance*

Step 1: Introduction to the practice session (20 minutes)

Begin Session 7 in the field immediately after ending Session 6. An experienced mechanic should be on hand to assist. Initiate the session through questions and answers to warm up participants.

Ask: What are the common causes of failure/breakdown of a power tiller and a PTOS machine?

Allow one or two participants to share their experience with PTOS breakdown or other malfunctioning problems. If they have not operated a PTOS before, ask what they expect problems could be.

List important points on blank poster paper or whiteboard.

Next, refer to the flipchart *Session 7: Troubleshooting and maintenance* to discuss common causes of PTOS failure/breakdown and their solutions. Consider the following points:

- horizontal transmission shaft and its casing break
- seed metering shaft bends
- hitching gears (both on PTOS and 2WT)
- seed/fertilizer on-off clutch does not work
- rotary shaft does not rotate
- leveling roller bearings jam
- casing on the vertical transmission chain-sprocket box breaks

Use the flipchart to review the importance of maintenance and proper storage of the machine, emphasizing the following points:

- Remove and clear away straw and other particles from machine parts and tighten nut bolts.
- Fill the rotovator chain-sprocket casing with lubricant if quantity is low.
- Apply lubricant to each moving part (e.g. bearings, bush, chain-sprocket).
- For long-term storage at the end of the season, the machine should be washed and cleaned properly after necessary repairing. Ideally, store the PTOS under a shed or cover with a polythene sheet.
- Re-paint the PTOS when necessary.
- Store the machine in a dry place and beyond the reach of children.

Step 2: Demonstration of faulty PTOS parts (40 minutes)

If available, an experienced mechanic demonstrates faulty parts of the machine and how to repair/replace them, and demonstrates/discusses maintenance and storage of the machine. If a mechanic is not available, engage an experienced service provider; if not available, the facilitator should complete this part of the training.

Step 3: Quick review (10 minutes)

At the end of this session, conduct a quick review of sessions 3, 4, 5 and 6, using the same procedure as outlined above for the review of sessions 1 and 2 (carried out at the end of Session 2).

At the end of Session 7, return to the classroom.

Session 8

Starting a PTOS business

Learning objectives

At the end of the session, participants should know how to:

- explain the meaning of 'business' and 'business plan'
- work out how much it costs to operate a PTOS for line sowing different crops
- develop a smart business plan so that both they and their clients can profit
- provide a PTOS service to farmers efficiently and profitably
- record financial information (costs and benefits) and do a rough analysis of the profitability of providing a PTOS service

Key messages

Service providers use business plans to make the most money possible while keeping farmer-clients satisfied. Participants should be able to answer the following questions. If they have any trouble, the facilitator should assist them.

1. Where can you find farmer-clients for line sowing different crops?
2. What is the demand for line sowing different crops? How can a service provider increase this demand?
3. What is my capacity to provide this service? What more do I need to know or learn to start and run a PTOS business?
4. What machinery and equipment do I need for line sowing different crops?
5. What is the profit from my proposed PTOS business?

Training aids required

For this session, you will need the following resources and materials:

- the flipchart *Session 8: Starting a PTOS business*
- A4 printed copies of the flipchart as a handout for each participant
- blank poster paper/whiteboard, whiteboard stand, marker pens
- a service provider successfully marketing PTOS services (if available)

Step 1: Introduction to running a PTOS business (15 minutes)

If available, introduce a successful PTOS service provider and ask him/her to share his/her experience running a PTOS business. Cover the following points:

- Why did you decide to start a PTOS business?
- How are you running your PTOS business?
- What are the costs and benefits of the business?
- When did you break even on the cost of investing in the PTOS (that is, when did the income gained equal the purchase cost of the PTOS)?
- What activities/strategies make your PTOS business profitable?
- What are the challenges do you face?
- What benefits are the farmers-clients obtaining from using the service?

Encourage participants to interact with the service provider and discuss the use of the PTOS as a business.

If a successful PTOS service provider is not available, the facilitator should present a generic business model and cost-benefit analysis based on a successful service provider's practice, or on general material using the flipchart.

The next step is to work with participants to develop their own successful business model and cost-benefit analysis of PTOS use, based on (a) a successful service

provider, or (b) the general material in the flipchart
Session 8: Starting a PTOS business.

Step 2: Group exercise to work out the costs of running a PTOS business (60 minutes)

Briefly discuss the following points, referring to the flipchart:

- What is a business?
- What is a business plan?

Lead a participatory/group exercise (participants should stay in the groups they formed at the beginning of the training) to develop a business plan and cost-benefit analysis. Use the flipcharts to calculate how to make a profit selling PTOS services while at the same time benefiting farmers.

Guide the discussion using the questions below, which participants should discuss in their group, arriving at answers that make sense to the group. Make a note of the decision agreed on by all the groups and enter it in the respective boxes. When all the boxes are complete, the resulting information will give one version of a PTOS service business plan/model and its related costs and benefits. Note: this model is likely to change in different locations and for different crops, machines, and so on. The goal here is to get participants to carefully think through the different aspects of running a service provision business in ways that benefit both themselves and the smallholder farmers who purchase their services.

Use wheat as a case study crop (or use an alternative crop as an example if appropriate, but note that the types of tillage, sowing and fertilizing may be different):

a. What is the cost of tilling land with a two-wheeled tractor power tiller + manual seed sowing and fertilizing + re-tilling or laddering for wheat?

First, participant groups should decide the 'unit area of land' according to which the cost will be determined (this will help other calculations later on). For example, allow the group to agree on what percentage of a hectare, area in m² or local land unit to consider for this exercise. It is probably best to use the average unit size of a farmer's field in their area.

To make it easier to work through this question, you can ask about the cost of each operation separately, and then combine the results:

1. What is the cost of tilling land by power tiller for wheat? Note that providing tillage for wheat usually requires several passes with a power tiller. Where this is the case, decide on the cost of each pass and then add them up and record the total cost for the sum of all passes.

2. How much does it usually cost to do manual sowing and fertilizer application? (Note: for this question, it is best to include the value of family labor in the calculation. This is called an *opportunity* cost and is an important consideration for family farmers and smallholders).
3. What is the cost of re-tilling or laddering?
4. Should farmers determine the cost based on time? Based on size of the land? Or based on number of laborers?
5. For wheat, what is the total cost of tilling by power tiller + manual sowing + laddering and fertilizing unit area of land (decimal/acre/hectare)? In Box A on the flipchart, include the sum of the costs agreed to by three groups for traditional tillage and hand sowing of wheat.

b. How much does a PTOS cost?

In Box B, note the purchase price of a PTOS (plus the purchase cost of a two-wheeled tractor, for new buyers only) as agreed to by all the groups.

c. How much does it cost a service provider to operate a PTOS for tilling + sowing + fertilizing in the unit size of land agreed on by the farmers, for wheat?

Again, to make it easier to work through this question, ask about the cost of each operation separately and then combine the results:

1. How much oil and fuel would be needed for the unit of land area agreed on by participants? How much does it cost to make a single pass with the PTOS on this land area?
2. How much time will it take for a service provider to use a PTOS (to till, seed and apply basal fertilizer to the unit of land area decided on by the participants? What is the value of this time? This is known as the *opportunity* cost of the SP's labor. It is usually best to use the average labor cost per hour or per day as the value of the SP's labor. However, this is an abstract economic concept, and may be too complicated for the participants to grasp. If so, choose to simply value their time as zero (meaning no monetary expenditure will be counted for the SP's labor and time).
3. Does this differ from other crops (e.g. jute, mungbean) or alternative crops in your area? Encourage participants to choose and analyze at least 1-2 alternative crops that can be seeded with the PTOS.

Log the oil-fuel cost per unit area in Box C.

A PTOS tills, sows seed and applies fertilizer simultaneously, meaning that no additional labor cost is incurred for sowing and fertilizing. However, in Box D, enter the value of the opportunity cost of the service provider's labor and time taken (or, if calculating the opportunity cost is too complicated, enter zero) to use the PTOS in a farmer's field (based on the consensus of the three groups).

d. How much money should service providers charge for PTOS tillage, sowing and fertilizing?

Again, to make it easier to work through this question, ask the following:

1. How much does one pass to till, seed, and provide basal fertilizer application cost?
2. If a power tiller costs a certain amount of money (which you can refer to in monetary value in units of 'X') then how much should the PTOS cost (which you can refer to in units 'Y')? Y may be greater than 'X' as it serves both tillage and seeding and fertilizing, or it may be lower than 'X' because the participants might agree that the power tiller needs to be used several times before seed can be sown (thus using more than one pass). These subtle differences need to be discussed clearly with participants and worked out collectively.

Guide the participants to work out an amount that brings them profit but ideally is lower than the total cost of power tiller plowing (which may require multiple passes in the same field) + hand sowing and fertilizing + re-tilling or laddering on the same land area (if the latter is the applicable practice for a particular crop). *This point is very important, as the lower cost of PTOS services is what will attract farmers to pay for PTOS tillage, sowing and fertilizing.*

In Box E, note down the PTOS service provider's service charge per unit area as agreed on by the three groups.

Note: it is also beneficial to discuss that use of the PTOS generally saves time for farmers compared to multiple power tiller passes (which are often practiced on separate days), and compared to hand sowing and fertilizing, followed by re-tillage or laddering (if this is the sequence of steps for the crop in question). The yield of wheat in South Asia, for example, usually declines each day a field is planted late. This is because late planted wheat matures when the temperature in the spring is hotter, which reduces the amount of days the crop is growing in the field, and because it can cause sterility of the wheat spikes. Using a PTOS allows earlier crop establishment – sometimes, 5-7 days earlier. In general, less total time and effort is needed to establish a field using a PTOS, which can be powerful and attractive to farmers.

e. How much does the service provider profit per unit area of wheat land (tilling + sowing + fertilizing)?

Calculate this amount by subtracting the oil-fuel cost per unit land area from the money farmers pay as service charge:

Service provider profit per unit of land chosen= [E- (C+D)]

Next, write in Box F on the flipchart the service provider's profit per unit of land chosen by consensus of the groups.

f. How much do farmers save per unit area of wheat land using the PTOS for tilling + sowing + fertilizing?

Again, to make it easier to work through this question, address it step-by-step, as follows: Subtract the money farmers will pay as a service charge (for the chosen unit of land area) from the cost of tilling by traditional power tiller (which again may require multiple passes) + laddering + manual sowing and fertilizing. The resulting value is the savings farmers gain from using the PTOS for Box G:

Savings for farmers using the PTOS= [A- E]

In Box G, write the savings in the correct place on the flipchart listed as "[A- E]."

g. The following additional calculations can also be considered:

The PTOS can be used for many crops, not only wheat. It can be used to seed maize, mungbean, sunflower, lentils, jute (if care is taken in the process of calibration and seeding) and many other small- and medium-sized seed crops. Generally, the fluted rollers can be changed to accept seeds of different shapes and sizes, although the machine will need to be carefully recalibrated.

Participants can calculate the same information for crops other than wheat, and work out the profit for farmers and their service provision businesses in the same way as described above.

Following the above procedure, complete the boxes for 'Alternative crop 1' (boxes H to N) and 'Alternative crop 2' (boxes I to U) as shown on the flipchart. Care should be taken to include the correct number of tillage operations and oil-fuel cost; these are likely to vary with each alternative crop.

h. What area of land (in units chosen collectively by the participants) do you think you can till + sow + fertilize with a PTOS in a single day?

Participants should agree on the area of wheat, or 'Alternative crop 1' and 'Alternative crop 2', or a combination of crops, that one can till + sow + fertilize with a PTOS in a single day. Make a note of the area for each of the crops on the flipchart, that is, in Box V for wheat (AA=), Alternative crop 1 (AB=) and Alternative crop 2 (AC=).

Here, focus should be on the crops available in the area where the training is taking place.

- i. **How many days do you think a service provider can till + sow + fertilize different crops with a PTOS in one year?**

Participants should agree on the number of days an SP can provide PTOS services (tillage + sowing + fertilizing) for different crops (grown in the area the training is taking place) in different cropping seasons in one year. Note the number of days that a PTOS service can be rendered for each of the crops on the flipchart, that is, in **box W** for wheat (AD=), Alternative crop1 (AE=) and Alternative crop 2 (AF=).

- j. **How much does a PTOS service provider profit from tilling + sowing + fertilizing wheat, or 'Alternative crop 1' and 'Alternative crop 2' with a PTOS?**

Multiply the land area of wheat that can be serviced in one day and the number of days a PTOS service can be provided for wheat in one year by the profit per chosen land area. Write the result in Box X. This is the approximate annual profit from using the PTOS to seed wheat (note: this may vary slightly if the SP charges different farmers differently for their fields, or if field size varies. The point of this exercise is to provide a general idea of profitability potential). Apply the formula below, using the calculations already made and logged on the flipchart:

Potential annual profit from PTOS tilling+sowing+fertilizing of wheat (AG)=
 $[AA \times AD \times (E-(C+D))]$

Next, calculate the annual profit from other crops, using the following formula:

Potential annual profit from PTOS tilling+sowing+fertilizing Alternative crop 1 (AH)=
 $[AB \times AE \times (L-(J+K))]$

The formula below can also be used:

Potential annual profit from PTOS tilling+sowing+fertilizing Alternative crop 2 (AI)=
 $[AC \times AF \times (S-(Q+R))]$

Participants should thus arrive at a consensus about the total profit in a year. Note this in Box Y.

- k. **Breaking even is the point at which a service provider has accumulated profits that equal the cost of investing in a PTOS machine. How many days or how much land must be tilled + sowed + fertilized by the PTOS to break even?**

Dividing the cost of purchasing the PTOS by the total annual profit earned from PTOS service sales to farmers will result in the time required to break even. Calculate this using the formula below:

Time estimated to break-even on investment in the PTOS = $B/(AG+AH+AI)$

In consensus with the three groups, write the 'estimated time to break even' in Box Y.

Note: this calculation gives only the estimated time to break even, *considering the total profit from the whole year (all crops seeded within a year).*

But how much area has to be tilled + sown + fertilized using the PTOS to break even? To answer this, use the following formula, inserting values decided on by the groups instead of the letters:

Estimated total land area required to till+sow+fertilize using the PTOS to break even = $B/[(AA \times AD)+(AB \times AE)+(AC \times AF)]$

Write the 'required area to break even' on the flipchart, based on the consensus of the groups.

If it takes too long to break even, ask the SPs how they could change their business models to profit more while still keeping tilling prices lower than that of traditional power tiller and hand sowing + fertilizing + laddering (where applicable). The goal is to find ways for participants to make a profit quickly, while giving farmers an opportunity to prepare land at reduced cost.

- l. **For more advanced participants, start a discussion about the interest on the credit used to purchase the machine, and the time needed to repay these loans. Use additional calculations to determine when the loan and interest should be repaid.**
- m. **Finally, ask each group to note if they see any difference(s) between the real-world, observed PTOS businesses and the ones they have developed, and suggest strategies/activities for a profitable PTOS service business. Each group should present their assignment on a sheet of poster paper. If time does not permit, a single business model analysis can be presented.**

Step 3: Discussion (10 minutes)

Discuss the following points and record any important aspects of running a PTOS service business on the flipchart.

- primary investment
- monthly expenditure on and income from the PTOS
- list of potential farmers to whom a PTOS service could be provided
- (for advanced groups) cost of a loan, interest and other considerations

Step 4: Review of the session's key messages (5 minutes)

Review the key messages using the Session 8 flipchart.

Session 9

Review of key messages, post-training evaluation and close of training

Materials required

For this training session, you will need the following resources and materials:

- the flipchart *Session 9: Review of key messages, post-training evaluation and close of training*
- a copy of the post-evaluation questionnaire for each participant
- handouts or other materials (e.g., leaflets, brochures, if available)

Step 1: Question-and-answer session to review key points of the training (20 minutes)

Review each session by asking participants to recall the key messages, to make sure they have understood those which are essential.

Ask the following questions:

- What are main parts of a PTOS?
- What are the benefits of line sowing by PTOS?
- What is calibration?
- What is full tillage and strip tillage?
- What are the potential major failures or breakdowns of the PTOS and their cause(s)? What are their solutions?
- What is a business plan?
- How can you make PTOS services profitable, while also benefiting farmers?

Check the “Participants’ expectations” as noted in Session 1 of the training and ascertain whether these have been fulfilled. If not, address them through discussion or follow-up meetings and consultations.

Step 2: Complete the post-training evaluation questionnaire (30 minutes)

Distribute the post-training evaluation questionnaires to participants and allow about fifteen minutes to complete it. Calculate the scores, and check them against their pre-training evaluation. Give both the pre- and post-training evaluations back to participants for review, and record each participant’s score in a training or project logbook. Take time to discuss any common errors with participants and correct any misconceptions before closing the training.

Step 3: Distribute additional materials (5 minutes)

Distribute any handouts, leaflets, brochures and other materials among participants.

Step 4: Close the training (10 minutes)

Thank participants and guests. Give positive feedback about the commitment and performance of the participants. Make sure participants have the trainers’ contact information and handouts. Close the training.



Flipcharts and handout materials*

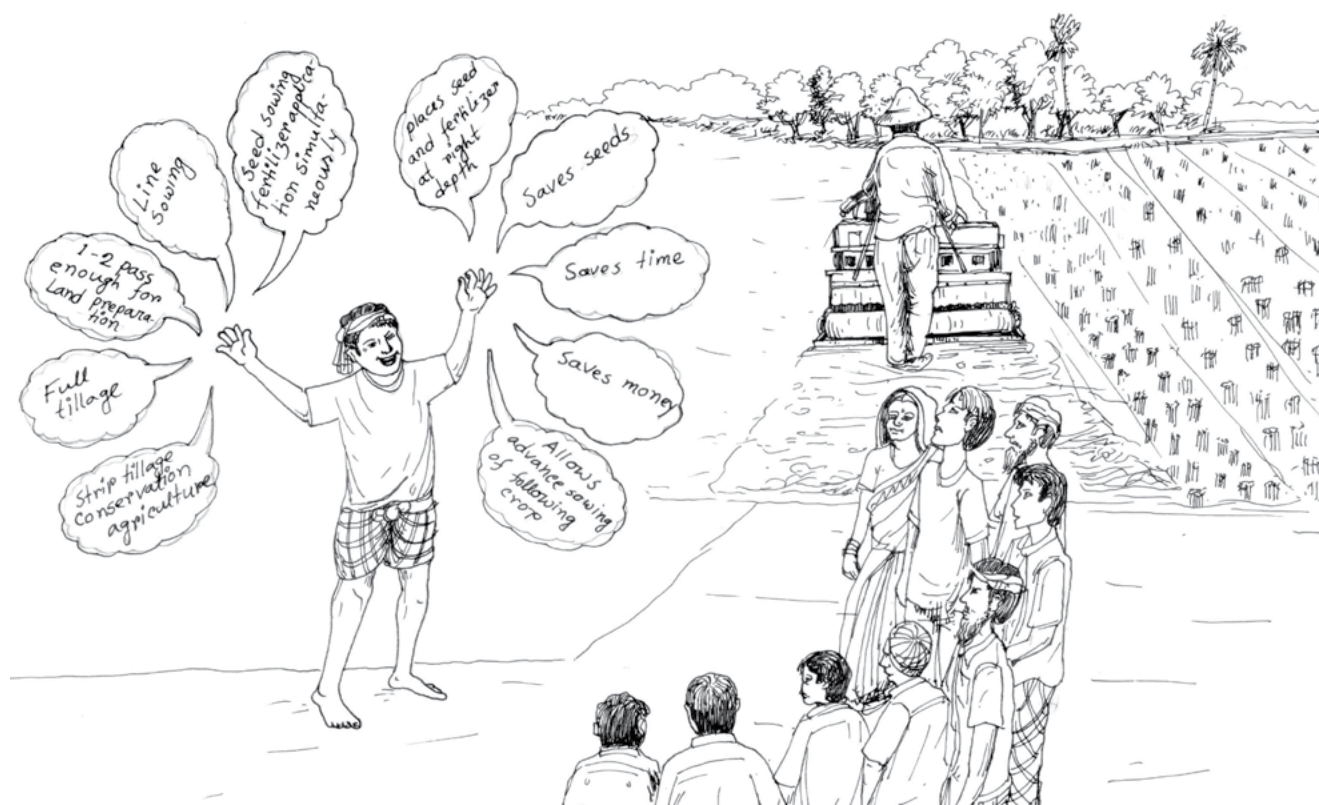
* PowerPoint files of the flip charts in 'ready to present' format can be downloaded from here (for English language: <https://bit.ly/2FR5SYY>) or here (for Bangla language: https://csisa.org/wp-content/uploads/sites/2/2019/12/191204_PTOS-SP-AM-smh.pdf).



Session 1

Introduction, training objectives and pre-training evaluation

Power Tiller Operated Seeder one-day training flipchart



What do you expect to learn from this training?

♦ In groups, discuss what you think you'll learn today.



♦ Choose one of the participants to speak for the group.

♦ Take notes.



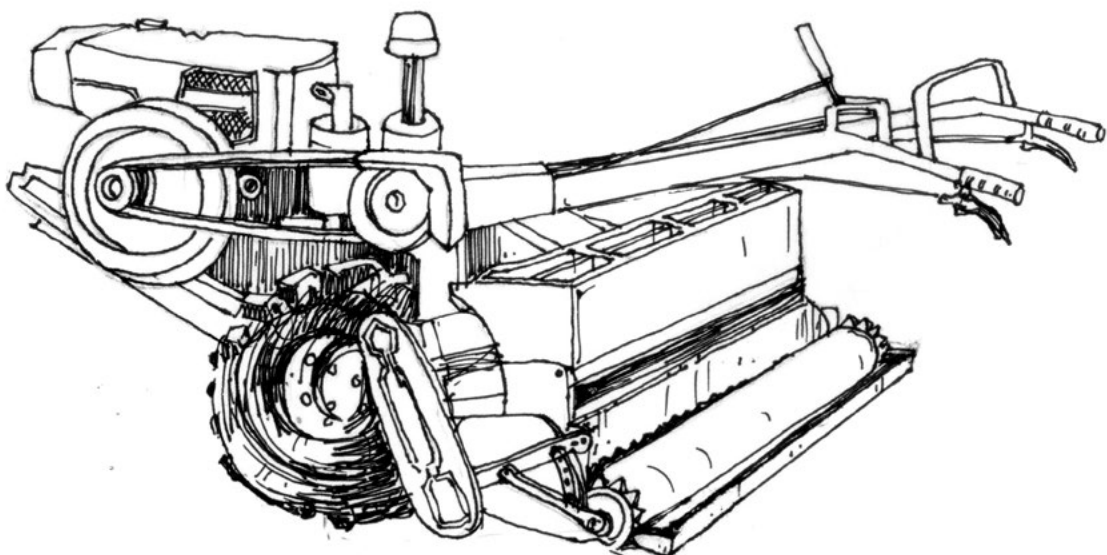
Today's sessions

- 1. Introduction, training objectives and pre-training evaluation**
- 2. Introduction to the two-wheeled tractor**
- 3. Introduction to the PTOS**
- 4. Main parts of the PTOS and their functions**
- 5. Calibration (practical exercise)**
- 6. How to use a PTOS safely and effectively**
- 7. Troubleshooting and maintenance**
- 8. Starting a PTOS business**
- 9. Review of key messages, post-training evaluation and close of training**

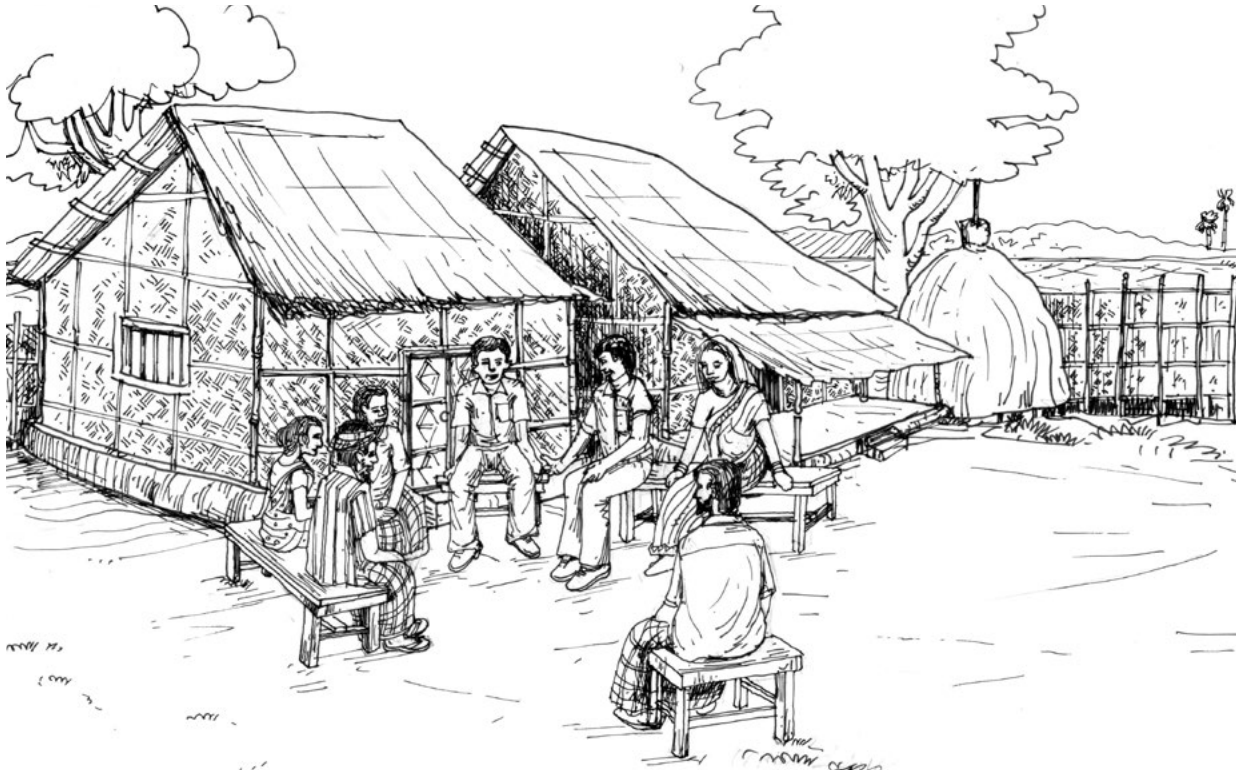
What kind of training is this?

This is *participatory* training, so:

- ◆ Ask questions and speak up.
 - ◆ Learn by experience: try mechanical seeding yourself.
- ◆ Discuss each topic with your group.
 - ◆ Speak up when the facilitator asks questions – and ask questions yourself. This way we can learn from each other.



Please enjoy this training!

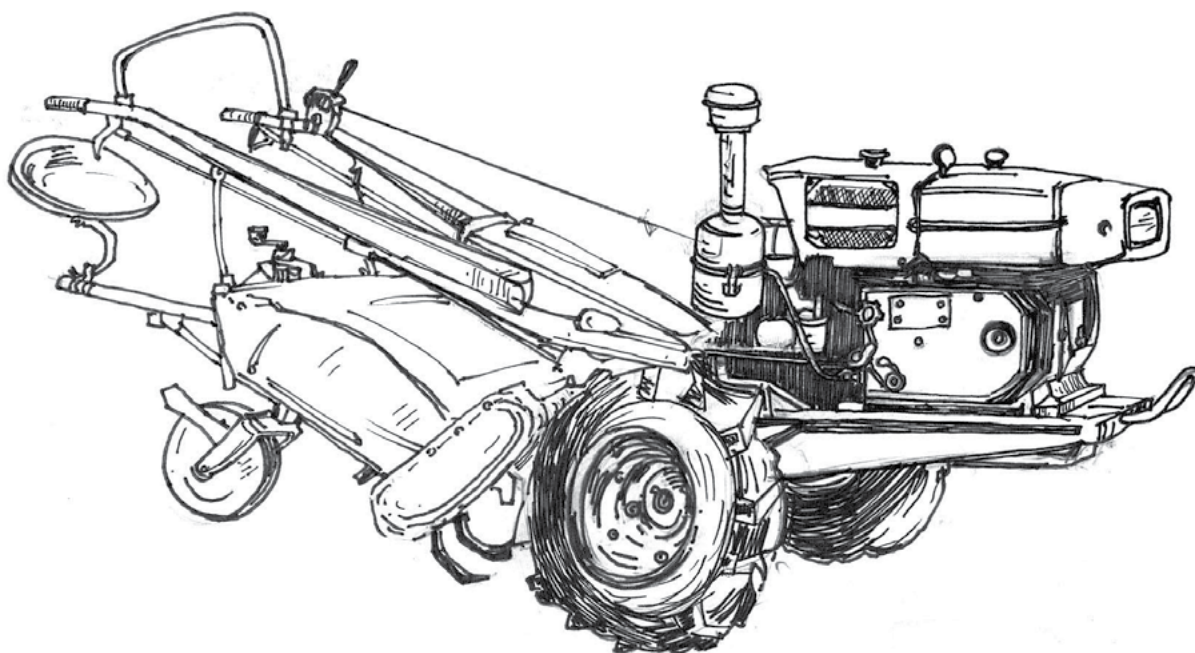


- ◆ **Feel free to ask questions and contribute your knowledge.**
- ◆ **Make sure you get time to practice calibration of the mechanical seeders.**
- ◆ **Have fun!**

Session 2

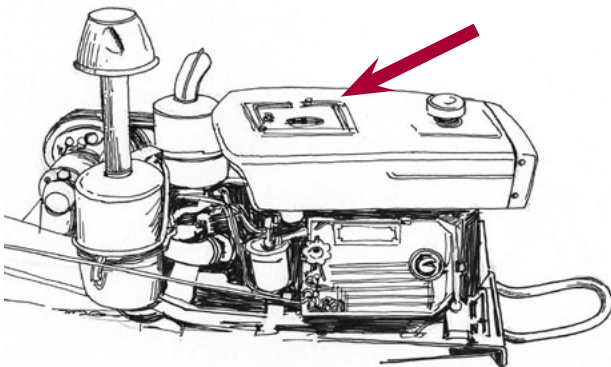
Introduction to the two-wheeled tractor

Power Tiller Operated Seeder
one-day training flipchart

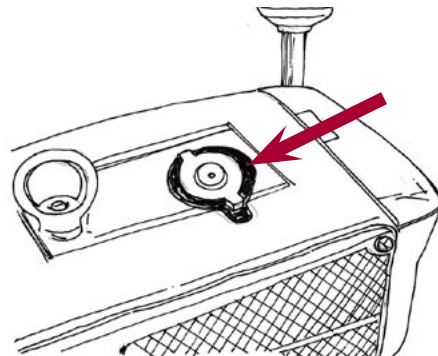


Inspecting the two-wheeled tractor before starting (1)

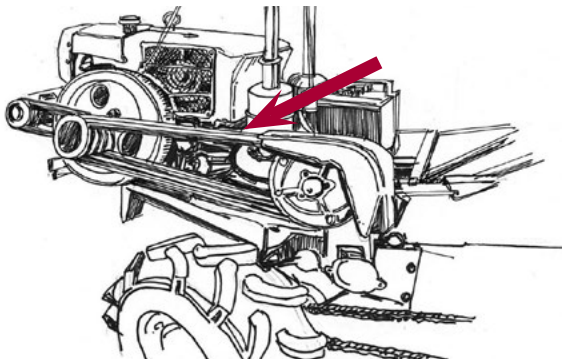
Start by checking the bolts and tightening them.



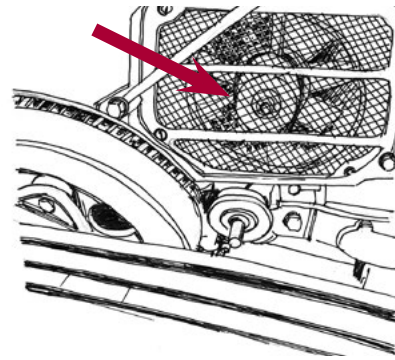
Fill the radiator with water.



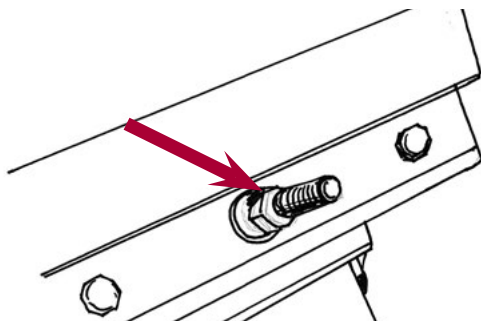
Fill the tank with high quality fuel.



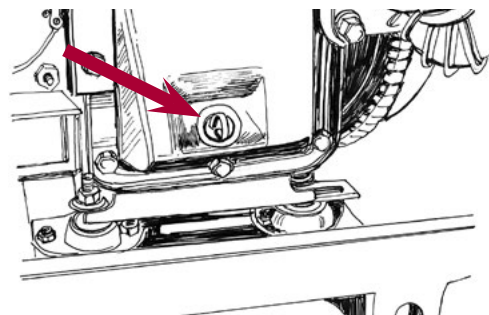
Make sure the V-belts are tight.



Make sure the small fan belt is tight.

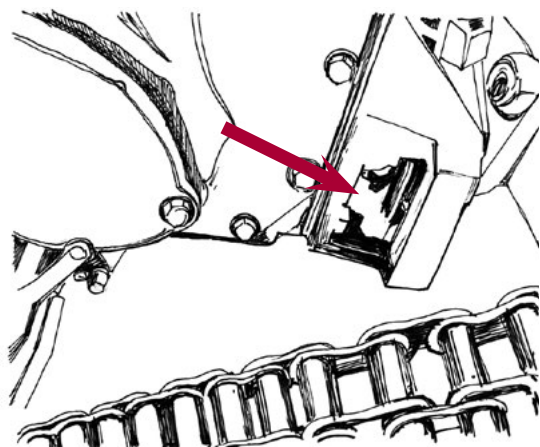


Tighten the tension belts with the adjusting screw.

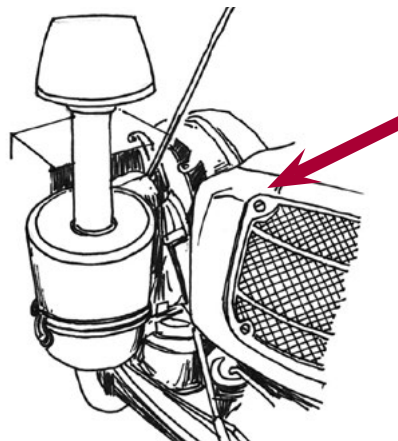


Add engine oil (if needed).

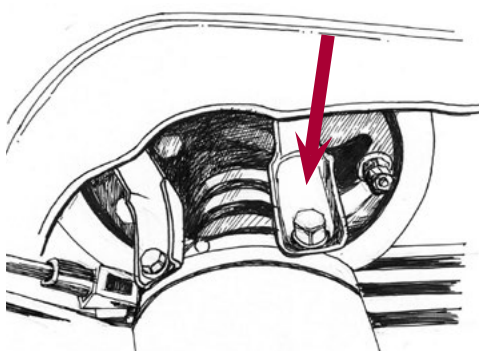
Inspecting the two-wheeled tractor before starting (2)



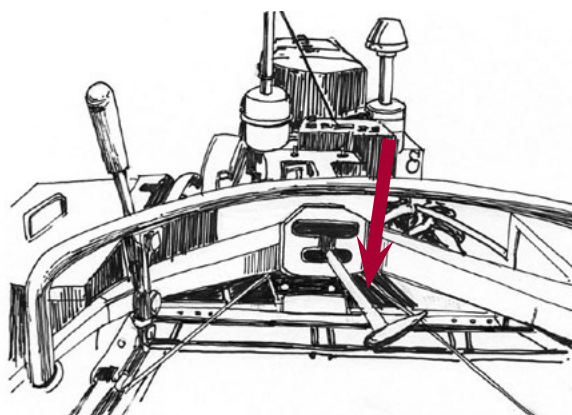
Check and fill the oil transmission.



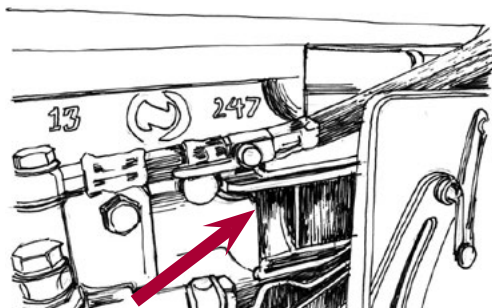
Verify the air filter and exhaust pipe are not blocked.



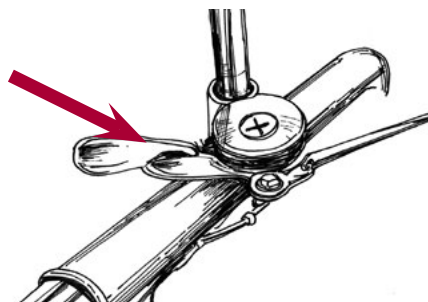
Apply light touch of oil to oil clutch and bearings.



To start, make sure all gears are in neutral.

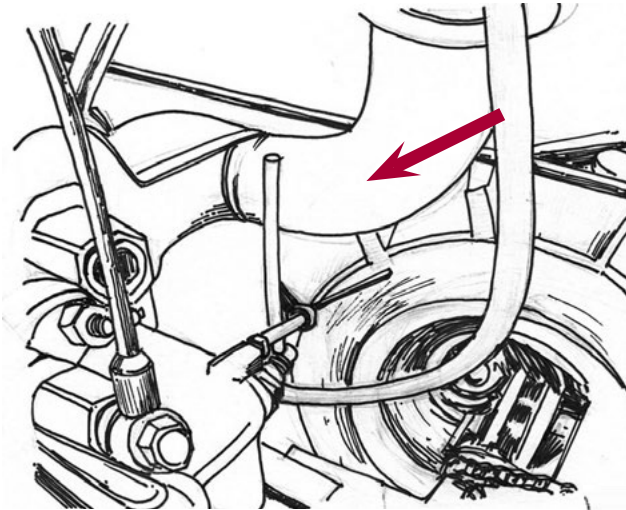


Turn the fuel tap to the left to the 'on' position.



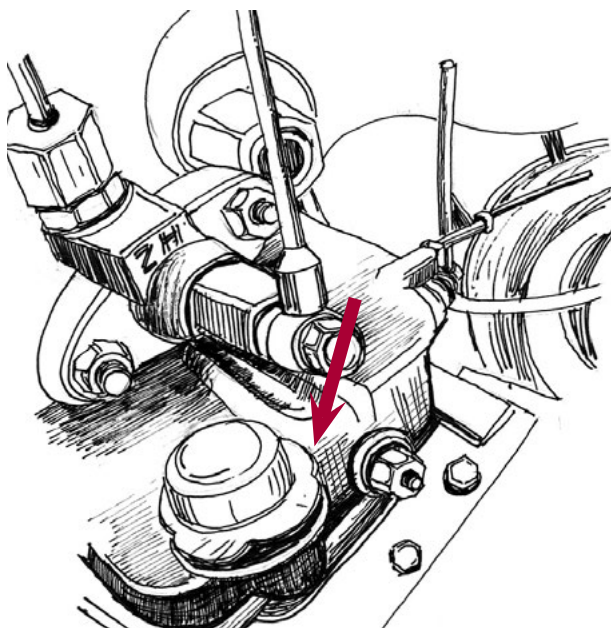
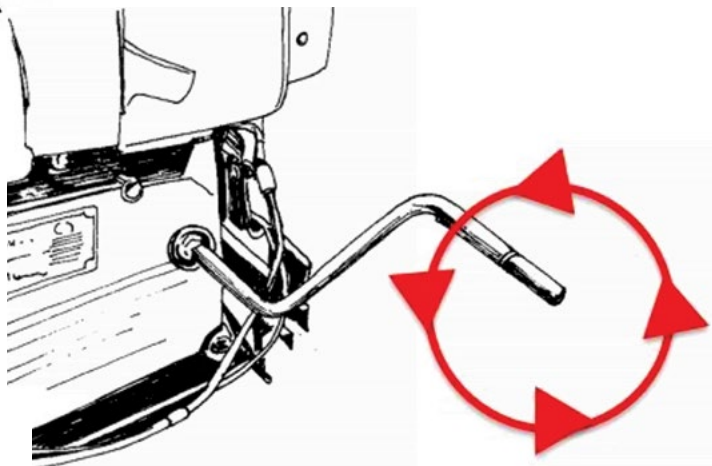
Turn the throttle fully to 'on' position.

Starting the two-wheeled tractor



Turn the decompression lever left and hold down.

Turn the crank clockwise as fast as possible until the engine starts.

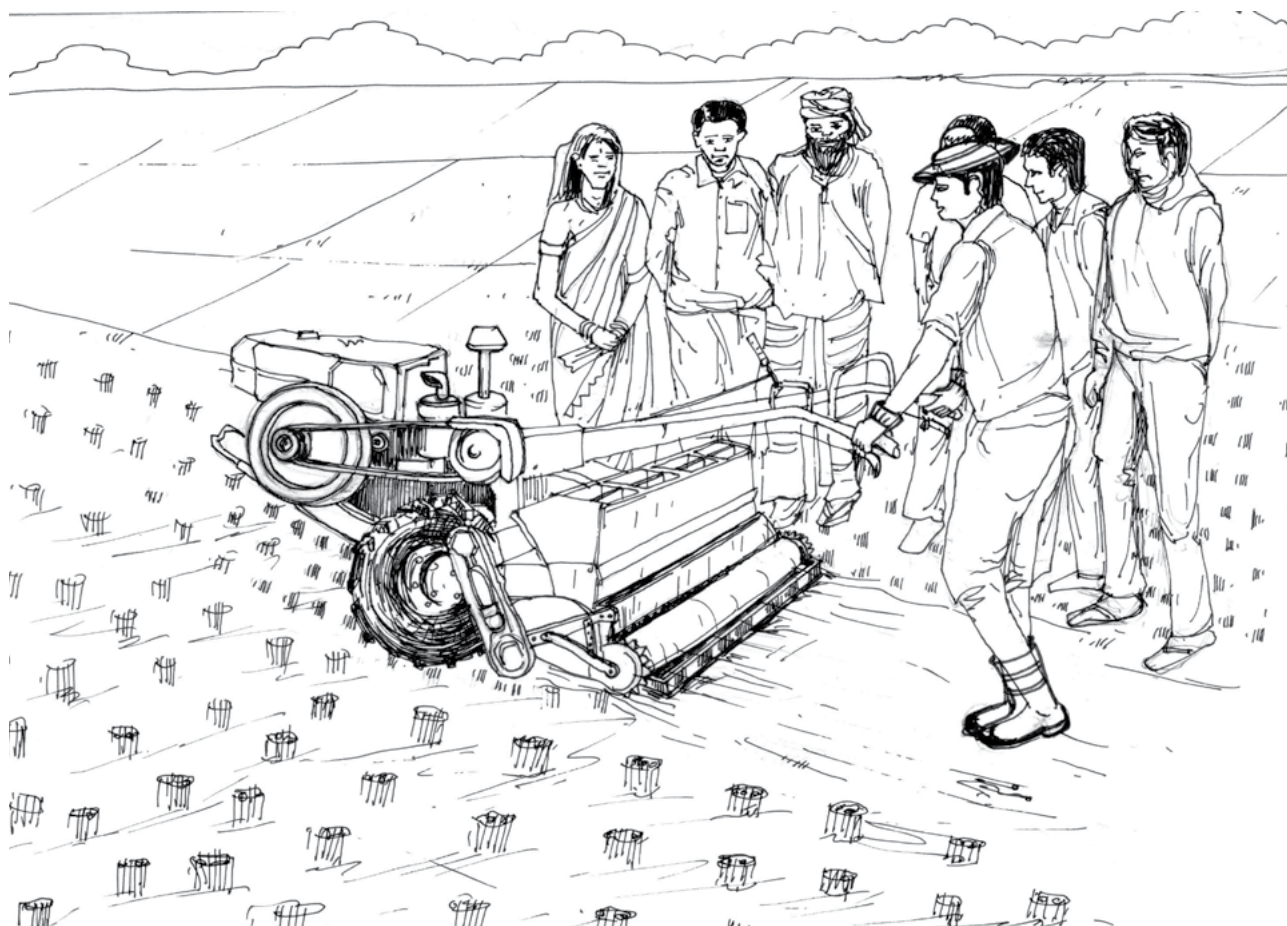


After starting, verify the engine has enough oil. Add more if needed.

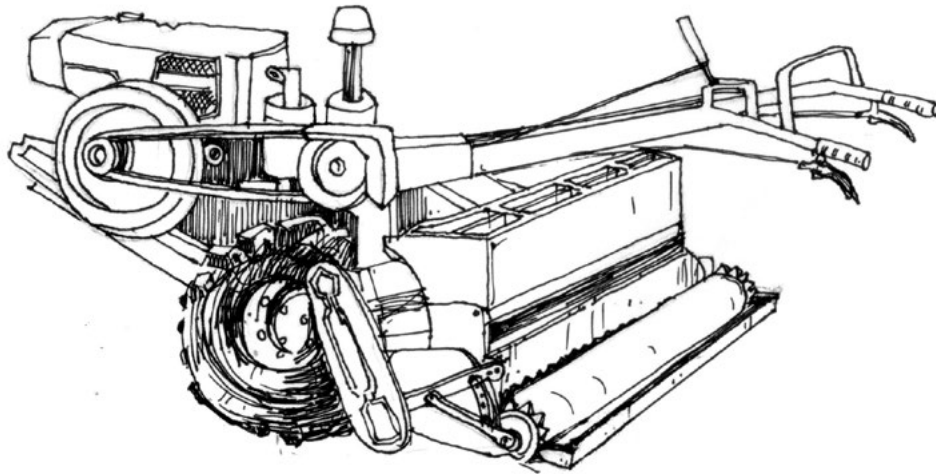
Session 3

Introduction to the PTOS

**Power Tiller Operated Seeder
one-day training flipchart**



What is a PTOS?



A power tiller-operated seeder, or PTOS:

- ◆ tills the soil and plants seed and places fertilizer at the same time.
 - ◆ can be attached to a Dongfeng or Sifeng two-wheeled tractor.
- ◆ has 48 blades for tilling the soil (compared to 18 on a power tiller).
 - ◆ reduces the time needed to till and plant a field.

Using a PTOS to plant farmers' fields can be profitable – both for the machine owner and the farmer!

Most PTOS are 1.2 m wide, but some are 1 m wide.

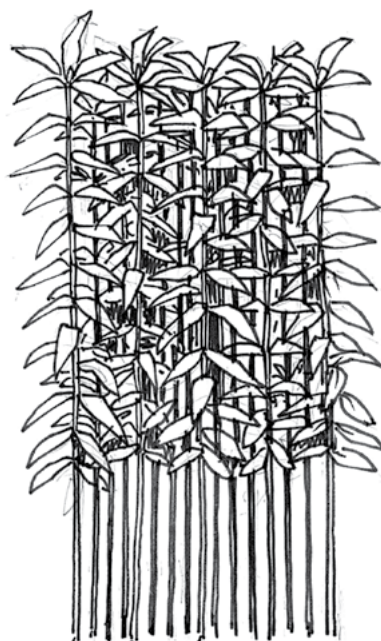
- ◆ **The depth of tillage is adjustable, but can be as deep as about 6 cm.**
 - ◆ **The PTOS usually weighs about 145 kg.**
- ◆ **Power tillers require between 2-4 passes to complete tillage and sowing – the PTOS needs only one pass.**



What crops can be sown with a PTOS?

- ◆ wheat
- ◆ maize
- ◆ rice
- ◆ pulses (legumes)
- ◆ jute
- ◆ mustard
- ◆ sesame
- ◆ sunflower
- ◆ barley
- ◆ many other small and medium-sized seed crops

Different seeding mechanisms must be used with the PTOS for different crops.



What are the advantages of using the PTOS for line sowing?

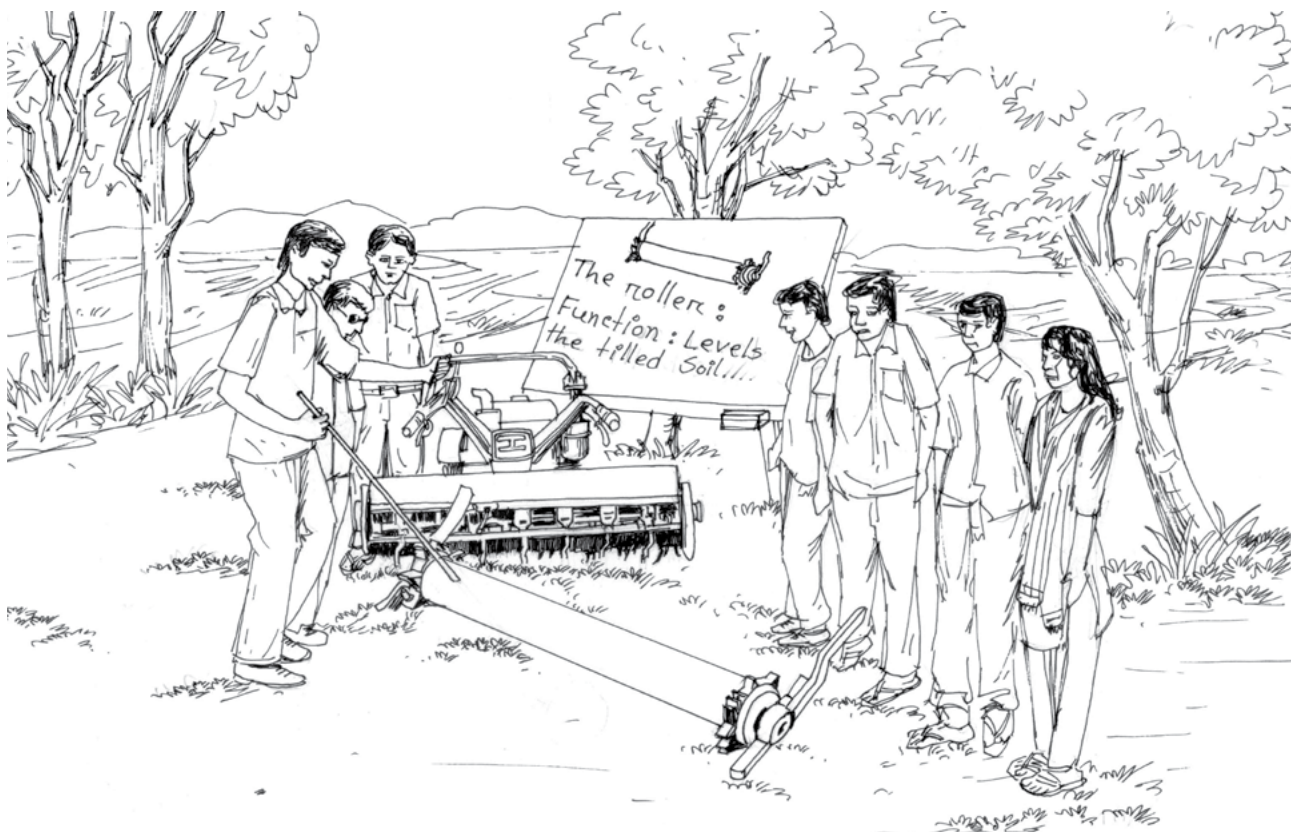


- ◆ Seed and fertilizer are placed in the ground in the same line. This improves the use of fertilizer by the crop.
 - ◆ Seeding depth is uniform, which means better seed germination and crop establishment.
- ◆ It is easier to move around the field to weed and manage the crop without stepping on the plants.
 - ◆ The optimum crop density can be more easily established by PTOS.
- ◆ Good crop density can increase yield.

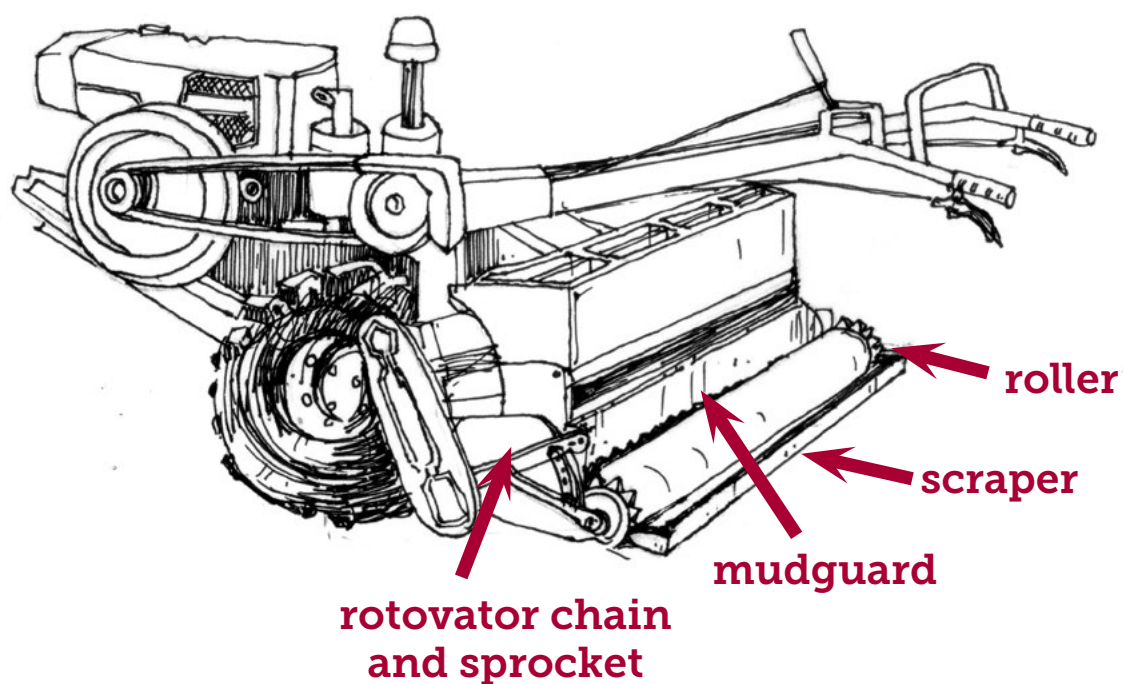
Session 4

Main parts of the PTOS and their functions

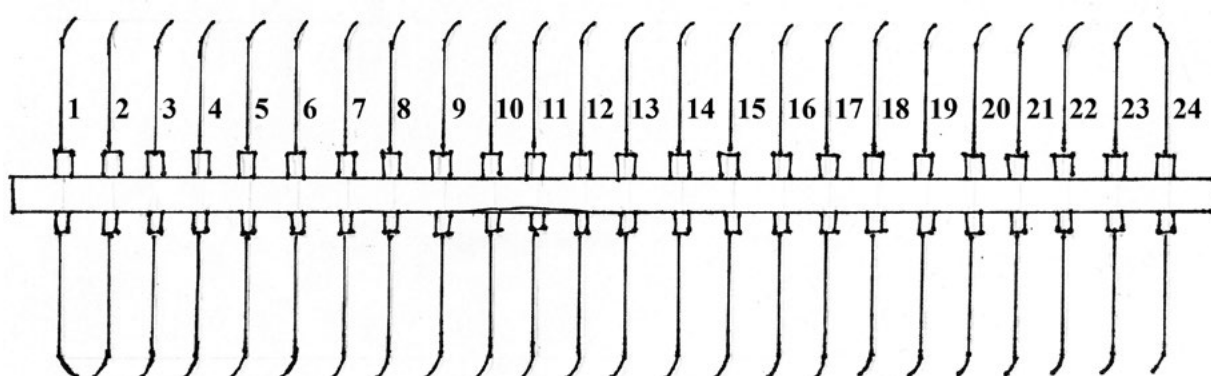
Power Tiller Operated Seeder
one-day training flipchart



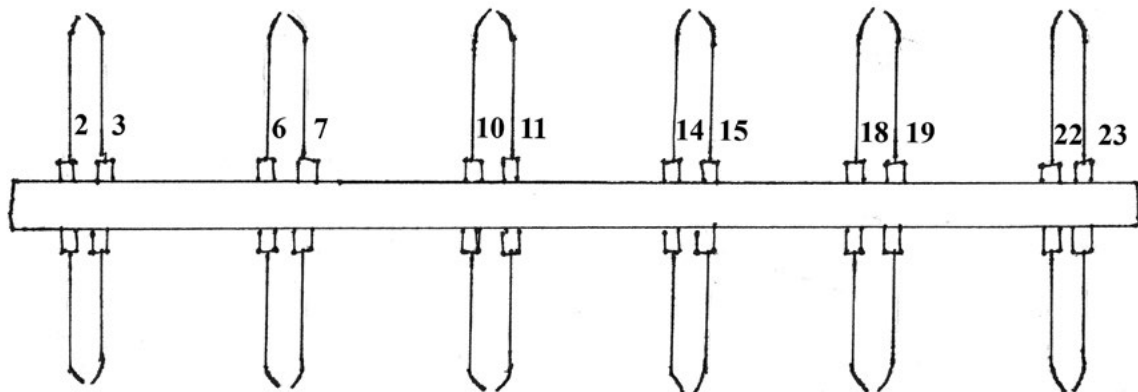
Main parts of the PTOS (1)



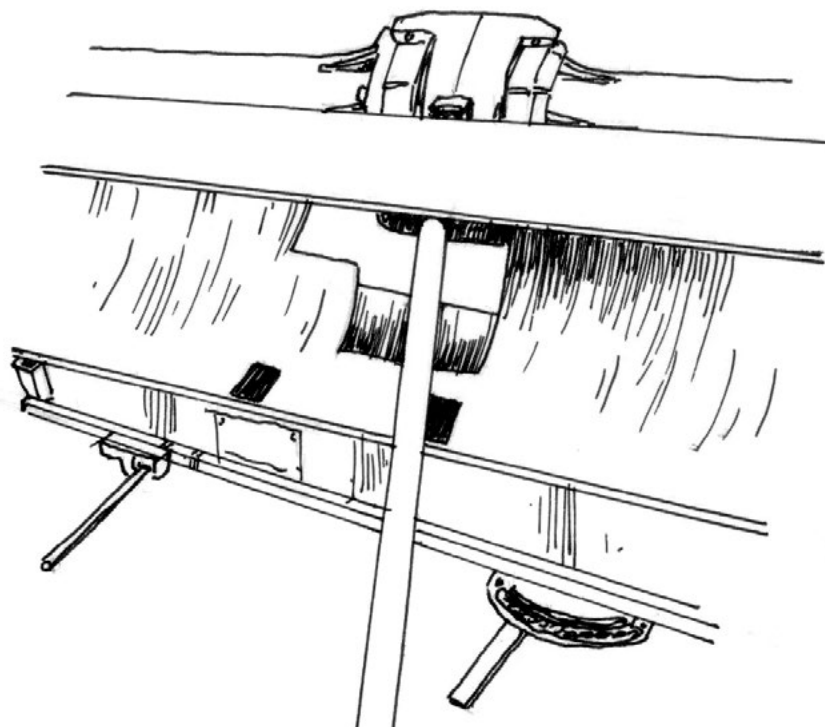
The rotovator



rotovator with 48 tines used for full tillage



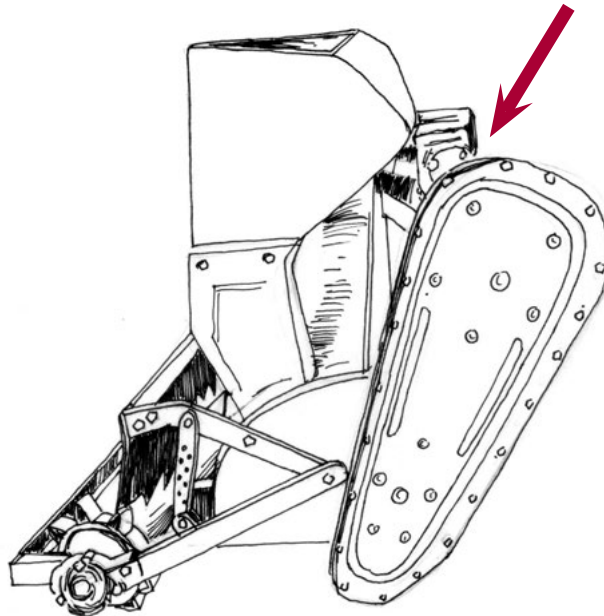
rotovator with 24 tines arranged for strip tillage



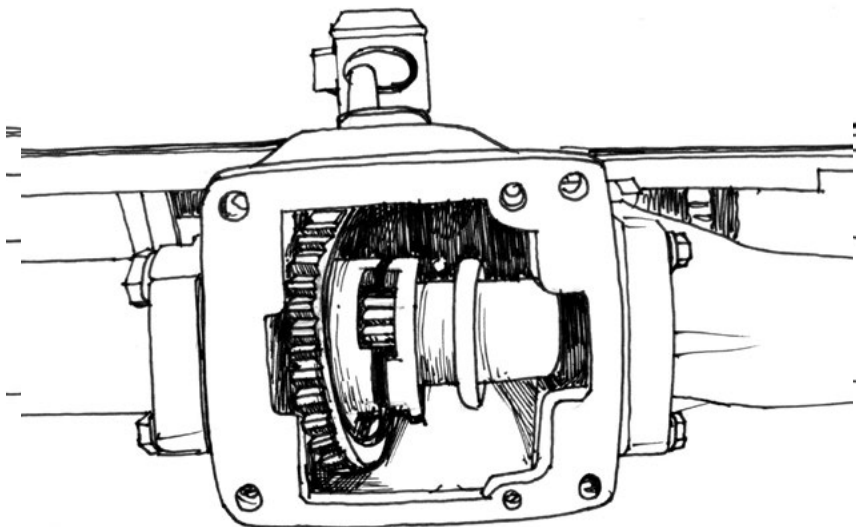
the rotovator on-off clutch

Function: the rotovator tills the soil with rotating tines. These rotate faster than with a typical power tiller.

The hitching gear



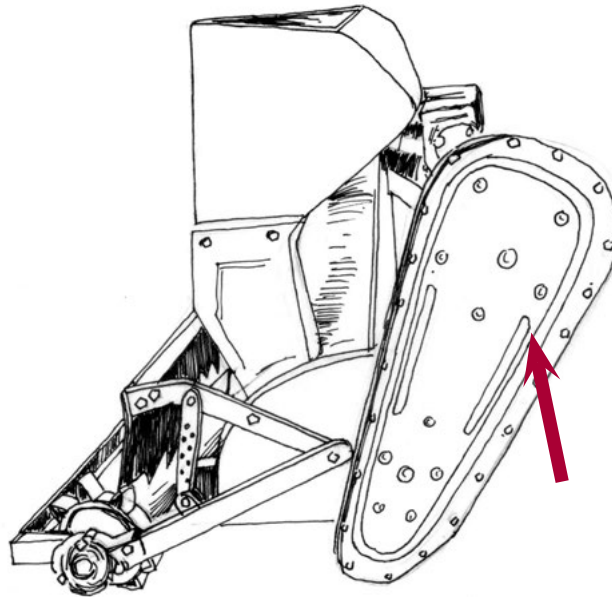
location of the hitching gear



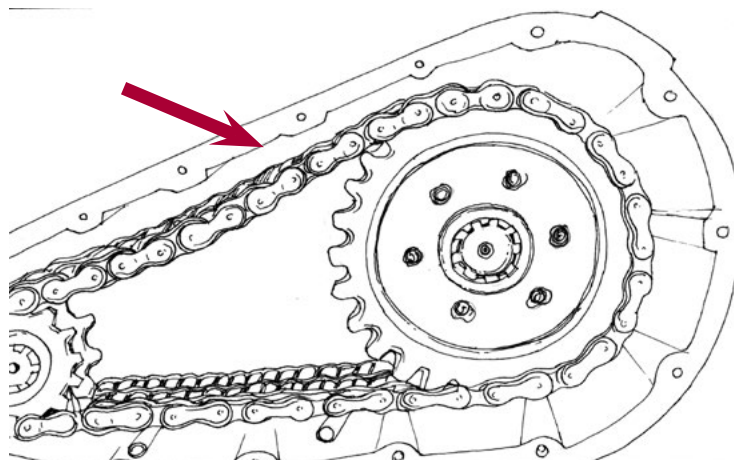
close-up of the hitching gear

Function: the hitching gear connects the PTOS to a two-wheeled tractor and transmits power to it from the tractor.

The rotovator chain and sprocket



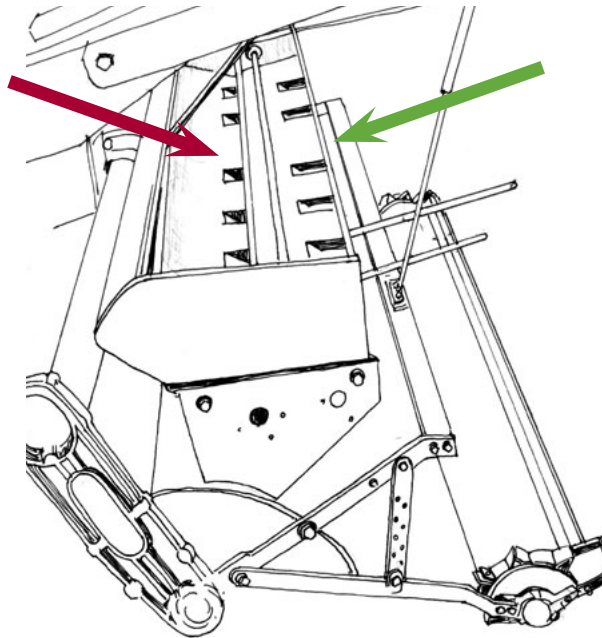
location of the chain cover



close-up of the chain and sprocket with the cover removed

Function: the chain cover protects the rotovator chain from dust, straw, soil and other materials. It is important to protect this part of the PTOS and to keep it regularly oiled and greased.

The seed and fertilizer boxes

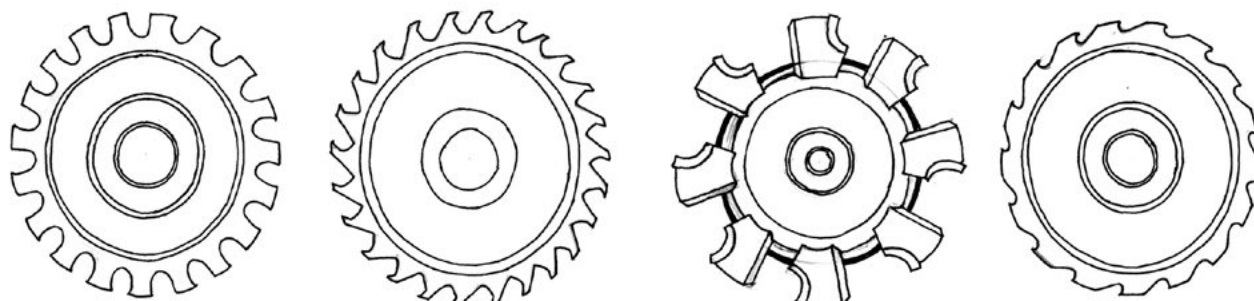


location of the seed box (red arrow) and
fertilizer box (green arrow)

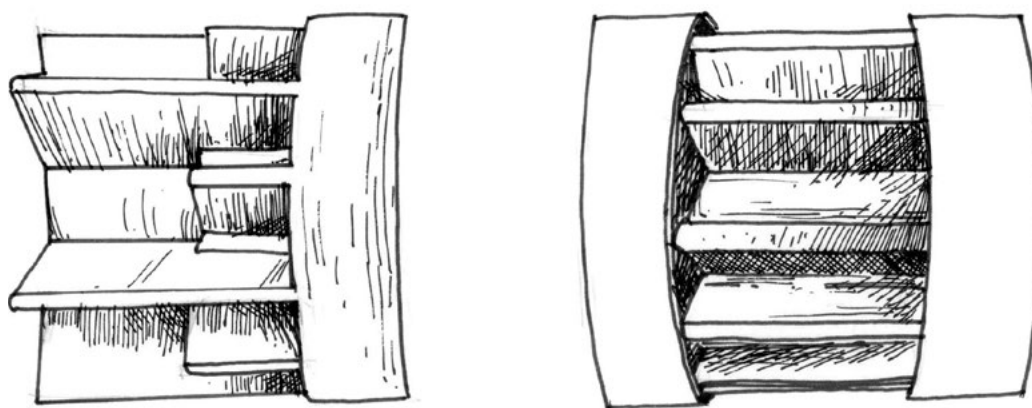


Function: these boxes hold the seed and fertilizer before they are placed in the soil.

The seed and fertilizer meters



inclined plate-style seed meters

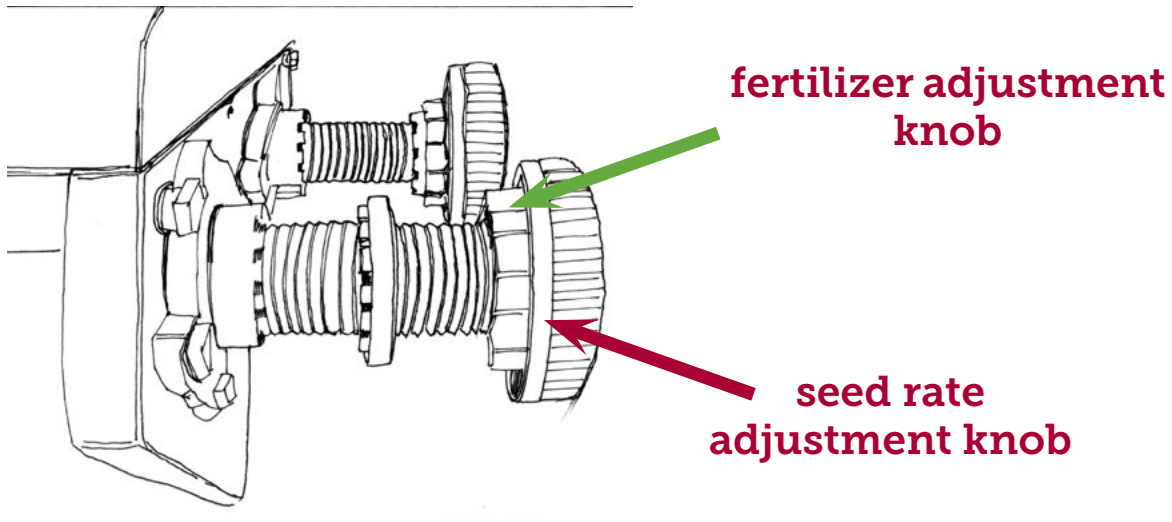


fluted roller seed meters

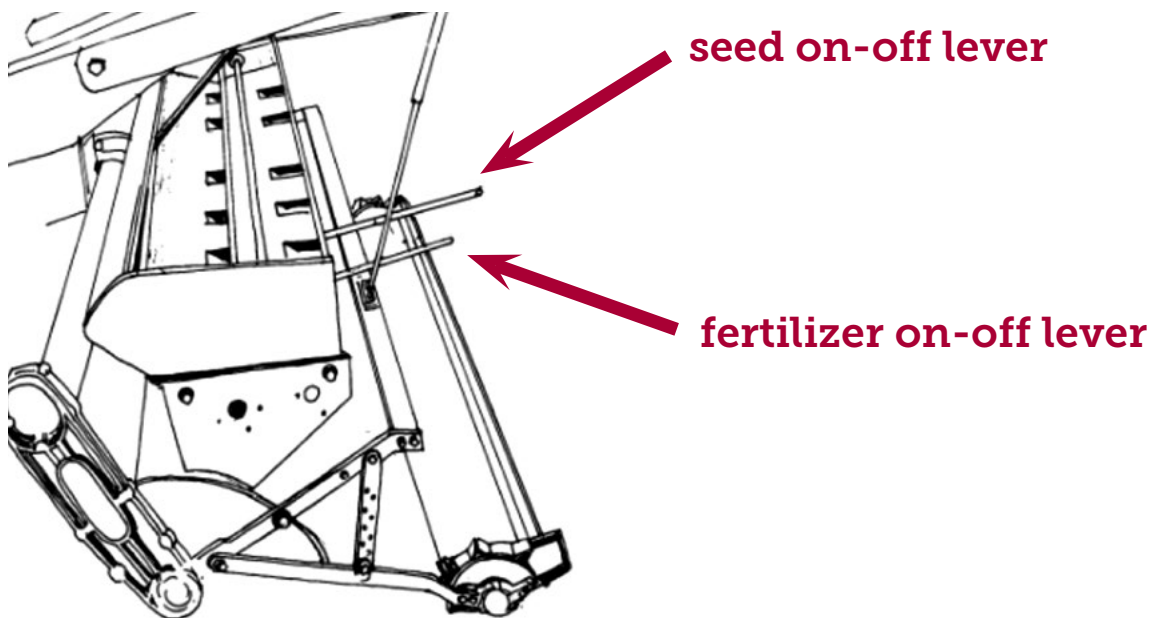
With most PTOS, these are more common for seed and fertilizer.

Function: these meters deliver seed and fertilizer from the seed boxes to the seed tubes. They rotate as the machine moves, capturing seed and fertilizer, and dropping them into the seed tubes.

The seed and fertilizer rate adjustment knobs



The seed and fertilizer on-off lever/clutch



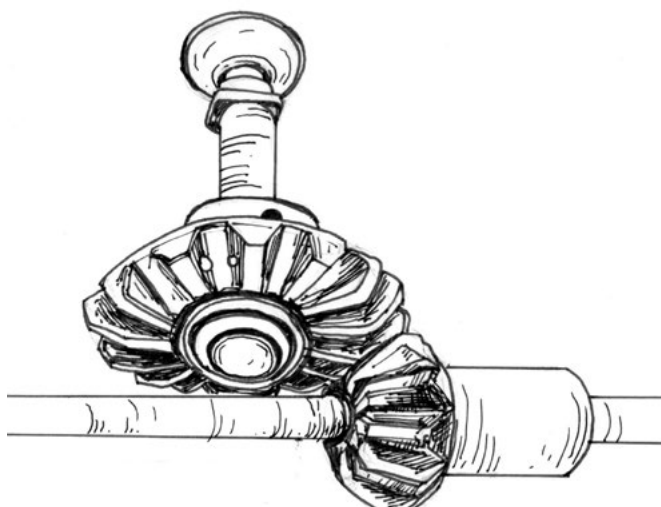
Function: the seed/fertilizer on-off clutch switches the seed and fertilizer meters on and off.

Seed metering shaft or bevel gear shaft

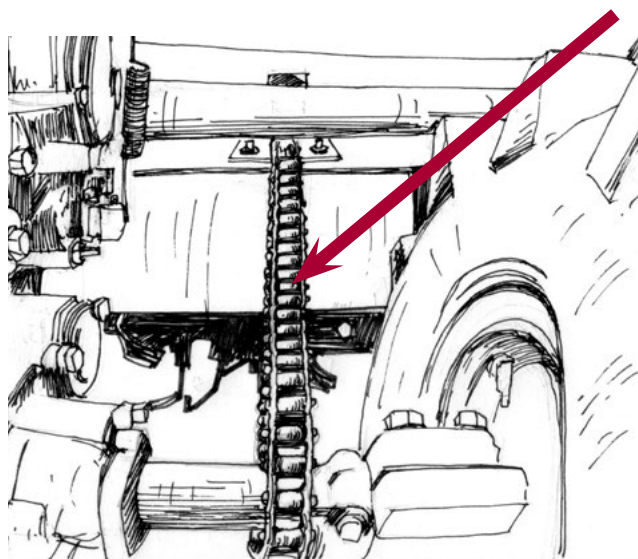
Function: the seed metering shaft or bevel gear shaft transmits power to

the seed meters.

Note: this kind of shaft is found only on inclined plate-style seed meters. It is not used for fluted roller meters.

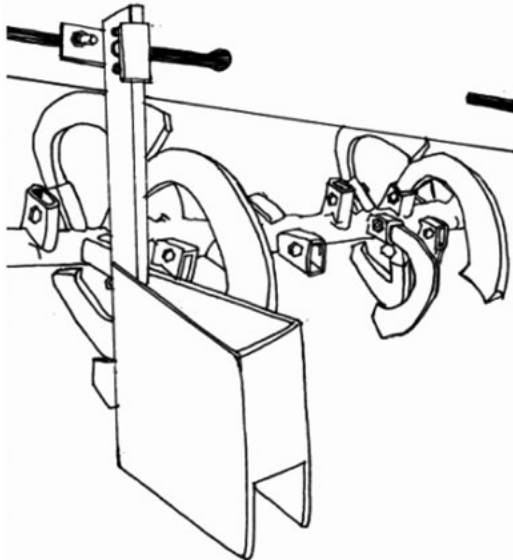


Power transmission chain

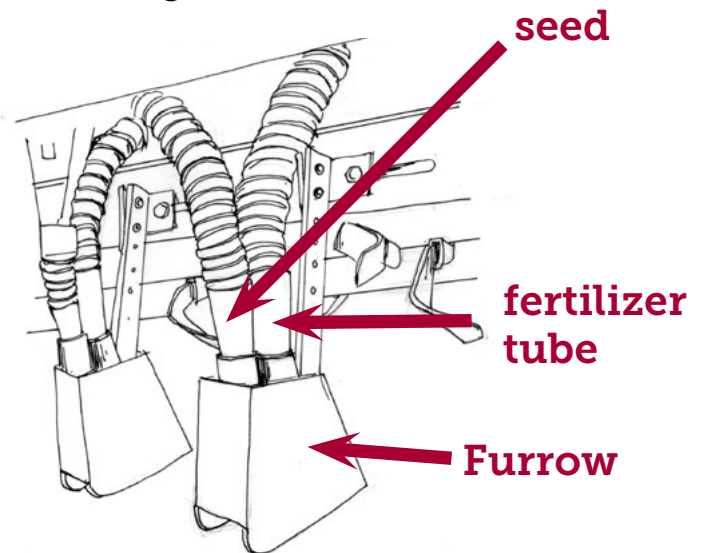


Function: the power transmission chain transmits power from the wheel axle to the seed and fertilizer metering shafts.

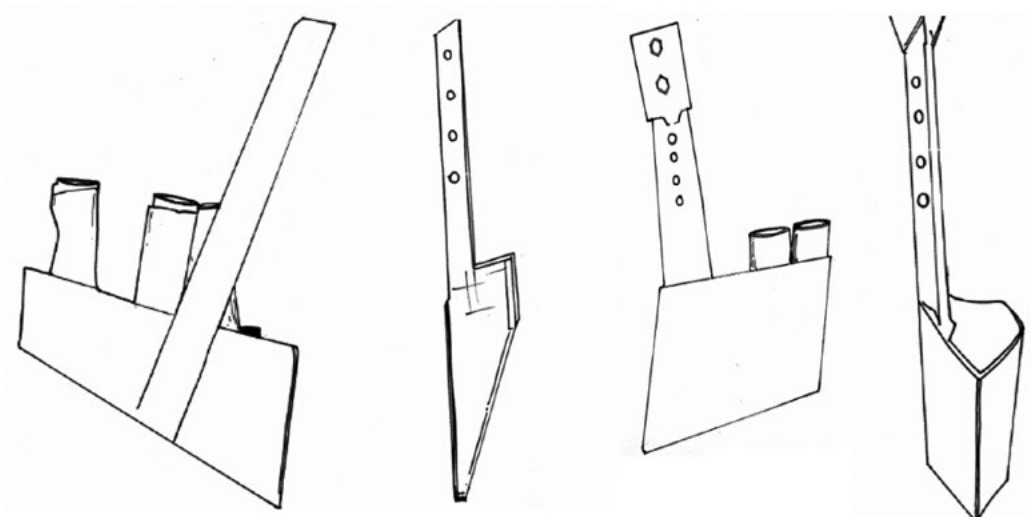
Furrow opener assembly



Top: Furrow openers at the rear of the PTOS (shown without the attached seed and fertilizer delivery tubes).



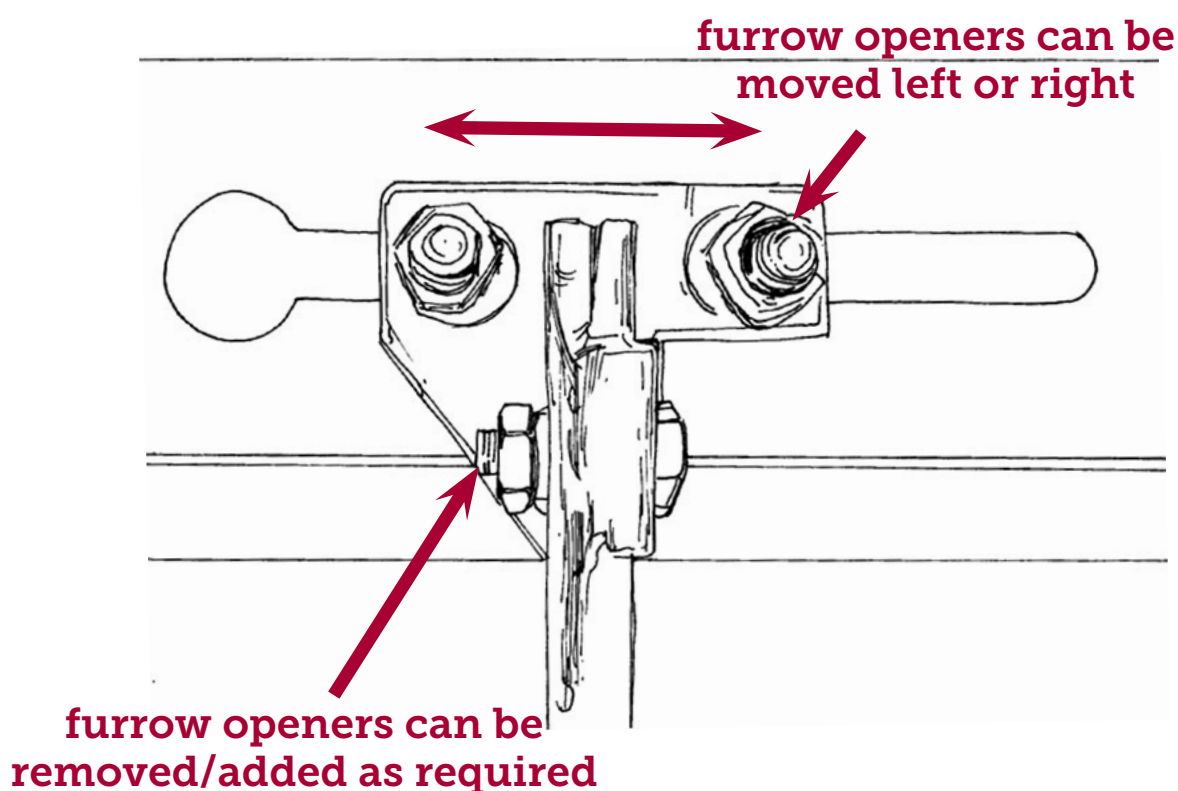
Top right: Furrow opener, detail, showing seed and fertilizer tubes. Note the fertilizer tube is at the front, the seed tube is at the back.



Four kinds of furrow openers.

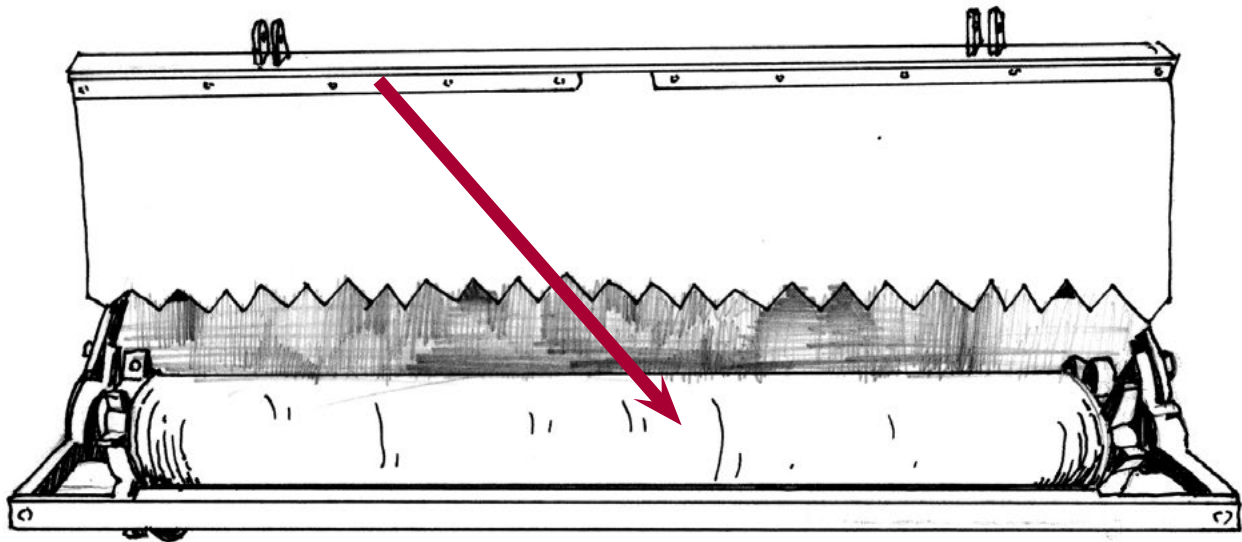
Function: the furrow opener is dragged behind the rotovator blades and opens the soil to place seed and fertilizer.

Furrow opener setting and adjustment bolts



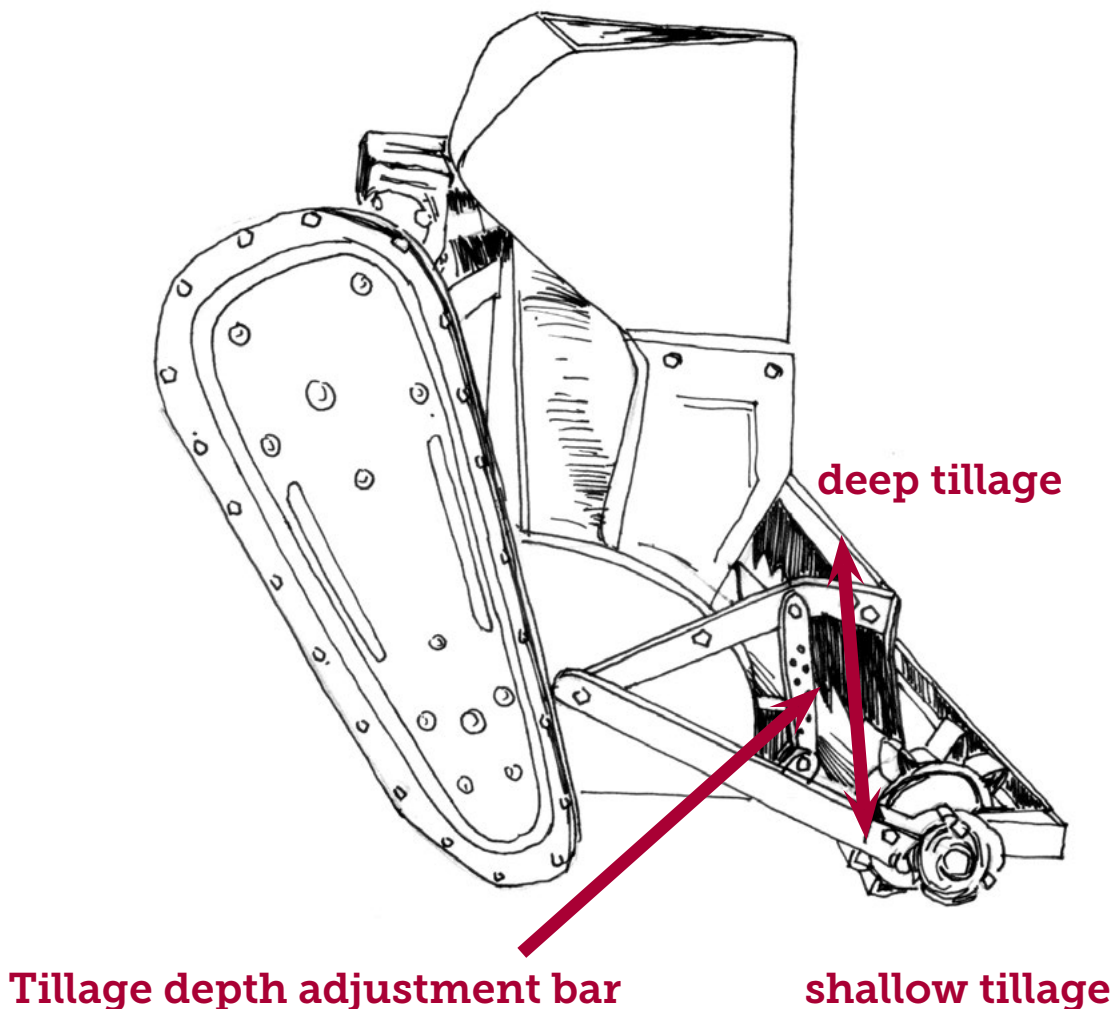
Function: adjust the furrow openers to maintain the correct line-to-line distance when sowing the crop. On most PTOS, use the adjustment bolts to add or remove the furrow openers, or to shift them left to right. Other models have a 'tool bar' that uses "U" clamps to attach the furrow openers.

Leveling roller



Function: the leveling roller is at the back of the machine. It moves tilled soil back into the slots created by the furrow openers, covering the seed. When used for strip tillage, it also pushes the residue down into a mulch. Note the mud lap and scraper at the very end of the machine, which remove soil from the roller.

Tillage depth adjustment bar



Function: the tillage depth adjustment bar allows the tillage depth to be increased or decreased. Remove the bolts, move the position of the roller bar, and re-bolt the adjustment bar.

Note: the depth needs to be adjusted on both sides of the machine to be correct.

Key messages

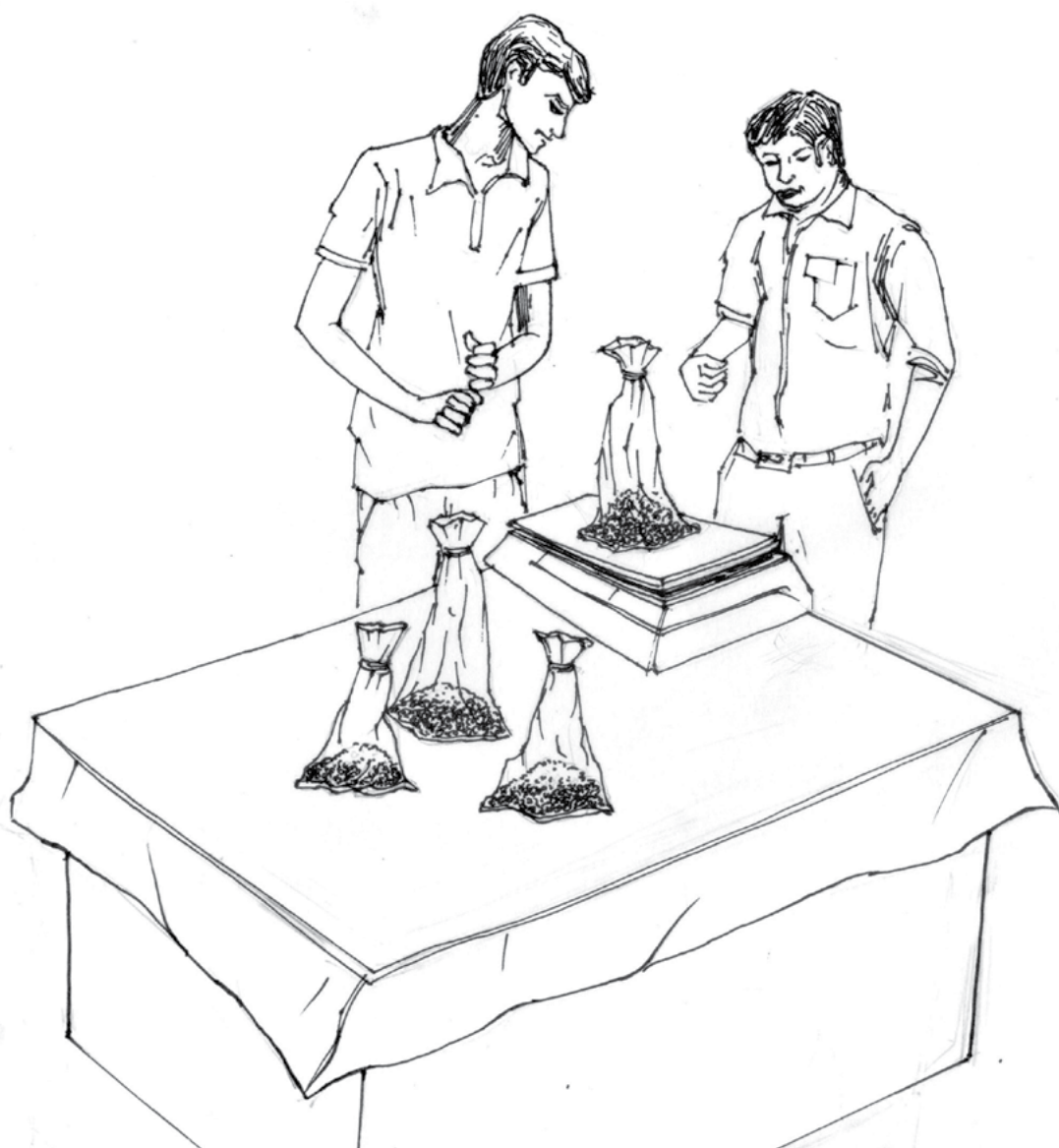
The main parts of a PTOS are:

- ◆ rotoator (with rotary blades, also called tines) and the rotoator on/off lever
 - ◆ hitching gear
- ◆ rotoator chain and sprocket
 - ◆ seed/fertilizer boxes
- ◆ seed/fertilizer meters
 - ◆ seed/fertilizer rate adjustment knobs
- ◆ seed/fertilizer on-off levers (clutch)
 - ◆ seed metering shaft or bevel gear shaft (on select PTOS models only)
- ◆ power transmission chain
 - ◆ furrow openers
- ◆ furrow adjustment set-up
 - ◆ leveling bar or roller
- ◆ tillage depth control bar

Session 5

Calibration of the PTOS

**Power tiller-operated seeder
one-day training flipchart**



What is calibration – and why is it important? (1)

Calibration is essential to make sure that the PTOS meters the correct rate of seed (or fertilizer) per unit land area.

Calibrate the PTOS by changing the length of the fluted rollers (so they provide more, or less, seed and fertilizer).

Some machines have ***inclined plates*** – you can change these for different seed types. Inclined plates provide precise seeding, though calibration checking is still necessary.

Calibrate your PTOS at least once at the beginning of every season, and when you change from sowing one crop type to another.

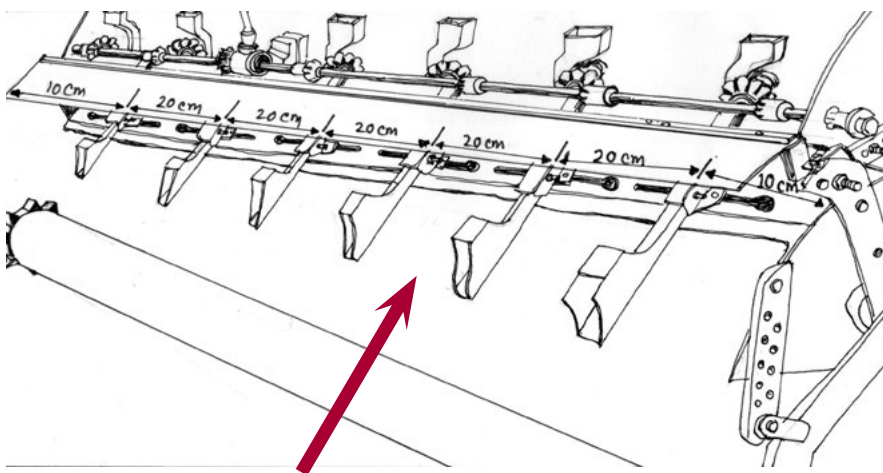
Calibrating the PTOS: An example

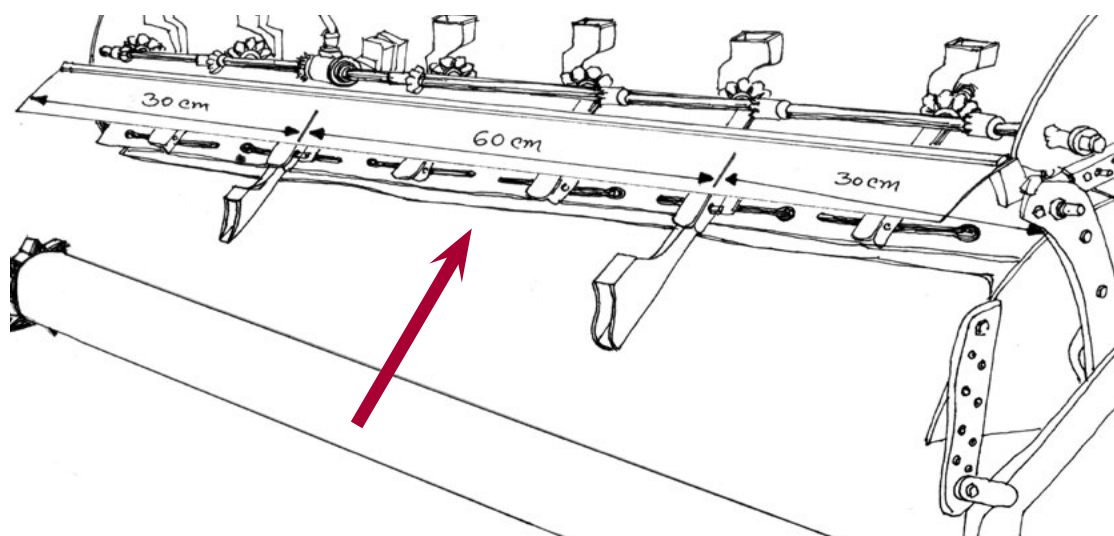
Remember: 1 ha = 7.5 *bigha*, around 247 *decimals* or 10,000 m².

The recommended seed rate for machine-sown wheat is 100 kg per ha (16 kg per *bigha*, or 0.4 kg per *decimal*).

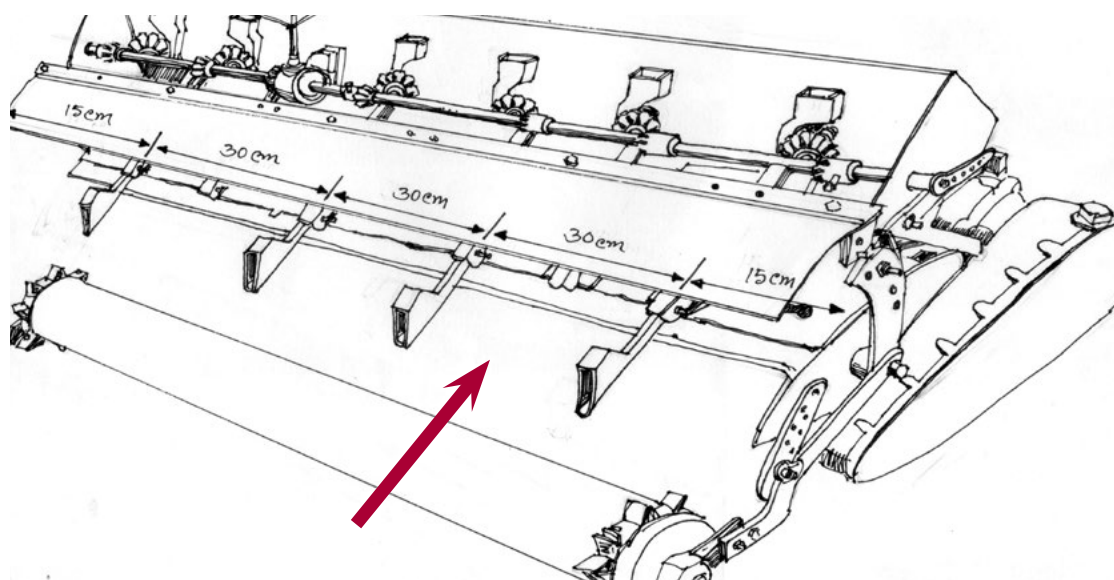
Following the appropriate line distance for the crop being sown (for wheat this is 20 cm from row to row), set the position and number of furrow openers starting at the middle point of the machine.

For wheat, 6 furrow openers will give a line-to-line average distance of 20 cm (0.2 m), and a full length of 1.2 m – so place the furrow openers starting at the center of the machine (0.6 m).





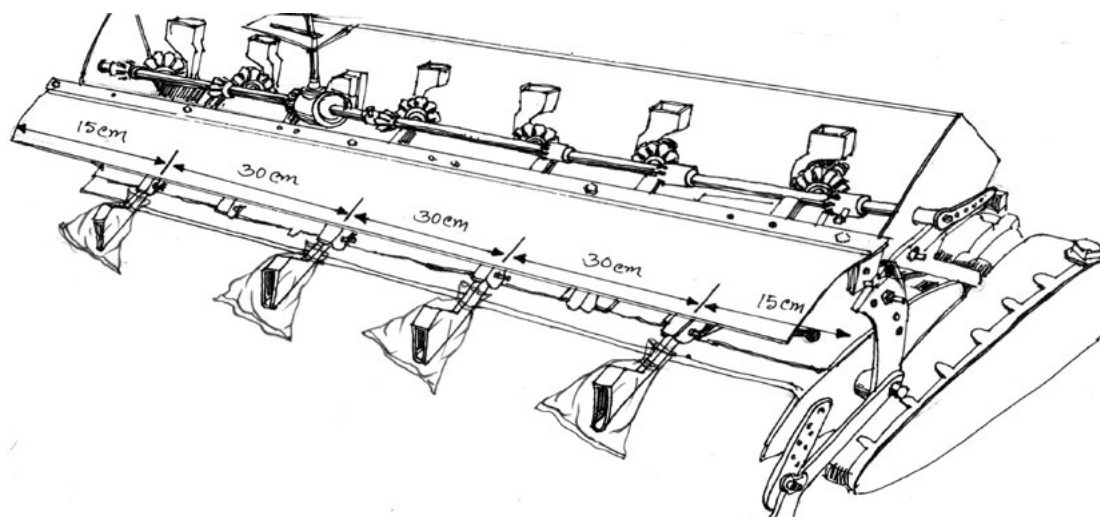
For maize, 2 furrow openers will give a line-to-line average distance of 60 cm (0.6 m) – so set them both 30 cm away from the center of the machine at 0.6 m, measured from the side of the machine.



For mungbean, 4 furrow openers will give a line-to-line average distance of 30 cm (0.3 m) – so set the first left and right ones 15 cm from the center (at 0.6 m), then the others 30 cm away.

Remove unused furrow openers and attach plastic bags to the remaining ones (unless sowing maize or sunflower).

- 1. If you are sowing 4 rows, remove the extra furrow openers.**
- 2. Cover the openings to these furrow openers' seed tubes in the seed and fertilizer boxes with tape (this keeps the seed and fertilizer from spilling onto the ground).**
- 3. Attach plastic bags to the end of the seed delivery tube (by removing the tube from the furrow openers you will use) with rubber bands. Make sure there is enough space for them to collect seed or fertilizer.**



Calibration calculation (1): Smaller seeds

To meter seed at the correct rate we need to know how much seed is required in each line's plastic bag before running the machine in the field. This can be determined by using a simple generic calculation:

$$\text{Required seed quantity in plastic bag (kg)} = \frac{\text{desired seed rate (kg/ha)} \times \text{line to line distance (m)} \times \text{plot length}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

For wheat sown at a rate of 120 kg/hectare on a trial plot 20 m long, with a line-to-line distance of 20 cm, the calculation is:

$$= \frac{\text{Required wheat seed quantity in plastic bag} \times 120 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

Which gives this result:

$$\frac{120 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}} = 0.048 \text{ kg (or 48 grams) per plastic bag for each line}$$

Calibration calculation (2): Big seeds

For crops like maize where the *number* of seeds per unit of land area is more important than the *weight*, the calculation is different. For example, irrigated maize is often seeded at a rate of 83,333 plants per hectare, and at 60 cm line-to-line spacing.

To calibrate for this rate using the same 20 m trial plot, do not use plastic bags. Instead, let the seed fall on the ground and count the number of seeds per 1 m length (do this along several one-meter lengths to ensure consistency).

Here is the formula for maize using this seed rate:

$$= \frac{\text{Number of seeds per 20 m length for 1 line} \\ 83,333 \text{ (seeds/ha)} \times 0.6 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

Now try to calculate: how many seeds would you count in a 1-meter length?

Calibration calculation (3): Big seeds and fertilizer

For maize, the formula on the previous page gives the following result:

$$\frac{83,333 \text{ (seeds/ha)} \times 0.6 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}} \\ = 100 \text{ seeds (per 20 m line) or 5 seeds for 1 m}$$

Now, what about fertilizer? Imagine you want to add 100 kg of urea to the soil when you seed wheat. What is the correct calculation procedure?

$$\text{Required urea quantity in each plastic bag (kg) Fertilizer} \\ = \frac{\text{rate (kg/ha)} \times \text{line to line distance (m)} \times \text{plot length}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

This gives the following calculation:

$$\text{Required urea quantity in each plastic bag} \\ = \frac{100 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)}}{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}$$

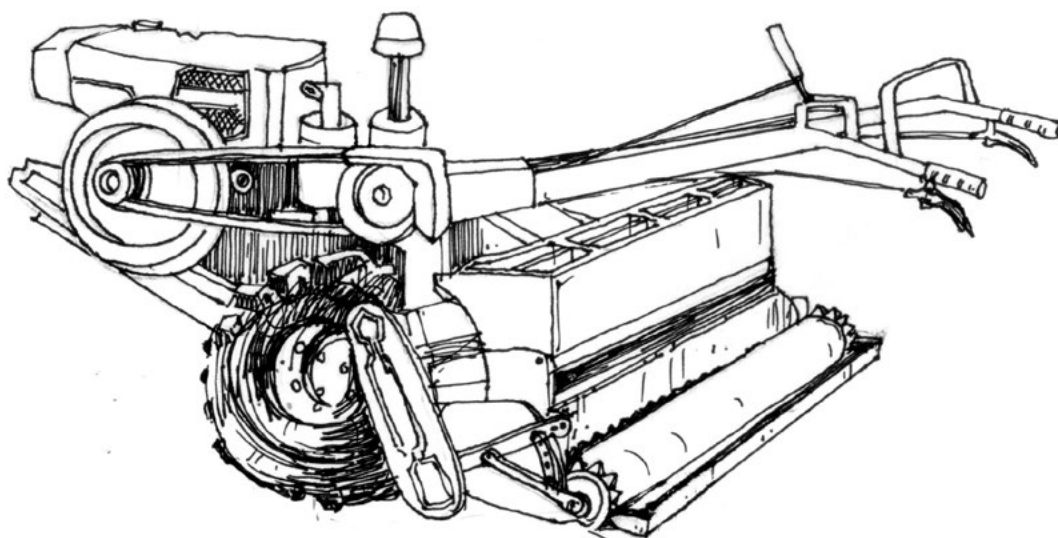
Now, in your group, calculate: how much urea fertilizer is needed per plastic bag for each row?

Calibration calculation (4): Fertilizer results

$$(100 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)})$$

$$\frac{10,000 \text{ m}^2 \text{ (equal to 1 hectare)}}{100 \text{ (kg/ha)} \times 0.2 \text{ (m)} \times 20 \text{ (m)}} = 0.040 \text{ kg (or 40 grams) per plastic bag for each line}$$

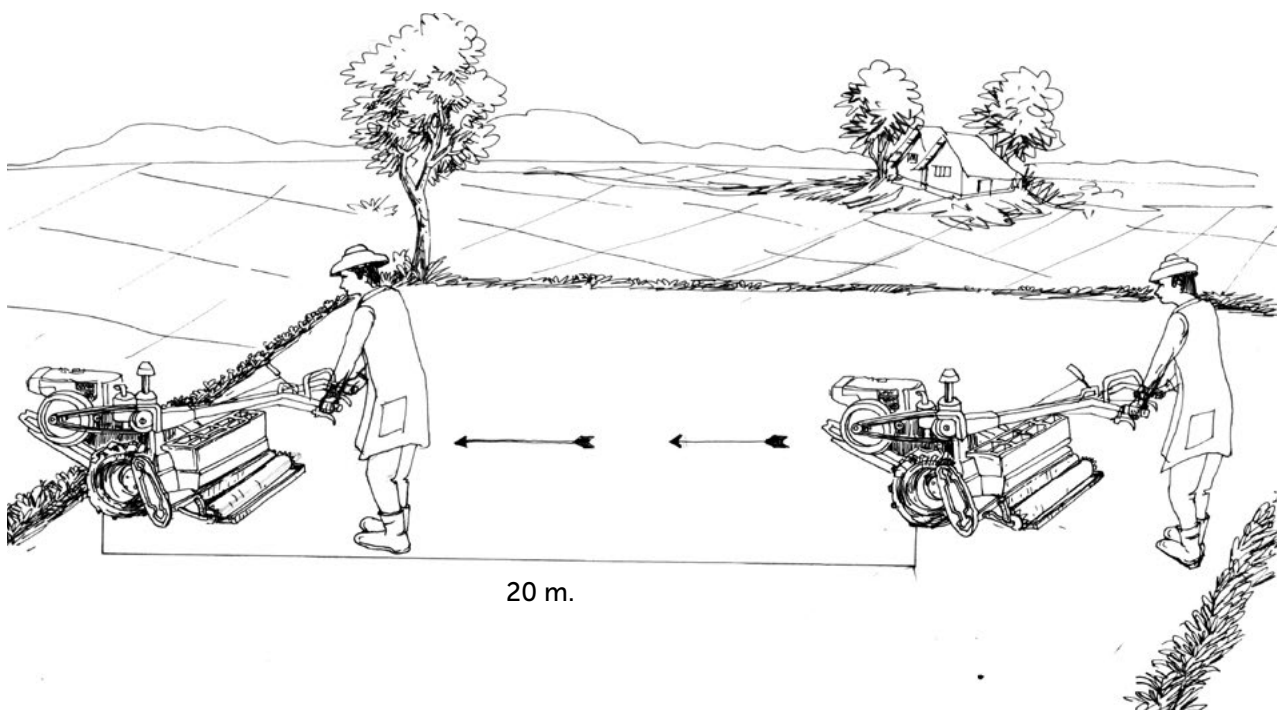
Did you get the calculation correct?



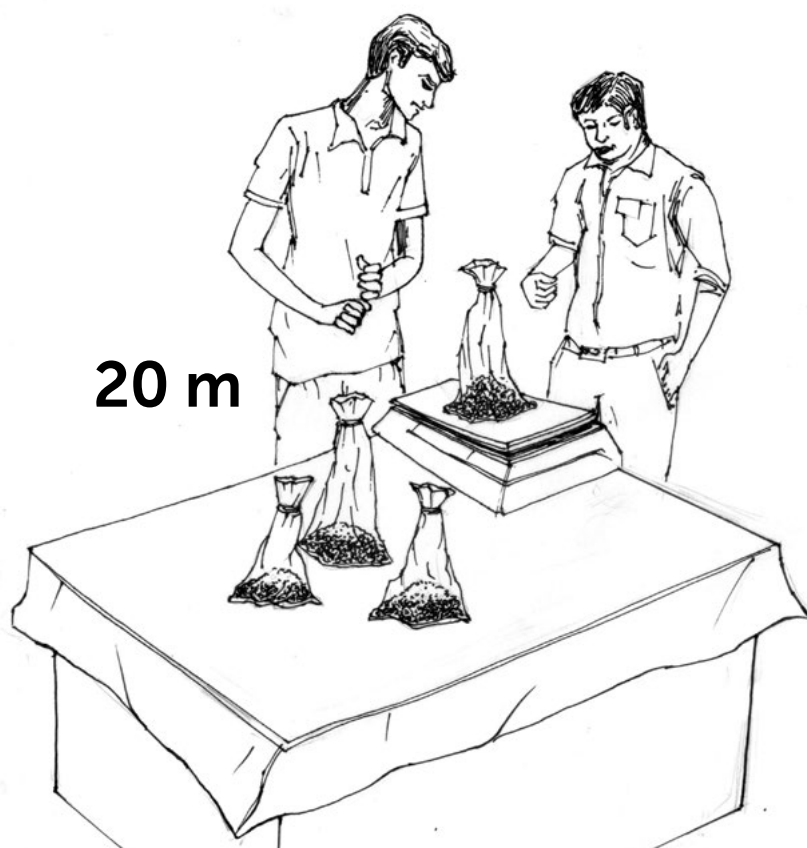
Congratulations! You are now almost a calibration expert. Now all you need is practice!

Calibration practice (1)

1. Put the seed and/or fertilizer in the seed and fertilizer boxes.
2. Select the uppermost hole of the tillage depth control bar, making sure the tines don't touch the soil.
3. Run the machine for 20 meters.



4. Weigh each plastic bag of seeds separately using a digital balance (or for maize or sunflower and big-seeded crops, count the number of seeds) and observe whether an equal amount/number of seeds is dropped in each line.



5. If the lines are not equal or if the seed rate is incorrect, adjust the PTOS by rotating the knobs.

Calibration practice (2)

If you are using a *fluted roller* and seeds are found to be more (or less) than the required amount, turn the knob to the right (or left) to reduce (or increase) the size of the fluted roller that is visible from the top of the seed box.

This changes how much seed is metered.

Repeat this process until you have achieved the correct seed rate.

When you have arrived at the right seed rate, use a permanent marker to mark on the machine where to set the knobs for each crop (although it's advisable to check this calibration at the beginning of each season).

Some PTOS use an *inclined plate seed meter* – these don't require much adjustment, as each plate is made specifically for the type of seed you want to meter, at the correct rate.

For these seed meters, the seed rate depends on the number of cells on the periphery of the plate and the number of revolutions per minute the plate turns.

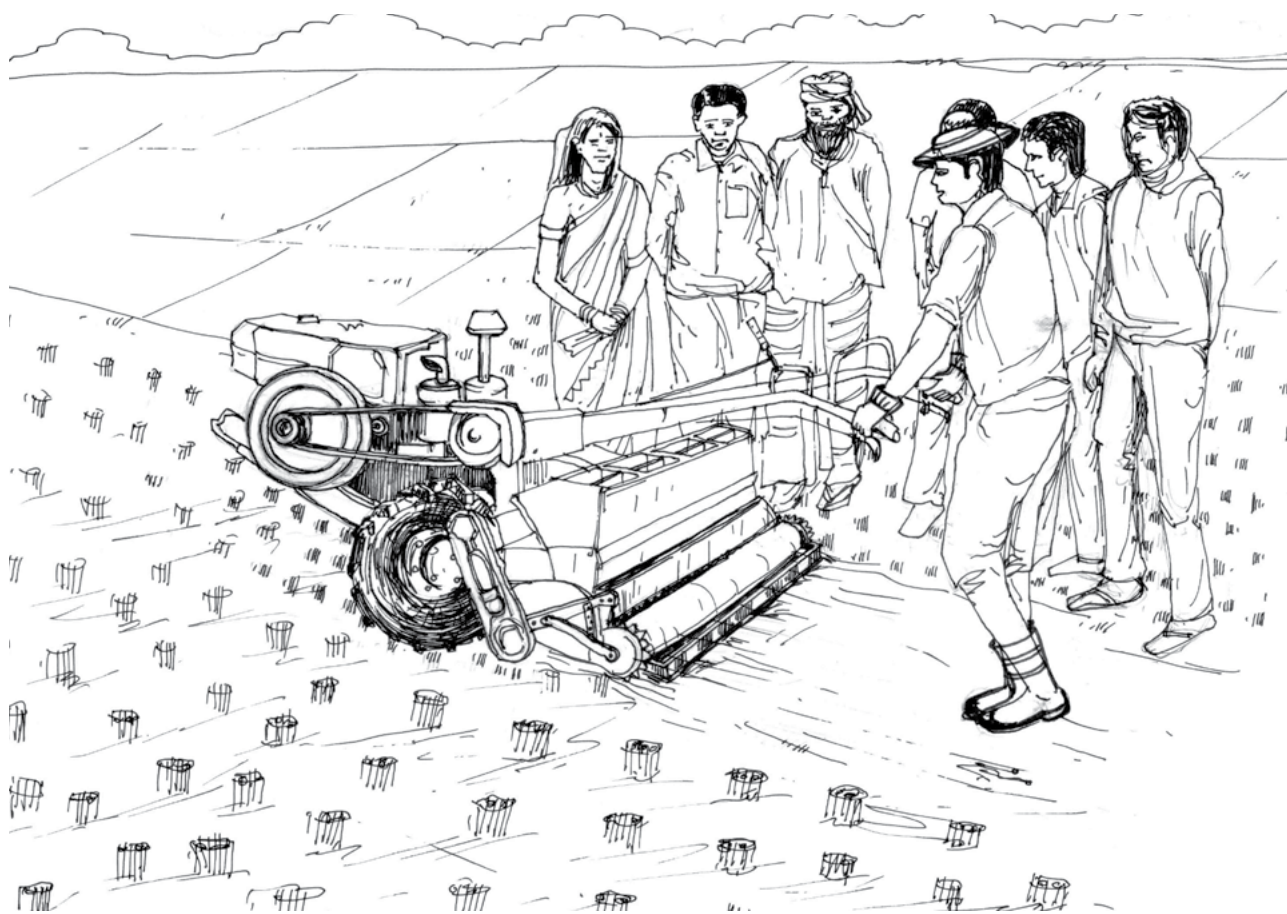
Seed and fertilizer calibration – key messages

- ◆ Calibration means setting up the PTOS to get a definite seed or fertilizer rate before operating the machine.
 - ◆ Calibrate seed meters, considering 1) the style of seed metering plate (whether fluted or inclined), and 2) the type and size of seed.
- ◆ It is best to calibrate (1) at the beginning of each season, and (2) before and after you change crops.
 - ◆ To calculate the metering length, use the mathematics and procedure given in this module
- ◆ Set the metering roller length by moving the metering knob clockwise or counter clockwise, to change the amount of seed or fertilizer picked up and rotated by the fluted rollers, before it's dropped into the soil.

Session 6

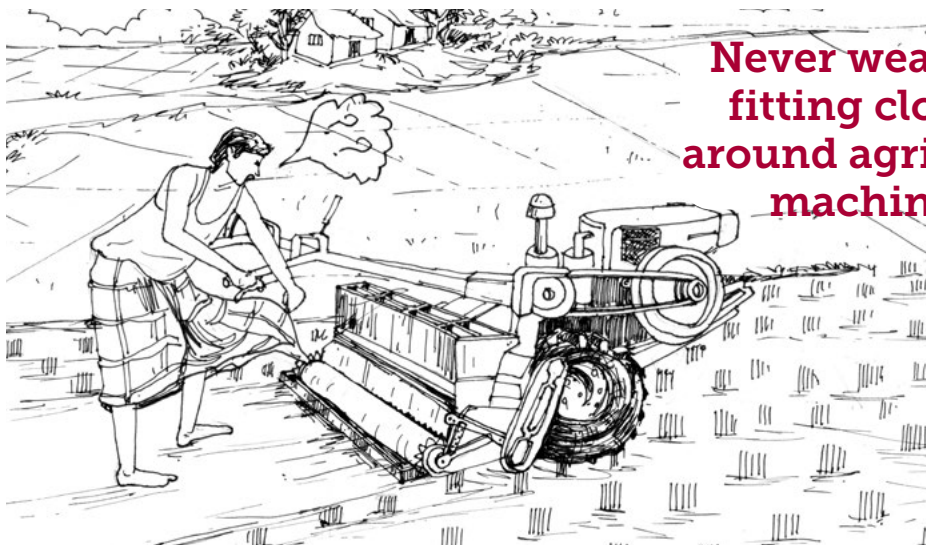
How to use a PTOS safely and effectively

Power tiller-operated seeder
one-day training flipchart



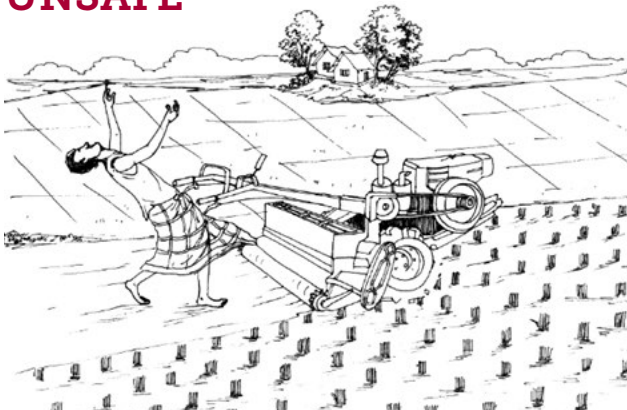
Safe PTOS operation is a must! (1)

- ♦ The PTOS can be dangerous – it's important to stay safe when using it.
- ♦ Wear tight clothing when operating a PTOS machine, so it won't become tangled in its moving parts – this can cause injury or even death.

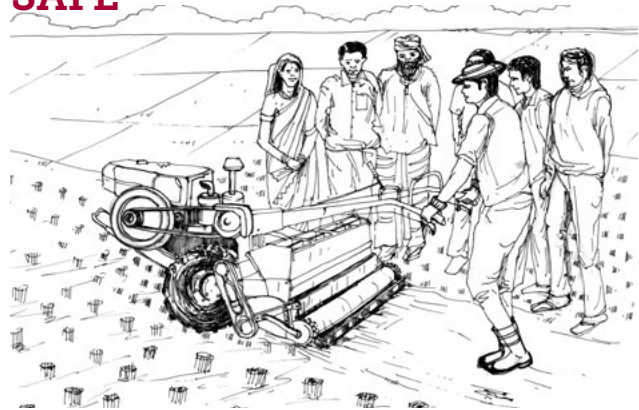


Never wear loose fitting clothing around agricultural machinery!

UNSAFE

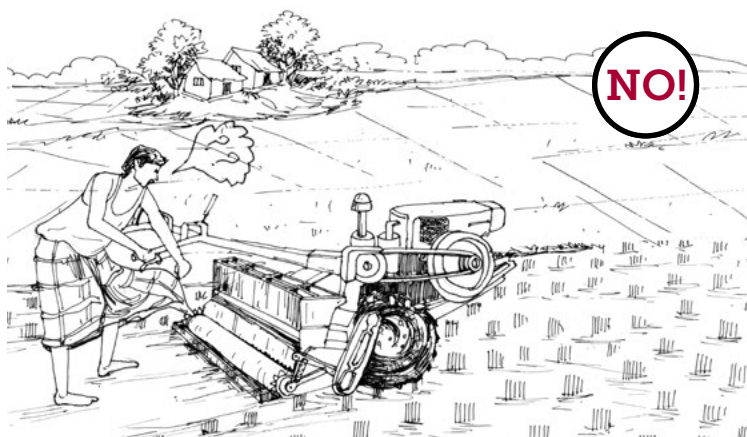


SAFE



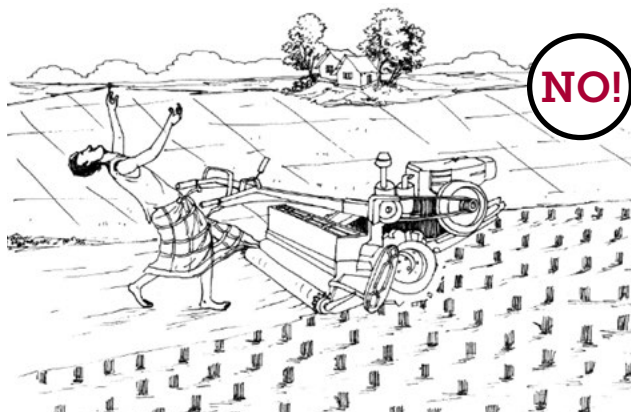
Safe PTOS operation is a must! (2)

Never use the PTOS around children – they can easily get hurt.

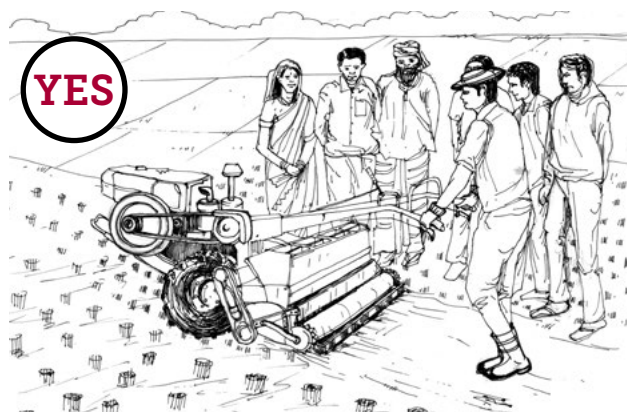


Never wear loose fitting clothing around agricultural machinery!

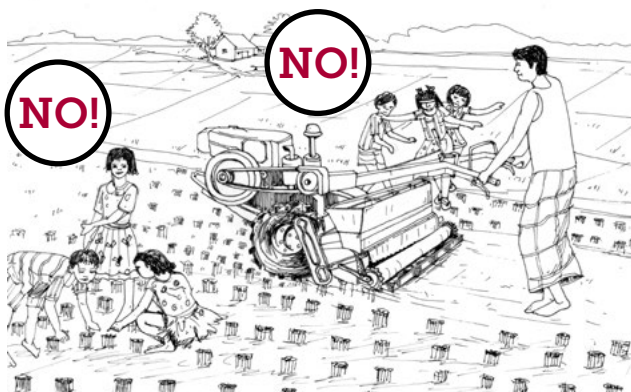
Never work without shoes!



UNSAFE



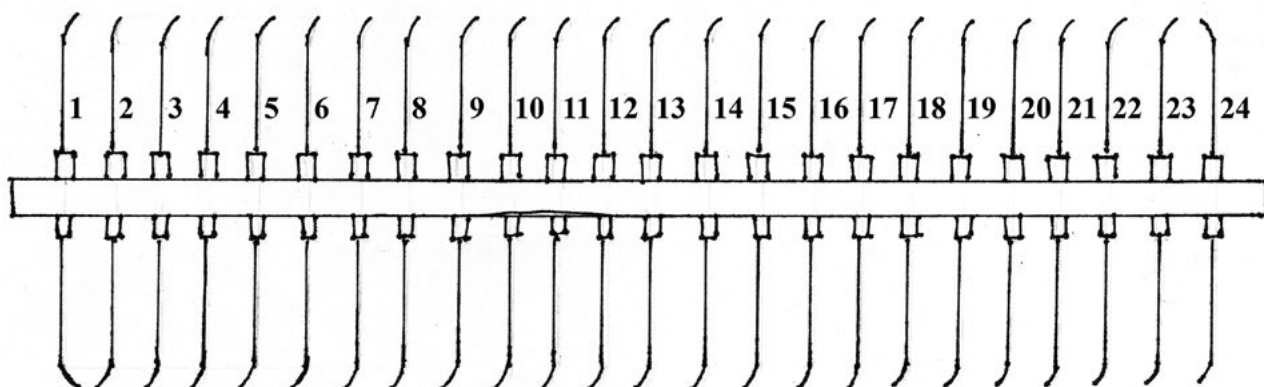
SAFE



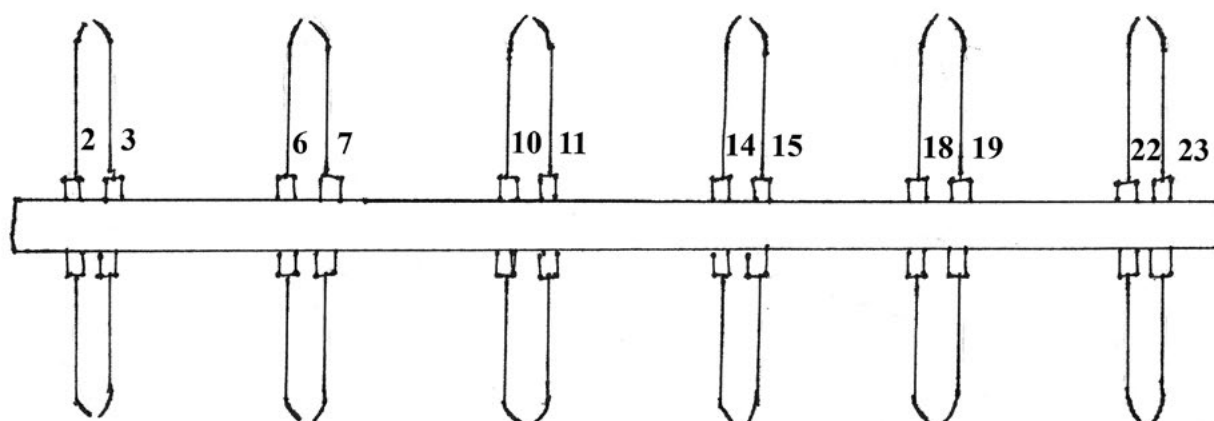
NEVER use the PTOS around children – they can easily get hurt

How do you prepare the PTOS for use in the field?

- ◆ Be sure there is enough fuel, engine oil and water in the radiator to run the machine and complete the day's work.
 - ◆ Check the nut and bolts on the PTOS, and the belt pressure and tine setting. Make sure all the nuts and belts are tight.
- ◆ Check the tine settings and make sure they are correct for the type of tillage (48 tines for full tillage and 24 tines for strip tillage), and that you have the right blades for your soil type.



**rotovator with 48 tines used for full
tillage of wheat**



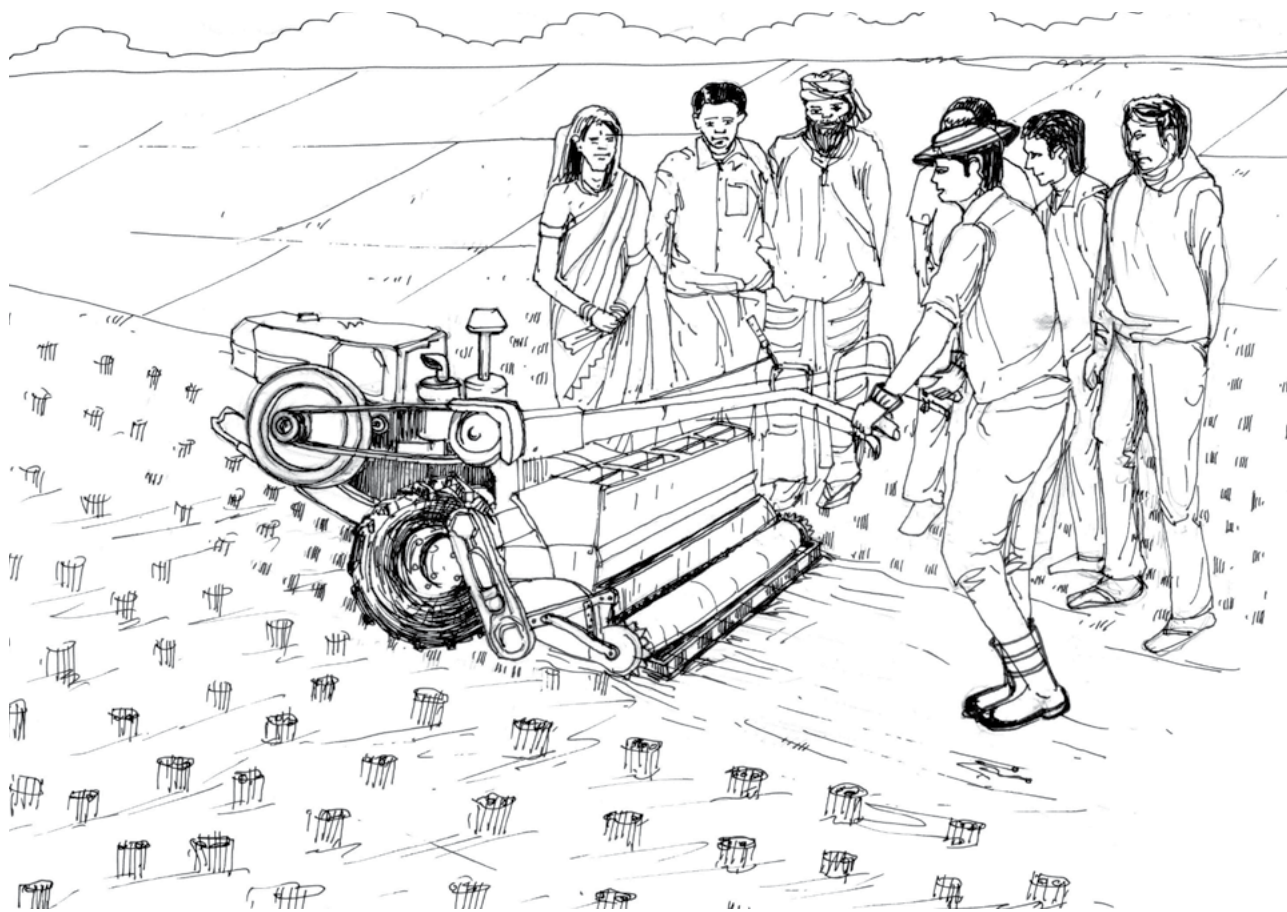
**rotovator with 24 tines arranged for
strip tillage of wheat; blade arrangement
should be changed for other crops,
depending on line-to-line distance.**

**◆ Keep the rotovator on-off lever in
the off position until starting the
machine.**

Session 7

Troubleshooting and maintenance

**Power tiller-operated seeder
one-day training flipchart**



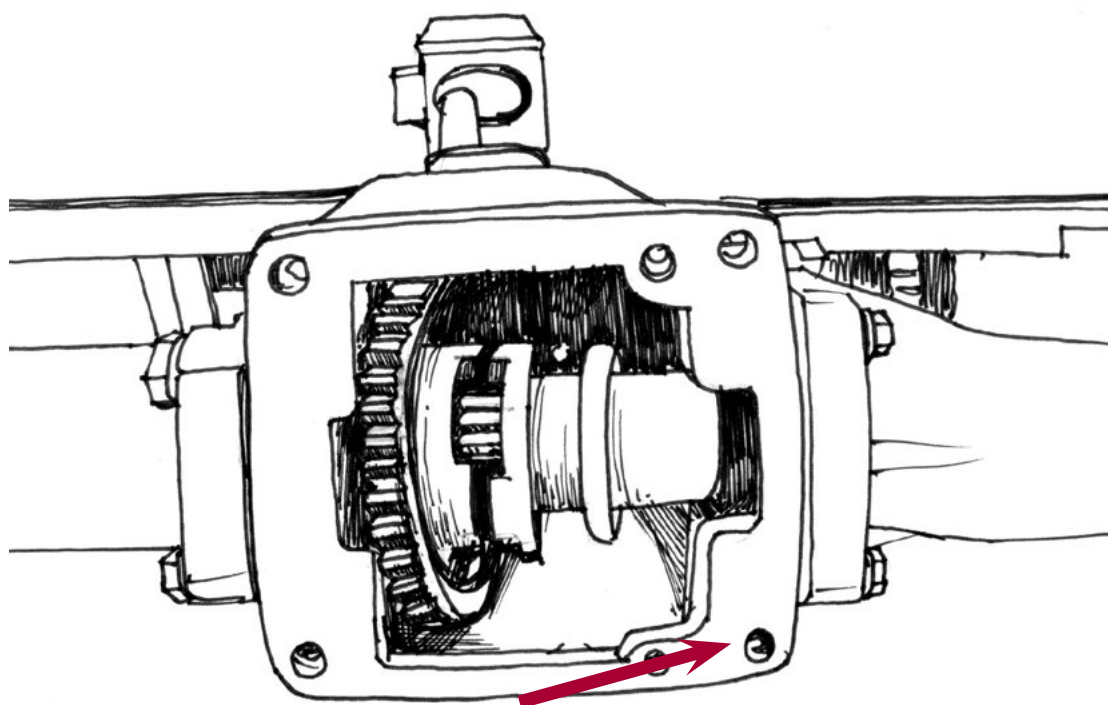
Problem 2: The hitching gears on the PTOS and 2-WT do not work

Symptoms:

gear pinion slips and produces a grinding noise.

Causes:

overload on the gear pinion (from tilling hard soil or deep tillage) and/or lack of sufficient gear lubricant.



Effects:

complete machine failure

Solutions:

replace the gear/pinion and/or
replace the shaft/casing

Spare parts required:

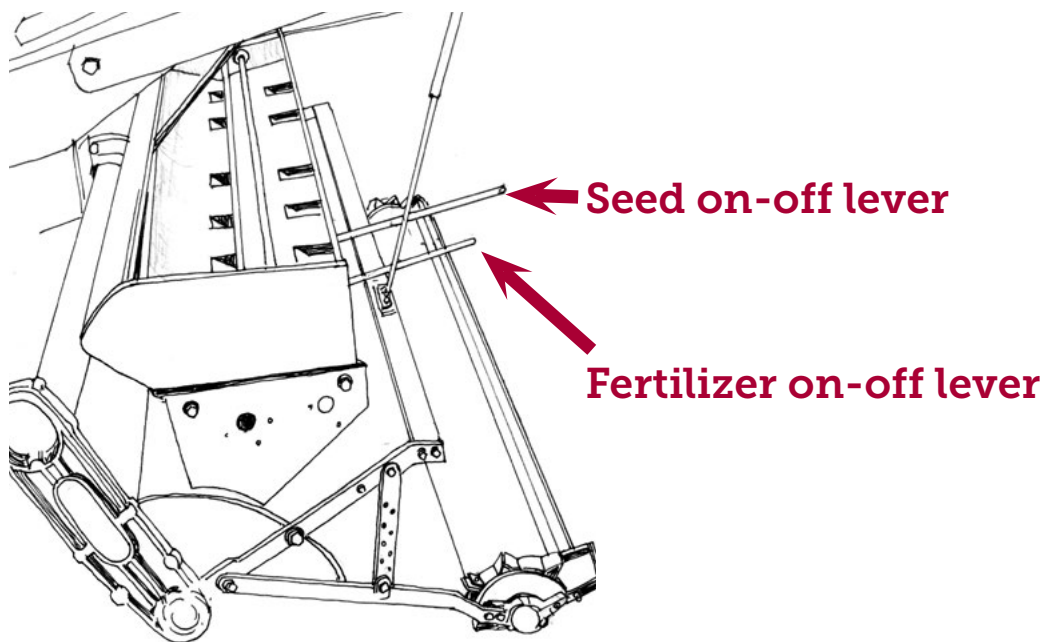
new gear

Where to get or make/repair spare parts: spare gears can be obtained from a dealer or made at a local workshop

Tools required:

dual wrench set, adjustable
wrench, screwdriver

Problem 3: The seed and fertilizer on-off lever does not work



Symptoms:

PTOS will not run or stops metering seed/fertilizer.

Causes:

worn out/broken clutch, worn out clutch ball, loosening or wearing out of the spring inside the clutch.

Effects:

the seed and fertilizer meter cannot be turned on or off.

Solutions:

repair the faulty parts; replace with new spare parts

Spare parts required:

clutch ball, springs, or clutch

Spare parts required:

clutch ball, springs, or clutch

Where to get or make/repair spare parts: obtain from PTOS dealer or from a shop dealing in spare parts for two-wheeled tractors

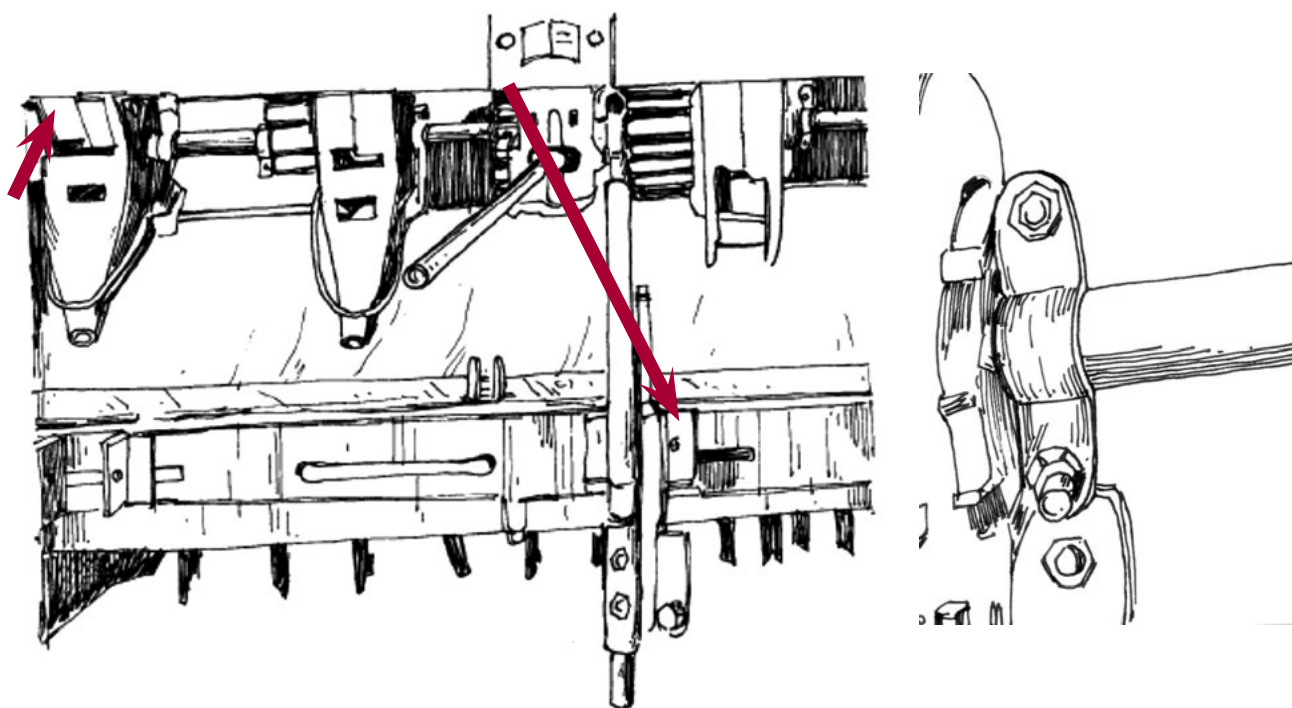
Tools required:

dual wrench set, adjustable wrench, Allen or hex key, screwdriver

Problem 4: The locking clamps on the seed/fertilizer metering shafts are loose/rusted and cannot be tightened or loosened

Symptoms:

the metering roller length varies (observable from the top of the seed/fertilizer boxes) and seed/fertilizer metering is uneven



Causes:

loose nuts and bolts; rusted clutch

Effects:

seed and fertilizer rates vary between rows, even after correct calibration

Solutions:

adjust and tighten bolts or replace them, or use nuts that automatically lock

Spare parts required:

nuts and bolts, clamps

Where to get or make/repair spare parts:

obtain new clamps from a dealer or have them made in local workshops. Nuts and bolts are usually available in hardware and tool stores

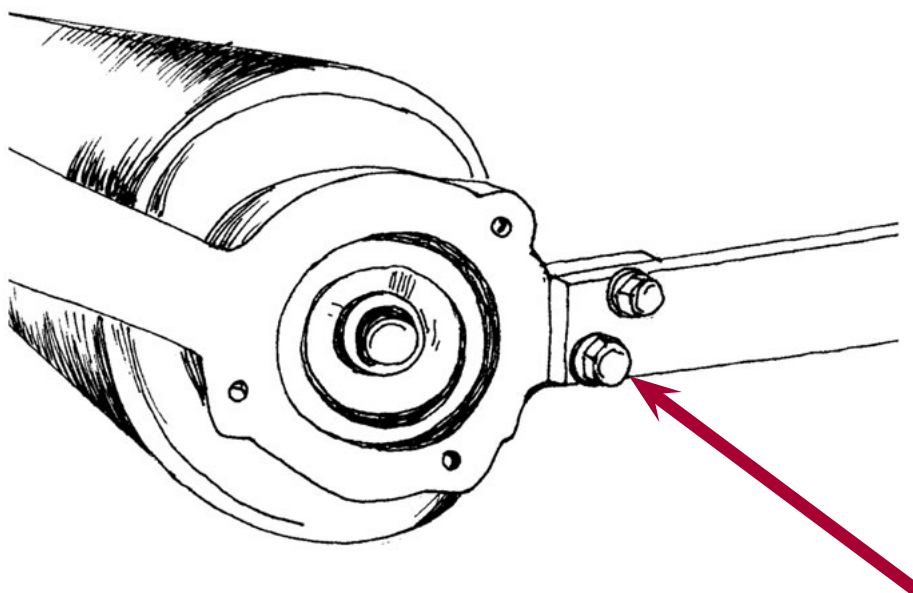
Spare parts required:

obtain new clamps from a dealer or have them made in local workshops. Nuts and bolts are usually available in hardware and tool stores

Tools required:

Dual wrench set, adjustable wrench, screwdriver

Problem 5: The leveling roller bearings jam



Symptoms:

roller does not rotate properly or is dragged across the soil

Causes:

rusting, bearing seal damage or corrosion, bent roller shaft

Effects:

roller does not rotate freely, soil accumulates in front of the roller during tillage, roller drags crop residues (in the case of strip tillage)

Solution:

remove the bearings, lubricate them, and replace them, or remove and replace with new bearings

Spare parts required:

new bearings, circular clips

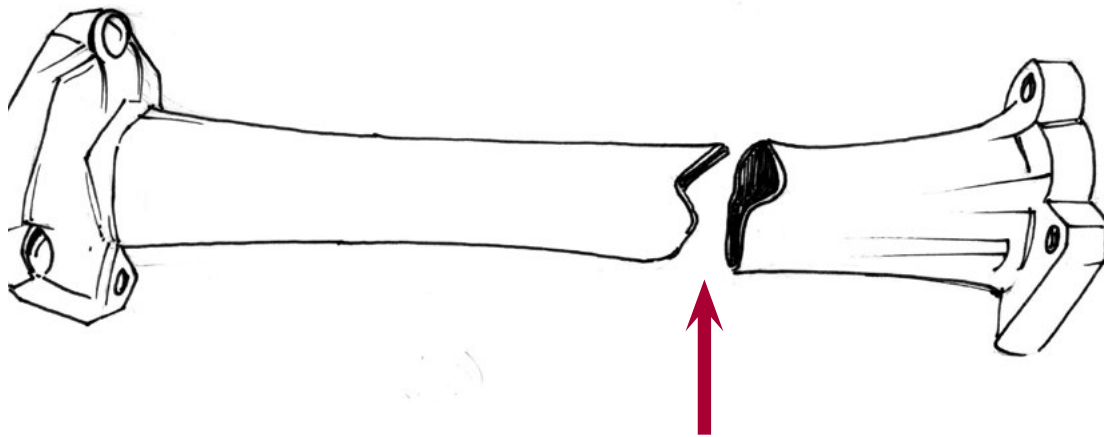
Where to get spare parts:

most tool shops

Tools required:

dual wrench set, adjustable wrench, screwdriver

Problem 6: The horizontal transmission shaft and its casing break



Symptoms:

machine stops, or cracks found in the transmission casing

Causes:

excessive overloading

Effects:

complete machine failure

Solution:

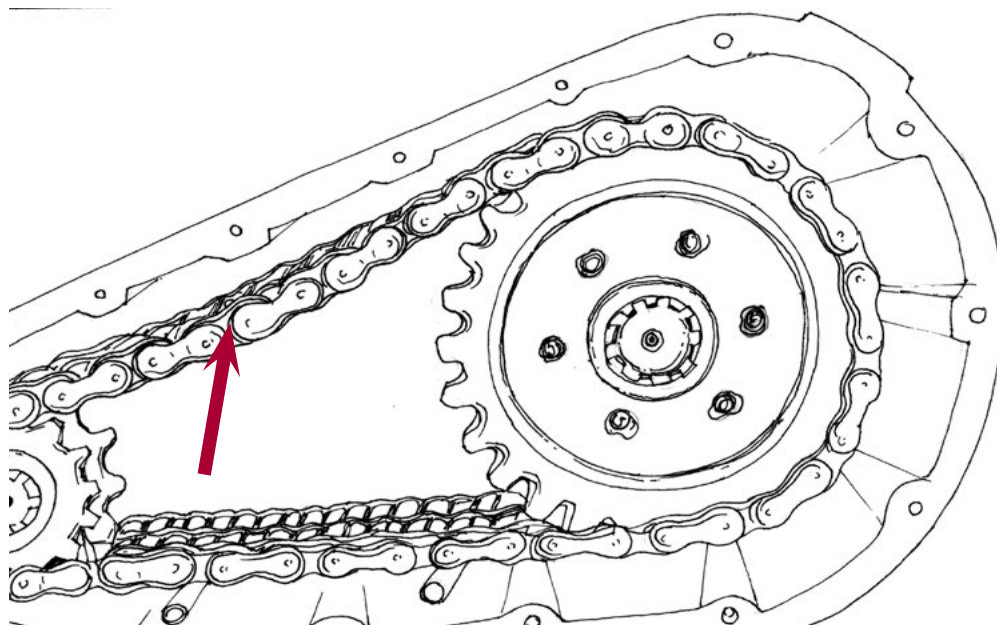
replace shaft/casing

Spare parts required:
shaft/casing

Where to get spare parts:
PTOS dealers

Tools required:
dual wrench set, adjustable
wrench, screwdriver

Problem 7: The transmission chain and bearing break



Symptoms:

the rotary shaft does not rotate and produces noise

Causes:

lack of gear oil, excessive load, worn out bearing(s), loss of or lack of sufficient chain lubricant, deposition of dust in chain-sprocket

Effect:

rotary shaft does not move

Solutions:

rejoin the chain link, replace with a new link if broken, replace bearings, replace the gasket and fill it with new gear oil

Spare parts required:

chain link, chain, bearing and gasket

Where to get spare parts:

dealers/shops dealing with spare parts for two-wheeled tractors

Tools required:

dual wrench set, adjustable wrench, screwdriver, hammer and chisel

PTOS maintenance and storage

For extended storage (between seasons)

- ◆ **Remove straw and other objects from machine parts regularly; clean, and tighten nuts and bolts.**
 - ◆ **Make sure the rotovator chain-sprocket casing has sufficient lubricant.**
- ◆ **Apply lubricant to all moving parts like bearings, bushings and chain-sprockets.**

For extended storage (between seasons)

- ◆ **Carefully wash and clean the PTOS**
 - ◆ **Store the PTOS out of the rain.**
- ◆ **Store the PTOS on a platform so it does not contact the soil.**
 - ◆ **If necessary, paint the PTOS to avoid rust.**
- ◆ **Cover the gearbox with a polythene sheet.**
 - ◆ **Store the PTOS in a dry place, out of the reach of children.**

Key messages (1)

Troubleshooting

- ◆ The horizontal transmission shaft can sometimes break due to excessive loading and cause complete machine failure.
 - ◆ The seed-metering shaft may bend due to jams in the metering system, and cause non-uniform seed metering.
- ◆ Overload of gear pinions during tillage, or a lack of gear oil, can cause damage to the hitching gears. This may reduce engine power.
 - ◆ The seed/fertilizer on-off clutch may not work (1) due to overuse, or (2) if it is damaged, or (3) the ball clutch wearing out, or (4) damage to the spring inside the clutch or (5) due to spring fatigue.

- ◆ **The rotary shaft may not rotate and produce noise because of a lack of gear oil and/or excessive load or due to worn out, old bearings**
 - ◆ **The leveling roller bearings can become jammed or faulty due to rusting or damage to the bearing seal (a result of soil gathering on it) or the roller shaft is bent.**
- ◆ **Mishandling or excessive wear and tear can cause the casing on the vertical transmission chain-sprocket box to break**

Key messages (2)

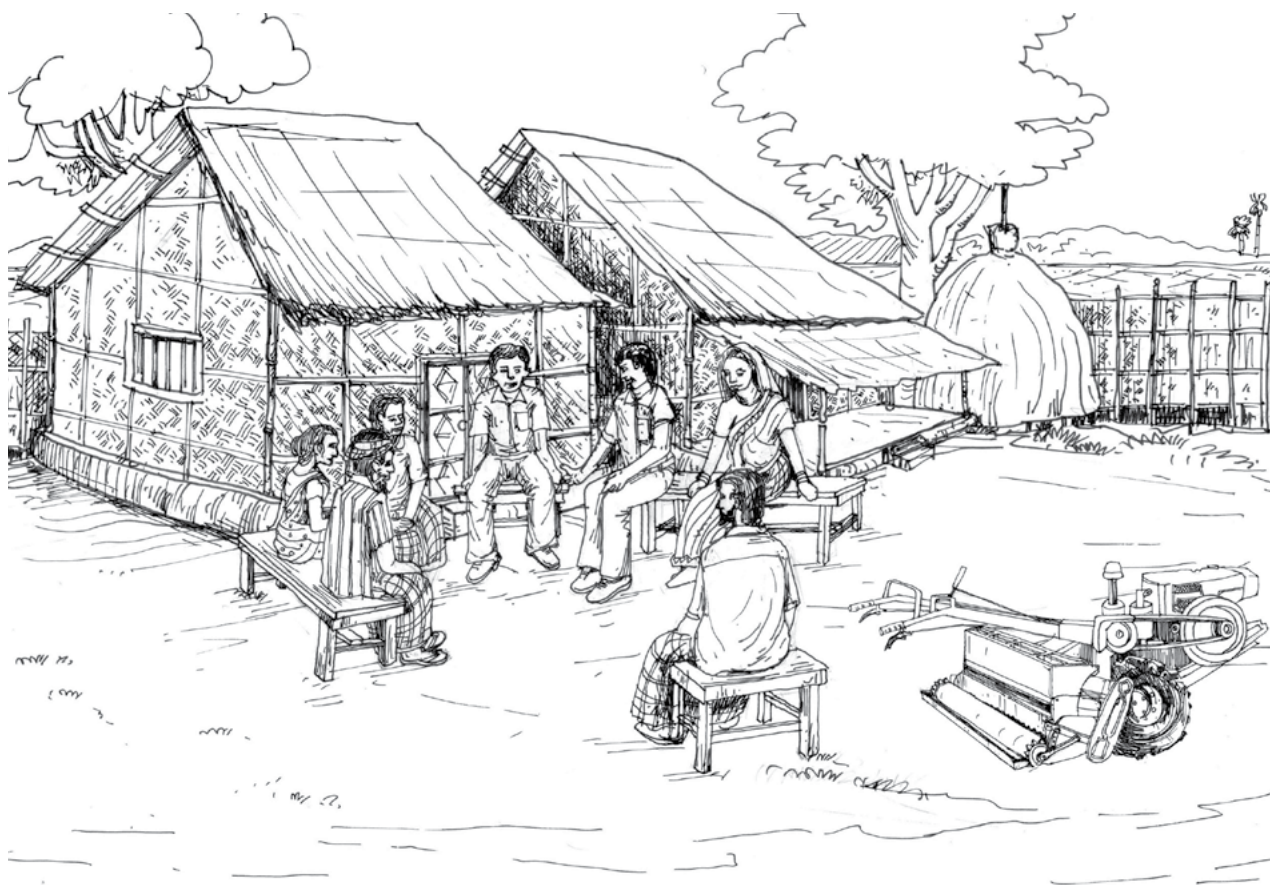
Maintenance

- ◆ Regularly replace lubricant in the rotovator chain-sprocket casing.
 - ◆ Regularly apply lubricant to moving parts, including bearings, bushings, chain-sprocket, etc.
- ◆ Between seasons, store the PTOS on a platform so it does not contact the soil.
 - ◆ Between seasons, and if needed, the PTOS should be painted to avoid rust.
- ◆ Between seasons, the gearbox should be covered with polythene sheet.
 - ◆ Between seasons, store the machine in a dry place and beyond the reach of children.

Session 8

Starting a PTOS business

**Power Tiller Operated Seeder
one-day training flipchart**



What do we mean by a 'business'?

- ◆ The activity of making, buying or selling goods, or providing a service in exchange for money or for other goods and services.
- ◆ Any activity/occupation run by an individual or group to obtain a profit and satisfy customer needs.

Most farmers who buy a PTOS use it to run a business and make money by hiring it out.

Some types of businesses are:

- ◆ manufacturing
- ◆ trading
- ◆ running a store
- ◆ farming
- ◆ providing agricultural machinery services to farmers

What is a business plan?

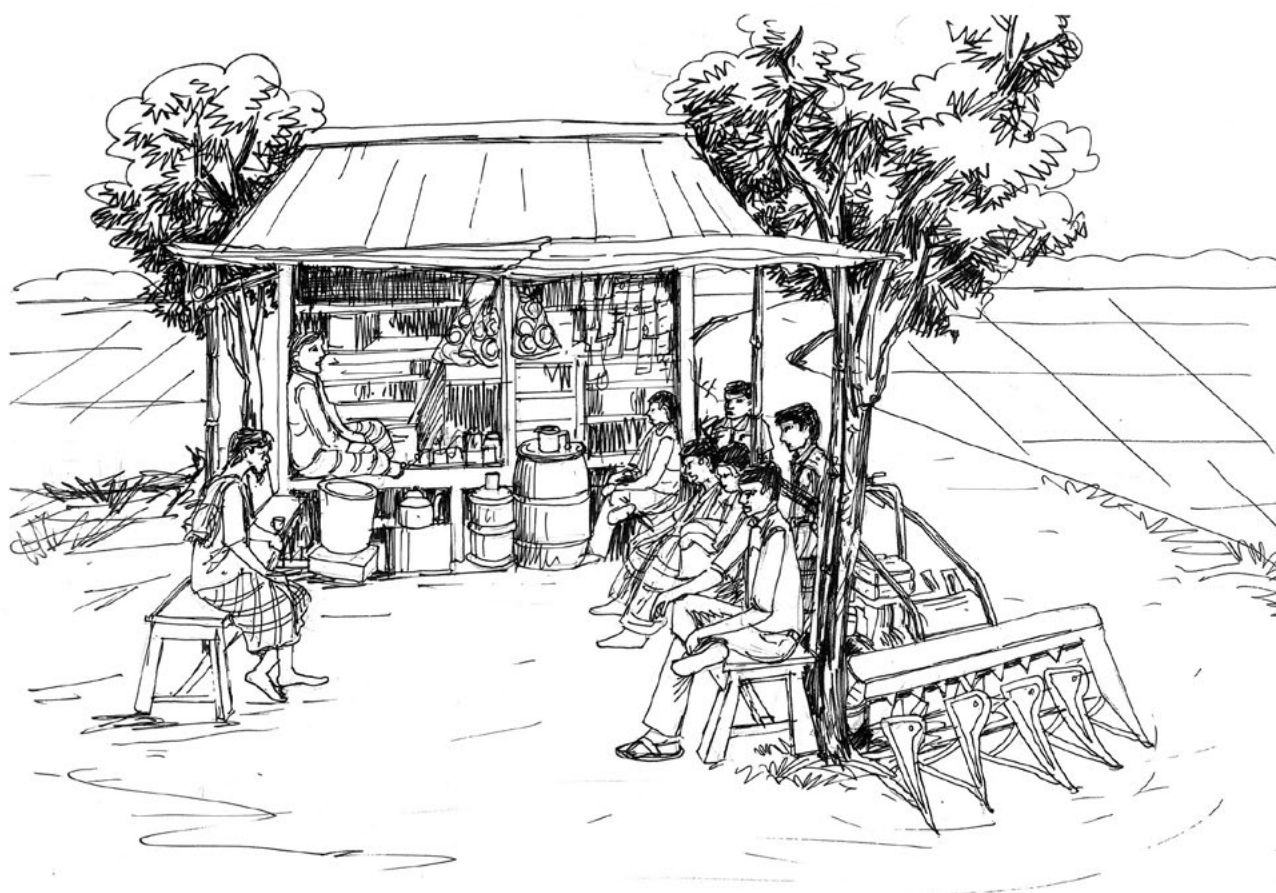
- ◆ It sets out a sales and marketing strategy
 - ◆ It identifies possible profits and losses

A PTOS business plan asks

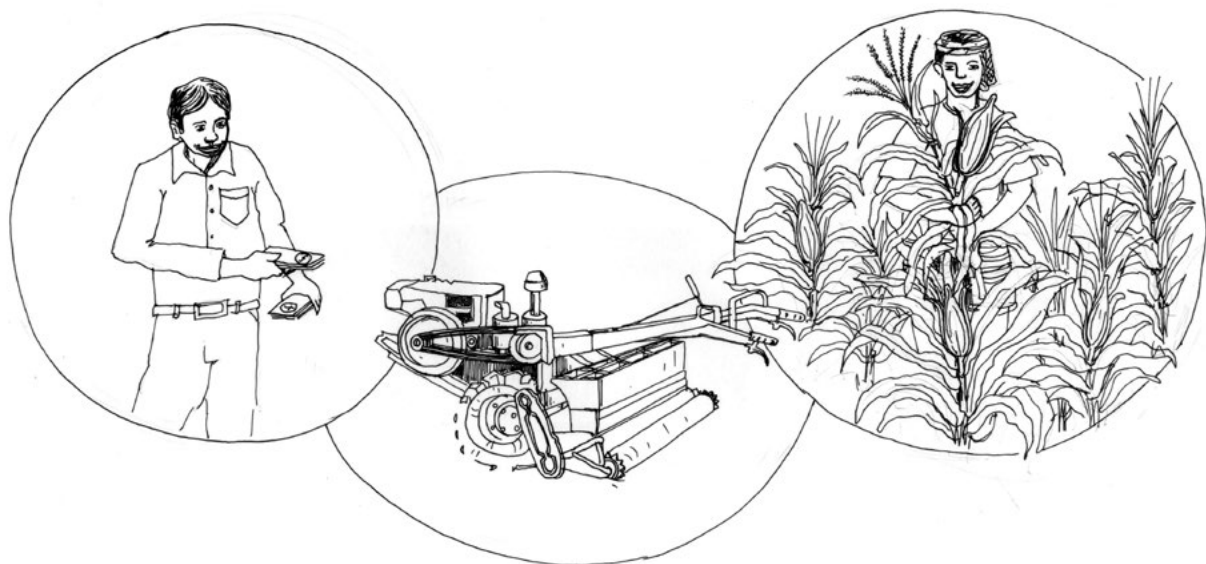
- ◆ Where is my market for a PTOS service – where will farmers pay for PTOS sowing?
 - ◆ What is the demand for a PTOS service in my area? Other areas?.
- ◆ What is my capacity to provide a PTOS service?
 - ◆ What machinery, equipment, fuel and spare parts are needed to run a PTOS business?

- ◆ **What is my source of capital? How can I afford to buy a PTOS?**
- ◆ **What profit can I obtain from my proposed PTOS business?**
- ◆ **How can I get as many farmer-clients as possible to pay to use the PTOS?**

Service provider experience sharing



Do you know any successful PTOS service providers?

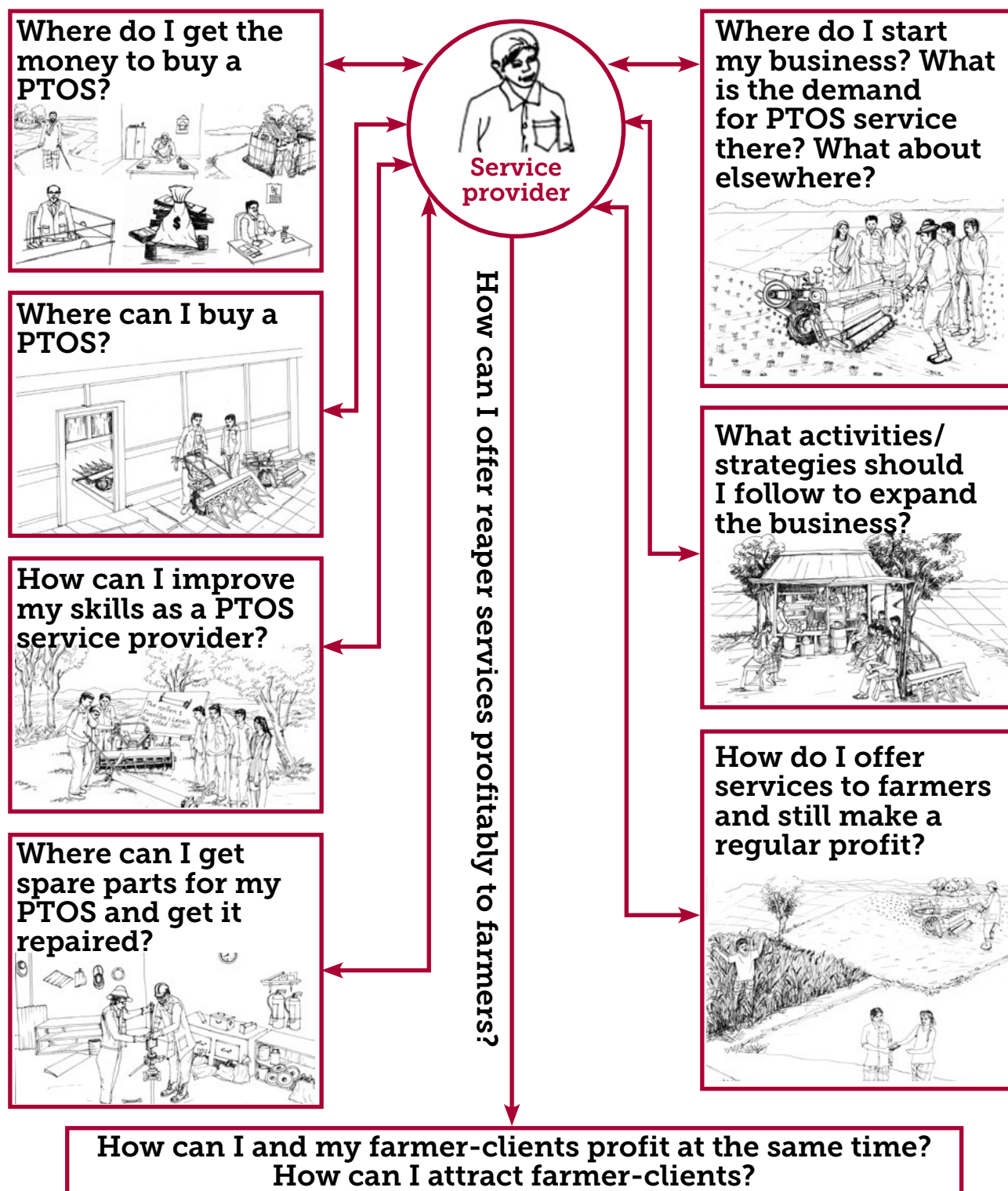


Ask them some questions!

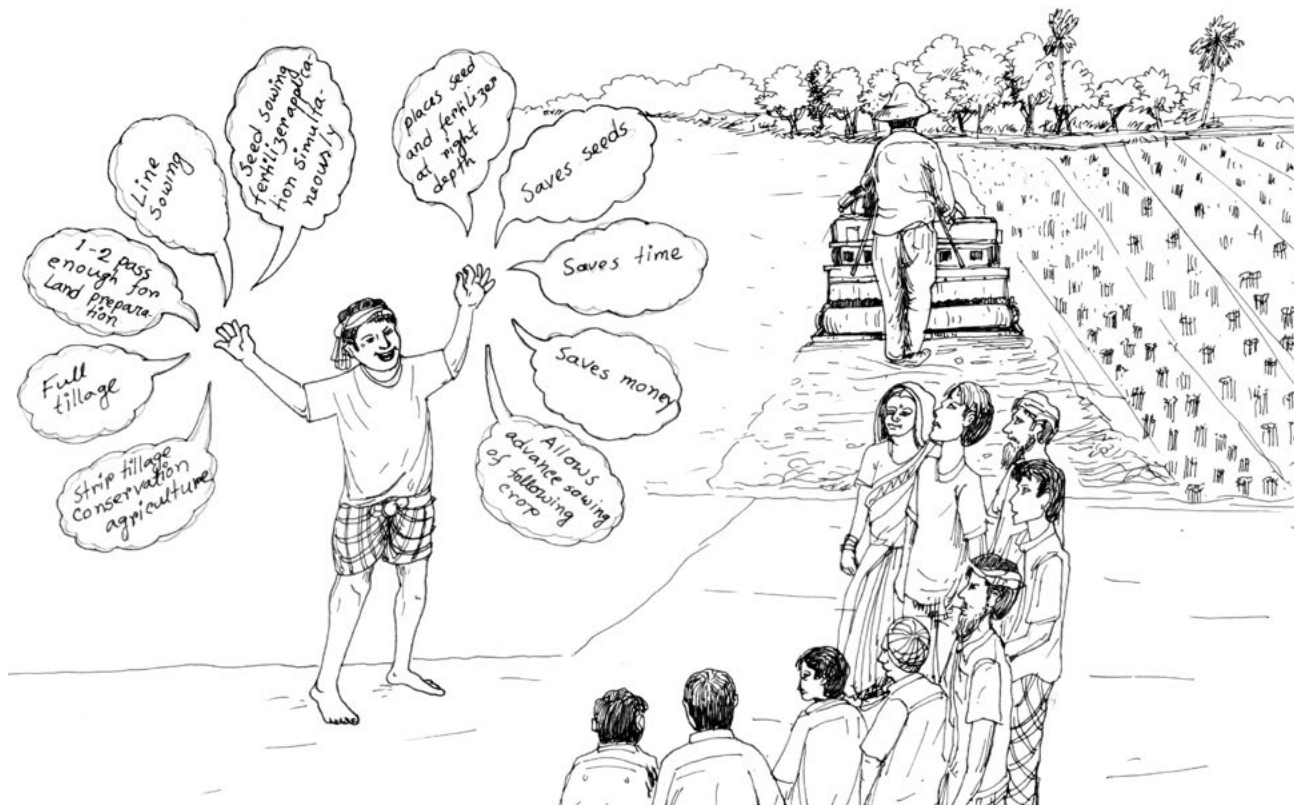
- ◆ **Why did they start a PTOS business?**
- ◆ **How are they running their business?**
- ◆ **What are the costs and benefits of running a PTOS business?**

- ◆ How long did it take to break even – or how long do they think it'll take?
 - ◆ What activities/strategies make their PTOS business profitable?
- ◆ What challenges do they face?
 - ◆ What benefits do the farmers (their clients) obtain?

Questions to ask yourself before becoming a PTOS service provider



To attract farmer-clients, you must advertise – ‘sell’ the idea of the PTOS to farmers in your village and in villages nearby



What are the benefits of a PTOS? Benefits of the PTOS

- ◆ It allows you to till, seed and fertilize at the same time.
- ◆ It can be used for full or strip tillage.
- ◆ The PTOS sows the seed in lines.
- ◆ It improves crop establishment and makes it easy to walk around in the crop to carry out weeding and other work.
- ◆ Crop establishment is better with the PTOS than with broadcast seeding.
- ◆ The PTOS saves the farmer time, money and labor.
- ◆ For some crops, you need less seed if you use a PTOS.
- ◆ You can sow the crop early and quickly - this often increases yield.

PTOS business: Cost benefit analysis

Traditional tillage and hand sowing	Machine sowing with a PTOS			
Box A: Wheat: Tillage+sowing (cost to farmer) Area = Tillage (multiple-passes) = Seed sowing = Fertilizing = Total =	Box B: PTOS (capital cost) Cost of a two-wheeled tractor =	Box C: (consumables cost)(wheat) Fuel+oil cost for tillage =	Box D: SP labor (opportunity cost)(wheat) =	Box E: PTOS service charge (cost to farmer) (wheat) Till+sow+fertilize =
	Box F: Reaper service profit (wheat)		Box G – Wheat Farmer savings	
Box H: Alternative crop 1: Tillage+sowing (cost to farmer) Area = Tillage (multiple passes) = Seed sowing = Fertilizing = Total =	Box J: Alternative 1 (consumables cost) Fuel+oil cost for tillage =	Box K: Alternative 1 (opportunity cost) SP's labor =	Box L: Alternative 1 PTOS service charge (cost to farmer) Till+sow+fertilize =	
	Box M: SP profit (Alternative 1)		Box N: farmer's savings (Alternative 1)	
Box I: Alternative crop 2: Tillage+sowing (cost to farmer) Area = Tillage (at least two passes) = Seed sowing = Fertilizing = Total =	Box Q: (consumables cost) Fuel+oil cost of tillage =	Box R: SP labor (opportunity cost) =	Box S: PTOS service charge (cost to farmer) Till+sow+fertilize =	
	Box T – SP profit (Alternative 2)		Box U: farmer's savings (Alternative 2)	
Box Y: Time/area required to break even Time (in years) required Area to till+sow+fertilize =	Box V – Area you can till+sow+fertilize in 1 day Wheat (AA) = Alternative crop 1 (AB) = Alternative crop 2 (AC) =		Box W: No. of days to till+sow+fertilize per year Wheat (AD) = Alternative crop 1 (AE) = Alternative crop 2 (AF) =	
X - 1 bigha = 0.33 decimal/acre = 0.134 hectare	Box X: SP yearly profit Wheat: Alternative 1: Alternative 2:			

Importance of keeping financial records

Keep careful records of your profits and how much you spend – these are important for working out how long it takes to break even, and to figure out ways to profit more. Here are some examples you can use:

A) Primary investment

Item	Date	Quantity/No.	Unit price	Own money	Credit
1. Two-wheeled tractor					
2. PTOS					
3. Transportation					
4. Other					
Total investment =					

B) Monthly income-expenditure

Month	Expenditure (for operating the PTOS)			Income (as service charge)		
	Item	Quantity/ no.	Money paid (BDT)	Farmer	Area and crop	Money paid (BDT)
March	Diesel/Gasoline	10 liters	400	Abdul Malek	0.25 ha (jute)	800
	Mobil/ grease	500 ml	100	Ramijuddin	0.45 ha (wheat)	1,000
	Spare parts	2 nos.	60	Sheikh Mafiz	0.25 ha (mung)	1,200
	Transportation		50	Shafiq Mia	0.5 ha (jute)	1,600
	Labor	1	300			
	Other					
Total cost =			910	Total income =		4,600
Total profit (total income – total cost)						3,690
April						
Total cost =				Total income =		
Total profit (total income – total cost)						

Month: (for example, March 2015)

Keep a list of farmer-clients – this also helps profits

Sample:

List of farmers to receive PTOS services next month

Farmer's name, address, mobile no.	Crop	Land area	Date (tentative)	Time
Shahidul Khan. Dumuria sub-district, Khulna. Tel: +88017648892	Wheat	1 <i>bigha</i> (0.13 hectare)	15/04/2015	11 a.m

Review of key messages

Now that we have learned that service providers use business plans to make the most money possible while keeping farmer-clients satisfied, can you answer the following questions?

- ◆ **Where can I find a market for line sowing crops using the PTOS?**
 - ◆ **What is the demand for line sowing? How can I increase this demand?**
- ◆ **What is my capacity to provide PTOS services? What more do I need to know or learn to start and run a PTOS business?**
 - ◆ **What machinery and equipment do I need for line sowing different crops?**

- ◆ **What does it mean to 'break even' on an investment?**
 - ◆ **How can I provide services profitably?**
- ◆ **What is the potential profit from my proposed PTOS business?**
 - ◆ **How much time (in months or years) might be required to break even?**
- ◆ **What benefits will farmers (my clients) obtain from my proposed PTOS business?**

Session 9

Review of key messages, post-training evaluation and close of training

- ◆ **What are the main parts of a PTOS?**
- ◆ **What are the benefits of line sowing with a PTOS?**
- ◆ **What is calibration? How do you do it?**
- ◆ **What are the potential major failures or breakdowns of the PTOS and their cause(s)? What are their solutions?**
- ◆ **What is a business plan?**
- ◆ **How can you make PTOS services profitable, while also benefiting farmers?**
- ◆ **Why is financial record keeping important?**

Annexes

Annex 1

Evaluation questionnaires and answers

Pre-training evaluation questionnaire

Venue:
(to be completed by the facilitator)

Batch:

Date:

Name: _____

Please check (✓) or circle the correct answer **Total time: 10 minutes**

Question	Answer		
1. What is the function of the rotovator?	It levels the soil	It tills the soil	It helps to move the machine forward
2. What does it mean to calibrate your PTOS?	Calibration determines the speed at which you should run the PTOS	Calibration is the adjustment of the seed and fertilizer meters to the correct rate	Calibration is the process by which you make sure the PTOS is correctly attached to the two-wheeled tractor
3. How many tines does the PTOS have?	22	24	48
4. What is the effect of line sowing?	It generally helps to increase yield and makes it easier to move around in the field to weed	Yield is lower because the number of plants goes down	The field will not look nice
5. Why might the seed metering shaft bend?	You are running the machine at a high speed	You have tilled too large an area of land	There is a jam in the seed metering system
6. What might happen if you till with a PTOS too deeply, or on excessively hard, heavy or wet soil?	The hitching of the PTOS to the tractor may break	The seed metering shaft may break	The bevel gear may break
7. Why might the roller jam?	Wear and tear of the roller bearings	The roller shaft is bent	Both answers are possible
8. What is a 'stale seedbed'?	A rice seedbed with too few seeds	Irrigating, germinating, and then tilling in weeds	A field with crops that do not germinate
9. What should you do if seeds do not drop at equal spacing in a line?	Change the metering shaft	Recalibrate the machine	Reduce the two-wheeled tractor's speed
10. Why might it be that the seed-fertilizer meter can't be turned on or off?	It is worn out or broken	The ball clutch is broken	Both reasons are possible

(Continued on page 115)

(continued from page 114)

Question	Answer		
<p>11. If the seed rate of wheat is 120 kg/ha and the width of the PTOS machine is 1.2 m, how much seed (in grams) can be collected in each of the six plastic bags attached to the seed tubes after the machine has covered a distance of 20 m? How much seed will indicate that calibration has been carried out correctly? Formula:</p> <p>Total amount of seed in the six bags = 2 x width of machine (m) x seed rate (kg/ha)</p>	24 g	36 g	48 g

Post-training evaluation questionnaire

Venue:
(to be completed by the facilitator)

Batch:

Date:

Name: _____

Please check (✓) or circle the correct answer Total time: 10 minutes

Question	Answer		
1. What is the function of the rotovator?	It levels the soil	It tills the soil	It helps to move the machine forward
2. What does it mean to calibrate your PTOS?	Calibration determines the speed you should run the PTOS at	Calibration is the adjustment of the seed and fertilizer meters to the correct rate	Calibration is the process by which you make sure the PTOS is correctly attached to the two-wheeled tractor
3. How many times does the PTOS have?	22	24	48
4. What is the effect of line sowing?	It generally helps to increase yield and makes it easier to move around in the field to weed	Yield is lower because the number of plants goes down	The field will not look nice
5. Why might the seed metering shaft bend?	You are running the machine at high speed	You have tilled too large an area of land	There is a jam in the seed metering system
6. What might happen if you till with PTOS too deeply, or on excessively hard, heavy or wet soil?	The hitching of the PTOS to the tractor may break	The seed metering shaft may break	The bevel gear may break
7. Why might the roller jam?	Wear and tear of the roller bearings	The roller shaft is bent	Both answers are possible
8. What is a 'stale seedbed'?	A rice seedbed with too few seeds	Irrigating, germinating, and then tilling in weeds	A field with crops that do not germinate
9. What should you do if seeds do not drop at equal spacing in a line?	Change the metering shaft	Recalibrate the machine	Reduce the two-wheeled tractor's speed
10. Why might it be that the seed-fertilizer meter can't be turned on or off?	It is worn out or broken	The ball clutch is broken	Both answers are possible
11. If the seed rate of wheat is 120 kg/ha and the width of the PTOS machine is 1.2 m, how much seed (in grams) can be collected in each of the six plastic bags attached to the seed tube after the machine has covered a distance of 20 m? How much seed will indicate that calibration has been carried out correctly? Formula: Total amount of seed in the six bags = 2 x width of machine (m) x seed rate (kg/ha)	24 g	36 g	48 g
• Did you understand all the messages you heard from the facilitator today?	No	Partly	Fully
• How do you rate the training?	Not very useful	Useful	Very useful
• Do you feel confident that you now know how to make money using a PTOS while also offering PTOS services at a price which will be profitable for farmers?	Yes	No	Unsure

Answers to questions 1 to 10

- 1. It tills the soil**
- 2. Calibration is the adjustment of the seed and fertilizer meters to the correct rate**
- 3. 48**
- 4. It generally helps to increase yield and makes it easier to move around in the field to weed**
- 5. There is a jam in the seed metering system**
- 6. The hitching of the PTOS to the tractor may break**
- 7. Both answers are possible**
- 8. Recalibrate the machine**
- 9. Both answers are possible**
- 10. 48 g**

Annex 2

Video resources

Several training videos are included in this compendium of experiential learning and modular training resources. We encourage using them as audiovisual learning aids to improve the quality of training. The appropriate video for a specific module is indicated in each chapter and module. Descriptions of the videos can be found below.

Save more, grow more, earn more



How do farmers grow more, while saving time, water and money? Irrigation, fertilizer, fuel and labor costs are rising, and this video shows how farmers in Bangladesh are innovating to overcome these problems by using small-scale and appropriate machinery, and crop management practices that reduce tillage and save time, soil moisture and money. Inspiring case studies are presented from two distinct environments in Bangladesh. In the coastal regions, soil salinity and insufficient irrigation are significant constraints that keep farmers from growing a dry season crop. However, by using simple machinery that reduces tillage to allow earlier planting, and keeping crop residues on the soil surface to conserve soil moisture and reduce salinity, a group of women in southern Bangladesh show how to forgo fallow and grow a profitable maize crop. In central Bangladesh, where the cost of irrigation and farm labor is skyrocketing, farmers and local service providers team up to demonstrate the benefits of planting wheat, maize and legumes on raised

beds to reduce labor and irrigation requirements. The crop management principles both groups of farmers use can be applied anywhere -- it is possible to grow more, while saving time, water and money! You can download this film by clicking here: <https://www.youtube.com/watch?v=TqeU1ZRov3Y>

Power Tiller-Operated Seeder

The power tiller-operated seeder (PTOS) is an attachment for two-wheeled tractors which is not uncommon in Bangladesh. It allows single-pass tillage, fertilizing and seeding in a single line with a rotovator covering a 100-120 cm (1-1.2 m) width. Rice, wheat, maize, jute, mungbean, lentil, sesame and mustard can easily be sown in lines with a PTOS; using a PTOS means that less seed is often needed compared to when the seed is broadcast, and yields of wheat and other rabi crops can be increased by up to 15%. Line sowing also allows farmers to move inside the field easily for weed control, and allows enough sunlight and open spaces for a healthy crop and increased yield. This short video shows how the PTOS can enhance total cultivation, increasing efficiency and ensuring a healthy profit margin both for farmers and service providers. You can download this film by clicking here: <https://www.youtube.com/watch?v=2Y5oaVcNVeo&t=1s>



Annex 3

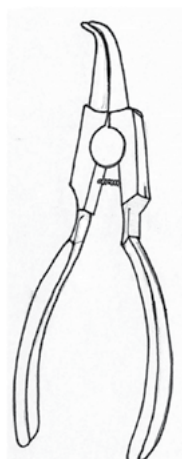
Common tools required for maintaining the PTOS



Adjustable wrench: An adjustable tool for gripping hexagonal nuts with an adjusting screw.



Hammer: A hand tool with a heavy head used for striking objects.

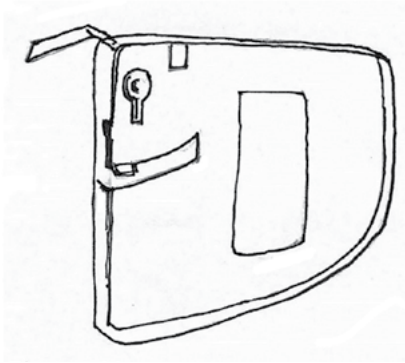


Pliers/cutting pliers: Used to grasp small objects, and to insert/extract or turn them. Pliers often have small cutting blades that can also be used to cut wire or other materials.



Grease gun: A common workshop and garage tool used to apply lubricant to machinery.

Common tools required for maintaining the PTOS (2)



Measuring tape: A flexible scale used as a common measuring tool.



Screwdriver (star/Phillips head): Used to screw in or out screws with a + shape at the head of the screw.



Screwdriver (flat head): used to screw in or out screws with a – shape at the head of the screw.



Dull wrench: Used to turn bolt heads to the left or right. This one has two ends, the circular one has the best grip.

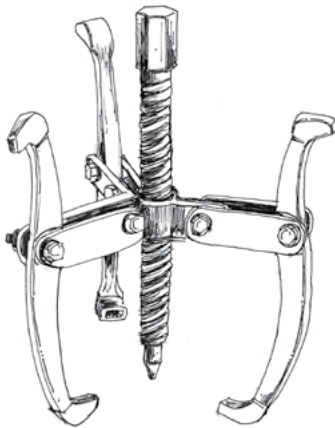
Common tools required for maintaining the PTOS (3)



L-dull wrench: Used to grip bolt heads. This one has two gripping areas at each end.



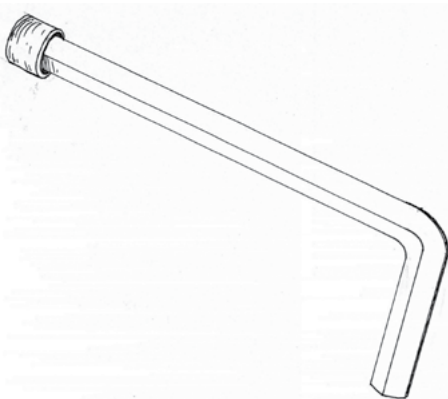
Ratchet: Used to turn the head of a bolt in one direction but not the other. It makes it easy to tighten or loosen bolts without having to take off the tool each time (as with pliers or wrenches).



Three-jaw puller: Useful for removing components such as a gears, pulleys or bearings from a shaft.



Files (flat and round): Used to grind or file different metal parts to the shape required. They can be useful in difficult repair jobs.



Allen key (hex key) wrench set: Used to tighten or loosen bolts that have an 8-sided hex shape at the head of the bolt.

Annex 4

Accurate procedure for measuring fuel consumption by two-wheeled tractors and the PTOS

In order to improve participants' learning, it can be instructional to measure how much fuel the machines consume when following different tillage or seeding systems (for example, comparing full tillage to conventional tillage or PTOS). Fuel consumption can be calculated in two ways: (1) directly, by measuring the force and forward speed (for tractors) or torque and rotary speed (for rotary tillage implements), and (2) indirectly, by measuring the engine's fuel consumption directly. The latter is easier for service providers to understand, and is the most useful.

Both methods require taking measurements under idling and moving tillage conditions. The fuel consumption can be calculated from their difference. The direct method requires a load cells/ torque transducer and speed measurement system (potentiometer) and is quite accurate. Conversely, the indirect method requires simple tools, is considerably less expensive and can be performed in the field during training; however, it may be slightly less accurate. Simply completely filling the tank, using the machine, and measuring how much fuel was used is also quite inaccurate, so we recommend the simple and inexpensive indirect method of measuring fuel consumption, explained below. This method is applicable for both two-wheeled and four-wheeled tractor-based implements, as well as engines that are used to power irrigation pumps.

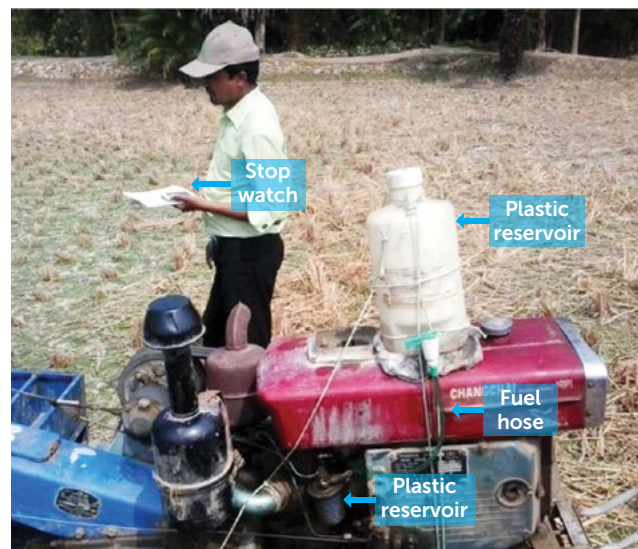
Tools required for measuring fuel consumption

- a tractor known for its good performance and fully equipped with standard parts and settings. It should be filled with sufficient fuel, oil and water
- implements to be tested (fully equipped with standard parts and settings), for example, power tillers vs. power tiller-operated seeders
- a plastic can (2 L capacity) with a tap (see Fig. 1)
- a hosepipe (fuel hose) to connect the plastic can and the fuel filter
- hose clamps to attach the hose

- a measuring cylinder
- a stopwatch
- a tachometer (if available)

Steps

1. Place the tractor fitted with the test implement near the field (unless it is being used for irrigation; then the pump should be set up where there is water). Each plot size should be large enough to run the tractor for at least 10 minutes without stopping (but 30–60 minutes is preferable). Plots need to be roughly identical in size and shape for an accurate comparison.
2. Fasten the plastic fuel reservoir securely to a suitable place on the tractor (no lower than the height of the fuel tank).
3. Fill the plastic fuel reservoir with 2 L of fuel (diesel).



Setting up the plastic can and connection of fuel hose for fuel consumption measurement of a power tiller-operated seeder, or PTOS(2BG-6A model).

4. Remove the tractor's existing fuel hose and use a new fuel hose, long enough to reach the plastic fuel reservoir with the fuel filter (see the photo above). This hose should be clamped into place with hose clamps.
5. Remove any air inside the hose or fuel pump/injector by squeezing it out by hand.
6. Idle the engine for about five minutes at the desired engine rpm (i.e., rpm that will provide the desired forward travel speed using the tachometer, if available), and lock the engine throttle lever.
7. Measure the size of the experiment plot in m² (A).
8. Place the tractor fitted with the test implement at an exact position in the field to start the tillage or seeding operation.
9. Adjust the settings of the machinery, if required. Record the setting of the tractor (gear position, engine rpm) and test implement (type, depth, width, spacing).
10. Replenish the fuel tank up to the 2 L mark and start the test immediately at the set rpm.
11. In minutes:seconds using a stopwatch, record the time (δt) it takes to complete land preparation while covering the whole plot without interruption.
12. Stop the engine immediately after completion.
13. Replenish the fuel can up to the 2 L mark using the measuring cylinder and record the required amount in ml (δV).
14. Follow these steps for other implements/settings and other fields or machines.
15. Calculate the fuel consumption using the formulas below:
16. Fuel consumption (L/ha): $((\delta V))/((A)) \times 10000/1000$
 where δV = fuel required per plot (ml), and
 A = area of the experiment plot (m²).
 Fuel consumption (L/h): $((\delta V))/((\delta t)) \times 3600/1000$
 where δV = fuel required per plot (ml), and δt = time required to cover one plot, in seconds.

[illegible]



This set of training modules focuses on ensuring that local service providers are able to make repairs to power tillage-operated seeders efficiently and correctly. This booklet is designed so that anybody who uses these materials can easily conduct training – even those with a limited background in and understanding of agricultural engineering or machinery. This training uses an experiential and hands-on modular format. It is based on a foundation of experiential and hands-on work, combined with discussion and reflection among participants. This means that although the facilitator is instructed on how to carry out the training and how to present the materials, the format in which this is done should be horizontal and participatory, with room for adaptation and modification.

The technical materials included in this document should therefore be seen as a guide to supplement the in-depth knowledge that the trainee farmers and agricultural machinery service providers already have. By the conclusion of the training module, participant service providers will be well-equipped to repair power tillage-operated seeders as part of their ongoing agricultural machinery service business. Nonetheless, users of this booklet should carefully read all the instructions on how to implement the training effectively in order to ensure the best learning experience possible for the participants.

Funded by



USAID
FROM THE AMERICAN PEOPLE

**BILL & MELINDA
GATES foundation**

Partners



CIMMYT^{MR}
International Maize and Wheat Improvement Center

IFPRI
INTERNATIONAL
FOOD POLICY
RESEARCH
INSTITUTE

IRRI