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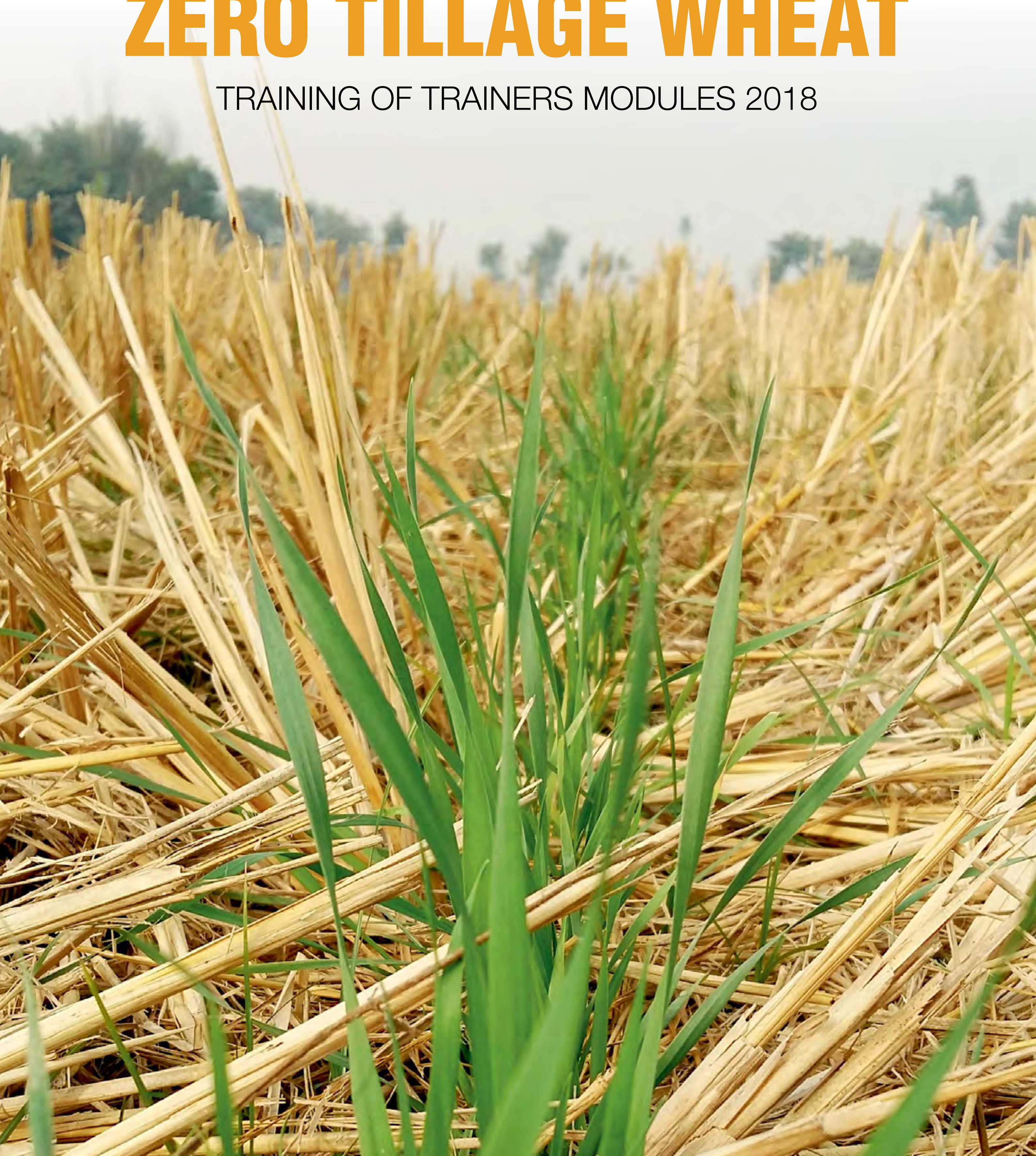
ZERO TILLAGE WHEAT

TRAINING OF TRAINERS MODULES 2018



The Cereal Systems Initiative for South Asia (CSISA) is a regional initiative to sustainably increase the productivity of cereal-based cropping systems, thus improving food security and farmers' livelihoods in Bangladesh, India and Nepal. CSISA works with public and private partners to support the widespread adoption of resource-conserving and climate resilient farming technologies and practices. The initiative is led by the International Maize and Wheat Improvement Center (CIMMYT), is jointly implemented with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI), and is funded by USAID and the Bill & Melinda Gates Foundation.

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Concepts, Agronomic Management and Operations

SESSION I

Introduction and Training Objectives

Introduction

Zero tillage (ZT) technology plays an important role in the sustainable intensification of rice–wheat cropping system and adoption of better-bet management practices, such as timely crop establishment, in India. Nearly two decades ago, ZT was first introduced to help farmers reduce tillage costs and advance the planting time of wheat and other Rabi crops. In successive years, ZT marked the evolution of the concept of conservation agriculture in rice–wheat cropping systems. ZT now offers significant opportunities in cropping system optimization for greater system productivity, especially in the eastern Indo-Gangetic Plains of India. As the majority of farmers in rice–wheat cropping systems still burn the residues of the rice crop to enable their rapid disposal before wheat sowing, recent advances in ZT makes it possible to sow wheat successfully into heavy residues and facilitate the use of residues as mulches for weed suppression and moisture conservation. One example is the Happy Seeder that can seed wheat in heavy residue mulch of up to 8 to 10 t/ha without any adverse effect on crop establishment. The success of ZT depends on the creation of service providers in the system, who face cash flow risks and are unable to afford costly machines, to have access to ZT technology through custom-hiring.

This manual has been prepared by drawing on and leveraging the collective wisdom of diverse stakeholders including farmers and manufacturers. An attempt has been made to instill confidence among trainees and master trainers in the technology and among service providers about the business logic. ZT technology is financially attractive and creates demand among farmers. It will be a viable business proposition for tractor owners to purchase machines and take up custom services for smallholders and relatively resource-poor farmers. For building a successful and sustainable business model, tractor-owning farmers can be persuaded to purchase ZT drills available on subsidy. Past experience shows that more than 60% of ZT adopters did not have tractors or ZT machines.

Skills, knowledge and coordination with partners including the Department of Agriculture (DOA) and state agricultural universities (SAUs) are essential prerequisites for facilitating accelerated adoption of the technology. Extension material needs to be developed to show how the technology operates and saves cost.

This training manual aims to cover critical topics in the principles and operation of ZT technology. It will also provide guidance to service providers (SPs) on cost and returns analysis, and benefits of starting a business enterprise for ZT custom-hire services. This training is designed for agronomy experts, business development professionals and senior staff from Krishi Vigyan Kendras (KVKs), the Department of Agriculture, non-governmental organizations and the private sector.

Training Objectives

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

- Understand the benefits, challenges and operation of ZT technology.
- Tell how ZT helps in the intensification of cropping systems.
- Explain the role of custom hiring services through private service providers.
- Understand the basic business concepts underlying custom-hire services for zero tillage.
- Demonstrate simple profitability calculations to plan a ZT-based business and evaluate its performance.
- Understand the importance of keeping business records as a basis for profitability calculations and learn what kind of information is needed.

Key Messages

- The productivity advantages of ZT wheat result from earlier planting (and thus avoiding terminal heat damage during the grain filling stage), control of *Phalaris minor*, a major weed of wheat, better nutrient management and water savings.
- Other advantages include improved soil and water conservation, increased use of land through intensification of cropping systems, reduced labor and energy requirements, reduced equipment inventories, reduced wear and tear on tractors and equipment, and greater environmental benefits.
- ZT reverses the loss of soil organic matter that happens in conventional tillage.
- Provides excellent seed-soil contact and hence facilitates uniform emergence of seeds.
- Improves soil quality and water retaining capacity by adding organic matter. As crop residues decompose, this creates an open soil structure that lets water in more easily, reducing runoff.
- Helps reduce CO_2 emissions and mitigate the adverse effect of global warming.
- ZT use leads to reduction in air pollution by minimizing crop residue burning.
- Improves the biological diversity of soil that increases the number of beneficial insects and keeps many insect pests in check.
- Establishing the wheat crop through zero tillage can be undertaken as a business.

Duration

The course is designed to span three days including classroom and hands-on training. The site of the training should be close to a farm for the demonstration of a ZT machine.

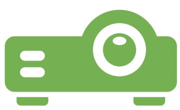
Session	Topic	Duration (minutes)
	Day 1: ZT Introduction and Benefits	
I	Introduction and training objectives	90
II	Integrating zero tillage concepts, residue management, trade-offs and sustainable intensification of cropping systems	120
III	Agronomic management practices	120
	Day 2: ZT Operation	
IV	Parts of the ZT seed-cum-fertilizer drill and their functions	120
V	Practical exercises with a ZT seed drill in the field	120
VI	Discussion about field problems and their solutions	90
	Day 3: Service Provision as a Business Opportunity	
VII	Introducing concepts: Fixed and variable cost components and their calculations	100
VIII	Profitability calculations: Scenario analysis	120
IX	Introducing concepts: Opportunity costs, risks, competition	60
X	Expanding the business portfolio	30
XI	Record keeping	30
	Open discussion	60

Key Considerations for this Training

- The facilitator should start the training by first conducting a theory session in the class room. Content given in this manual could be used in conducting this session. Explain each topic slowly and clearly and encourage participants to ask questions.
- The facilitator should briefly introduce himself/herself and other resource persons present.

- The facilitator should then ask the participants to introduce themselves and explain their current tillage practices, listing them in order of preference. After completion of each topic, the facilitator should conduct a Q&A round and clarify any doubts.
- The facilitator should discuss the following topics during the training:
  - Local cropping systems and the ecologies in which participants are working.
  - Optimal transplanting time for rice and sowing time for wheat to help participants understand the importance of timely sowing in the intensification of cropping systems.
  - The present yield levels of different crops to indicate what yields can be achieved through the intensification of cropping systems and by advancing sowing times.
  - Explain why system productivity is more important than the productivity of an individual crop, as well as the system productivity based on the duration of varieties and seeding of crops in rotation.
  - Critical factors in the adoption of ZT so that questions can be answered as part of the training.
  - Potential future subsidy trends on ZT machines in relation to other tools and implements for mechanization.
  - Availability of machines in the state/area, the existing system of custom-hire services, and maintenance and repair facilities.
- Custom-Hire Services.

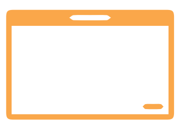
Training Requisites



PROJECTOR

LAPTOP

POWER POINT PRESENTATION



WHITE BOARD

MARKERS

FLIP CHARTS

SESSION II

Integrating Zero Tillage Concepts

Introduction

The facilitator should start this classroom session by giving the participants a verbal overview of conventional tillage, zero tillage, and conservation agriculture. Participants should be encouraged to think about crop residue management and to raise queries, which should be clarified during the session.

By the end of this Session, Participants should be able to:

- Understand the reasons why they should adopt zero tillage technology
- Explain the advantages of establishing a crop using zero tillage
- Explain the agronomic management practices required for establishing wheat and other crops

Conventional Tillage

Conventional tillage is used to soften the soil and prepare a seedbed that allows seeds to be placed easily at a suitable depth into moist soil, using seed drills or bullock-drawn Indian plough or manual equipment. This results in uniform seed germination. Generally, this method involves plowing or intensive (i.e., numerous) tillage operations.

Photo 1: Seeding under conventional tillage

Residues from the previous crop are incorporated, along with any soil amendments (fertilizers, organic or inorganic) into the soil. Crop residues, especially loose residues, create problems for seeding equipment by raking and clogging.

Tillage gives temporary relief from compaction using implements that can shatter below-ground compaction layers formed in the soil (see Photo 1). Implements like rotavators create serious problems such as soil compaction, water stagnation and the yellowing of wheat leaves after the first irrigation. The use of rotavator also leads to farmers using broadcast sowing, which is a harmful agronomic practice as it does not lead to proper crop geometry. Overall, tillage consumes large quantities of fossil fuels, adds to the cost of cultivation, emits greenhouse gases (mostly CO_2), delays the planting of crops, leads to a decline in soil organic matter, leaves the soil bare and loose – eventually leading to soil erosion – disrupts the root channels of the previous crops and results in more wear and tear of agricultural machines.

Zero Tillage

Zero tillage (ZT) can be defined as the placement of seed into the soil by a seed drill without prior land preparation. A common definition of zero tillage (i.e., no-till) specifies that 30 percent of the soil surface should be covered by crop residues at the time of planting. Zero tillage improves the total productivity, meaning the efficiency of labor and capital used.

A tractor-drawn ZT seed-cum-fertilizer drill is the core of the technology (see Photo 2), allowing wheat seed to be sown directly into unploughed fields with a single pass of the tractor, often with simultaneous basal fertilizer application, especially phosphorus. It can also be used for planting other crops like lentil, chickpea, mustard, green gram, rice and maize.

Photo 2: Direct drilling of wheat in a combine harvested field.

ZT technology has also been successfully used under small-scale farming conditions using a two-wheel tractor.

ZT technology is a more sustainable and environment friendly management system for cultivating crops, especially in South Asia, where sustainable intensification is key to the success of smallholder farmers. It can enable farmers to achieve sustainable agricultural production.

Why Adopt Zero Tillage?

Farmers in South Asia will have to produce more food from less land by making more efficient use of their natural resources and with minimal impact on the environment. That seems possible by adopting methods such as zero tillage, which allows for the intensification of cropping systems and saving of resources The sequence of events leading to zero tillage adoption in India is given in the table (history of zero tillage).

History of Zero Tillage

Time	Developmental stages
18000 B.C.	Planting by stick, earliest version of zero tillage
6000 B.C.	Draught animals replaced humans in the ploughing process
3500 B.C.	Plowshare a wedge-shaped implement tipped with iron blade loosens the top soil
1100 A.D.	Mold bold plough
Mid 1800	Still mold bold plough
Early 1900	Tractors
1940s – 50s	Less tillage, herbicides like 2, 4-D & Atrazine to manage weeds
1960s	No-till seeders developed (First no-till farmer was Harry Young in Kentucky, USA)
Late 1970s	ICI promoted zero tillage to sell Paraquat
Late 1970s	ZT was tried & tested in India and was at a dead end until the early 1990s
Mid 1990s and Early 2000	ZT evolved and was adopted in India

Conservation Agriculture

ZT was a transitory step towards the evolution of conservation agriculture (CA). CA aims to conserve, improve and make more efficient the use of natural resources through the integrated management of available soil, water and biological resources, combined with external inputs. It contributes to environmental conservation as well as to enhancing and sustaining agricultural production. CA has now been used as a part of sustainable intensification for optimizing cropping system. The three key principles of CA are: permanent soil cover with at least 30% of the soil surface covered with crop residue (see Photo 3), minimal soil disturbance and crop rotations.

Photo 3: Direct drilling of wheat with 100 percent crop residue

Happy Seeder-Based ZT

Happy Seeder technology (see Photo 4) should be used along with the entire system of mechanization to ensure good crop establishment, proper placement of fertilizer and the handling of crop residues. Earlier, problems were encountered with combine harvester due to the inverted-T opener-based ZT machines available in South Asia. To overcome these problems, a seeder-based ZT machine was developed. Different options available are as follows:

- Stubbles can be partially burnt, as is presently done in most conventional farming systems.
- Happy seeders can also handle seeding wheat into 100% rice residue immediately after the harvesting of rice.
- Combine harvesters can also be modified to chop the straw into small pieces and distribute it evenly on the soil surface.

Photo 4: Happy seeder for direct drilling with 100 percent residue load.

Strip Tillage

In strip tillage, the soil is left undisturbed between harvest and planting, except for strips up to 1/3 of row's width (strips may involve only residue disturbance or may include soil disturbance). Planting or drilling is accomplished by using disc openers, coulter(s), or rototillers. Other common terms used to describe strip tillage are 'direct seeding' and 'row-till'.

Surface Seeding

Surface seeding is the simplest method of ZT, involving the placement of seed onto the soil surface without any land preparation. Farmers in parts of eastern India, Bangladesh and Nepal commonly use this practice to establish legumes and oilseeds, and occasionally wheat. Wheat seed is broadcast before or after rice harvest (relay planting/*utera* or *paira* cropping).

Reduced Tillage with Two- and Four-Wheel Tractors

Reduced tillage with a 12-horsepower, two-wheel diesel tractor prepares the soil and plants the seed in one operation, even planting into anchored rice stubble on heavy soils. This system consists of a shallow rotavator followed by a six-row seeding system and a roller for compaction of the soil.

An alternate definition is full-width tillage involving one or more tillage trips, which disturbs the entire soil surface and is performed prior to and/or during planting.

Zero tillage differs from reduced tillage (RT) in the sense that the latter still retains some minimal tillage prior to seeding, although this often still implies a significant reduction in tillage intensity compared to conventional farming practices.

Conservation Tillage

ZT will be used to describe a system with minimum soil disturbance along with residues from the previous crop in rotation. Conservation tillage is also used where there is minimum soil disturbance with residue mulch. However, for the purpose of this training module, the term ZT will be used as it represents the whole cropping system rather than a single crop, which is frequently used in the context of conservation tillage.

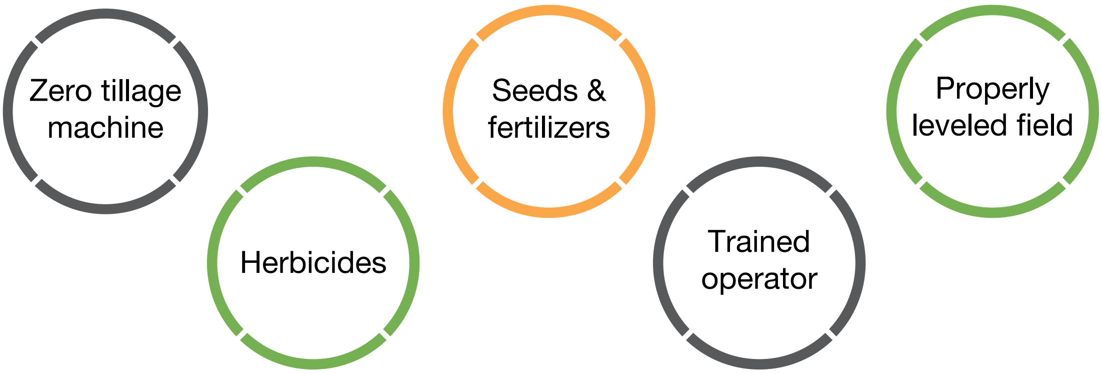
Crop Residue Management

Crop residue management is a year-round conservation tillage management system beginning with the selection of crops that produce sufficient residue. The system may include the use of cover crops after low residue producing crops. Crop residue management includes all field operations that affect residue amounts, orientation and distribution throughout the cropping system cycle. Retention of crop residues improves organic carbon content, water-stable aggregates, bulk density,hydraulic conductivity and soil biological activities. Residue management influences soil temperature, moisture conservation and weed and pest management.

Residue retention assumes greater importance when cereals are grown immediately after other cereals and with minimal cultivation. There is no direct evidence of deleterious effects due to phytotoxins released during rice straw decomposition on the growth and yield of wheat in the Indo-Gangetic Plains. There is a need to study the effect of surface retention of crop residues on the growth and yields of crops in the rice–wheat system, particularly in the absence of puddling.

For facilitating ZT operations, the straw should be chopped into small pieces and evenly distributed on the soil. These small pieces of straw will not interfere with the inverted-T openers and will leave stubble mulch on the soil surface for residue retention.

Requisites for Zero Tillage



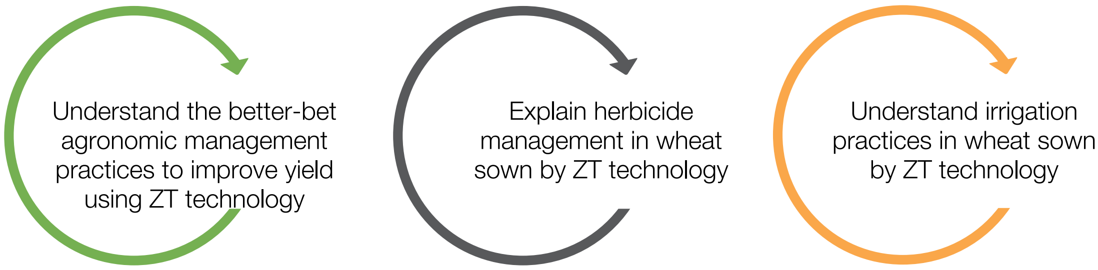
Various causes and effects of conventional tillage, zero tillage and conservation agriculture

Issues	Conventional tillage	Zero tillage	Conservation agriculture
Soil physical health	Lowest	Significantly improved	Best practice
Soil compaction	Used to reduce compaction but can also induce compaction by destroying biological pores	Reduces compaction	Residue and proper crop rotation help reduce compaction
Soil biological health	Lowest	Moderately better soil biological health	More diverse and healthy biological properties
Water infiltration	Lowest with clogging of soil pores	Good water infiltration	Best water infiltration
Soil temperature	Surface soil temperature more variable	Moderation of soil temperature	Best case scenario for moderation of soil temperature
Timeliness	Operations are frequently delayed	Operations are optimized	Best case scenario for timely operations

SESSION III

Agronomic Management Practices

By the end of this Session, the Participants should be able to:



Important Agronomic Practices

Zero tillage technology is most reliable and use cases of this technology indicate precise placement of seed and fertilizer, good seed and soil contact, uniform emergence and profound tillering leading to high productivity at less cost (see Fig.1)

Time of Sowing

- For high yield, wheat sowing should be done between 1 and 15 November.
- If sowing is not possible by 15 November, then it should be done at least before 25 November, as each day's delay beyond this date will result in a loss of 25-35kg kg/ha.

Method of Sowing

- Sowing should be done with the help of a ZT machine as it saves both time and money.
- If sowing is done after the field is tilled, there is yield loss as well as unnecessary investment in tillage.

Wheat Varieties

- HD 2967, HD 2733, HD 2824, HD 2967 and PBW 550 or varieties recommended by the state agricultural universities.

Seed Rate

- Seed rate of 40-45 kg per acre has to be followed when sown with a zero tillage machine.

Precise placement of seed and fertilizer

Good seed to soil contact results into good rate and extent of germination.

Uniform emergence will lead to synchronized maturity.

Multiple tillering starting from initial single seed.

Fig. 1: Emergence growth and development of wheat under zero tillage

Tiller counts
increased with time.

Late tillering stage and
jointing stage. Plant begin
elongating photo taken on
19 January 2018

Beginning of post anthesis
stage. Photo taken on
21 February 2018

Uniform growth, development
and synchronized maturity -
a win win situation

Fig. 1: Emergence growth and development of wheat under zero tillage

Pre-Sowing Herbicide Management

If weeds are present prior to seeding, these weeds should be killed by spraying pre-seeding non-selective/burndown herbicides such as glyphosate @ 1.0 kg ai/ha [product dose 975 ml/acre roundup or glycel using 100-150 liter water] or 1.0-1.5% by volume i.e. 10-15 ml roundup or glycel/liter of water or 6-10 g *Mera* 71/liter of water about 2-3 days prior to wheat sowing. Note the following important points.

- If weeds are in patches, perform spot treatment to save time and costs.
- Spraying should be done using a multiple nozzle boom fitted with flat-fan nozzles. If a multiple nozzle boom is not available, then a cut/flood jet nozzle with single nozzle boom should be used. Do not use a cone-type nozzle for herbicide application.
- Pre-seeding herbicides should not be applied after wheat sowing.

Fertilizer Dosage (per acre)

- At sowing: 50kg DAP (used in the ZT machine), 32kg MOP, 10kg Zn (applied manually).
- At 1st irrigation: 42kg Urea (applied manually).
- At 2nd irrigation: 42kg Urea (applied manually).
- If wheat is sown after a pulse crop, the dosage of nitrogen may be reduced by 25%.
- If wheat is sown after 30 November, the fertilizer dose can be reduced by 25%.

Major Weeds	Herbicides	Active ingredient (g a.i)/ha	Product g/ acre
Mixed weeds	Total (Sulfosulfuron + metsulfuron)	32	16
	Vesta (Clodinafop + metsulfuron)	64	160
	Sulfosulfuron + carfentrazone	25 + 20	13.3 + 20
Narrow-leaved weeds	Leader/ Safal/ Fateh (Sulfosulfuron)	25	13.3
	Topic (Clodinafop)	60	160
Broad-leaved weeds	2,4-D Na Salt	400	200
	Affinity (Carfentrazone)	20	20
	Algrip (Metsulfuron)	4	8

Note: Herbicide application should be done 30-35 days after sowing in 120-150 liter of water per acre using a flat-fan nozzle.

In a *Solanum* sp. infested area, use sulfosulfuron + carfentrazone for mixed weed flora or carfentrazone if only broadleaf weeds are present.

Irrigation

Experimental data have validated the usefulness of zero tillage in saving water in first irrigation (see Photo:5)

1st IRRIGATION
20-21 Days after sowing (DAS)
(at crown root initiation stage)

2nd IRRIGATION
40-45 DAS
(at the time of tiller initiation)

3rd IRRIGATION
60-65 DAS
(at node formation)

4th IRRIGATION
80-85 DAS
(at the flowering stage)

5th IRRIGATION
100-105 DAS
(at the milking stage)

Note: The field should be irrigated during the grain filling period in March to avoid terminal heat stress.

Photo 5: ZT saves water during first irrigation

Points to Note

- The sowing of wheat with a zero-till seed-cum fertilizer drill is best accomplished when soils have 3-4% more moisture than under the conventional method. Germination of wheat and other crops is adversely affected if the soil is too dry. Conversely, the zero-till machine does not work well in fields where moisture levels are too high (wheel slippage occurs) and under such situations, care must be taken to prevent the blockage of seed and fertilizer tubes.
- Longer duration varieties such as HD 2967, having better vigor during early growth and profuse tillering, cover the soil surface and are more competitive with weeds. Select cultivars with better competing attributes.
- Due to better seed and soil contact the roots are very well anchored. This helps reducing lodging in wheat (see Photo:6)
- There is no need for planking before or after planting crops with zero-till drill.
- Irrigation immediately after wheat sowing is not recommended. If needed, post-sowing irrigation may be given a week ahead of the conventionally practiced irrigation schedule.
- When weed pressure is not a factor, soil tilling is not needed and reduced tillage (1-2 ploughings) and cross-sowing methods do not provide any additional advantage over zero tillage. Rather, these methods may reduce crop germination and yield as well as induce germination of *P. minor*, besides increasing the cost of cultivation. The germination and emergence of wheat is not adversely

Photo 6: Zero tillage facilitates better anchoring of roots

affected even if rains occur just after sowing of wheat because crust formation does not take place under zero tillage. However, crops planted with zero till in reduced till plots may bury seed deeper and may adversely affect crop stand.

- Germination of *P. minor* is reduced by 30-40% if soil disturbance is reduced to the minimum, as in the case with the zero tillage. *P. minor* seed generally fail to germinate if seed depth is > 5 cm.
- Non-selective herbicides should to be used only to knock down pre-germinated weeds including *P. minor* (see Photo 7).

Photo 7: Spraying of non-selective herbicide

- Spraying of post-emergence herbicides should be accomplished at 2- to 3-leaf stage of *P. minor*.
- Broadleaf weed emergence in place of *P. minor* under long-term zero-till fields is expected. However, it will be comparatively easy and cheap to control broadleaf weeds in wheat using herbicides like 2, 4-D, metsulfuron or carfentrazone. Based on long-term permanent trials in places like Haryana since 1997/98, it has been observed that there is no significant shift in weed flora to date.
- Encouraging results for wheat sown with zero-till machines have also been realized under saline and alkaline soils.
- Zero-till wheat sowing is possible in standing paddy stubble (just after harvest) without burning, which not only adds residue to the soil to increase and improve its quality but also prevents environmental pollution. If loose paddy straw is lying on the soil surface, it should be collected and kept aside before seeding to avoid interruption of the seeding operation. It should be uniformly broadcast as mulch after seeding.
- There is no need to increase the use of nitrogenous and phosphatic fertilizers in zero tillage. Keep application rates the same as followed under conventional methods of planting.

SESSION IV

Parts of Zero Till Seed-Cum Fertilizer Drill and Their Functions

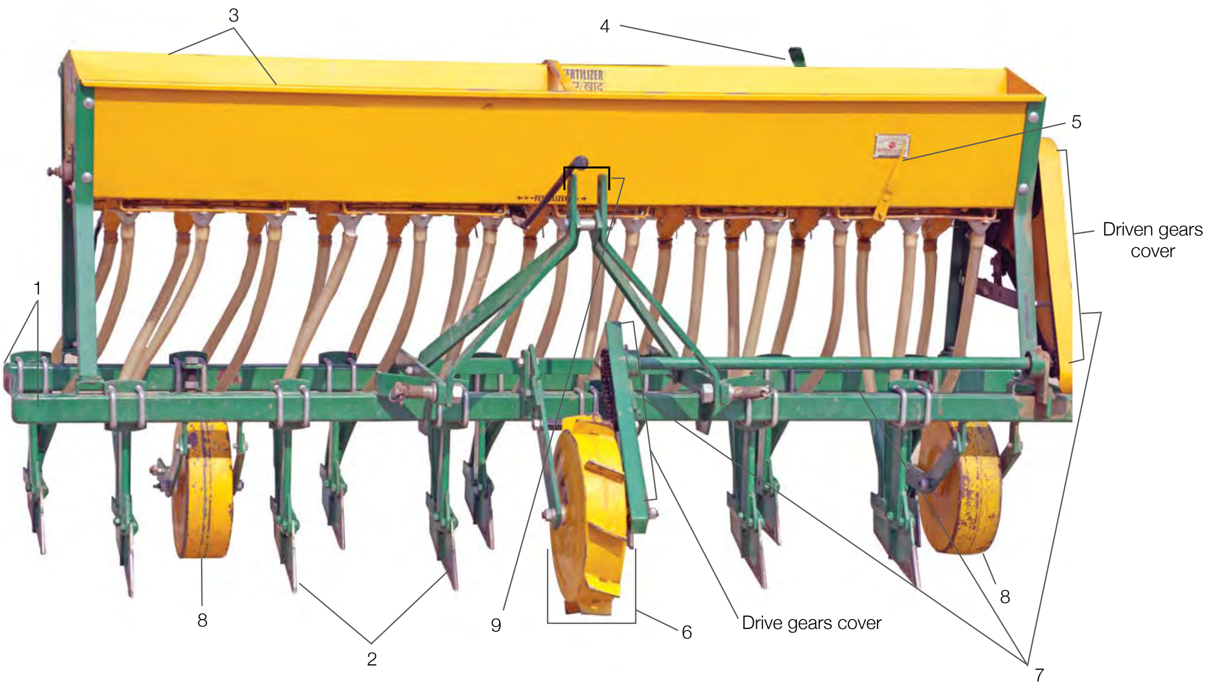
By the end of this Session, Participants should be able to:

- Explain the different parts of the zero tillage machine
- Calibrate zero tillage as per the given operational guidelines
- Understand the repair and maintenance procedures related to zero tillage

Parts of Zero Till Seed-cum-Fertilizer Drill and Their Function

With the significant increase in the adoption of zero tillage technology in several areas of the Indo-Gangetic Plains, the zero till seed-cum-fertilizer drill has become a useful and important agricultural machine for the farmers (see photo 8). All of the new models are improved version of the traditional seed drill used by farmers for decades. Seed drilling is accomplished in a narrow slit created by a zero till seed-cum-fertilizer drill.

Major Components and their Description



1. Frame 2. Slit/furrow openers 3. Seed and fertilizer boxes 4. Seed adjustment lever
5. Fertilizer adjustment lever & indicator 6. Drive wheel 7. Power transmission unit
8. Depth-control wheels 9. Top link hitch point

Photo 8: Major components of the zero till seed-cum-fertilizer drill machine

A brief description of each of the above components is given below:

Frame

The zero-till drill frame is 200 × 60 cm. It is made of two mild steel angle irons (6.5 × 6.5 × 0.5 cm) welded together to provide the desired strength and rigidity. This is true in a drill of 9 tynes but in 11-tine drill, the length of frame is about 220 cm. Tynes are 20 cm apart (adjustable, see photo:9) and provided in the frame to vary the spacing between furrow openers (see photo: 8). In new models, a provision for fastening clamps (diamond/box types) has been refined to achieve desired line to line spacing. The machine can easily be drawn by any 35 hp tractor. The height of the machine ranges from 110 to 145 cm and weighs around 200 to 260 kg, even up to 350 kg in some models.

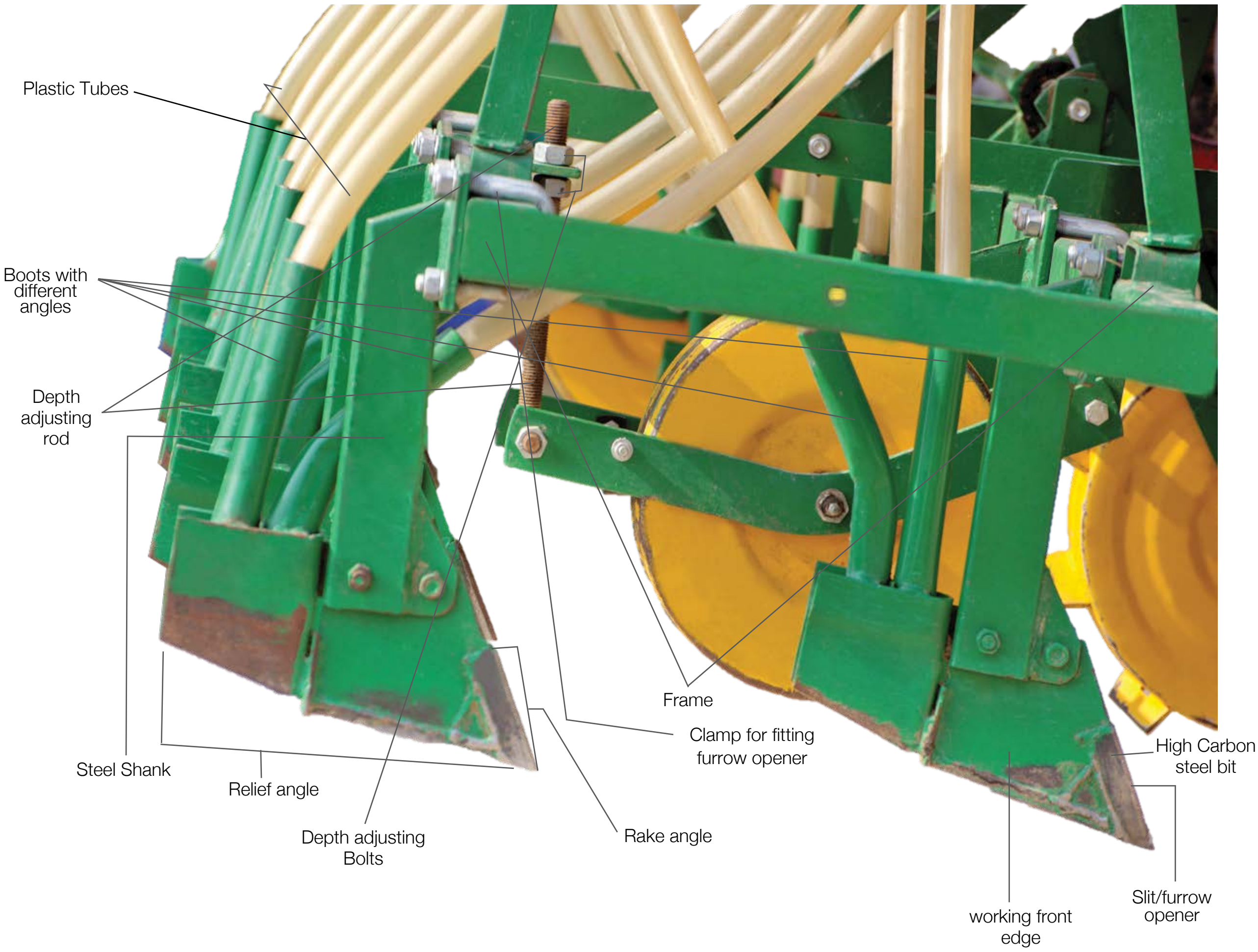


Photo 9: Different components fitted on a machine frame

The zero till seed-cum-fertilizer drill has 9-13 inverted T-type slit/furrow openers (see photo:8) depending on the model/brand. These can be spaced as needed for different crops. These T-type slit/furrow openers, when attached to a tyne, opens a narrow slit 3-5 cm wide. The cutting portion of the slit/furrow openers is made by using 8 mm thick high carbon bit welded to a mild steel plate (see photo: 9). The working front edge of the slit/furrow openers has a piece of carbon steel (hardness 65 RHN) welded all around the nose, tip and sides to reduce wear and tear (see photo:9). In some drills, manufacturers have provided chisel-type slit/furrow openers. The rake angle (see photo:9) is generally kept at around 20 degrees in order to make a narrow slit with minimum of soil disturbance. The relief/

clearance angle of the slit/furrow openers is normally kept at 5 degrees. The relief angle (photo:8) can be further adjusted with the help of the top-link (mounted with tractor) to vary seeding depth. The furrow opener is welded to the mild flat steel shank (straight leg standard mounted with T-type slit openers, see photo: 9). The blades can be of a “welded on” or “bolted on” or even “knock down” type. The disadvantage of “welded on” blades is that they require a machine shop for replacement, whereas, a farmers himself can replace the other two types of blades in new models. The quality of material used to make the slit/furrow openers will ultimately determine the operational quality and durability of the drill. Double boot (see photo: 9) with different angles is provided behind each furrow opener to receive a tube (steel ribbon or polyethylene tube (hard type) with a minimum diameter of 25 mm) each from seed and fertilizer metering devices. This will help avoiding blockage during seeding. The furrow openers are adjusted to make 3–5 cm wide and deep slits. The depth of seeding can be adjusted by raising or lowering the depth-control side wheels. However, depth of seeding can also be adjusted (independent of the depth-control side wheels) by raising or lowering the shanks of the furrow openers (photo:9). The depth control can also be effected by three-point hitch hydraulics, in addition to the depth-control wheels. The top link is used to level the seeder. The unlevelled machine may otherwise lead to variable seeding depth in different rows leading to uneven seed placement. Since the side link hydraulics often get damaged or become non-functional in most tractors, with the farmers, it is advisable to use both the depth control wheels and the top link simultaneously.

Seed and Fertilizer Boxes

Trapezoidal seed & fertilizer boxes, made of mild steel sheet (2 mm thick), are mounted side-by-side on the frame, fertilizer box in front and seed box (see photo: 10) in the rear. The boxes are generally 145 cm long and 28 cm deep sufficient to hold 50 kg DAP and 50 kg wheat seed at a time, respectively. Box dimensions can vary but these generally depend upon the effective width of the machine and will increase with an increase in the number of the slit/furrow openers. For example, in case of the 11-tyne drill, the length of seed and fertilizer boxes will be around 178 cm.

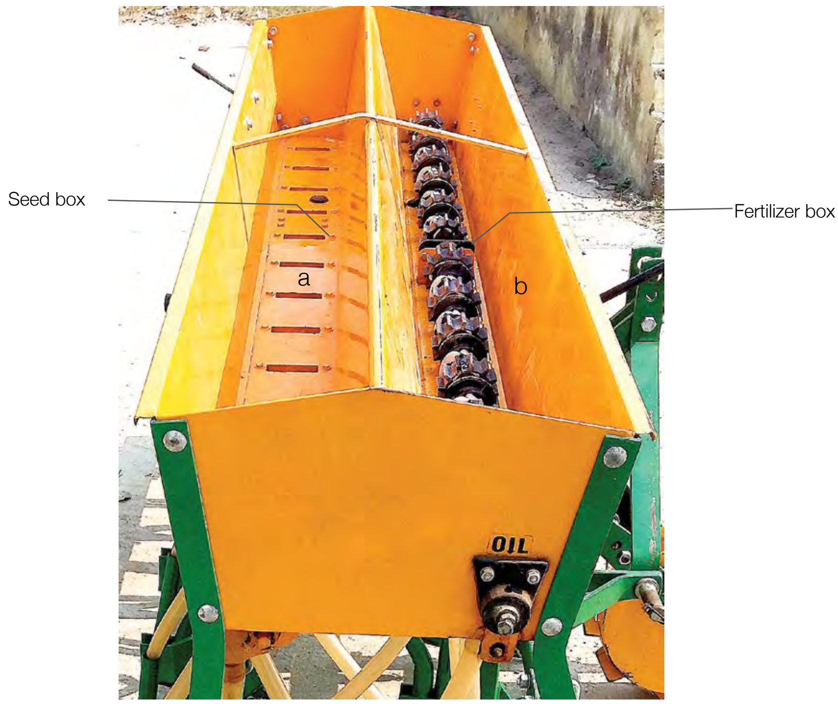


Photo 10: Seed and fertilizer boxes

Seed Metering Device

A seed metering device has the following components (photo: 10):

1. Seed adjustment lever	2. Fluted rollers	3. Flow control tongue
4. Aluminium cup	5. Plastic tube	6. Seed boot

Fluted rollers (photo: 11a) made of aluminium facilitate the continuous seeding of crops where the control of plant-to-plant distance is not needed (e.g., wheat, rice, mustard). Tooth size, depth of the groove and the number of flutes depend on the seed size. For example, there are 10 flutes in each roller for wheat seed. The rollers are fitted in a series on a shaft. Aluminium/plastic cups are fitted on these rollers to regulate the seed rate. Below the fluted rollers are aluminium or plastic tongues to hold the seed and check its free fall of seed (see photo: 11a &13). The tongues can be raised or lowered depending on the size and texture (in the case of rice) of the seed. As the fluted rollers turn, they push the seed over the edge of the seed cups attached at the bottom of seed metering box which funnels the seed through the plastic seed tubes (photo: 9) to the slit/furrow opener through seed boots. Inclined plate seed metering device has been provided for precise seed placement (see photo 11b).

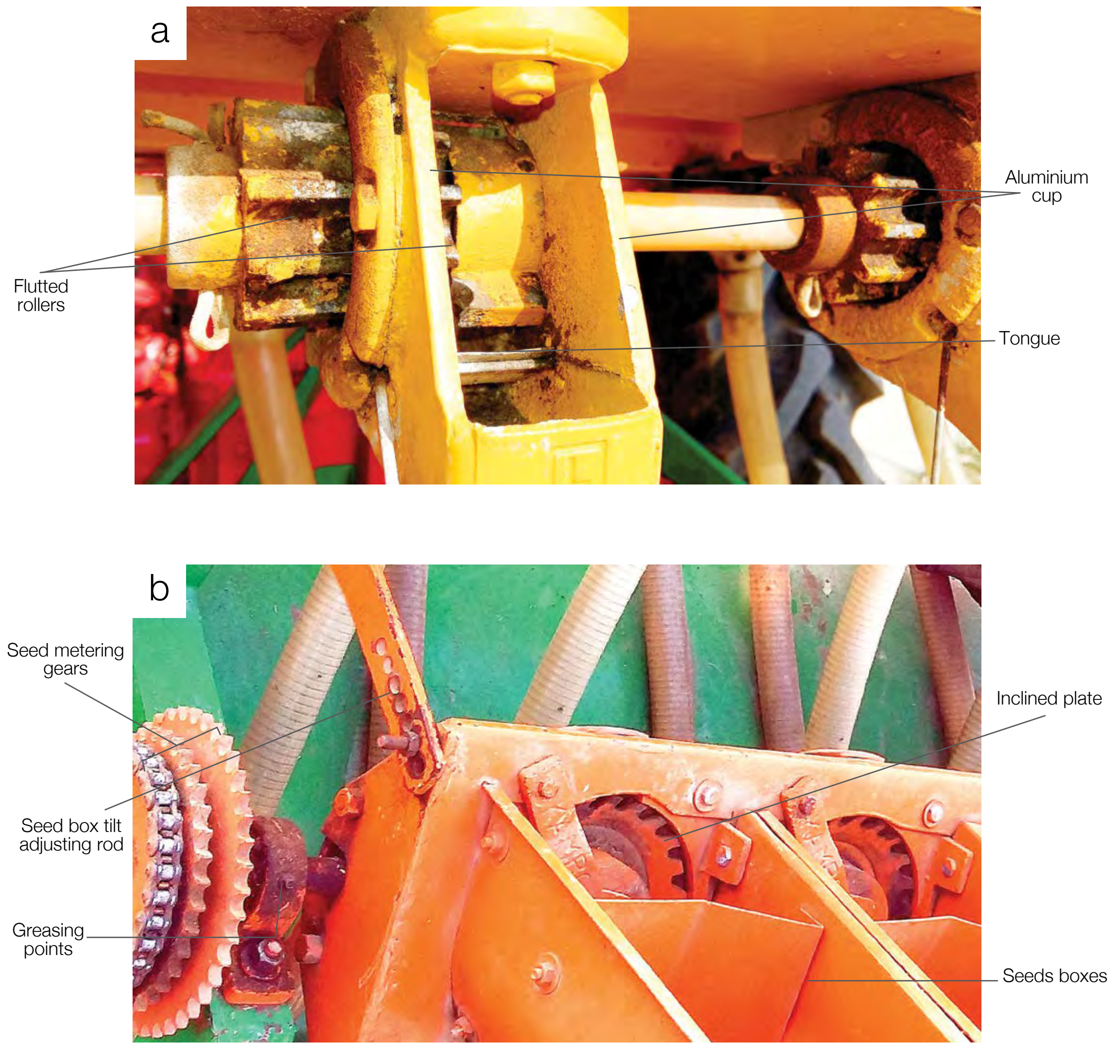


Photo 11a & b: Seed metering devices

A precise seed rate adjustment is obtained by sliding the fluted roller in or out with in the aluminium cups. The more is the exposed area inside the cups of the fluted roller, the higher will be the seed rate and vice-versa.

Calibration of the Seed Drill (in a laboratory)

i. Measure the diameter (D) of the drive wheel and calculate its circumference i.e. πD in meters.

ii. Measure the effective width of coverage (W) in meters of the drilling machine by multiplying number of furrows and spacing.

iii. Then distance/length (L) to cover one hectare is calculated by dividing 10,000 m^2 (area of one hectare) by effective coverage (W).

iv. The distance (L) i.e. I/100th of a hectare will be equal to L/100 in meters.

v. To cover distance L, the drive wheel has to take 'n' turns i.e. = $l/\pi D$.

vi. Allowing 10% slippage of dry wheel in field condition, the distance can be covered in 'N' turns i.e. = (n–0.1 n).

vii. Raise the seed drill so that drive wheel becomes free to be turned. Fill the seed box, set the seed rate adjusting lever and rotate the wheel till seed starts falling on the ground. Put a chalk mark on the drive wheel rim and again rotate the wheel for 'N' turns.

viii. Collect the total seed under the seed-drill and measure its weight. Thus, seed rate per hectare can be calculated. Any change in the seed rate, if required, can be accomplished by adjusting the lever and recalibrating the machine till the desired seed rate is obtained.

ix. Weigh the quantity of seed dropped from each opener and record on the data sheet to know the variation in different rows, if any.

Example, say circumference of the drive wheel = 0.4 m

Width of machine = 1.85 m

As we know area of one hectare=10,000 m^2

Then distance/length (L) to cover one hectare will be = (10,000/1.85)=5405.4 m

The distance (l) i.e. 1/100 of hectare will be = 54.5 m

To cover distance (l), the drive wheel has to take turns (n) = 54.5/0.4=136.25

Allowing 10% slippage, the distance (l) can be covered in 'N' turns (n–0.1n) = 123 (approx.). Put seed and fertilizer in the boxes. Set the rate control adjustment lever as prescribed by the manufacturer. The rest of the procedure will be similar as described above in steps vii-ix.

Calibration of the Seed Drill (in situ)

Step 1:

Measure the width of the seed drill by placing one end of a measuring tape at the middle of the first tyne and the other at the middle of the last tyne and note the width in a notepad. Add 20cm (row-to-row spacing) to the width of the seed drill to arrive at an effective width of the seed drill (or multiply the number of tynes by row spacing to arrive at an effective width of the seed drill).

Step 2:

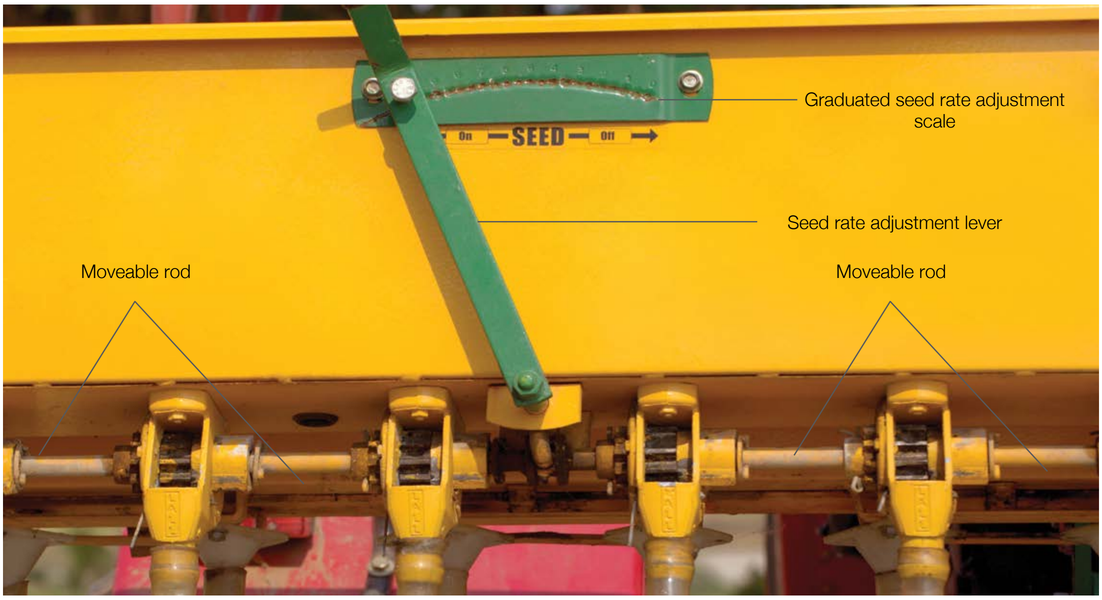
Adjust the seed metering indicator in the appropriate delivery notch. The major changes in the seed rate are achieved by changing the seed rate gear (driven gear).

Step 3:

Take the seed pipes out from the boot of the furrow openers and tie a polybag at the end of each outlet. Before tying up polybags make sure that seed flow has started. This can be attained either by rotating the drive wheel manually, keeping the drill in an up-standing position or by moving the drill to a point 4-5 feet behind the marked starting point.

Step 4:

In the case of the fluted roller type/groove roller type mechanism, fill the seed box at least up to a level that the seed metering system is fully covered with seed while operating it. For the inclined plate metering system fill the seed in each hopper to about 1/3 to 1/2 of the inclined plate to prevent the over-dropping of seeds. The seed rate can also be varied in the inclined plate system by adjusting the inclination of the seed box through grooved blades attached downside (6-8 holes). For example, the seed box adjusted at the third and fourth hole from the downward end of the grooved blade will drop rice seeds at approximately 10 and 8 kg per acre, respectively.



Step 5:

Measure a 20 m distance starting from the front end of either the back or the front set of the furrow opener and mark the point where the same set of furrow touches a 20 m distance.

Step 6:

Run the tractor in a straight line to cover 20 m distance. Drive the tractor slowly (limited to 3-5 km/hr).

Step 7:

Keep checking whether the seed is falling freely in the poly bags or not.

Step 8:

Measure the weight of seed collected in each bag separately and compare. The weight should be similar in all pipes. If not, check the metering system, particularly the tongue (fluted roller), brush (inclined plate) and seed pipes again.

Step 9: Seed rate $\frac{\text{kg}}{(\text{acre})} = \frac{(4000 \times \text{Total weight of seed (g)})}{(\text{Effective width of seed drill (m)} \times 20\text{m} \times 1000)}$

Step 10:

If this seed rate is not equal to the desired seed rate then go to step 2 and change the seed rate setting accordingly and follow the full procedure again until the desired rate is achieved.

Fertilizer Metering Device

The fertilizer metering device (photo: 12) has the following components:

1. Bottom of the fertilizer box with diamond- shaped holes 2. Scale 3. Fertilizer setting lever 4. Plastic / Aluminium cup 5. Agitators (Photo: 13) 6. Fluted roller (Photo: 13) 7. Fertilizer metering shaft (sometimes coated with plastic to avoid rusting, see photo: 14).

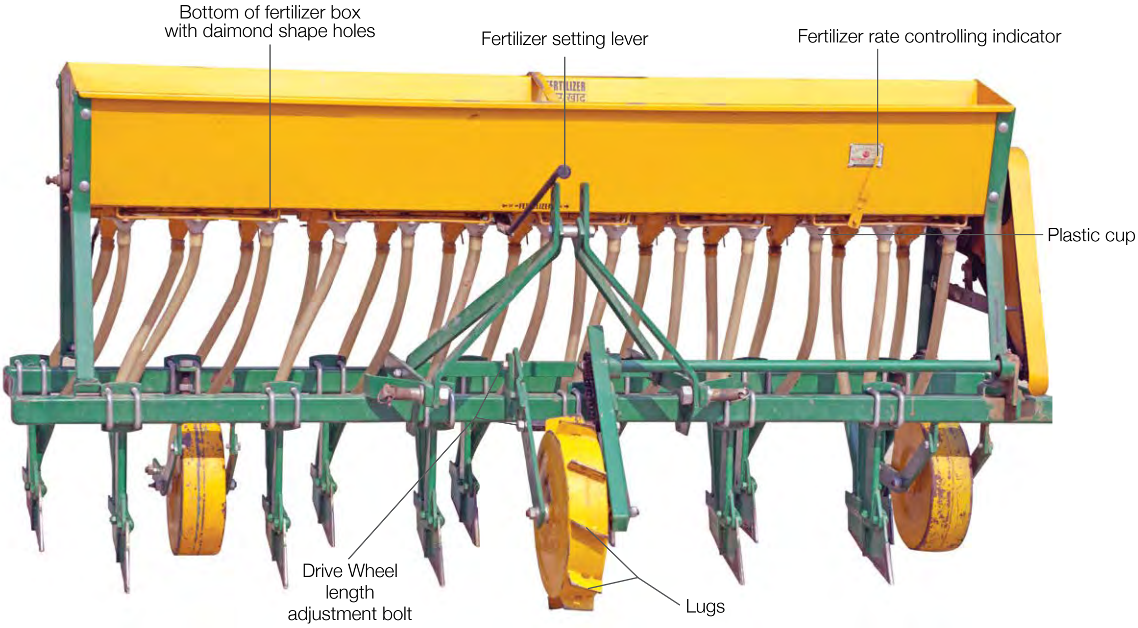


Photo 12: Fertilizer metering device in zero till machine

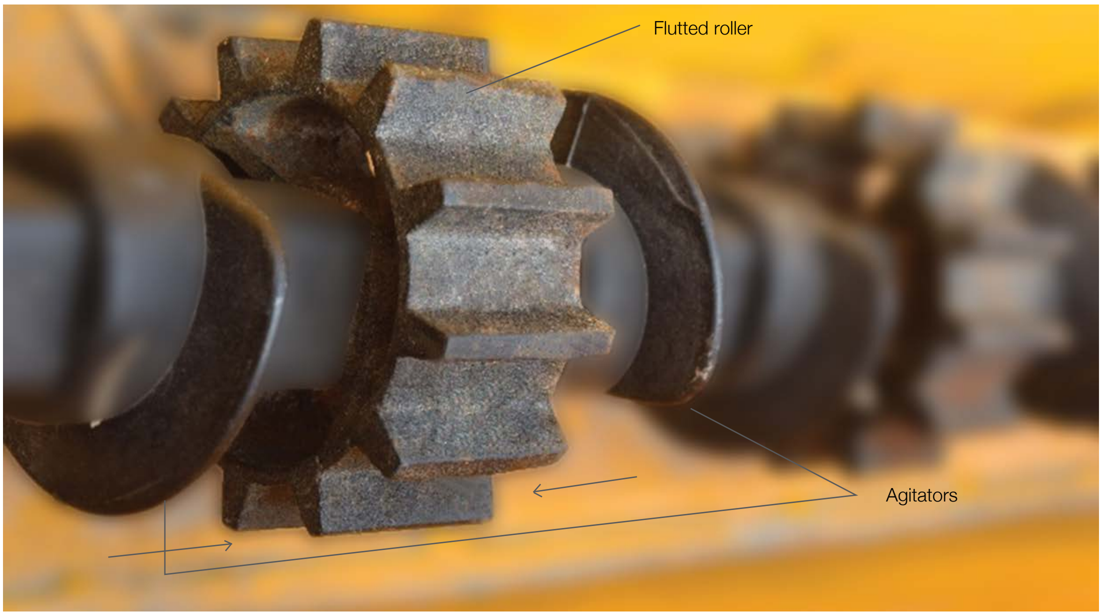
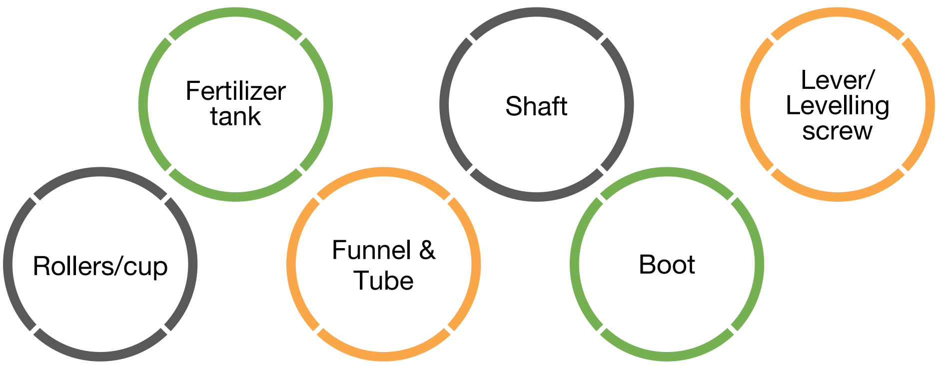


Photo 13: Flutted roller and Agitators

The fertilizer metering device generally used in drills is of hole mesh type (gravity-cum forced feed type) arranged on a shaft (Photo: 12). Sometimes it is called an agitator-type fertilizer metering device. In the bottom of the fertilizer box, diamond-shaped holes are made. The quantity of fertilizer is changed by adjusting the size of these holes. Star-shaped agitators (Photo: 13) are provided to avoid the bridging of fertilizer and to feed fertilizer continuously through the holes. The fertilizer setting handle/ lever (Photo: 12) with scale is provided to adjust the required quantity of fertilizer. The fertilizer passes through the hole, into a funnel, to deliver fertilizer into the slit/furrow opener through boots and pipes.

Rotating-type Fertilizer Metering Device

In other machines, the fertilizer box delivers the material to a cup fitted with rotating cells (Photo: 14). The rotating cells pick up the fertilizer granules (small or large) and deliver them to the fertilizer tubes. This mechanism has the advantage of handling small- or large-sized fertilizer granules such as urea super granules (USG), and places them at desired soil depth. Deep placement of USG in rice culture is known to improve efficiency by 20%. Also there is no free flow of fertilizers on turnings of the tractor at field corners. The rotating cell-type fertilizer metering device (Photo: 14) has the following components:



In the cell-type fertilizer metering device, cells are fitted in separate compartments to allow fertilizer placement as required in each row, or in some selected rows only. Fertilizer can be increased or decreased by lifting or lowering the fertilizer tank, respectively, or by changing the sprocket wheel. Fertilizer is simply metered by a series of cups on a roller and fertilizer level as well. However, calibration of the machine in the laboratory or in situ for setting the required rate of fertilizer can be accomplished with procedure similar to the one mentioned earlier under the heading “Calibration of seed drill (in laboratory)” and “Calibration of seed drill (in situ).”

Seed pouring mechanism

Photo 14: Rotating-type fertilizer metering device

Power Transmission Unit

The power required to operate seed and fertilizer metering devices is provided by a floating-type lugged drive wheel 40 cm in diameter and 10.5 cm in width through a chain and sprockets (Photo:15). However, the size of the drive wheel may vary in different models. Fourteen lugs each of 3 cm height at an angle of 90^0 are provided on the drive wheel to avoid slippage. Wheels are of iron closed-type or with rubber on them for better traction. This ground wheel or drive wheel is mostly attached to the frame in front, it may be also on the backside or inside the machine. Traction can be adjusted through a groove and spring as desired. Attachment of the drive wheel on the front side of the frame sometimes creates a problem in the free movement of the wheel due to soil or stubble blockage or due to its location being very near the hook of the tractor. A motorcycle roller chain of 12.50 mm pitch with 14 or 37 teeth on the mild steel sprocket is provided for power transmission from the drive wheel to the seed and fertilizer metering devices. Power from the ground wheel is transmitted to a shaft (1:1) (Photo:15) mounted on the front of the frame. From this shaft power is transmitted to seed and fertilizer metering shafts (2.5:1) through the chain sprocket arrangement. However, the size of the roller chain and sprocket can vary in different models as per requirements. An idler has been provided to tighten or loosen the chain for its smooth running.

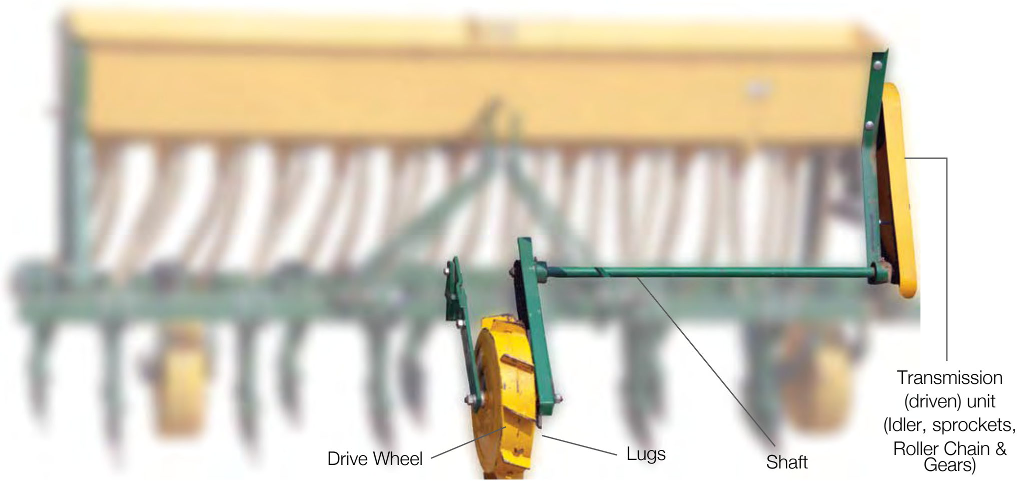


Photo:15 Power transmission unit

Depth-control Wheels

Two wheels (one on either side of the drill), each 40 cm in diameter (Photo:16) and made of mild steel sheet (closed type), or in some models made of rubber, are provided to set the required seeding depth. The size of these wheels may vary in different models. With the help of depth adjusting screws (Photo:16), these wheels can be raised or lowered to increase or decrease the depth of seeding. Seeding depth in the case of wheat varies from 3-5 cm. However, it can be adjusted as per one's requirement. If there is a large amount of loose straw in the field, these depth wheels can jump due to lumps of straw. If this happens, the depth control wheels can be removed and depth control be maintained with the tractors' hydraulics.

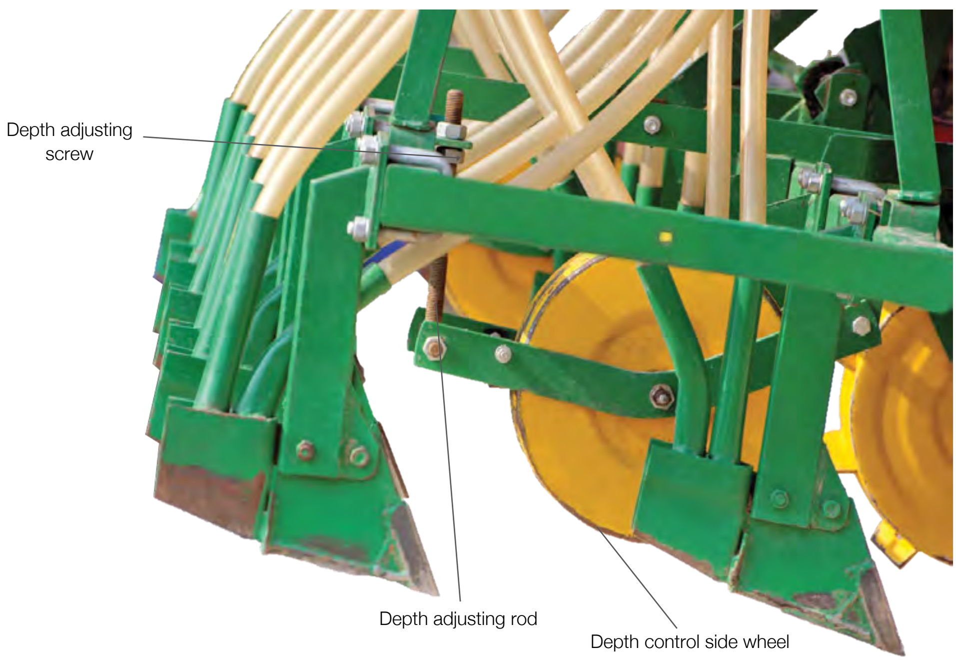


Photo 16: Depth control wheels

Hitch Points

The drill has three standard hitch points; two lower and one upper (Photo17). The machine is attached to tractor through these three hitch points with the help of link pins. The top link hitch point also helps in levelling the machines.

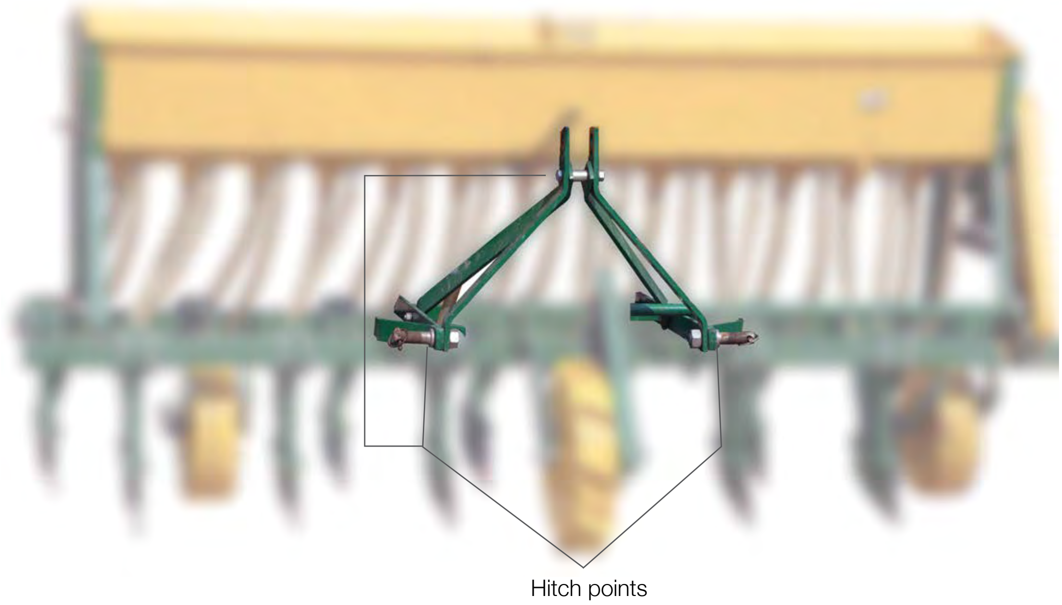


Photo 17: Hitch Points

Iron or Wooden Platform or Stand

An iron or wooden stand or platform is also attached to the rear of the frame. One person can either stand or sit on this platform while the machine is in operation to keep watch that the seed and fertilizer are running properly through the respective plastic tubes without any blockage. This is a precautionary measure and not a requirement, per se. It may be mentioned that this practice enables the sitting person to remove the raked residues as well. Therefore, it is advisable to follow this practice.

Usage and Maintenance of Machine

- Ensure all nuts and bolts are tight.
- Clean seed and fertilizer boxes properly.
- Prevent folds in the plastic pipes for fertilizer and seed.
- After sowing, remove seed and fertilizer from the boxes.
- Do not use Urea and other powder form fertilizer in the fertilizer box.
- Adjust the depth control wheel to achieve the proper seed depth.
- Park machine in the shed to avoid rusting.
- Remove pipes after the sowing season to increase durability.

Zero Tillage Multi-Crop Planters

Multi-crop planters are available for the direct drilling of several crops including wheat, rice, maize, green gram, chickpea, lentil, mustard and barley without any preparatory tillage. Multi-crop planters have precise seed metering systems using inclined rotary plates with variable groove numbers and sizes and its thickness for different seed sizes and spacing for various crops. The same multi-crop planter can be used for planting different crops by simply changing the inclined plates. As in the case of ZT machines, the inverted T-type furrow openers are used in zero tillage multi-crop planters. The cutting portion of furrow openers (point of share) is made of 8 mm thick high carbon bits welded to a mild steel plate. The working front edge of the furrow openers has a piece of carbon steel (hardness 65 RHN) welded all around the nose, tip and sides to reduce wear and tear. This mechanism ultimately decides the operational quality and durability of the planter.

The dimensions of seed and fertilizer boxes can vary depending upon the effective width of the machine and will increase with an increase in the number of furrow openers. For example in the case of the 9-tyne planter, the length of the seed and fertilizer box will be around 160 cm. While the fertilizer box has the same mechanism as the ZT machine, the following components are important in the seed box of multi-crop planters:

1. Seed box: Used to store the seed in the planter.
2. Inclined metering plates: These rotating plates have grooves that guide the seed and drop it into the cups. There is a three-gear system to achieve the desired seed rate. To fine-tune a nearly exact seed rate one needs to correct the inclination of the seed box with the help of bars with holes.

3. Seed rate adjusting strip/Seed-metering strip: An iron bar that has holes in it. By changing the hole, one can change the rate of the seed to be planted in the field. The seed rate is written on the strip with the corresponding holes.

4. Seed Cups: These cups receive seeds dropped by the inclined rotary plates and then dispense the seeds to the seed delivery pipe. These seed cups must be smooth and free from any obstacle from the inside to ensure the unobstructed delivery of the seeds.

5. Seed delivery pipe: It is used to take the seed from the cups to the seed boot.

6. Seed boot: Seed boot finally drops the seed into the slit in the soil opened by the furrow opener. The seed-metering strip is mounted on the seed box. It is attached to the seed box in such a manner that the seed box is tilted when there is an adjustment on the system. It is a strip of iron on which equally spaced holes have been drilled. The holes connect the strip to the seed box with nuts.

Operational Guidelines Under Field Conditions

The seed and fertilizer should be placed at uniform depths and uniform quantities in all of the furrow openers without causing any damage to the seeds. The fertilizer should not come in contact with the seed.

This can be achieved by carrying out the following operational procedure:

- Employ the standard hitching procedure for mounted implements. Reverse the tractor to attach the zero-till machine. Attach both links by adjusting the length of the right and left arm, the top link and stabilizer chain after centering the equipment.
- After the equipment is hitched to the tractor make the preliminary adjustment and carry out daily maintenance.
- Now fill the seed and fertilizer boxes to 3/4 of its capacity, calibrate/set the machine for the required seed and fertilizer rates and ensure that the seed and fertilizer are clod free.
- Lift the machine and rotate the drive wheel to ensure that the seed and fertilizer are falling freely from the metering device to the seed tube into the furrow opener.
- Take the machine to the field; select the point from where the operation will be started. As the tractor enters the field, lower the machine using the position control lever.
- Check that the drive wheel touches the ground fully; if not, lengthen the top link. However, during this process, the levelling of machine should not get disturbed. Continue driving the tractor for about 10 meters and stop again. Check the drop of seed and fertilizers. Also check the penetration of furrow openers. If the desired depth has not been achieved adjust the position control lever of tractor hydraulic or machine depth-setting wheels until the desired depth of planting is obtained. Repeat the above sequence of operations at the other end of the field to assure highest efficiency or output from the machine.

PART II
Service Provision as a Business Opportunity

SESSION V

Introducing Concepts - Fixed and Variable Cost Components and Their Calculation

By the end of this Session, Participants should be able to:

- Understand the basic business concepts underlying custom-hire services for zero tillage.
- Do simple profitability calculations in order to plan the ZT service business and evaluate its performance.
- Understand the importance of keeping business records as a basis for profitability calculations and learn what kind of information is needed.

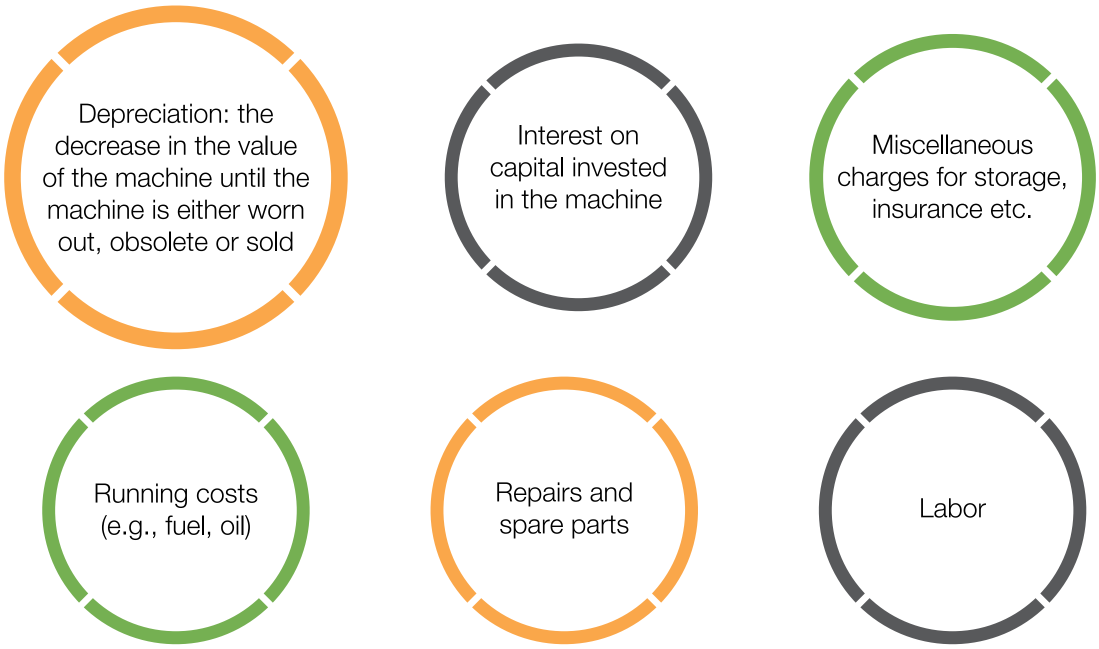
Basic Business Concepts

The main purpose of a business is to make a profit. Profit is the difference between the revenue received from the custom-hire services offered and the costs incurred by operating the machines. Costs fall into two categories: fixed and variable. The attainable revenue depends on the amount of work that can feasibly be undertaken in the time window available and the charge rates that can be sustained. In this session, different components that need to be considered when calculating the profit of a (ZT) hire service business are explained, followed by a practical example with variations.

Fixed and Variable Costs

Mechanized custom-hire services have two basic types of costs: fixed and variable. Fixed costs do not change. No matter how many customers and/or acres are being serviced, the fixed costs remain largely the same. Variable costs change (vary) with the volume of services offered, such as fuel and oil as well as labor for operating the machine. If more service is provided, the variable costs increase. If less is provided, variable costs decrease.

To calculate machine operating costs, consider the following factors:



As mentioned before, these costs can be divided into fixed and variable costs.

Fixed Costs

When machinery is bought it is a capital investment. Often, money has to be borrowed to finance the investment, and interest will likely have to be paid on the loan. Even if the owner finances the machinery from his own savings, interest will still need to be included in the profitability calculation. This will be discussed in more detail in Session VII: 'Opportunity cost,' below. Any shelter or storage that the machinery needs is also included in this category. Interest on capital, charges for machine storage and insurance are also largely independent of the amount of annual use. Because these costs are unavoidable and do not vary with the amount of usage, they are called fixed costs. Each of these major items is elaborated below:

Depreciation

The custom-hire service business involves money invested in machinery and as such the value of the investment will decline to a re-sale or scrap value at the end of its useful life. This reduction in value is known as depreciation and is represented by an annual value.

Depreciation is most simply calculated by subtracting the resale or scrap value from the purchase price of the machine and dividing the result by the number of years of useful life:

$$\text{Annual depreciation (Rs.)} = \frac{\text{Purchase price (Rs.)} - \text{Scrap value (Rs.)}}{\text{Useful life (years)}}$$

Interest

Interest on capital is another fixed cost item. Whether the investor uses savings or borrows money to procure a machine, there is a cost known as the interest rate. Of course if a businessperson uses his own savings there will be no need to pay the interest on a loan. But on the other hand neither can he invest that money in another way that will earn him interest. So in both cases there is a cost, although in the second case it is a lost opportunity and so is called an opportunity cost. The money used to invest could obtain a return if invested in the bank (see Session VII: ‘Opportunity cost’).

Usually the interest rate (i) used in an annual cost calculation for machinery is the rate that would have been charged if a loan had been given. This rate will vary by locality. Although many business people may obtain loans at rates lower than the normal commercial rates, the commercial loan rate is usually used to estimate interest charges.

Interest charges are made on the average capital investment. Calculation of the annual charge assumes that the average annual capital investment is half the sum of the purchase value plus the scrap value, multiplied by i:

$$\text{Annual interest charge (Rs.)} = \frac{\text{Purchase price (Rs.)} + \text{Scrap value (Rs.)}}{2} \times i$$

To illustrate this with an example, if you purchased a machine for Rs. 50,000, which had a scrap value of Rs. 10,000 at the end of its useful life, the ‘average’ capital invested in the machine would be Rs. 30,000. If you deposited this Rs. 30,000 in a bank account you would earn interest, but since the money is invested in the machine, there is an opportunity cost. In the calculation, it is important that the interest rate in percent is divided by 100, i.e., it is written as a decimal fraction, for instance: 10% = 10/100 = 0.10. In the example, the opportunity cost of the capital invested in the machine would be accounted for by an annual charge of 30,000 Rs. × 0.10 = Rs. 3,000.

Other Fixed Costs

There may be some other fixed costs associated with machinery use that will need to be investigated and quantified for specific circumstances. For instance, items can include insurance against theft or loss, or shelter for the machine when not in use.

Variable Costs

Variable costs are those costs that change with the volume of services provided. Variable costs increase as the service business expands to serve more customers and the number of hours of operation or acres covered increase. Variable costs include fuel, lubricants, labor of machine operators, replacement of worn-out parts and routine repairs and maintenance. These costs vary with the amount of use of the machinery.

Fuel

The calculation of fuel costs is straightforward. You probably have a good idea of how much fuel your tractor consumes for different activities. For ZT services using a 35 – 40 hp tractor, a fuel consumption of 4 liters per acre is a reasonable estimate. This figure would be multiplied by the cost of fuel per liter to get the total fuel cost per acre.

Maintenance and Repairs

Agricultural machinery maintenance and repair costs fluctuate considerably from machine to machine because of different working conditions, operators' skill level, care for regular servicing and quality of the make and model. The cost of maintenance and repair also varies according to the life of the machine. Repair costs increase with usage and age of the machine. Maintenance costs are related to regular servicing, including, for instance, engine oil changes, lubrication of other moving parts and replacement of filters, tyres and brake pads.

A simple method of assessing average annual repair and maintenance costs is to estimate them as a percentage of the initial cost of the machine divided by the useful life of the machine; e.g., the annual repair cost of a ZT drill can be estimated as:

$$\text{Annual repair cost ZT drill (Rs.)} = \frac{\text{Purchase price (Rs.)} \times \text{Estimated repair cost share (\%)}}{\text{Useful life (years)} \times 100}$$

In addition to the repair of the ZT drill, repair costs of the tractor also have to be accounted for. For a tractor and ZT drill that are used with average intensity, it is reasonable to assume that 25% of their initial value will be spent on maintenance and repair across their entire useful life. However, a tractor is used for multiple purposes, not only for ZT service provision; in order to estimate the repair costs that can be attributed to ZT service provision, we multiply total annual repair costs by the time share that the tractor is used for ZT services:

$$\text{Annual ZT related repair cost tractor (Rs.)} = \frac{\text{Purchase price (Rs.)} \times \text{Estimated repair cost share (\%)}}{\text{Useful life (years)} \times 100} \times \frac{\text{Time share tractor is used for ZT services (\%)}}{100}$$

For example, let's assume that a tractor is used for a total of 1,000 hours per year. Among many other activities, it is used for ZT service provision on 80 acres and, on average, it takes 75 minutes (= 1.25 hours) to service one acre. Then, the total time taken for ZT service provision is 100 hours (80 acres * 1.25 hours/acre), which is 10% of the total tractor operating time. Therefore the annual repair costs of the tractor would have to be multiplied by 0.10 (= 10%/100) to estimate that part of the repair costs that should be attributed to ZT service provision. As a general formula, this calculation can be written as follows:

$$\text{Time share tractor is used for ZT services (\%)} = \frac{\text{Acres serviced per day} \times \text{Days of service provision} \times \text{Service time per acre (hours)}}{\text{Total time of tractor use per year (hours)}} \times 100$$

Labor

Labor is needed to operate the tractor and ZT drill, and the rate can vary depending on demand and the operator's experience and skills. Importantly, similar to the interest on capital calculation above, labor costs need to be included in the profitability calculation even if you operate the machinery yourself. The reason is that opportunity costs are again incurred because you cannot do anything else at the same time that would earn you some income (see Session VII: 'Opportunity cost').

Setting the Hire Charge for the Service

How much will farmers be prepared to pay for your service? Setting hire charges at the right level is very important. If the price charged is too high, demand for the service may drop. It may also be that someone else is able to provide the service at a lower cost. If the price charged is too low, it may mean that not enough money is made from the business to cover the costs. While the price will depend on what people are willing to pay, as a businessperson you will have to check that it at least covers all the costs. Check the costs carefully, both fixed and variable, to see whether it is possible to reduce any of them. Cutting costs must not result in a lower quality of service. If this happens, fewer people would want to receive the service in the next season. The charge rate needs to be correctly estimated to start with, but may have to be revised as you gain more experience and information under your local conditions.

Expected income can easily be overestimated when planning the business. It is important to be realistic and not too optimistic about the volume of expected business. Volume is likely to grow over time as the business matures. When the business starts up, a benchmark figure for charge rates will be those which other service providers close to your locality are charging, as it will be difficult to break into a market by offering services at a higher rate. Some flexibility in hire rates can/should be allowed, as shown in Table 1.

Table 1. Some factors that can affect hire rates for custom mechanization services

Lower rates may result from:	Higher rates may be needed because:
• Informal arrangements between family members and friends	• High draught work demanding more fuel and time
• Close proximity of the customer to the business location	• Poor conditions in the field, such as: rocks, tree stumps, steep slopes, irregular shape
• The operator's wish to keep the equipment in work and recover at least part of the fixed costs (plus variable costs)	• Small jobs in conditions of low field efficiency
• The use of older equipment which may be fully depreciated	• Use of novel machinery giving a superior end result
• Discounts for customers demanding large amounts of work	• Use of highly skilled operators providing improved customer satisfaction

Revenue, Gross Margin and Net Profit

Multiplying the hire charge per acre by the number of acres serviced equals the revenue of the service business. Deducting all variable costs (but not fixed costs) results in the gross margin. The gross margin should cover all of the fixed costs; any remainder is the net profit that the businessperson makes. If the gross margin is just large enough to cover the fixed costs, but the net profit is zero, the business breaks even.

Hire charge per acre × number of acres serviced =	Revenue
minus	Variable costs
=	Gross margin
minus	Fixed costs
=	Net profit

If the gross margin is negative, it means that the revenue does not even cover the variable costs, and the businessperson loses money with every acre serviced. Such a business should be stopped immediately! If the gross margin is positive, but net profit is negative, it means that the business contributes to recovering the fixed costs, but does not generate a profit. Such a business is not profitable and therefore does not make sense economically.

However, a farmer may decide to invest in a ZT drill (or any other machine) mainly for use on his own farm. Cost savings in his own cultivation and a possible yield benefit will ultimately recover the initial investment cost and therefore make the purchase of the ZT drill worthwhile. This cost recovery can be accelerated by providing ZT services on a small scale (e.g., by servicing some friends or relatives only). As long as the gross margin of this small-scale service provision is positive, some contribution will be made to recovering the investment in the ZT drill. This makes economic sense, even if the ZT services alone are not enough to generate a net profit, but the investment becomes profitable by using the machine on one's own farm as well.

The purpose of this training, however, is to look at ZT service provision as a self-sustaining business opportunity, one that generates a profit on its own, irrespective of whether the machine is used on the service provider's own farm. Our goal is therefore not only to attain a positive gross margin, but a positive net profit!

SESSION VI

Profitability Calculations - Scenario Analysis

Example Calculations

We will now apply the concepts introduced in session 5 in an example profit calculation for ZT services. Using the information provided in Table 2 (given below), we will go through an initial scenario ('base scenario') in detail and then see how profitability changes if we modify the base scenario. In particular, we will explore the effects of expanding the area serviced and of receiving a subsidy on the purchase price of the ZT drill.

Table 2: Example values for profit calculation - Base scenario

Basic ZT service data		
1	Number of acres serviced per day	3
2	Number of days of service provision per year	25
3	Service fee charged per acre (Rs.)	800
4	Time taken to service one acre, incl. average travel time to reach field (hours)	1.50
Fuel and labor		
5	Fuel consumption per acre (liters)	4
6	Fuel cost per liter (Rs.)	58
7	Wage rate per day (Rs.)	300
Tractor data		
8	Purchase price tractor (Rs.)	550,000
9	Scrap/resale value tractor (Rs.)	150,000
10	Repair and maintenance cost tractor (%)*	40
11	Useful life of tractor (years)	10
12	Use of tractor per year (hours)	1,000
ZT drill data		
13	Purchase price ZT drill (Rs.)	55,000
14	Scrap value ZT drill (Rs.)	4,000
15	Repair and maintenance cost ZT drill (%)*	25
16	Useful life of ZT drill (years)	5
17	Subsidy on ZT drill (Rs.)	0
Interest rate		
18	Interest on capital (%)	10

*Percent of purchase price over the entire life of the machine

Auxiliary Calculations

To make the following profit calculation very clear and straightforward, we will first calculate two values that we will plug into our profit calculation later on. These values are shown in Italics.

1. Number of acres serviced per year = 3 acres/day x 25 days = 75 acres.
2. Proportionate use of tractor for ZT services = (75 acres/year x 1.5 hours/acre) / 1000 hours/year = 0.1125 (= 11.25%).

Profit calculation (on a yearly basis)		
Total revenue (Rs.)	**60,000**	**= 75 acres x Rs. 800/acre**
Variable costs (Rs.)		
Fuel	17,400	= 75 acres x 4 liters/acre x Rs. 58/liter
Hired labor	7,500	= 25 days x Rs. 300/day
Repair & maintenance ZT drill	2,750	= Rs. 55,000 x 0.25 / 5 years
Repair & maintenance tractor	2,475	= (Rs. 550,000 x 0.40 / 10 years) x 0.1125
Total variable costs (Rs.)	**30,125**	
Gross margin (Rs./acre)	**398**	**= (Rs. 60,000 – Rs. 30,125) / 75 acres**
Fixed costs (Rs.)		
Depreciation ZT drill	10,200	= (Rs. 55,000 – Rs. 4,000) / 5 years
Interest on capital ZT drill	2,950	= ((Rs. 55,000 + Rs. 4,000) / 2) x 0.10
Prop. depreciation tractor	4,500	= ((Rs. 550,000 – Rs. 150,000) / 10 years) x 0.1125
Prop. interest on capital tractor[1]	3,938	= ((Rs. 550,000 + Rs. 150,000) / 2) x 0.10 x 0.1125
Total fixed costs (Rs.)	**21,588**	
Net profit (Rs.)	8,288	= Rs. 60,000 – Rs. 30, 125 – Rs. 21,588
Net profit per acre (Rs./acre)	111	= Rs. 8,288 / 75 acres
Net profit per day (Rs./day)	332	= Rs. 8,288 / 25 days
Break-even area for this scenario (acres)	54	= Rs. 21,588 / Rs. 398/acre

[1]While the depreciation of the tractor and related interest on capital are fixed costs, the share that can be attributed to ZT service provision is proportionate to its use for this activity.

Interpretation: The first important value to check in the above calculation is the gross margin, which is usually shown on a per-acre or per-hectare basis. We can see that it is positive (398 Rs./acre), meaning that all the variable costs and at least part of the fixed costs are covered. Next, we check the net profit, which amounts to 8,288 Rs. This indicates that ZT service provision in this scenario is a profitable business (even if the ZT drill was not used on the service provider's own farm), as both variable and fixed costs are fully covered and some profit is generated. By dividing total net profit by the number of acres serviced, we see that per acre, a net profit of 111 Rs. is attained. Likewise, we may want to know how much the service provider earns per day of ZT service provision, which is 332 Rs. Whether ZT service provision is an attractive business under this scenario depends on how much the service provider could earn from alternative activities during the same time of year (see Section 3 'Opportunity cost'). Net profit per day may be the most suitable measure to compare the profitability of alternative activities. Finally, the break-even area indicates that, in this scenario, 54 acres need to be serviced for the gross margin to fully cover the fixed costs. i.e., from the 55th acre onward, profit is generated.

Variant 1

Description: Same as base scenario, but the farmer receives a subsidy of Rs. 30,000 on the purchase price of the ZT drill; referring back to Table 2, this change concerns item no. 17:

Subsidy on ZT drill (Rs.)	30000

The resulting profitability values are as follows (variable costs not shown; they remain the same as in the Base scenario):

Gross margin (Rs./acre)	**398**

Fixed costs (Rs.)	
Depreciation ZT drill	4,200
Interest on capital ZT drill	1,450
Prop. depreciation tractor	4,500
Prop. interest on capital tractor	3,938
Total fixed costs (Rs.)	14,088
Net profit (Rs.)	15,788
Net profit per acre (Rs./acre)	211
Net profit per day (Rs./day)	632
Break-even area for this scenario (acres)	35

Interpretation: The subsidy decreases the fixed costs associated with the ZT drill and therefore increases net profit substantially to Rs. 15,788 overall and Rs. 632 per day.

Variant 2

Description: Same as Base scenario, but the farmer services 4 acres per day instead of 3 (item no. 1 in Table 2; we reset the ZT drill subsidy to 0 for this variant):

Number of acres serviced per day	4

The resulting profitability values are as follows:

Total revenue (Rs.)	**80,000**
Variable costs (Rs.)	
Fuel	23,200
Hired labor	7,500
Repair & maintenance ZT drill	2,750
Repair & maintenance tractor	3,300
Total variable costs (Rs.)	**36,750**
Gross margin (Rs./acre)	**433**
Fixed costs (Rs.)	
Depreciation ZT drill	10,200
Interest on capital ZT drill	2,950
Prop. depreciation tractor	6,000
Prop. interest on capital tractor	5,250
Total fixed costs (Rs.)	**24,400**
Net profit (Rs.)	18,850
Net profit per acre (Rs./acre)	189
Net profit per day (Rs./day)	754
Break-even area for this scenario (acres)	**56**

Interpretation: The change from 3 to 4 acres per day (i.e., from 75 to 100 acres serviced in total) affects both the variable and the fixed costs. The fixed costs attributed to ZT service provision increase because the time-share for which the tractor is used for this activity increases from 11.25% to 15.0%.

Despite the absolute increase in fixed costs, they are now distributed across a larger number of acres, leading to a decrease in fixed costs per acre; therefore, the net profit per acre increases by 70% from Rs. 111 to Rs. 189, and the net profit per day increases even more (by 127%) from Rs. 332 to Rs. 754, leading to a total net profit of Rs. 18,850 rather than Rs. 8,288 in the scenario.

Note that the one-third increase in area serviced (from 3 to 4 acres per day) leads to a more than proportionate increase in profitability: total profit increased by 127%, and even the profit per acre increased by 70%!

Note also that the area increase in this variant enhances total net profit much more than the Rs. 30,000 purchase subsidy on the ZT drill presented in Variant 1 (Rs. 18,850 versus Rs. 15,788).

Variant 3

Description: Same as base scenario, but the farmer manages to service 5 acres per day instead of 3; because of the longer working hours, he increases the wage of the tractor operator from Rs. 300 per day to Rs. 350 per day; because the area serviced increases substantially from 75 acres in the base scenario to 125 acres in Variant 3, the maintenance and repair costs of the ZT drill are likely to increase: we change this cost from 25% of the purchase price (across the entire life of the machine) to 35%:

Number of acres serviced per day	**5**
Wage rate per day (Rs.)	**350**
Repair and maintenance cost ZT drill (%)	**35**

The resulting profitability values are as follows:

Total revenue (Rs.)	**100,000**
Variable costs (Rs.)	
Fuel	29,000
Hired labor	8,750
Repair & maintenance ZT drill	3,850
Repair & maintenance tractor	4,125
Total variable costs (Rs.)	**45,725**
Gross margin (Rs./acre)	**434**
Fixed costs (Rs.)	
Depreciation ZT drill	10,200
Interest on capital ZT drill	2,950
Prop. depreciation tractor	7,500
Prop. interest on capital tractor	6,563
Total fixed costs (Rs.)	**27,213**
Net profit (Rs.)	**27,063**
Net profit per acre (Rs./acre)	**217**
Net profit per day (Rs./day)	**1,083**
Break-even area for this scenario (acres)	**63**

Interpretation: The net profit per acre increases by 15% (from Rs. 189 to Rs. 217) compared to Variant 2; more importantly, by servicing an extra acre per day, net profit per day increases substantially by another 44% from Rs. 754 to Rs. 1,083 despite the higher wage paid and the higher repair and maintenance cost of the ZT drill.

Variant 4

Description: Same as Variant 3, but the farmer is able to provide ZT services on an extra 5 days per year:

Number of days of service provision per year	30

The resulting profitability values are as follows:

Total revenue (Rs.)	**120,000**
Variable costs (Rs.)	
Fuel	34,800
Hired labor	10,500
Repair & maintenance ZT drill	3,850
Repair & maintenance tractor	4,950
Total variable costs (Rs.)	**54,100**
Gross margin (Rs./acre)	**439**
Fixed costs (Rs.)	
Depreciation ZT drill	10,200
Interest on capital ZT drill	2,950
Prop. depreciation tractor	9,000
Prop. interest on capital tractor	7,875
Total fixed costs (Rs.)	**30,025**
Net profit (Rs.)	**35,875**
Net profit per acre (Rs./acre)	**239**
Net profit per day (Rs./day)	**1,196**
Break-even area for this scenario (acres)	**68**

Interpretation: With this additional expansion of the area serviced, the fixed costs per acre are further reduced compared to Variant 3. This leads to an increase in the net profit per acre (Rs. 239 instead of Rs. 217) and an increase in net profit per day (Rs. 1,196 instead of Rs. 1,083).

Variant 5

Description: Same as Variant 4, but the farmer receives a subsidy of Rs. 30,000 on the purchase price of the ZT drill; including the subsidy is realistic under the current policy conditions:

Subsidy on ZT drill (Rs.)	30,000

The resulting profitability values are as follows (variable costs not shown; they remain the same as in Variant 4):

Gross margin (Rs./acre)	**439**
Fixed costs (Rs.)	
Depreciation ZT drill	4,200
Interest on capital ZT drill	1,450
Prop. depreciation tractor	9,000
Prop. interest on capital tractor	7,875
Total fixed costs (Rs.)	**22,525**
Net profit (Rs.)	**43,375**
Net profit per acre (Rs./acre)	**289**
Net profit per day (Rs./day)	**1,446**
Break-even area for this scenario (acres)	**51**

Interpretation: Compared to Variant 4, the subsidy on the ZT drill lowers the associated fixed costs and therefore enhances profitability further to Rs. 289 per acre and Rs. 1,446 per day.

Variant 6

Description: Same as Variant 5, but the farmer services six acres per day, which can be viewed as the maximum which can be achieved under ‘average’ conditions; we assume that an additional bonus of Rs. 50 per day is paid to the tractor operator to compensate for the long working hours, bringing his wage up to Rs. 400 per day; furthermore, due to the intensive use of the ZT drill, we assume that its useful life is reduced from five to four years:

Number of acres serviced per day	6
Wage rate per day (Rs.)	400
Useful life of ZT drill (years)	4

The resulting profitability values are as follows:

Total revenue (Rs.)	**144,000**
Variable costs (Rs.)	
Fuel	41,760
Hired labor	12,000
Repair & maintenance ZT drill	4,813
Repair & maintenance tractor	5,940
Total variable costs (Rs.)	**64,513**
Gross margin (Rs./acre)	**442**
Fixed costs (Rs.)	
Depreciation ZT drill	5,250
Interest on capital ZT drill	1,450
Prop. depreciation tractor	10,800
Prop. interest on capital tractor	9,450
Total fixed costs (Rs.)	**26,950**
Net profit (Rs.)	**52,538**
Net profit per acre (Rs./acre)	**292**
Net profit per day (Rs./day)	**1,751**
Break-even area for this scenario (acres)	**61**

Interpretation: In this 'maximum scenario', the net profit per acre increases to Rs. 292/acre, and total net profit amounts to approximately Rs. 52,500.

Lessons from the Example Calculations

The first important point to make is that the gross margin per acre is very similar across all the presented scenarios, ranging from Rs. 398 in the base scenario and Variant 1 to Rs. 442 in Variant 6. However, the gross margin must not be mistaken for the profit made per acre since it does not account for the fixed costs.

Only when we include the fixed costs in our calculations do we get a realistic picture of how much we really 'earn' from a business – and that's when the differences between the presented variants become apparent.

The provision of ZT services becomes more and more profitable – not only overall, but also per acre - the larger the area serviced. This is called 'economies of scale' in economics and is due to the fixed costs being spread across a larger number of acres. Even paying a higher wage to a tractor operator and spending more on maintenance and repair of the ZT drill (see Variant 3) will be worthwhile if it enables you to increase the area you service. The subsidy on the ZT drill adds to the profitability, but even if the subsidy were reduced or removed in the future, purchasing a ZT drill with the main purpose of providing custom-hire services can be an attractive investment. The attractiveness of the investment is relative, depending on the profitability of potential alternative income-earning activities that could be undertaken during the same period of time (see below).

SESSION VII

Introducing Concepts - Opportunity Cost, Risk & Competition

Opportunity Cost

Another cost that is often overlooked but is important in economics is opportunity cost. Because resources (land, labor and capital) are limited, when a decision is made to use them for one activity, they are not available for an alternative activity. As a simple example, if a farmer decides to grow wheat during rabi season, he cannot grow maize on the same plot at the same time. Therefore, the net profit that the farmer could have made by growing maize is an opportunity cost of growing wheat – just as well as the net profit that the farmer could have made by growing wheat is an opportunity cost of growing maize.

Opportunity costs of labor – the time spent on one activity rather than another – are specific to each person because their 'opportunities' depend on their skills, qualification and location. Especially for farmers, opportunity costs also vary across the year, depending on the stage of the cropping season: at times when you need control the weeds in your crop, your opportunity cost of doing something else (e.g., helping a friend to repair his house) would be quite high, because you are likely to suffer a yield loss if you don't control weeds at the right time (a loss in yield equals a cost). But once you have done the weeding on your own farm and there is nothing pressing to do, your opportunity cost of helping your friend would be much lower.

Similarly, if a farmer decides to provide ZT services at the beginning of the rabi season, he cannot use his tractor (and his time, if he does not hire an operator to do the service provision) for alternative uses at the same time. Therefore, in order to judge whether ZT service provision is an attractive business for the farmer, he needs to evaluate the profitability of ZT service provision against alternative uses of the same resources at the same time, i.e. the tractor, operator time and the capital invested in the ZT drill.

However, ZT service providers usually use the ZT drill on their own farm –they possess a tractor anyway for their own farm operations. Therefore, the capital is invested in the machinery irrespective of whether they provide custom-hire services. Under these conditions, providing ZT services allows the farmer to use his machinery more productively, leading to a quicker recovery of the capital invested. Conversely, if no ZT services are provided, the ZT drill would just sit idle once the farmer has completed his own sowing. The opportunity costs of providing ZT services are particularly low if the farmer has limited options of using his tractor for other income-earning activities at the beginning of the rabi season (apart from the operations on his own farm).

Risk

In any business, risks can affect both the expected revenue and the level of expenses. As a result, profits are always uncertain to some extent. In the case of ZT service provision, risks are very low since service providers have made the largest part of the capital investment – the purchase of a tractor - for their own farm purposes. The capital investment in the ZT drill is relatively moderate, and even lower under the current subsidy policy; therefore, even if a farmer invested in a ZT drill for the sole purpose of providing ZT services, and the demand for his services dropped, the potential loss for the service provider would be limited. Usually, however, the service provider uses the ZT drill on his own farm too, and ZT is a risk reducing practice as it reduces costs and saves time as compared to tilling the soil before sowing. The time saving means that wheat can be sown earlier than with soil tillage, and it therefore reduces the risk of the crop being affected by heat stress (see Part I). When the farmer benefits from investing in the ZT drill on his own farm, there is no risk involved in engaging in ZT service provision (as long as the gross margin is positive, as explained above). On the contrary: since farming is inherently a risky business, engaging in ZT service provision is a risk reducing strategy that can be used to compensate for potential losses in the service provider's own farm operation. Thus, a farmer's investment in a ZT drill contributes to reducing the risk involved in his own farm operation, and engaging in ZT service provision reduces the risk further by providing a stream of income that is independent of the service provider's own farm.

Competition

Competition is an important part of your business environment, potentially affecting the demand for your services. However, as explained above, the risk of losing money is very low in ZT service provision (even if the demand for your services decreases due to increasing competition (See Photo 18), as long as the service charge covers all variable costs), and it is non-existent if you use the ZT drill on your own farm. However, as a business person, you want to make full use of the opportunity to earn extra money from providing custom-hire services, and competitive advantage is what keeps your business model strong over time and competitors at a distance. In order to have a solid and durable business model you must always work on having some form of meaningful competitive advantage. Competitive advantage is the sum of all the aspects of your business model that make the services you offer more attractive to your customers than the services that your competitors offer.

Photo 18: Showing the competition between service providers

You need to understand your competition, and this should be part of your marketing strategy. By understanding the strengths of your competitors you can learn to improve your business. For instance, what discounts do they give and receive? What services do they offer their customers (including beyond ZT)? What gaps are there in the services that are presently available to farmers in your area (see Section 4)?

New competitors can enter the market at any time. How can you gather 'competitive intelligence,' which is not easy to come by? Here are some hints:

- Ask your customers; they are your eyes and ears. Don't only ask them about your competitors, ask your customers to evaluate the services you offer; how content they are with the quality, timeliness and rate charged. What suggestions do they have for you to improve your services?
- Visit the customers of your competitors. Find out their perceptions of and preferences for the services they receive.
- Talk directly with service providers outside your area of operation, since they are no direct competitors, they may not see you as a threat and may give you information and advice.
- Network with friends and family members to kick-start your business; once their friends and neighbors see the result of your services, they may be interested in becoming your customers as well.
- Make sure your machines (both tractor & drill) are in good working condition well before sowing season. Also, ensure that the operator is properly trained, equipped and committed.
- Keep your eyes on early vacating/fallow plots in your locality and stay in touch with concerned farmers to begin the operation well in advance. An early demonstration of your service would attract the attention of other farmers. Better select initial sites that are either easily accessible or frequently visited by the community.
- Knowledge of basic wheat agronomy under ZT might give you an edge over your competitors. Try to set a dialogue around potential gains of ZT with basics like planting time, varieties and irrigation. Go beyond providing the mechanical service.

SESSION VIII

Expanding The Business Portfolio

Once you become engaged in providing custom-hire services for ZT, you may become interested in providing other kinds of agricultural services as well. While details of additional potential services are beyond the scope of this training course, Table 3 below lists potential services that can be provided at different times of the year. Expanding your service portfolio may enhance your competitive advantage as you may serve as a 'one-stop-shop' for your customers. Depending on the nature of the business opportunity, expanding your service portfolio can also serve to reduce risk further by diversifying your income sources, especially during those times of the year when your opportunity costs are low (see Section 3 for details on the concepts in Italics).

Table 3. Opportunities for service provision during the year

Months	Potential services (required machinery in brackets)
January	Paddy threshing (using axial flow thresher), herbicide spraying in wheat, rice shelling (using tractor-operated sheller)
February	Paddy threshing, maize planting (using multi-crop planter), land levelling (using laser land leveller), rice shelling
March	Zero tillage sowing of green gram, maize planting, rice shelling, land levelling
April	Wheat harvesting (using reaper-cum-binder ,), straw collection (using straw reaper after combine-harvesting), wheat threshing (using axial flow thresher), land levelling
May	Land levelling, zero tillage sowing of rice (direct-seeded rice (DSR)), preparing mat-type nursery & sale of rice seedlings, herbicide spraying in DSR
June	Zero tillage sowing of rice, land levelling, preparing mat-type nursery & sale of rice seedlings, rice transplanting (using mechanical transplanter), maize planting, herbicide spraying in DSR & sale of herbicides
July	Rice transplanting, maize planting, herbicide spraying in paddy & maize, sale of herbicides
August	Rice transplanting, herbicide spraying in paddy & maize, sale of herbicides
September	Pesticide spraying in paddy & maize
October	Zero tillage sowing of mustard, land levelling, sale of wheat seed, paddy threshing
November	Zero tillage sowing of wheat & mustard, sale of wheat seed, maize planting, herbicide spraying in wheat, sale of herbicides, paddy threshing, rice shelling
December	Zero tillage sowing of wheat, sale of wheat seed, herbicide spraying in wheat and maize, sale of herbicides, rice shelling

SESSION IX
Recordkeeping

Records are a critical part of a successful and profitable business. Without records, businesspeople cannot evaluate, diagnose or properly plan their business. Records do not have to be sophisticated or complex, but they do have to systematically record some key pieces of information.

How can Records Improve Your Business?

1. **Records show you how your business is performing.**

   Your records help you identify problems before it is too late. Use your records to find out if something is wrong, if costs are too high, if customer numbers are falling, etc.

2. **Records help you plan for the future.**

   Records show how well your business did in the past and how well it is doing now. When you know your strengths and weaknesses, you can properly plan for the future.

   Table 4 is a template that can be used to record the information necessary to calculate the total revenue and fuel and labor costs of service provision, on a daily basis. By aggregating the information across all days with ZT service provision in a given year, the values of items 1 through 7 listed in Table 2 (session 6) can be calculated for your business based on Records A and B in Table 4. This information needs to be supplemented with data on the fixed costs associated with ZT service provision, as listed in items 8 through 18 in Table 2 (refer to page 46). You can then perform a profitability calculation for your own ZT service business, as outlined in session 6.

   As there are opportunity costs of time, the purpose of Records C in Table 4 is for the businessperson to get an idea of the time spent on ZT service provision, which is not directly accounted for in the profitability analysis.

Table 4. Logbook for zero tillage (ZT) services

Date of sowing: _____ /_____ /_________

A. Records per customer

S. No.	Name of customer (Farmer)	Village	Area serviced (Acres)	Fee charged per acre (Rs.)	Time spent for doing the sowing (Minutes)
1					
2					
3					
4					
5					
6					
7					
8					
9					

B. Records per day of ZT services

Total travel time spent to reach your customers' fields that day (minutes):	__________
Total fuel used for ZT service provision that day, including travel to/from your customers' fields (liters):	__________
Fuel price paid (Rs./liter):	__________
Total wage paid to tractor operator that day (Rs.):	__________
C. Time not accounted for in the profitability assessment	
Time spent that day by the service provider or any member of his/her family in the field without any charge (minutes):	__________
Time spent by the service provider for organizing the appointments with customers of that day (minutes):	__________

Annex I: Pre-Evaluation Form

Extension agents, farmers and service providers' training pre-evaluation form:

Venue: ____ **Date:** ______________

Name of participant: ____

Profession: ____

Please put tick (√) mark on the correct answers **Total time: 10 minutes**

Question	Please tick the correct answer		
What does zero tillage technology mean?	Sowing crop by zero tillage machine after tillage	Sowing crop by zero tillage machine without tillage	Both
Which methods of wheat establishment incur higher cost?	Zero tillage method	Conventional tillage method	Both methods incur same cost
Is surface seeding of legumes & oilseeds a type of zero tillage technology?	Yes	No	Don't know
What is zero tillage machine in wheat sowing used for?	Placing wheat seed at desired depth	Placing DAP fertilizer at desired depth	Both for seed & fertilizer
What is the turbo seeder used for?	Land preparation	Chopping crop residue	Planting wheat in residue rich field
Zero tillage method in wheat enables farmer in?	Saving cost of cultivation	Realizing higher yield	Both
What should be the time for wheat sowing to harvest best possible yield?	1 – 15 Nov	16 – 30 Nov	1 – 15 Dec
Which crops can be planted by a multi-crop planter?	Rice & wheat	Maize & mung bean	All four crops
Which of this cost is considered as fixed cost in zero tillage service business?	Driver's/Operator's fee	Fuel cost of tractor	Depreciation on zero tillage machine
Which of this cost is considered as variable cost in zero tillage service business?	Depreciation on tractor	Fuel cost of tractor	Depreciation on zero tillage machine

Annex II: Post- Evaluation Form

Extension agents, farmers and service providers' training pre-evaluation form:

Venue: ____ **Date:** ____________

Name of participant: ____

Profession: ____

Please put tick (√) mark on the correct answers **Total time: 10 minutes**

Question	**Please tick the correct answer**		
What is conservation agriculture?	Minimum soil disturbance (Zero tillage)	Permanent soil cover (Mulch)	Minimum soil disturbance, permanent soil cover & crop rotation
What is sustainable agriculture?	Modern agriculture with zero tillage	Incorporate the residue of previous crop	Agriculture being endured and maintainable over a long period
Soil biological health	Lowest with frequent tillage	Significantly improves with zero tillage	Best maintained with conservation agriculture
Why is soil organic matter reduced in tillage?	Tillage oxidizes soil organic matter & causes its loss	Tillage builds up organic matter	Soil organic matter builds up on the soil surface
Which is the best practice to moderate the soil temperature?	Crop rotation	Zero tillage with residue	Zero tillage without residue
Which practice leads to timely sowing of wheat?	Operations can be delayed by frequent tillage	Timeliness of operation is optimal under zero tillage	Timeliness of operation is best with zero tillage combined with early vacation of field by preceding crop
Which practice helps in reducing the population of Phalaris minor?	Frequent tillage	Zero tillage	Zero tillage and early wheat sowing

What is the function of depth-control side wheels in zero tillage machine?	To increase or decrease the depth of seeding	To decrease the depth of seeding	To increase the depth of seeding
Which fertilizer should not be used in the fertilizer box of zero tillage machine?	Urea	DAP	SSP
What is the most important factor to increase zero tillage business profitability of service providers?	Number of acres service per day	High service charge but less coverage	Providing service for several years

Annex III: Frequently Asked Questions

1. How can we obtain high yields in a zero tillage system?

- The field should be properly levelled, weed free and must have adequate moisture at the time of wheat sowing.
- The drill should be properly calibrated.
- Depth of sowing should be maintained at 4-5 cm.
- All tynes should be adjusted at the same spacing.

2. What should one do if the residue of previous crop has lodged?

- Remove the loose and lodged residue from the field after the rice harvest.
- If not removed, it may create serious problems for the planting operations of a drill fitted with inverted T openers.
- Wherever possible it is better to use happy seeder to overcome residue raking problems in combine-harvested areas and where the previous crop has lodged.
- Farmers may use a chopper to facilitate easier planting.

3. Do wheat yields increase with zero tillage?

- Field surveys in Bihar have shown a yield increase of 19.4% due to zero tillage as compared to the conventional method. Whether comparing total operational cost or final yield, zero tillage always realizes higher profits for the farmer.
- ZT wheat sowing increases the duration of wheat by facilitating early sowing.
- Seeding must be done on time.
- This technology typically enhances yield, provided there is proper time management.

4. What is the magnitude of the productivity loss due to late planting of wheat?

- On average in Eastern UP, wheat is sown in the first week of December, and in Bihar, it is sown in the second or third week of December.
- In Punjab and Haryana, wheat sowing starts from 25 October while in eastern ecologies wheat sowings start from 20 November.

- Delayed planting can result in yield losses of 30-35 kg/ha/per day in northwest Indo-Gangetic Plains and 50-65 kg/ha/day in the east.
- Recent data suggest that in eastern UP and Bihar, it is better to plant wheat starting from November 1 and finish sowing within November.

5. How can ZT help farmers avoid late planting of wheat and other winter crops?

- Sowing of wheat and other winter season crops is often delayed because of the previous crop – late transplanting of rice due to long-duration rice and sun drying of rice in the field for threshing.
- Wherever possible use medium-duration rice varieties or hybrids.
- Avoid sun drying in the field, for this use an axial flow thresher after stacking rice in one place.
- Transplant long-duration rice varieties before July 15.
- If a tractor is used in rice cultivation, it should not create ruts in the field.

6. What is surface seeding and can wheat be planted if the rice soils are too wet?

- Operation of a tractor in wet fields spoils the level of the field and creates ruts. To avoid late planting of wheat and other crops after the rice harvest, it is best to go for surface seeding under such situations.
- If the soil moisture is relatively low compared to the optimal for surface seeding (soil moisture generally glistens on applying pressure), it is advised to toss the seed and to irrigate to avoid any planting delay.

7. How does late irrigation for mitigating heat stress help to sustain wheat yields?

- High temperatures can shorten wheat's grain filling period, hasten maturity, and reduce the harvest index and grain yield in wheat.
- In order to overcome the potentially adverse effects of heat stress, it is usually beneficial to irrigate wheat during the grain filling stage.
- Many farmers, however, do not apply this last irrigation for fear of crop lodging.
- This is where zero tillage can help farmers because there is little or no lodging in zero tillage fields.

- When combined with early sowing, late irrigations for wheat are even more useful.
- Experience shows that in case of rains in February or early March (if no hailstorms occur), there is no lodging in zero tillage fields. In conventional till fields lodging is quite common.

8. What's the difference between full-tillage farming and no-till farming?

Full-tillage farming is the conventional approach to farming and involves cultivating the topsoil prior to sowing new crops. This can require many passes to totally break down the soil to create a soil bed for sowing.

No-till farming involves one pass over the soil with minimal soil being disturbed.

9. No-till philosophy

No-till combines key components that improve soil quality, water use efficiency and crop yields. These components include minimum soil disturbance, full residue retention, permanent soil cover and diverse crop rotations. High quality no-till is required to deliver the full agronomic, economic and biological benefits. No-till reaches its greatest efficiency during the 'maintenance phase' which can take 20 years to achieve.

10. For how long should farmers practice zero tillage?

Experience from places like Haryana show that zero tillage in wheat in the rice–wheat cropping system, sorghum–wheat cropping system and bajra–wheat cropping system can continuously be practiced for 20 years. In Ara, Buxar, Rohtas, Maharahganj, Champaran and Kushinagar in Bihar and Eastern UP, many farmers have implemented zero tillage for more than 8 years.

11. What is the impact of long-term zero-till wheat on soil physical properties and wheat productivity under the rice–wheat cropping system?

Work conducted in Haryana showed that ZT increased soil organic carbon significantly to a depth of 0.10, 0.15 and 0.25 m in sandy loam, loam and clay loam soil, respectively, indicating its build up to deeper depths with increase in fineness of soil texture. Carbon stock in the top 0.4 m of soil increased by 19%, 34.7% and 38.8% over conventional tillage in 15 years in sandy loam, loam and clay loam soil, respectively. The corresponding carbon sequestration rates were 0.24, 0.46 and 0.62 Mg/ha/year.

No-till/zero tillage has been reported to increase soil aggregates, reduce soil erosion rates and increase soil organic matter across a range of soil types, cropping systems and climates. Few agricultural practices provide similar opportunities to deliver positive benefits for farmers, society and the environment. The potential benefits of no-till are not being fully realized, however, in large part because no-till is rarely practiced continuously and many fields suitable for no-till are still conventionally tilled.

12. What will be the status of weeds under conservation agriculture technologies like zero tillage? Can zero tillage lead to increased weed pressure?

- The weed spectrum is closely tied to tillage, cropping systems and the growth of each crop in the cropping system.
- Zero tillage helps advancing the sowing time and increases the the growing cycle of wheat grown in rotation with rice. will equip both crops with more productive and efficient use of resources.
- There are three indicators of how ZT will impact weed flora . In relative terms, wheat will compete better than weeds but in the rainy season crops the use of pre-seeding herbicide may help to create competition in favor of crops.
- *Phalaris minor* population is reduced in zero tillage and its population reduces further if ZT is practiced as part of early sowing.

13. What are the salient features of the zero tillage drill?

- Inverted T-type slit opener with lower rake angle of 500 for easy penetration in untilled soil and tearing of rice stubble.
- Hard-surfaced (Hardness 65 RHN) openers for reduced wear and draft, and higher life expectancy of over 250 h.
- Tubular steel frame and adjustable clamping system for lateral positioning of slit/furrow openers.
- Two lateral adjustable depth control wheels and a free floating central wheel for power transmission to metering systems.
- Available in 9, 11 and 13 tyne configurations for different power sources at an attractive price band of Rs 40, 000 to 60,000.
- If a multi-crop drill for the sowing of lentil, pea, mustard, green-gram and coriander etc. is not available then a ZT machine can sow these crops.

14. Why is zero tillage technology sustainable for India?

- Reduces seeding time by about 6 days on small farms to over 17 days on large farms.

- Saves diesel for various field operations by an average of over 45 lit/ha in NW India and 25 liters/ha in Eastern UP and Bihar.
- Saves water during the first irrigation. Moreover, in conventional tillage, heavy irrigation can result in nitrogen losses severe enough to show deficiency symptoms after the 1st irrigation, which could require additional nitrogen application to correct the problem.
- Based on data from CSISA the increase in average yield of ZT wheat in places like Bihar by 19.4%.
- Saving in cost of cultivation by over Rs 3900/ha.
- Most farmers are satisfied after adopting ZT technology in wheat.

15. What is the effect of zero tillage on pathogens in the rice–wheat cropping system?

Research in Haryana indicated that the population of soil fungi was greater in conventional than zero-till fields at crown root initiation (CRI) and dough stage of wheat, while no uniform trend was observed in paddy. *Fusarium* species, *D. rostrata* and *Penicillium* species were the predominant fungi in the rhizosphere of wheat and rice. The population of *F. moniliforme* was more in conventionally sown wheat fields than zero, while it was more or less same in paddy. *F. moniliforme, F. pallidoroseum, D. oryzae and D. rostrata* were found pathogenic on paddy and *A. triticina* and *B. sorokiniana* on wheat. Studies show that therewas no significant difference in the incidence and severity of major diseases of rice-wheat sequence in the Haryana state .

16. What is the effect of zero tillage on the insect spectrum?

Twenty-four on-farm sites sampled in Haryana (data published in 2005) every two weeks during the regular growing season of rice recorded 61 species of insects and spiders. The number was considerably less in the wheat crop. The spectrum of insect fauna particularly in and around the no-till wheat field at all sites appeared substantially rich in beneficial fauna, the rice stubble providing cover to a variety of spiders, ants, earwigs, lady beetles and bugs. This beneficial fauna was also observed to take refuge in grasses and other weeds growing on the bunds of wheat fields or nearby wastelands. Albeit their number generally declined under low temperatures, it increased gradually over the seasons. The no-till sites with rice stubble shaved off or burnt *in situ* harbored a lower number of natural enemies than those with stubble intact. This fauna in wheat fields sown with conventional or raised-bed methods was, however, almost absent. The yellow stem borer of rice, *Scirpophaga incertulas* and pink borer, *Sesamia inferens* were the main hibernating pests in soil stubble. Wherever there was some incidence of armyworm in eastern UP or Bihar, it could be controlled easily by insecticides

17. How are the terms resource-conserving technologies (RCTs) and conservation agriculture terminologies used?

Resource-conserving technologies refer to those practices that enhance resources or input use efficiency, including zero or reduced tillage practices, which save fuel and improve plot-level water productivity, and land leveling practices that help to save water.

In contrast, conservation agriculture practices will only refer to the RCTs with the following characteristics:

- Soil cover, particularly through the retention of crop residues on the soil surface.
- Sensible, profitable rotations; and
- A minimum level of soil disturbance, e.g., reduced or zero tillage.

18. How much water savings result from zero tillage?

Savings of natural resources should be looked at on a command-area basis rather than at the farm level. Zero tillage may save only 5% water but the savings at the command area level could be higher compared to a technology which has the potential to save 30% water but which was only adopted on 1,000 ha.

19. How should we evaluate conflicting reports about zero tillage in the literature?

We are taking a broad approach to collecting literature from countries where cropping intensities are different, 100% in many cases. Most published work before the 1990s says zero tillage does not work. But the availability of new machines and herbicides changed the whole scenario in favor of zero tillage.

Zero tillage could be much more useful in the Eastern Indo-Gangetic Plains where the yield gains are higher than in northwest India. The reasons are quite different for different ecologies. Broad conclusions that we derive for publications may not really add practical value. We need to segregate the work done in USA, Brazil, Australia, Africa and South Asia and look at the differences. In the Eastern Indo-Gangetic Plains, the yield gains are more than in the Western Ingo-Gangetic Plains, but if you look at profits, zero tillage works in both systems.

20. What about zero tillage vs. strip till drills?

Strip till can make a difference, but how much? In India the slow pace of adoption in the initial years was because it took some time to resolve which of the two was better. By the time research teams concluded the results, more farmers adopted zero tillage than strip tillage.

21. Why has zero tillage adoption required a change in mindset among farmers?

The vast majority of Indian farmers are psychologically in favor of conventional tillage for almost all crops. This philosophy has been passed on from one generation to the next. Most growers and more specifically the older ones still believe that “the more you till the more you grow. These arguments are often used to support age-old perceptions and to convince their children to opt for more field preparation before any crop is sown. This mindset still holds so firmly that it looks like you are betraying the public when you even suggest such radical techniques like zero or no-tillage. However, training is changing some of these perceptions. Availability of good quality machines and new herbicides have made it possible to change the mindset of farmers and scientists.

22. Why is zero tillage so special for the rice-wheat cropping system?

The management practices employed in one crop will have a bearing on the performance of the other crop in the rotation. The rice–wheat cropping system has a distinct identity and the respective successes of rice and wheat are deeply interdependent. Both crops are so interdependent that commodity approach for research on these crops is meaningless. Since each crop influences the other crop, we need to take into account the management options available for both rice and wheat. The evolution of zero tillage and then its subsequent acceleration through the EIGP has led to the optimization of the cropping system as a whole.

23. What does crop rotation mean?

Crop rotation is the systematic planting of different crops in a particular order over several years in the same growing space. This process helps maintain nutrients in the soil, reduces soil erosion, and prevents plant diseases and pests. When a single crop is grown on one field for many years in a row, the crop will cause the depletion of particular nutrients from the soil. This depletion of nutrients leads to poor plant health and lower crop yield.

With crop rotation, particular nutrients are replenished depending on the crops that are planted. For example, a simple rotation between a heavy nitrogen-using plant (e.g., cereals) and a nitrogen-depositing plant (e.g., pulses) can help maintain a healthy balance of nutrients in the soil. This is because the same type of crop planted repeatedly in the same area keeps draining the land of the same nutrients needed for that plant's growth.

Crop rotation also prevents plant diseases and pests by exchanging crops that may be susceptible to a particular disease or pest with a crop that is not susceptible. Second, certain pests can reach levels that are hard to control when they learn to make a home near a field that always has the same type of crop.

24. How does zero tillage affect sowing time in Bihar and eastern Uttar Pradesh?

Farmers in the EIGP lose valuable time during a short window – one or two weeks – between the harvesting of paddy and planting of wheat. If wheat sowing is delayed beyond the optimal time (ideally by November 25), yields plummet at the rate of 30 kg per hectare per day. The problem is particularly acute in Bihar and eastern UP where long-duration rice variety MTU 7029 is planted. Paddy harvesting is extended up to late December in this area, forcing farmers to raise short-duration wheat varieties (100–120 days as against the usual 145–150 day varieties). This results in a yield difference of over one tonne per hectare.

25. Why did it take so long for zero tillage to be adopted in India?

Zero tillage research, which was at a dead end in 1996, was taken up using a farmers' participatory approach. Farmers have long believed that frequent tillage is a must for high yields. The consensus on zero tillage was hard to reach. The farmers' participatory approach adopted under National Agriculture Technology Project (NATP) proved to be an accurate guide to its subsequent adoption by farmers in India. The surge in this innovation has continued with glaring advantages shown in the Eastern Indo-Gangetic Plains through implementation of CSISA, supported by USAID and Melinda & Bill Gates Foundation, since 2009. In addition to the accelerated adoption of zero tillage, another reform championed by this project has been farmers' participatory process.

26. To what extent can zero tillage lead to a reduction in greenhouse gas emissions?

Zero tillage practices have been reported to reduce greenhouse gas emissions through decreased use of fossil fuels in field preparation and by increasing carbon sequestration in the soil.

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