Operational Manual for Multi-Crop Zero Till Planter

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Cereal Systems Initiative for South Asia (CSISA)
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Operational Manual for Multi-Crop Zero Till Planter

1. Introduction

Multiple challenges associated with plough based conventional production practices that include deteriorating natural resources, declining factor productivity, shortages of water & labor and escalating costs of production inputs coupled with challenges of climate change both in irrigated intensive systems as well as low intensity rainfed ecologies are the major threat to food security of South Asia (Jat *et al.*, 2009; Ladha *et al.*, 2009; Chauhan *et al.*, 2012). Water and labor scarcity and timeliness of farming operations specially planting under the emerging uncertainties are becoming major concerns of farming all across farmer typology, production systems and ecologies in the region (Chauhan *et al.*, 2012). In many parts of Asia, over-exploitation and poor management of groundwater has led to declining table and negative environmental impacts. Conventional flooded rice receiving the largest amount of fresh water compared to any other crop is the major contributor to the problems of declining groundwater table ranging from 0.1–1.0 m $year^{-1}$ and increasing energy use. The problem has further been intensified with the unavailability of labor in time, and multi-fold increase in labor costs. Fragmented land holdings and nucleus farm families further exacerbates the problem of availability of farm labour.

Potential solutions to address these issues include a shift from intensive tillage based practices to conservation agriculture (reduced or no tillage) based crop establishment techniques (Saharawat *et al.*, 2010; Jat *et al.*, 2012; Gathala *et al.*, 2011). Direct drilling (seeding/planting with zero tillage technology) is one such practice that potentialy addresses the issues of labor, energy, water, soil health etc (Malik *et al.*, 2005; Gupta and Sayre, 2007; Jat *et al.*, 2009; Ladha *et al.*, 2009; Gathala *et al.*, 2011). However, due to fragmented and small land holdings it is not affordable to purchase many machines for the sowing of different crops. Therefore, multi-crop planter have been invented and are being used by many farmers across South Asia. The same multi-crop planter available in the region can be used for direct drilling of several crops including wheat, rice, maize, moongbean, mustard, barley etc without any preparatory tillage and also under reduced tillage situations. One of the major constraints in large scale adoption of this technology as well as sub-optimal use of planters is the lack of skills/knowledge on operation and calibration of the machinery for multiple uses. There are different field/crop/situation specific adjustments needed before the use of the machine in the field. These adjustments include proper seeding depth, fertilizer rate and the seed rate etc as per the crop and field conditions to realize the potential benefits of the technology. There are several machinery manufacturers who supply these planters but the operational manuals are not available for making adjustments, calibrations for multiple purposes, multiple

crops under local conditions. In absence of the manual guidelines/protocols for efficient use of these planters by the farmers, service providers, extension agents for different purposes and variable field conditions, many a times the desirable results are not achieved and even contradictory results are observed. This results in slowing down the adoption rates of the technology. Also, in absence of simple guidelines for maintenance of these planters, the farmers/service providers need to make huge investments on repairing at the start of the season. In this manual, we attempted to provide simple guidelines for calibration, operation, maintenance and troubleshooting for efficient use of multi-crop zero till planters by the range of stakeholders including farmers, service providers, extension agents and researchers.

2. Importance of multi-crop zero till planter

Due to fragmented and small land holdings and variable farmer typology, it is neither affordable not advisable to purchase many machines for the planting of different crops by the same farmer. The multi-crop planter can plant different crops with variable seed size, seed rate, depth, spacing etc., providing simple solution to this. In addition to adjustments for row spacing, depth, gears for power transition to seed and fertilizer metering systems, the multi-crop planters have precise seed metering system using inclined rotary plates with variable grove number and size for different seed size and spacing for various crops. This provides flexibility for use of these planters for direct drilling of different crops with precise rate and spacing using the same planter which does not exist in flutted roller metering drills. Hence, the same multi-crop planter can be used for planting different crops by simply changing the inclined plates. The planter can also be used to make the beds and simultaneously sowing the crop just by mounting the shovels and shapers which can be easily accomplished due to the given provision in the machine. The planter has the provision of drilling both seed and fertilizer in one go. Also, as seed priming is very important for good germination and optimum plant population, the multi-crop planters provides opportunity to use primed seeds which is not possible in flutted roller metering drills.

3. Major Components and description of multi-crop zero till planter

The multi-crop planter primarily consists of 10 components as depicted in Figure 1 and described in below section

3.1 Frame

The frame of multi-crop planter consists of 2 or 3 bars made up of mild steel on which all other parts are mounted/ attached. The frame works as a body in the planter. The bars are made up of mild steel angle irons (6.5 × 6.5 × 0.5 cm) welded together to provide the desired strength and rigidity. The frame of the 9- tyne planter is of the size of 185 × 60 cm while the frame of 11 tyne machine is 220 cm long. The tynes are attached to the frame which is used to drill the soil. Tynes are attached by U-Clamping as shown in Figure 2. Mainly 9 tynes or 11 tynes are fitted at desired spacing (equal or paired row arrangements) depending on crop. These U-shaped clamps can be unbolted to change the distance between furrow openers, no. of furrow openers and also to detach the furrow openers in order to attach some other part for a different function, for example shovel cum shaper assembly may be attached for raised bed planting.

1. Frame, 2. Furrow openers, 3. Tynes, 4. Fertilizer box, 5. Seed box, 6. Chain and gear drives, 7. Drive wheel, 8. Depth control wheel, 9. Fertilizer delivery pipe, 10. Seed pipe, 11. Fertilizer rate adjusting nut, 12. Seed rate adjusting strip

***Figure 1**. Components of multi crop zero till planter*

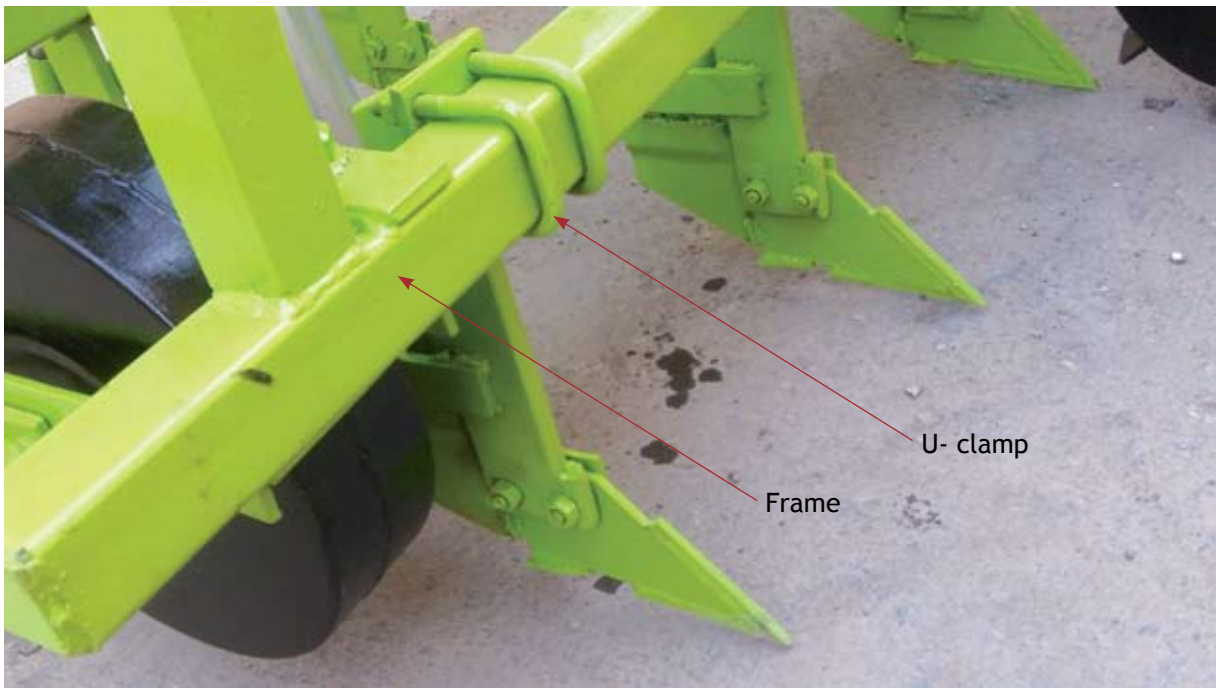

***Figure 2**. Components of Frame and its adjustment*

3.2 Furrow openers and slit

Furrow openers are (Figure 3) attached to the lower portion of tynes which are used to drill the soil. As the furrow openers drill the soil, the seeds and fertilizers come into the furrow opener through seed and fertilizer delivery pipes and drops the seed and fertilizer in the soil through slits. There are various types of furrow openers. The *inverted T-type* furrow openers are used in zero tillage multi crop planters. The spacing between two furrow openers are adjusted as per the desired row spacing of crops. The cutting portion of furrow openers (point of share) is made of 8 mm thick high carbon bit 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 round the nose, tip and sides to reduce wear and tear.

A 4 cm wide, 5 cm thick and 6 cm long stiffener plate is provided at back bottom of the inverted T-type furrow opener (5.0 × 1.2 cm) which is attached to the frame with nuts and bolts or directly with clamps. The furrow opener is welded to the mild flat steel shank (straight leg standard mounted with T-type furrow opener). The blades can be of "welded on" or "bolted on" or even "knock down" type. The disadvantage of "welded on" blades is that they require machine shop for replacement, whereas, a farmer can himself replace the other two types of blades. The quality of material used to make the furrow openers will ultimately decide the operational quality and durability of the planter. Double boot is provided behind each furrow opener to receive a tube (steel ribbon or polyethylene tube with a minimum diameter of 25 mm) each to host seed and fertilizer delivery pipes. The furrow openers are adjusted to make 3–5 cm wide slits.

3.3 Seed and fertilizer boxes

Trapezoidal shaped seed and fertilizer boxes, made of mild steel sheet (2 mm thick), are mounted side by side (fertilizer box in front and seed box in the rear) on the frame (Figure 4). The boxes are generally 180 cm long

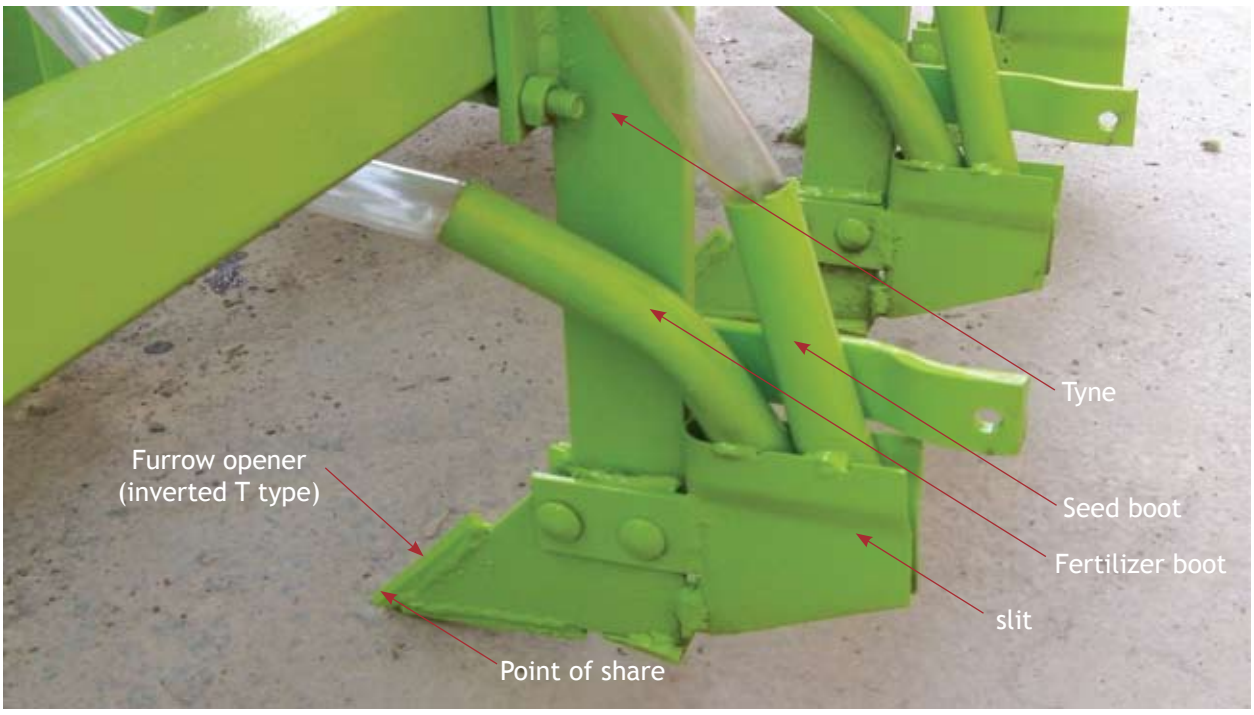

***Figure 3**. Furrow opener and their components*

***Figure 4**. Seed and fertilizer box*

and 24 cm deep. Box dimensions can vary depending upon the effective width of the machine and will increase with the increase in the number of the furrow openers. For example in case of 9-tine planter, the length of seed and fertilizer boxes will be around 160 cm.

3.4 Seed metering and delivery system

The seed metering and delivery system (Figure 5) consists of following-

1. **Seed box :** it is used to store the seed in the planter
2. **Inclined rotary metering plates :** these rotating plates have grooves which guide the seed and drop it in to the cups (Figure 6)
3. **Seed metering strip :** it is an iron bar which has holes in it. By changing the hole, we 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 (Figure 8)
4. **Seed Cups :** These cups receive seeds that are 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 unobstructed delivery of the seeds (Figure 7).
5. **Seed delivery pipe :** It is used to take the seed from 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 are provided. The holes connect the strip to the seed box with the help of nut. By changing the holes, the seed rate can be adjusted. The seed

***Figure 5**. Seed metering mechanism and its components*

***Figure 6**. Inclined rotary plates (inside the seed box)*

***Figure 7**. Seed cups & seed delivery pipe*

rate is generally written on the corresponding hole. However, these are just indicative and for actual quantity of seed to be delivered, it is always advisable for field calibration. The seed rate may also be adjusted by putting the chain on different gears (Figure 9). Using the gear with lesser teeth will lower down the seed rate and vice-versa.

***Figure 8**. Seed metering strip with seed rate scale on it*

***Figure 9**. Gear/Sprocket*

Type of inclined plates

There are different seed metering inclined plates for different crops as shown in Figure 10. The plates vary from each other in size of groove, number of grooves and shape of the grooves. The size, number and shape of the grooves are designed to suit the specific crops. To change the plates, the nut in the center of the plate is opened and then after changing the plate it is tightened again.

***Figure 10**. Types of inclined plates used in multi-crop planter*

3.5 Fertilizer metering system

Fertilizer metering system controls the amount of fertilizer application in the field. Generally there are two types of fertilizer metering system (Figure 11).

The first system is flutted roller type. It consists of following parts.

1. Fertilizer box
2. Lever
3. Drive shaft
4. Flutted roller
5. Aluminum tongue

In the flutted rollers metering systems (Figure 12), the fertilizer rate is adjusted with the help of the lever (Figure 14). The lever is set to the recommended fertilizer level. Before setting the fertilizer rate by the lever the nut as shown in figure 13 is loosened and after adjusting the level it is tightened again. However, for precise fertilizer rates, its always advisable to go for field calibrations. After making adjustments as per the calibrations for a specific fertilizer rate, the flutted roller pick the fertilizer from the fertilizer box and then drop it on the aluminum flow control tongue (Figure 13). The flow control tongue drops the fertilizer uniformly in to the fertilizer pipe which is then applied into the soil through the fertilizer boot attached in the furrow opener. In this system the flutted rollers are prone to clog.

***Figure 11**. Fertilizer metering system*

***Figure 12**. Flutted roller with shaft*

***Figure 13**. Flow control tongue*

The second system (Figure 15) is the rotating cell type fertilizer metering type. This system has the following components.

1. Fertilizer box
2. Shaft
3. Rollers
4. Cells/cups
5. Funnel
6. Adjusting nut
7. Scale

In this fertilizer metering device, cells are

***Figure 14**. Fertilizer rate adjustment lever with scale and nut*

fitted in separate compartments to allow fertilizer placement as required in each row or some selected rows only. Fertilizer can be increased or decreased by lifting or lowering the fertilizer box respectively. Fertilizer is simply metered by a series of cups on a roller (Figure 17). The rate of fertilizer can be read on the scale (Figure 16). However, calibration of machine for fixing desired fertilizer rates under laboratory situation as well as in field can be accomplished with the procedure mentioned later in this document. This system is almost maintenance free but the precision is less as compared to the first system.

3.6 Drive wheel

Drive wheel (Figure 18) is attached in the middle of the front bar of the frame. The function of drive wheel is to transmit power to the seed

***Figure 15**. Fertilizer metering components*

***Figure 16**. Fertilizer rate adjustment*

***Figure 17**. Cup/cell type roller*

and fertilizer metering gears. The diameter of the drive wheel in the multi-crop planters available in India is 25 or 30 cm. Chains are attached to the drive wheel and to the driving shaft. There are lugs on the circumference of drive wheel. Lugs are provided to avoid or minimize slippage (Figure 18). The trapezoidal lugs are of generally 5 cm height.

3.7 Depth control wheel

The depth control wheel (Figure 19) is essential for placement of seeds and fertilizer at right

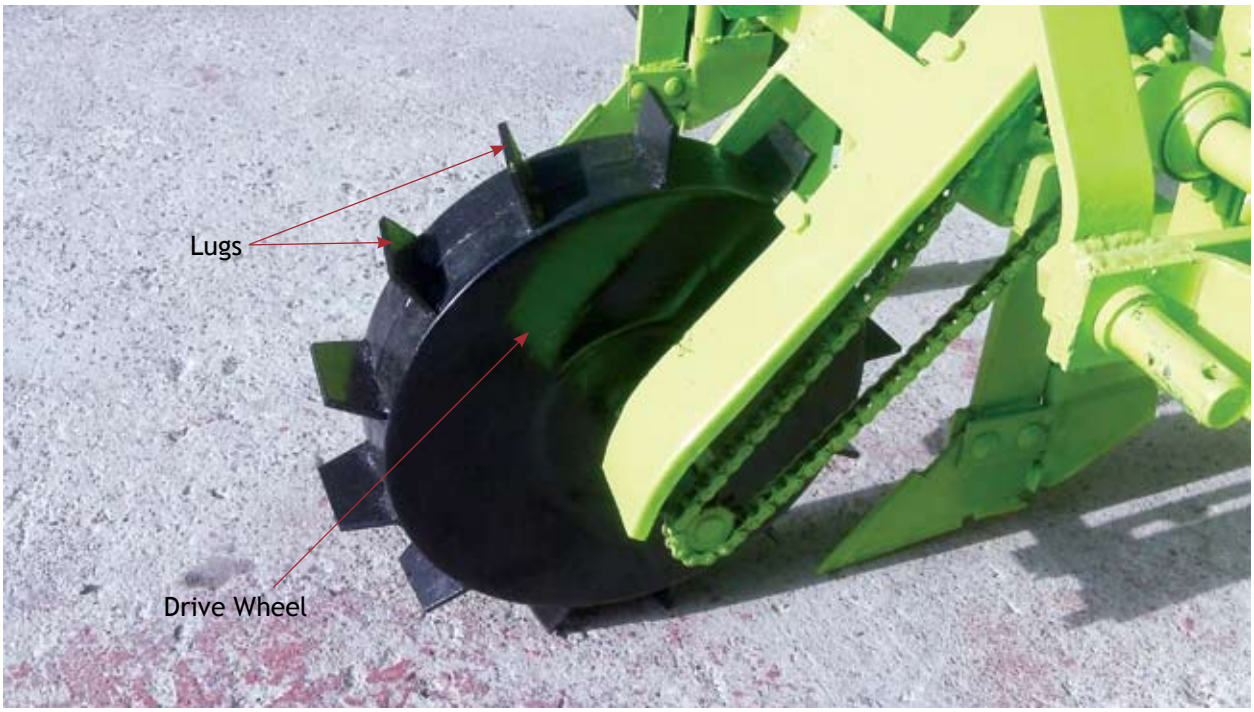

***Figure 18**. Drive wheel*

***Figure 19**. Depth control wheel and its adjustment*

depth. Two depth control wheels are attached to the frame. The diameter of wheels is about 25-30 cm. It is made of mild steel and of rubber in some types of planters. The function of these wheels is to control depth of the seed and fertilizer into the soil through regulating the depth of furrow openers. The depth of seed and fertilizer placement can be increased or decreased with the help of depth adjusting screw pointed out in figure 19. It is a nut and bolt mechanism attached to the frame. There are fix number of threads per inch in the bolt. The lower nut is adjusted for the depth control. For example, if we have to increase the depth of the machine by one inch and there are 9 threads per inch then we have to move the lower nut by nine threads in the upper direction and tighten the upper nut. The adjustment of depth control should be done in the field itself to capture the real field situation.

3.8 Power transmission unit/ chain mechanism

The power transmission unit has the following main components-

1. Drive wheel
2. Shaft
3. Idler
4. Sprocket
5. Roller chain

The function of power transmission unit (Figure 20) is to provide drive from drive wheel to all parts of the planter for example seed box rollers, fertilizer box rollers. First of all a chain set connects the drive wheel to the driving shaft. This shaft is connected to fertilizer and seed metering shafts with the help of another chain set which provide drive to the seed box roller and fertilizer box roller. Bevel gears are attached to the shaft drive for changing the vertical drive into the horizontal drive. The idler gear (Figure 21) is used to tighten or loosen the chain for its smooth operation.

***Figure 20**. Power transmission unit and chain Mechanism*

***Figure 21**. Power transmissions with Bevel gears*

3.9 Seed and fertilizer delivery pipes

Seed and fertilizers delivery pipes (Figure 22) are attached to the seed and fertilizer boxes with the help of aluminum cups. These pipes carry the seed/fertilizer from the cups to the seed/ fertilizer boot. The tubes should be connected to seed/fertilizer cups firmly so that these may not come out during field operation. The following precautions should be taken care of

- Tubes should be protected from bending and breakage.
- Old/bent tubes should be replaced.
- Excessive bend in the tubes should be avoided otherwise the bend will cause obstruction in free flow of seed/fertilizer and result in non-uniform application and poor crop establishment.
- The tubes must be inserted about one inch into the seed/fertilizer boot to ensure proper seed/fertilizer delivery.

4. Calibration of planter for seed and fertilizer rates

4.1 Laboratory calibration

Seed and fertilizer metering devices can increase or decrease seed rates within specified limits. To calibrate the planter to a desired seed and fertilizer rate, first fix the seed metering strip in the appropriate delivery notch and set the appropriate fertilizer rate with the help of lever or adjusting nut whatever mechanism is there in the planter. Measure circumference of drive wheel (Cd). Measure width of the drill (Wd),

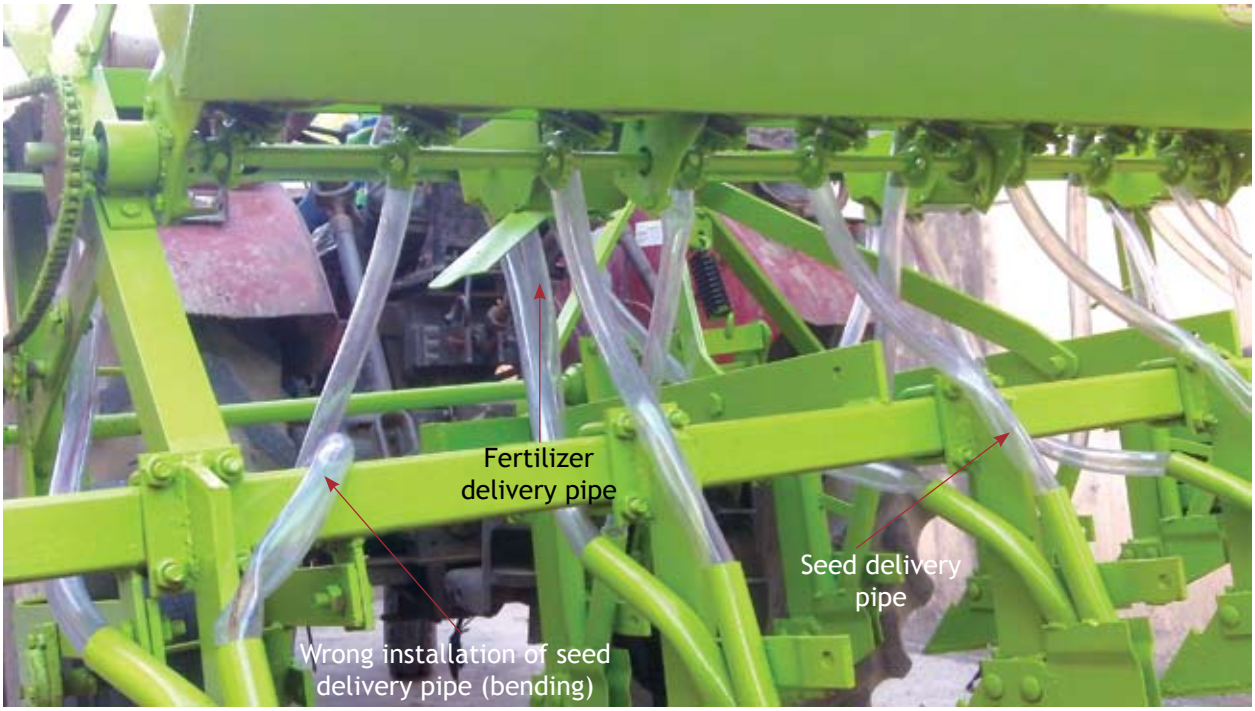

***Figure 22**. Seed and fertilizer delivery pipes*

else multiply the number of tynes with distance between two tynes. Put seed in seed box and fertilizer in fertilizer box then rotate drive wheel manually to ten full rotations and collect seed delivered from each seed/fertilizer delivery tube separately in polythene bags (Figure 23). Weigh the seeds and fertilizer in each bag and also determine the total seed weight (Sw) and fertilizer weight (Fw). If the difference in seed/ fertilizer weight between individual delivery tubes is more than 10%, contact a mechanic/ expert to adjust or repair the machine. Calculate seed and fertilizer application rate per hectare using the following formula:

Seed rate (kg/ha) = {Sw/(Cd × Wd)}

Where Sw (or Fw) = Total weight of seed or fertilizer released in 10 Revolution (g)

(Cd) = Circumference of drive wheel

Where C (d) = 2 x π x radius (measurement of radius shown in figure)

(Wd) = Width of the machine (m)

Fertilizer rate (kg per hectare) can be determined using the same formula by substituting the total weight of fertilizer released in grams (Fw) in place of total weight of seeds (Sw). It is cautioned that calculated seed and fertilizer rates can differ from the actual rates due to drag and slippage of the drive wheel depending upon the soil moisture, surface roughness, presence of crop residue and field level. Carry out minor adjustment in seed/fertilizer rates by testing the machine in the field.

4.2 Field calibration

First of all, fill the seed box and fertilizer box with seed and fertilizer and set the indicator at desired seed rate and fertilizer rate. Run the planter at a distance of 20 meters in the field. Collect the seed and fertilizer from the delivery pipes in polythene bags from each pipe. The amount of seed and fertilizer collected in each pipes in 20 meter run is then measured in grams. Then we calculate the seed rate and fertilizer rate by the given formula as under

One acre = 4000 m^2

Width of drill = ***x***

***Figure 23**. Seed and fertilizer calibration in laboratory*

***Figure 24**. Diameter of drive Wheel*

***Figure 25**. Distance between two alternate furrows*

Distance = 20 m

Weight of seed or fertilizer in pipes = y

Seed rate or fertilizer rate per acre =

$$\frac{4000 \times \text{Width of drill}}{\text{Weight of seed or fertilizer} \times \text{distance}}$$

If the seed or fertilizer rate is not equal to recommended rate then accordingly set the indicator at higher or lower rate and again follow the procedure of field calibration.

5. Hitching of machine

The planter has three standard hitch points (Figure 26); two lower and one top links. The

***Figure 26**. Hitching of machine through three-point linkage*

planter is attached to tractor through these three hitch points with the help of link pins. The top link hitch point also helps in leveling the machines. The three point hitch adjustments where the planter fixes to the tractor should be adjusted. The planter should level from side to side and have just enough forward and backward adjustment to enter the soil at the proper angle.

6. Field operation of planter

While operating the planter in the field for planting, the soil moisture must be optimum both for the operation of planter as well as germination of the crop. Though the soil moisture for operation of planter in the field depends on soil type but the field should be neither too wet nor too dry so that both rut and clod formation can be avoided. First of all, planter is attached to the tractor (say 35 HP) by three point linkage. As the tractor moves the planter, the drive wheel rotates which in-turn rotates the chain-set attached to it on one end and to the drive shaft at other end. The drive shaft then provides the drive to the seed box shaft and fertilizer box shaft as all of these shafts are attached with a chain and gear drive. The fertilizer shaft is attached to the flutted rollers and when flutted roller rotates, the fertilizer enters into the spacing between the teeth of the roller and goes to the aluminium cup which drops the fertilizer to the fertilizer delivery pipes. At same time, the seed box shaft rotates the bevel gears attached to it. A bevel gear is attached at an angle of 90 degree which gives motion to the seed rollers. As seed rollers rotate, the seeds in the seed box enter into the spacing between the teeth and seeds go to the aluminium cup which drops the seeds into the seed delivery pipes. Now, the seed and fertilizer goes to the boot of the furrow openers from seed and fertilizer delivery pipes. As the furrow opener moves, the fertilizer and seeds are drilled into the soil in such a manner that the fertilizer is placed below the seed.

6.1. Preparation of planter for planting

Before operating the planter for the first time, read and understand this manual to become familiar with the major components of planter, mechanism, adjustments, and operating systems of the planter. Before each use in the field, ensure following things to make sure all necessary items are checked and adjusted.

- Check the condition of the planter and make any adjustments or repairs necessary particularly, the fasteners, blade bolts and welds before operating. Replace any broken or worn out parts.
- Select the proper row spacing, seed quantity, and depth according to the field condition and crop. (Re-adjust seed rate and planting depth after trial).
- Make sure that the seeds to be planted are clean, and free of soil and pebbles. Do not mix fertilizer with the seeds when seeding, as this will damage the seed metering device.
- Add the seed to the seed box. Do not fill the seed box more than three quarters full, in order to prevent the automatic dropping of the seeds from the opening in the inclined seed plates due to vibration in planter while under operation.
- Make sure that the fertilizer is clod free.
- Calibrate the planter as given in heading 4 and 5.

6.2 Operating notes

Before operating the multi-crop planter, one should consider following operating notes:

- When tilling and seeding back and forth across the plot, line the planter up so the next row is at the desired spacing from the last row just planted.
- While operating, pay attention to how much seed is left, and whether the seeds are blocked in the seed delivery pipe or in the hole of the furrow opener. If the tractor is backed up while the planter is operating, soil will be jammed into the furrow opener (slits) and block seeding. If this happens, turn off the engine, and clean the furrow openers and seed delivery pipes as necessary. Restart the engine, raise the implement to back up, and re-plant the area that did not receive seed.
- Throttle down when approaching the end of the plot. Lift the planter through hydraulic system when about 2.5 metres away from the end of the plot, then turn the tractor. After turning, again bring down the planter with hydraulic system.
- Lift the planter through hydraulic system when the implement crosses a ridge or is in transport. Lower the roller to raise the blades to the maximum height while walking or transporting the tractor on the road.
- Stop the engine before fixing a breakdown or adjusting or changing implements.
- After completion of the operation, remove the remaining seeds, and fertilizer and wash the mud and weeds from the planter. DO NOT leave seed or fertilizer in the boxes over time as the seed attracts the rodents and can damage the inner parts of the seed box while fertilizer can chock the fertilizer metering system. After cleaning, lubricate the chain, and all other moving parts.

7. Maintenance

The planter should be properly serviced and maintained. It should be checked before use to ensure that all the nuts and bolts are tightened and that all the parts are in good condition. For example, if the openers are worn out, they should be replaced. The fertilizer and seed boxes should also be in good condition to allow free flow of seed and fertilizer. Chains should be adjusted and oiled. After use at the end of each day, the machine should be checked, the seed and fertilizer boxes cleaned, and the moving parts oiled. After the planting season, the machine should be properly stored.

8. Machine storage

Before storing the planter for any length of time, clean each part of the machine; apply grease/oil to the transmission chain and moving parts. Store the machine in a dry, well-ventilated store. Keep the appropriate tools with the machine during storage to ensure that they will be available when needed again.

9. Troubleshooting

Problem	Cause	Remedy
Seed not placed at desired depth	1. Adjustment of depth control wheel is not proper	1. Properly adjust the depth of furrow openers with the help of depth control wheel.

Contd...

Problem	Cause	Remedy
Seed/fertilizer is not dropping from furrow opener	1. The seed/fertilizer box is empty	1. Refill the seed/fertilizer box
	2. The furrow opener or seed delivery tube is blocked by soil/mud or fertilizer/seed delivery pipes bent.	2. Clean mud out of the opener and/ or seed delivery tubes
	3. Fertilizer flutted roller is blocked.	3. Clean the flutted rollers.
	4. The drive wheel does not touch the ground	4. Lower down the hitch to get the drive wheel in contact with the land.
	5. Broken chain/sprocket	5. change the broken part
Unequal depth of seeding among different rows/ furrow openers	1. Improper three point linkage balancing	1. Put the machine on a fairly level ground and then level all the furrow openers with the help of top link/ right lower link of the tractor.

10. References

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