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Training Manuals on Rice Transplanter, Harvester, Seed Planter and Irrigation Machinery

Appropriate Scale Mechanization Innovation Hub (ASMIH)-Bangladesh

Department of Farm Power and Machinery
Bangladesh Agricultural University
Mymensingh-2202
Bangladesh

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ILLINOIS

Training Manuals
on
Rice Transplanter, Harvester, Seed Planter and Irrigation Machinery

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Preface

The Appropriate Scale Mechanization Consortium (ASMC), University of Illinois at Urbana-Champaign in consistent with the goals and objectives of Sustainable Intensification Innovation Lab (SIIL) at Kansas State University, USA funded by the Feed the Future (FtF), USAID, USA intends to introduce multifunctional and modular mechanized technologies that are technically, environmentally, and economically appropriate for use by smallholder farmers with the flexibility to accommodate different power sources in four countries of Bangladesh, Cambodia, Ethiopia and Burkina Faso. In line of the ASMC goals and objectives, the project entitled "Appropriate Scale Mechanization Innovation Hub (ASMIH) - Bangladesh" was formulated for overcoming challenges in Southern Delta of Bangladesh. Agriculture in Southern Delta is characterized by low productivity due to salinity, water logging, less access to modern technologies, inadequate control over water resources and repeated crop losses due to natural calamities. Four years project was laid out with survey, assessing & adapting technologies of transplanting, harvesting and conservation agriculture machinery, capacity building, scaling up and sharing meeting with the partners. ASMIH-Bangladesh project has identified appropriate machines such as transplanter, reaper and mini-combine harvester and seeder as solutions for transplanting, harvesting and conservation agriculture practices in Southern Delta of Bangladesh. These machines save labor, time and cost. The project has developed hands-on training manuals on these technologies which are of great importance in imparting awareness and skills on operation & maintenance and custom hiring service provisions to custom hiring service providers, operators, mechanics, farmers and extension agents as well in extension and dissemination of the technologies.

The project acknowledges the Feed the Future and USAID, USA for rewarding research grant, and Sustainable Intensification Innovation Lab (SIIL), Kansas State University and Appropriate Scale Mechanization Consortium (ASMC), University of Illinois at Urbana-Champaign, USA for continuous technical and management support. The project also acknowledges the partnerships with Bangladesh Agricultural Research Institute (BARI), ACI Motors, Metal Pvt Ltd. for providing necessary supports in developing database for preparing these manuals. Special acknowledgement to Bangladesh Agricultural University for hosting the ASMIH-Bangladesh and all out support for implementing its activities.

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Chapter 1
RICE TRANSPLANTER

1.1 Introduction

Labor shortage is a major problem and there is a need to find an alternative method for rice cultivation that requires less labor and still allow the crop to be transplanted in time. The use of mechanical rice transplanter (Fig. 1.1) is one of the options to solve the existing problem.

In Southern Bangladesh, which is largely a rice growing environment, the timeliness of transplanting can be further improved by the replacement of puddled by un-puddled rice cultivation. This reduces the water requirement for land preparation, which increases the options for earlier crop establishment through un-puddled mechanical rice transplanting. The timeliness of planting can be further enhanced through the use of mat-type nursery that can produce seedlings of appropriate age whenever the conditions for transplanting are right. Soil structure for the next non-rice crop would also be improved by eliminating puddling.

Fig. 1.1: Rice Transplanter

This training module highlights the benefits of mechanical rice transplanting and discusses the operational and management procedures. It will help innovative farmers and others to use mechanical transplanting for rice with or without puddling with an easy and step-by-step guidence.

1.2 Purposes of the Training

- To know about mechanical transplanting methods
- To know how to prepare seed bed
- To know how to raise rice seedlings and seedling management
- To know about rice transplanting machine
- To know about rice transplanting machine operation
- To know of rice transplanting machine routine maintenance
- To know the problems of rice transplanting machine and its solutions.

1.3 Outputs of the Training

- Fermers/target beneficiaries will be able to raise rice seedlings for machine tranplanting and seedling management
- Machine operators, mechanics and service providers will be able to operate, repair and maintenance of the rice transplanter machine.

1.4 Mechanical Transplanting of Rice

Mechanical transplanting of rice is the process of transplanting rice seedlings, which have been grown in trays or mats, using a rice transplanter machine. Currently, in conventional manual transplanting operation, 18-24 laborers are required to transplant one acre land. However, by using self-propelled rice transplanter three person (1 Operator + 2 laborers) can transplant up to four acres of land in a day. Fuel consumption is 1.5-1.8 liters/acre.

1.5 Advantages of Mechanical Transplanting

- Transplanting of seedlings at the age of 15-30 days
- Uniform spacing and optimum plant density
- Higher productivity (5-7 t/ha) compared to traditional transplanting where plant spacing and density not always be consistent
- Less transplanting shock, early seedling vigor and uniform crop establishment
- Less drudgery and health risks for farm laborers
- Less time required for transplanting
- Less labor required for transplanting
- New employment opportunities for rural youth by engaging in custom hiring service business
- Reduce the problem of labor shortage
- Increases farmer's income.

1.6 Seedling Bed Preparation

1.6.1 Seed germination

For mechanical rice transplanting the seed germination rate should be more than 95% and vigor 80%. This is very important as it reduces the missing hill during transplanting. Healthy and good quality seed is required for seedling raising.

1.6.2 Seed treatment and selection

By using specific gravity method healthy seeds should be selected. For that, dry seeds are emerged in water to remove unfilled grains and other impurities. After soaking, the floating seeds are removed from water surface and after that seeds are chemically treated by Carbendazim powder (Labeled formulation) for maximum 24 hours to prevent seed borne diseases (Fig. 1.2-1.5).

Fig. 1.2: Sun drying before treatment

Fig. 1.3: Seed treatment

Fig. 1.4: Separation of seed by gravity method

Fig.1. 5: Chemical treatment

1.6.3 Seed sprouting

After treatment of the seed for maximum 24 hours (excessive soaking will decompose the seed) the seeds are washed and kept in bags for sprouting generally for 24 to 48 hours (Figure 1.6).

Fig. 1.6: Bagging of seed for sprouting

Fig. 1.7: Soil preparation for tray

1.6.4 Soil preparation

The nursery bed can be prepared by using dry soil and mud. For dry soil seedling bed, collected soil is crushed and sieved for removing all the stones and debrises from the soil. The soil then mixed with compost (Figure 1.7).

1.6.5 Seedling raising

There are two methods of seedling raising:

1. Tray method (with crushed and sieved soil)
2. Polythene mat method (with crushed and sieved soil or with mud)

1.6.6 Tray method

In tray method, plastic trays are used (0.58 m x 0.27 m) to raise seedlings. Dry-crushed and sieved soil is filled in the tray using hand and spread the soil uniformly on tray. After that using a scraper the upper part of the soil is leveled (Fig. 1.8).

1.6.7 Polythene mat method

For polythene mat method, a polythene sheet is used for making seedling bed instead of plastic tray. It is less laborious and need less time to prepare seed bed. Both crushed and sieved soil and mud can be spread on the polythene sheet for making the seed bed. Generally, width of the polythene seed bed is 2 tray equivalent size (e.g. 0.58 m) and length of the bed is as per land size (Fig. 1.9).

Fig. 1.8: Tray preparation

Fig. 1.9: Polythene mat preparation

Fig. 1.10: Sprouted seed

Polythene sheets are placed on the leveled field and perforated the sheet evenly to improve drainage and aeration. Then, soil is spread uniformly on the polythene sheet. This layer should not be more than 1.5-2.0 cm thick. To ensure an even depth, place a frame that is 1.5-2.0 cm high around the polythene sheet. For mud bed, the process is similar, only use the mud instead of crushed soil, which reduce labor and time requirement (Fig.1.11-1.12)

Fig. 1.11: Spreading seed on tray

Fig. 1.12: Irrigation on tray

1.6.8 Seed rate and seeding on tray or mat

After preparation of the tray with soil or mat sprouted seeds are spread on the soil. The seed is spread on the tray or mat by hand. Dry seed of 130 g for bold grain, 140 g of medium grain and 150 g of extra-long variety is recommended for reducing missing hills during the operation of the mechanical transplanter. After spreading the seeds on tray a thin layer of soil (0.5 cm) is spread over the seeds for covering and after that the trays or mat is irrigated by using a sprinkler or water bucket. To protect the seed bed from birds and animals the place is covered by plastic net.

1.6.9 Management of mat-type nursery

Irrigate the beds by sprinkling water using a watering can for the initial 3-4 days until the seedlings emerged and then irrigate beds by flooding furrows between the beds. Keeping the bed moist may require water to be sprinkled 4-8 times/day for the first 3-4 days. Ensure water retention on the top of the nursery bed by frequently irrigating the furrows until the seedlings are ready for use. Keep the height of levees/bunds higher than the bed height so that water can be retained on the top of the beds. Stop watering 12 hours before transplanting and drain excess water to ensure the mat is dry and ready for transplanting. Transplant when the seedlings are 12-15 cm tall, which is usually 12-30 days after establishment. In Boro season, due to cold 25-30 days are required for mat formation with BRRI Dhan28 and BRRI Dhan29 verities (Fig. 1.13).

Fig. 1.13: Tray with seedling

1.6.10 Nutrient supplement

Normally there is no need of extra nutrient. If needed, fertilizer can be used and also pesticide can be used accordingly.

1.7 Land Preparation before Transplanting

Field is puddled by a power tiller or a tractor. Puddled fields should be levelled and the soil needs to be allowed settling for 24-48 hours. When planting, maintain a uniform depth of 1-2 cm standing water. In un-puddled conditions, the soil should be treated with herbicides as per recommended dose (i.e. Roundup or similar) before 2-3 days of planting. Prior to transplanting, apply light irrigation before 24 hour and drain off any excess water.

1.8 Steps to be Followed during Transplanting

- Feed nursery mats onto the seedling platform
- Leave the area equivalent to one pass of machine on all four sides of the field before starting transplanting to avoid damage to the already-transplanted seedlings while turning the machine
- Start transplanting at the mark running parallel to one of the levees
- Take a U-turn at the end of the field. Each return pass should be parallel to the last row, maintaining the desired row spacing
- Lift the planting platform when driving over the levees
- Keep feeding the seedling mats as needed during the transplanting operation.
- Where there are gaps, fill them manually
- Maintain 1-2 cm of standing water on the field while transplanting and up to 4-5 days after planting
- After seedling establishment, follow management practices for water, weed, nutrients and pest control as recommended for conventional transplanted rice.

1.9 Operation of Mechanical Transplanter

The self-propelled mechanical rice transplanter has two sections: transport and planting. The transport section consists of an engine, a gear box, a lever for adjusting hill spacing or forward speed, two toothed wheel for field operation and steering. The planting section has a floating board, nursery platform, transplanting fingers with screws for adjusting the number of plants per hill and depth setting lever (Fig. 1.14-1.18)

Fig. 1.14: Depth control

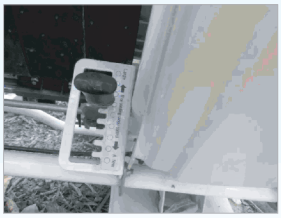


Fig. 1.15: Seedling density control

Fig. 1.16: Hill to hill distance control

Fig. 1.17: Clutch and accelerator

Fig. 1.18: Hydraulic and gear control

1.10 Specifications of Rice Transplanting Machine

Fig. 1.19: ACI DP 488 transplanter

ACI DP 488 Specifications (Fig. 1.19)

Item			DP-488
			Daedong KIOTI
Dimensions (length x width x height) (mm)			2410 x 1530 x 970
Weight (kg)			183
Model			GT600PN (Mitsubishi)
Type			Air-cooled, 4-cycle
Engine	Rated revolution (kw/rpm)		2.94/3,200
	Total displacement (cc)		181
	Fuel tank (liter)		4
	Fuel		Gasoline
Driving unit	Wheel	type	Rubber tread wheel
		diameter (mm)	660
	Transmission Level		Forward: 2 Levels, Reverse: 1 Level
Transplantation Unit	Transplanting interval (cm)		12,14,16,18, 20, 22
	Hill space within row (cm)		30
Traveling speed (m/s) Forward			0.6~1.12
Traveling speed (m/s) Reverse			0.2~0.44
Transplanting speed (m/s)			0.4~0.75
No of Row			4

Fig.1.20: Metal Asia ARP 4UM transplanter

Metal Asia ARP 4UM Specifications (Fig. 1.20)

Item			ARP 4UM
			Metal Asia
Dimensions (length x width x height) (mm)			2350 x 1480 x 800
Weight (kg)			177
Model			G351L
Type			Air-cooled, 4-cycle, gasoline
Engine	Rated revolution (kw/rpm)		2.5/1800
	Total displacement (cc)		141
	Fuel tank (liter)		4
	Fuel		Gasoline
Driving unit	Wheel	type	Rubber tread wheel
		diameter (mm)	660
	Transmission Level		Forward: 2 Levels, Reverse: 1 Level
Transplantation Unit	Transplanting interval (cm)		12,14,16,18, 20, 22
	Hill space within row (cm)		30
Traveling speed (m/s) Forward			0.5~1.4
Traveling speed (m/s) Reverse			0.2~0.44
Transplanting speed (m/s)			0.3~0.7
No of Row			4

1.11 Checking Points for Rice Transplanter Operation and Maintenance

Sl No	Description	To do
01	Engine oil	Check daily Change after 30 hours as per manufacturers guideline
02	Air filter	Check & clean after 3-4 days Change after 100 hours
03	Gear oil	Change after 100 hours
04	Planting gearbox oil	Check every day Change after 30 hours
05	Transplanting finger oil	Check every day Change after 30 hours
06	Finger push rods	Check ease of movement regularly
07	Nuts and bolts	Regularly
08	All moving parts	Regularly

1.12 Engine Checking Points

- Make sure fuel line is open
- Fuel tank is properly filled with fuel
- In cold weather chock valve is properly open
- Sparkplug is working
- Air cleaner is properly in place and there is no clogging
- Accelerator is in starting position
- Main gear is in neutral position.

1.13 Troubleshooting for the Mechanical Rice Transplanter during Operation

Problem	Cause	Solutions
Missing hills or uneven plant spacing	Check seedling mats for poor or uneven growth; Increased seed density in mats	Slow the cross feed time on transplanter; Check the planting claw for wear
Seedling mats collapse on seedling platform	Poor sliding and congestion on seedling platform	Wet the mats before planting and ensure proper size of the mat
Seedlings not released from planting claw	Clay soil of seed bed can create that problem	Reduce planting speed; Keep the mat dry; Increase the planting depth
Floating and moving seedlings	Soil not prepared and excess water in the field	Ensure the soil to be prepared for planting; Remove extra water from the field; Reduce the planting speed
Seedlings with poor root development and not established in soil	Poor seedling development and bad seed quality	Improve seed raising; Take better care for the seedling

1.14 Financial Analysis of Rice Transplanter

Description	Amount
Price of the rice transplanter (Tk)	3,50,000-4,50,000
Life time (Year)	6
Mechanical rice transplanting cost (Tk/ha)	14,000-15,000
Manual rice transplanting cost (Tk/ha)	30,000-32,000
Cost saving (%)	45-50

1.15 Business Opportunities

- Entrepreneurs can purchase rice transplanter for custom hiring service business
- Individual farmer or group of farmers can purchase the machine for custom hiring business
- The rice transplanter is a user friendly machine, and maintenance and operation can be done easily.

Chapter 2

MECHANICAL RICE HARVESTING

2.1 Background

Rice and wheat are the main cereal crops of Bangladesh, which contribute about 93.11% of the national food grain production. More than 80% of the cultivable land is under rice and wheat cultivation. Almost all of these crops are harvested manually by sickle which is laborious, time consuming and costly. Timely harvesting is utmost important, as delayed harvesting leads to a considerable loss of grain and straw owing to over maturity resulting in loss of grains by shattering and also delays in seed bed preparation and sowing operations for the next crop. The scarcity of labor in the peak harvesting season is forcing the farmers delay harvesting causing high postharvest losses and sometimes loss of the crop by natural calamities. Due to increase of cropping intensity and production of different crops, the demand of agricultural labor has increased significantly. Under these circumstances, adoption of appropriate harvesting practices is urgently needed to increase the crop productivity and economic emancipation in rural Bangladesh. Especially, in the Southern Delta of Bangladesh there are several constrains for mechanized harvesting due to coastal vulnerability and climate change, flooding, water-logging, salinity and landlessness, etc. To overcome such kinds of constrains, it is necessary to introduce harvesting machines through training and demonstration and promote coordination and linkages among different service providers for efficient and sustainable use of harvesting machines.

2.2 Purpose of the Training

- To introduce rice harvesting machines available in Bangladesh among the farmers or target beneficiaries in the project areas
- To provide guidelines for the target beneficiaries about operation, repair & maintenance of rice harvesting machines
- To build awareness/skill of target beneficiaries (operators, farmers, mechanics, and manufacturers, etc.)
- To provide information about advantages and economic benefits of mechanical harvesting machines over manual harvesting.

2.3 Expected Outputs of the Training

- Farmers/target beneficiaries will be informed about the mechanical harvesting system and its benefits and the repair & maintenance of the machines
- Operators, mechanics and service providers will be able to operate, repair and maintenance of the mechanical harvesting machines
- All stakeholders will be informed about coordination linkage among beneficiary stakeholders for sustainable use of harvesting machines.

2.4 Present Status of Rice Harvesting in Bangladesh

At present rice harvesting is done manually with hand tools like sickle. Modern rice harvesting machines like use of reaper and combine harvester are seen in limited areas of Bangladesh. Based on this, two types of rice harvesting are available in Bangladesh. These are:

- Traditional harvesting, and
- Mechanical harvesting.

2.5 Traditional Rice Harvesting

Traditional rice harvesting in Bangladesh is labor-intensive (Fig.2.1). During harvesting, laborers are scarce, which often affects the timely harvesting of rice and planting of next crops in the same land.

Fig. 2.1: Manual rice harvesting using sickle

2.6 Disadvantages of Traditional Harvesting

- Labor crisis at peak season of rice harvesting is due to change of occupation from agricultural farming to others
- High labor wage
- Harvesting cost is high as the traditional harvesting is labor intensive
- Crop harvesting is often delayed due to the un-availability of labors
- Delayed harvesting leads to a considerable loss of grains as affected by rain, storm, flash flood and other calamities
- Delayed harvesting resulting in loss of grains by shattering.

2.7 Mechanical Rice Harvesting

Mechanical rice harvesting is very important to increase rice production. Mechanical harvesting also helps in better management of farm by proceeding planting of next crop. To reduce crop losses and increase cropping intensity, it is essential to introduce mechanical harvesting machines.

2.8 Advantages of Mechanical Harvesting

- Low labor requirement
- Low harvesting cost
- Helps in timely harvesting
- Increase cropping intensity
- Reduce drudgery and harvesting loss.

2.9 Classification of Mechanical Rice Harvesting

At present there are three different types of rice harvesting machines available in Bangladesh as shown in Fig. 2.2, These are:

- Reaper
- Mini-combine harvester
- Combine harvester

Reaper | Mini-Combine harvester | Combine harvester

Fig. 2.2: Different types of mechanical rice harvesting machines

REAPER

2.10 Introduction

Reaper is very simple and easy to operate and transfer from one plot to another plot. The harvesting machine like reaper is suitable for poor and marginal farmers with fragmented land. Paddy harvesting by using reaper minimizes the time, drudgery, labor involvement, harvesting losses and increase cropping intensity. Small and marginal farmers are able to buy the reaper. When timeliness of rice harvesting operations is concern reaper appears as the most appropriate harvesting machine. Nowadays, reaper is becoming popular among the farmers as it performs harvesting operation with saving time, reduce drudgery and labor requirement in the operation.

2.10.1 Characteristics and Activities of Reaper

2.10.1.1 Characteristics

- Comparatively small in size
- Price is reasonable
- Repair and maintenance is easy
- Easy to transfer from one place to another
- Easy to maneuver.

2.10.1.2 Activities

- Required less harvesting time compared to manual harvesting
- Average effective field capacity is 55-75 decimal/ hr (0.022-0.26 ha/h)
- Fuel consumption is 3-3.5 liter/ha (1.0-1.0 L/h)
- Its capacity equivalent to 15 reaping laborers.

2.10.2 Advantages

- Reaper saves cost up to 75-85% over manual harvesting
- Labor requirement is only one for driving the reaper
- Reduce human drudgery and labor requirement in harvesting operation
- Can harvest in clay soil
- Shatter and cutter bar losses are almost zero
- Minimizes the harvesting losses
- By timely harvesting, it allows timly preparation of seed bed and sowing operation for the next crop.

2.10.3 Disadvantages

- It is not possible to operate the reaper when standing water is over 10 cm in the land.
- It is not possible to operate the reaper when rice stems are completely shattered on the ground.
- High initial investment is needed.

2.10.4 Technical Specifications

Model		VR-120
Type		Rice and wheat reaper
Working capacity (m^2/h)		2000-3000
Fuel consumption (litter/h)		1.0 - 1.5 Petrol
Crop		Rice, wheat
Harvesting loss (%)		1.0 - 1.2
Harvesting field		Dry, wet, or 10 cm-water flooded
Maximum angle of inclined crop plant (degree)		60^o
Reaping	Reaping width (cm)	120
	Reaping height (cm)	7 - 50
	Reaping device	Reciprocating blade bar
Engine	Type	4 cycle, air-cooled gasoline
	Power (hp@rpm)	4.0 - 6.5 @ 1800
	Fuel	Petrol
Travel speed (m/min)	Forward	60
	Reverse	45
Wheel		Cage wheel (cm): 46 × 28 Option: lug tire wheel (cm): 45 × 23
Operation and Control	Main clutch	Dog clutch
	Harvesting clutch	Dog clutch
	Height adjustment of handle (cm)	75 - 90
Delivery	Upper delivery device	Revolving chain with lug plates
	Lower delivery device	Revolving chain
	Crop plant release	Right side (viewed from rear of machine)
Dimension	L × W × H (cm)	200 × 135 × 110
	Weight (without engine) (kg)	120

2.10.5 Machine Structure and Working Process

The overall structure and components of reaper are shown in Fig.2.3.

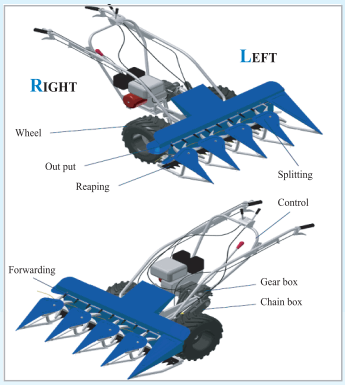


Fig. 2.3: Overall structure of reaper

2.10.6 Components and Assembly of Reaper

Important components and assembly of the components are necessary for operators and service providers. For the particular reason, details of all components and assembly are presented here.

- Splitting
- Reaping
- Forwarding
- Output
- Bevel gear box
- Chain box
- Gear box
- Wheels
- Control

i. Assembly of Splitting (Fig. 2.4)

1. Middle/right splitting bracket
2. Lower (short) spring
3. Upper (long)spring
4. Lower bush
5. Star wheel cover
6. Ball bearing
7. Star feeder
8. Upper bush
9. Right splitting cover
10. Middle splitting cover
11. Left splitting bracket
12. Left splitting cover

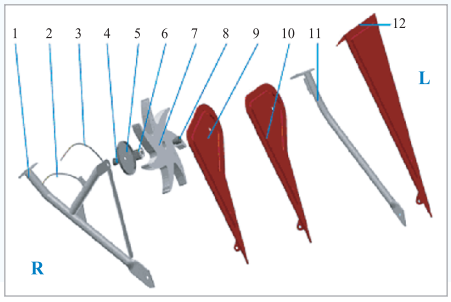


Fig. 2.4: Assembly of splitting

ii. Assembly of Reaping (Fig. 2.5)

1. Blade binder
2. Bold M8x25
3. Adjustable blocking-plate
4. Upper blocking-plate
5. Lower blocking-plate
6. Upper blade
7. Upper blade-bar
8. Lower blade-bar
9. Blade-bar bracket
10. Screw M 6 ×25
11. Lower blade
12. Rivet F5 × 20
13. Rivet F5 × 15

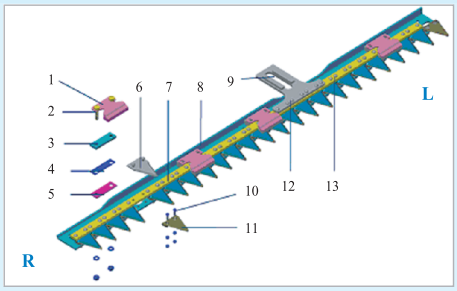


Fig. 2.5: Assembly of reaping

iii. Assembly of Forwarding (Fig. 2.6)

1. Upper forwarding chain
2. Lower forwarding chain
3. Sprocket Z22 - LK
4. Ball bearing 6002 2Z
5. Chain-adjusting screw
6. Sprocket Z22 - 1 (of left shaft)
7. Left shaft
8. Sprocket Z22 - 2 (of left shaft)
9. Sprocket Z22 - 3 (of left shaft)
10. Pillow block 6202 2Z
11. Chain 66
12. Sprocket Z12 - LK
13. Chain-tensioning bracket
14. Ball bearing 6202 2Z

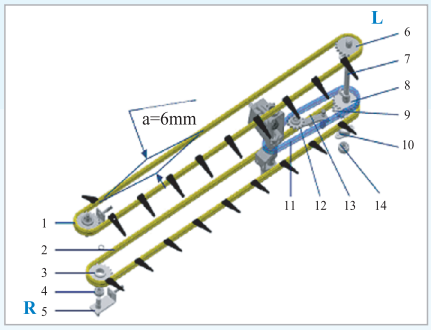


Fig. 2.6: Assembly of forwarding

iv. Assembly of Output (Fig. 2.7)

1. Upper short cover
2. Upper long cover
3. Upper output plate
4. Middle output plate
5. Lower output plate1
6. Lower output plate2
7. Long U rail
8. Middle long cover
9. Lower long cover

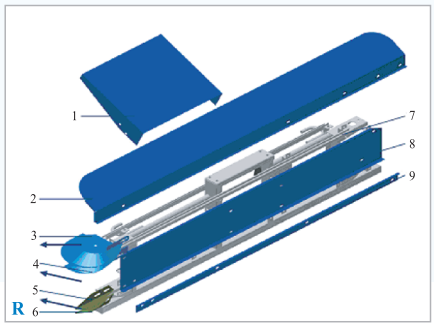


Fig. 2.7: Assembly of output

v. Assembly of Bevel Gear Box (Fig. 2.8)

1. Clutch
2. Clutch
3. Spring-12
4. Spring-28
5. Spring-12
6. Bevel gear
7. Clutch spring
8. Clutch disc
9. Horizontal bevel-gear-box shaft
10. Ball-bearing
11. Spring-35
12. Spring-15
13. Spring 32
14. Ball-bearing 6001 2Z
15. Bevel gear 2
16. Ball-bearing 6002 2Z
17. Vertical bevel-gear-box shaft
18. Sprocket Z9
19. Latch
20. Culit hub
21. Culit bush

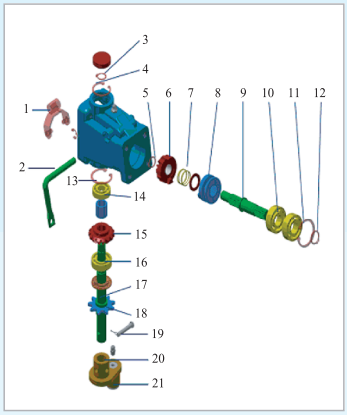


Fig. 2.8: Assembly of bevel gear box

vi. Assembly of Chain Box (Fig. 2.9)

1. Left clutch spindle
2. Wheel-shaft pillow block
3. Left gear-box-shell
4. Left wheel shaft
5. Ball-bearing 6006 2Z
6. Chain
7. Clutch
8. Right wheel shaft 1
9. Right clutch spindle
10. Right gear-box-shaft
11. Right wheel shaft 2

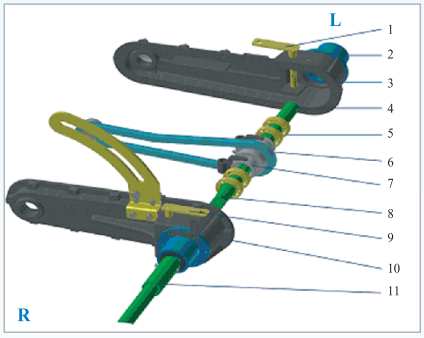


Fig. 2.9: Assembly of chain box

vii. Assembly of Gear Box (Fig. 2.10)

1. Gear-box-shaft-1
2. Clutch disc
3. Gear-box-shaft-2
4. Ball-bearing 6202 2Z
5. Gear-change shaft
6. Gear-box-shaft-3
7. Ball-bearing 6004 2Z
8. Clutch spindle
9. Transmission shaft

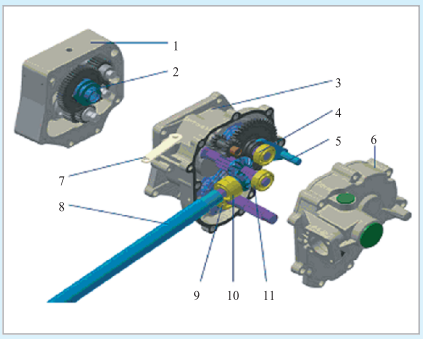


Fig. 2.10: Assembly of gear box

viii. Assembly of Wheels (Fig. 2.11)

1. Left cage wheel
2. Packing ring
3. Wheel hub
4. Right cage wheel
5. Left rubber wheel
6. Right rubber wheel

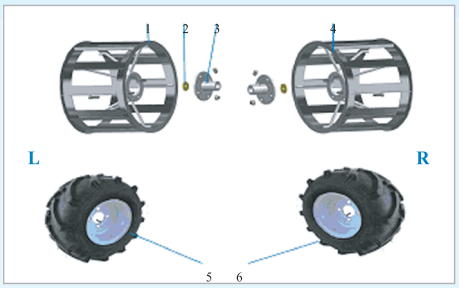


Fig. 2.11: Assembly of wheels

ix. Assembly of Control (Fig. 2.12)

1. Throttle switch
2. Right-turning clutch lever
3. Clutch cable
4. Throttle cable
5. Gear-change lever
6. Right handle (without clutch lever & throttle)
7. Left handle (without clutch lever & throttle)
8. Left-turning clutch lever
9. Reaping switch
10. Moving switch
11. Moving cable
12. Reaping cable

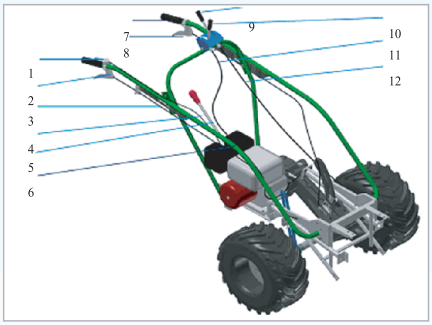


Fig. 2.12: Assembly of control

2.10.7 Power Transmission System

Power is transmitted to the cam by the chain and cam gives reciprocating motion to the cutter bar. It has two side clutches for better turning. It has also two handle levers by which the handle can move up and down to maintain the height of the operator. The reaper is powered by a light weight petrol engine. Its engine rotation is clockwise. The power transmission system of the reaper is shown in Fig.2.13.

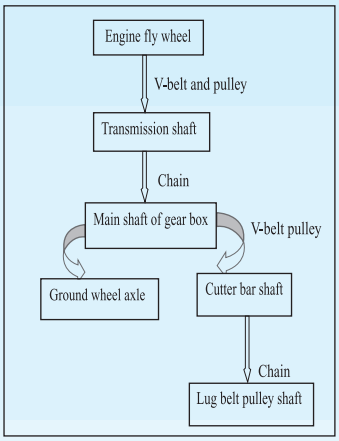


Fig. 2.13: Block diagram of power transmission system

2.10.8 Maintenance

2.10.8.1 Before operation

Before operating the reaper, it is important to check: fuel, engine oil, transmission oil, bevel gear box oil and lubricate the chain and blade. Lubricants used for transmission and gear box are SAE 40 (1.2 liters), chain box (1.0 liters). It is necessary to check lubricating oil using dipstick as shown in Fig.2.14. Guideline about filling of lub oil and checking of lub oil is shown in Table 2.1.

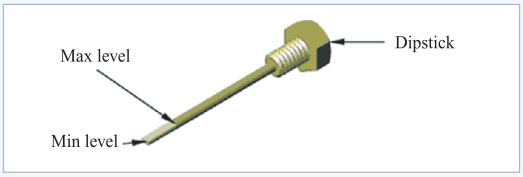


Fig. 2.14: Dipstick

Table 2.1 Guideline about filling checking of lubricating oil

Guide	Check oil level of gear box when the gearbox parallel to the ground, oil level must be between max and min oil level indicated on the screwed dipstick.
Note	Must be refill oil (if oil is below the min level) or replace with new oil (if oil doesn't have enough viscosity).

2.6.8.2 After operation

Some tasks are required to do after using the reaper. Important task and procedure are presented in Table 2.2.

Table 2.2 Required tasks after using the reaper

Guide	**Perform the following works:** i. Clean parts such as: blade, chain, output shaft ii. Lubricate the blade, chain, shaft iii. Check oil level in gearbox iv. After using the machine, if it is stored for a long time, it should be kept under shed.
Note	Must be placed in dry location to avoid rust, out of reach of children and keep in such a way that the gear box should be parallel to the ground to avoid oil leakage.

2.10.9 Operation Procedure

During operation, it is necessary to control the reaper through different levers and switches for perfectly using the machine as well as to avoid unusable situation. Controlling procedure of reaper during operation is shown in Fig.2.15 and Table 2.3.

Control Position

i. Gear-change level
- N: Neutral
- C: Backward
- F: Forward

ii. Moving switch
- A: Moving off
- AA: Moving on

iii. Reaping switch
- B: Reaping off
- BB: Reaping on

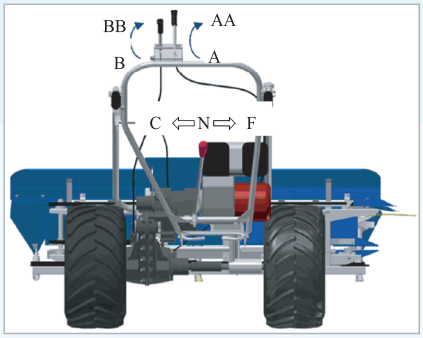


Fig. 2.15: Controlling procedure of reaper

Table 2.3 Guideline about control procedure of reaper during operation
Table 2.3.1 Movement control

Guide	**Forward Movement** ● Start up engine ● Keep throttle switch at min position ● For changing gear: change lever to position D ● For movement: switch to position AA ● Use throttle switch to speed up or down. **Backward Movement** ● Start up engine ● Keep throttle switch at min position

- For changing gear: change lever to position R
- For movement: switch to position AA
- Use throttle switch to speed up or down.

Table 2.3.2 Reaping control

Guide

- Start up engine
- Keep throttle switch at min position
- Switch moving: switch to position A (stop moving)
- Switch reaping: switch to position BB
- Control moving forwards to reap rice plants.

2.10.10 Trouble shooting

Different types of trouble may be observed during operation of reaper in the field. Some of the troubles may be simple and it is possible to solve instantly in the field. Commonly found troubles and possible solutions are presented in Table 2.4.

Table 2.4 Troubles and ways to solve

Guide

Rice plants obstructed in star feeders

- Stop engine
- Disassembly star feeders to take rice plants out
- Assembly star feeder.

Unable to reap rice plants while moving

- Stop engine
- Take out any accumulated rice plants at tip of splitting covers.

Rice plants fall in unexpected direction

- Stop machine
- Adjust output plated as described in section
- Output.

2.10.11 Financial Analysis of Reaper

Description	Amount
Initial fixed investment cost (Tk)	1,70,000
Machine's life time (yr)	5
Yearly fixed cost including interest on investment, shelter, tax and insurance (Tk/ha)	428
Harvesting cost by using reaper including fuel, oil, labor and R&M cost (Tk/ha)	1,404
Total harvesting cost by using reaper (Tk/ha)	1,832
Total rice harvesting cost by manual labor (Tk/ha)	9,200
Costs save by using reaper over manual harvesting (%)	80

MINI-COMBINE HARVESTER

2.11 Introduction

Combined harvesting-threshing-cleaning-bagging by a small machine, commonly known as Mini-Combine harvester is a highly efficient alternative to harvesting, threshing, cleaning and bagging done separately. In Bangladesh, the rice harvesting that includes harvesting, threshing, cleaning and bagging remains as labor-intensive and costly operations. Mini-combine harvester is an useful machine for harvesting, threshing, cleaning and bagging of rice and therefore its adoption in Bangladesh is important for improving production efficiency, reduce costs and minimize losses. In the areas which are prone to be affected by flash flood and other calamities, mini-combine harvester is the best solution to avoid such massive loss. Now-a-days, mini-combine harvester are becoming popular among the farmers as it performs several activities in single operation thus saving the time, drudgery and labor involved in these operations. It is suitable for both marginal and large farmers when operating on custom hiring service basis.

2.11.1 Characteristics and Activities of Mini-Combine Harvester

2.11.1.1 Characteristics

- Comparatively small in size
- Price is reasonable for custom hiring service to all farmers
- Repair and maintenance is easy
- Movement from one place to another is easy
- Wheel is crawler type, so it is possible to harvest paddy in soft soil/clay soil.

2.11.1.2 Activities

- Cutting, threshing, cleaning and bagging are possible in a single operation by mini-combine harvester
- Average effective field capacity is 25-30 decimals per hour
- Fuel consumption is 12-18 liters per hectare
- Paddy straws remain unbroken.

2.11.2 Advantages

- Cost saved 50-60% by using mini-combine harvester
- One labor required for driving mini-combine harvester and another one for carrying rice bag
- Harvesting loss is less than 2%, which is very small compared to traditional harvesting.

2.11.3 Disadvantages

- It can not operates in high standing water
- It can not harvests completly shattered rice
- High initial investment is needed

2.11.4 Machine Structure

The model 4LBZ-110 half feeding crawler self-propelling mini-combine harvester is composed of frame, table, cutter table, cutter head, transmission gear, diesel engine, control system, hydraulic system, electrical system, elevator device, storage and so on as shown in Fig. 2.16.

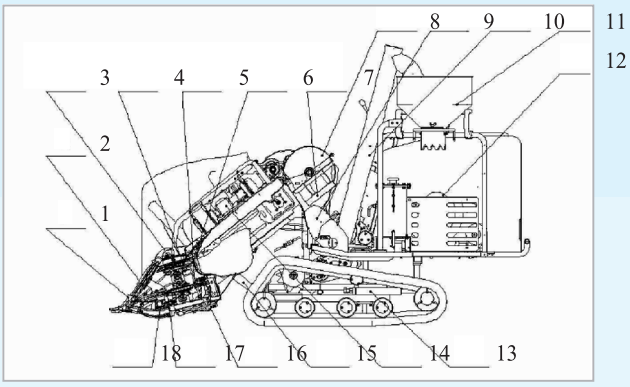


Fig. 2.16: Schematic diagram and pictorial view of overall structure

1. Dividers	7. Grass discharge	13. Chassis
2. Crop lifter	8. Second thresher drum	14. Oil elevator
3. Throwing wheel	9. Thresher grain screw	15. Header support
4. Crop conveyor chains	10. Lifting auger	16. Crop conveyor wheels
5. Crop clips	11. Grain funnel	17. Cutters
6. Threshing belt	12. Power	18. Throwing device

2.11.5 Working Procedure of Mini-Combine Harvester in the Field

During machine operation, the grain dividers (1) separates the crop, the crop lifter (2) guides the plant to the cutters (17) and after cutting off the stalk by these implements, the cut crop is sent to the crop clips (5) by the crop conveyor wheels (16) and chains (4). Under the function of crop clips and crop conveyor chains, the crop is moved forward simultaneously, during the crop conveying, the edible grain passing the rotating threshing belt (6). The debris are sent to the exit by the crop sending chains and are spurted out by the rotating throwing weed wheel (3) and throwing weed device (18), the unwanted straw chaff tumbles from the back of the machine and spread in rows on the field. The threshed grain and a little stalks and chaff pass along the threshing belt, entering the second thresher drum (8), dropping from the sieves into the thresher grain screw (9) and finally into the grain funnel along by the lifting auger (10). Then it is possible to bag. The debris and chaff are excreted into the field. Mini-combine operation in the field is shown in Fig. 2.17.

Fig. 2.17: Rice harvesting by mini-combine harvester

2.11.6 Daily checking before operation

Items	To be checked	To be done
Engine oil	Between the marks above and below	Add oil till the mark between the above and below
Engine cooling water	The water in the water tank is full	Add till it is full (floater on the top)
Hydraulic oil in the tank	Higher than the middle of the transparent oil indicate in the tank	Add till the middle or higher
Open gear and chains	Check the middle transmission and the pressing chaff wheels, all the chain wheels and chains	Add grease in the gear to the chain wheels and chains
Oil the gear in the walking gear	Between the marks above and below	Add oil till the mark between the above and below
Oil the gear of the main gear shaft	Between the marks above and below	Add oil till the mark between the above and below
Air filter	The filter element should not be blocked by the dirt and chaff	Lean and add the oil to till to the mark
Covers	Whether are in good conditions	Re-install and fix
Electrical parts	Whether are in good connection	Whether there is short circuit or open circuit
Silencer and the battery	Whether there is straw	Do away
Clearance between the cutters	front 0.5mm, behind 1mm	Adjust till it gets to the requirement
Screws and nuts	Not loose	fix
Lubrication of the movable parts	Whether needs oil	Add the lubrication oil
Belt, chain and crawler	Whether are loose or damaged	Adjust or replace
Transmission in the chassis	Whether are normal the gears and the turnings	Adjust
The horizontal turning parts of the elevator	Whether there is blocking	Deal with
Overall fuselage	Whether is entwined	Do away
Tools and auxiliary parts	Whether are carried with	Carry them with

2.11.7 Operation and Adjustment of Mini-Combine Harvester

2.11.7.1 Tasks to be done before operating

Before using the mini-combine harvester in the field, it is necessary to do some maintenance and repairing works to make sure that the machine is in good condition which means less trouble and less time with good efficiency and long using life. This work ought to be paid high attention by the operator. This work should focus on the key parts that bear large load, of high rotating speed and with high vibration frequency, and to the wearing parts such as cutter bars, conveyor chains, belts, threshing belts and the bearings and so on. The following task should be done before using the mini-combine harvester in the field:

- Check the fasteners and connectors such as the nuts on the fixed shaft on the header, the fixed nuts on the slider of the cutter top, the connecting bolts, the fixed rivets on the removable cutters and fixed cutters. If loose, must crew till tight.
- Check whether there is stripping and crack on the element.
- Check the threshing belt, crawler, belt and the chains whether are tensioned well.
- The lubricating points should be added oil strictly according to the request (all the chains, chain wheels, the middle conveyor chains and wheels, all the hinge, cutter and joint bearings etc. are as below in Fig. 2.18).
- Check whether there are unidentified objects inside the fuselage.
- Make the gear engaged in neutral, position the clutch up in off, turn the electric switch to "on" on the board and then pull the swift of the mechanism on the header to on. The cutter unit starts. Step slowly on the gas pedal till to the 80% (about 2000 rpm), check the ability of the all the parts and whether they are in good condition, whether there is noise and heating, if is, then park and deal it with.
- Check whether the shift lever and adjust up and down of the header are flexible.
- All the parts above should be checked again after finishing all the harvesting work, if obstacle found, deal away in time in order to work quickly next day.

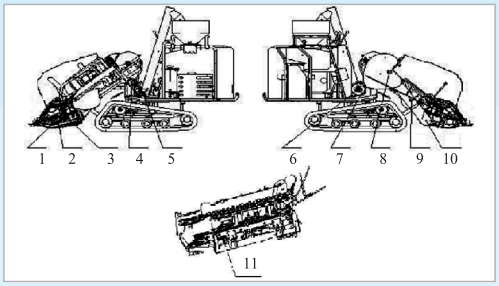


Fig. 2.18: Schematic diagram of the main parts to be lubricated

1.Cutters	5. Elevator chain wheels	9. Chains
2.Crop conveyor chains	6.Main transmission chains wheels	10. Gearbox chain wheel
3.Crop conveyor wheels	7. Chains	of the main shaft
4.Thresher grain exit screw chain wheels	8.Middle conveyor chain wheels	11. Joint bearing

2.11.7.2 Functions of the shift levers and control

The functions of the controlling structure and operating methods are shown in Fig. 2.19.

- Shaft one is for the control of gears, used to control their itinerary. There are four gears in total, three forward, one for reverse.
- Shaft two is for the clutch of the header mechanism, used to control the connection of the output on and off between the header and the diesel engine. When is positioned on off, the engine will start.
- Shaft three is for the control of the rise and fall of the header. Putting forward is fall, pulling up is rise.
- Shaft four is for the control of turning right and left and for the parking.
- Switch 5 is for starting the engine, when the key turns to right the engine starts, when it is loosened the switch returns.
- Switch six is for the control of the front and rear lights and the winnowing triple switch, used to control the lights and fan.
- Switch seven plays the dual role, is the switch of the electric clutch and the functions as protection of the engine when starting.

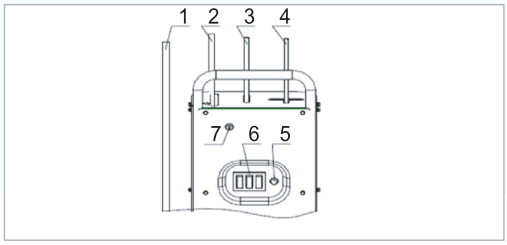


Fig. 2.19: Controlling structure of mini-combine harvester

2.11.7.3 Operating instruction

- **The off and on of the engine:** The shift lever of the gear should be engaged in neutral, and the one of the clutch of the header on off, the electric switch be on "on" before starting.
  - Start the electricity of engine: turn the key to the furthest right, then the engine starts; while relaxing the key it will reset to the neutral position.
  - When the engine cannot be started due to the insufficiency of the electricity, can start manually: pull out the decompression string of the engine, spread the bracket on the platform, insert the crank into the ignition of the engine and turn it quickly then can take it out and dismantle the bracket as shown in Fig.2.20.
  - Shut down the engine: turn the accelerator handle back to the lowest position for low speed, after a while can turn the handle manually back to the lowest to make it down completely.
- **The marching of the machine:** Select the gear by the shift lever and then turn the switch to the position which means walking.

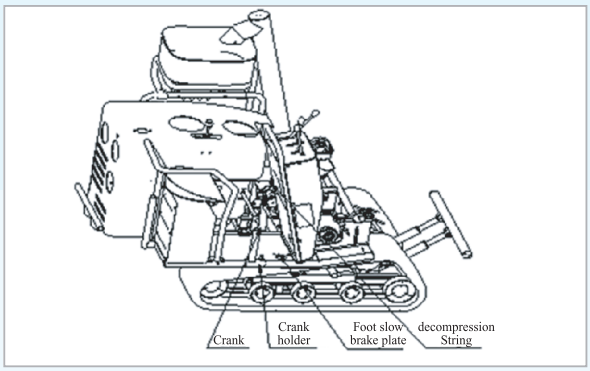


Fig. 2.20: Starting and slow braking

- **Shift and engage in gears:** At first pull back the brake handle (or turn the electric switch off) to stop the machine, then adjust the gears. When relax the brake handle (or turn the electric switch off), the machine marches. If the operator changes the gears incorrect manners, the transmission gear will be damaged.
- **The header and the cutter:** Position the clutch handle of the mechanism on, then the engine transmits the power to the header and cutter, if position off, then they stop working.
- **Elevate and let down the header:** Push the shift lever then the header descends, pull backward then it rises. During this operation, control the speed at a soft slow speed. Do not press the shift lever any more when the header has got to the top, or it will damage the oil tank and parts.

- **Turn right and left and brake:** Step on the braking pedal if pull backward then the machine stops completely. When turns in a sudden, there is no need the step on the brake pedal, just press the shift lever sideways to the left then the machine turns to the same direction, if to the right, then the machine also to the right.
- **Illuminate and winnow:** The switches are for illumination and for winnowing device.

Additional Instructions

- While operating, it is required to follow the indication on the board of the control table, this is because in right manners operating/operator can avoid the damages at most scale.
- As soon as it begins to walk the gears must be right while marching the machine. Take care whether there is somebody around at right, left or back when turn and reverse the machine.
- The operator should concentrate on all the parts running, adjust the feeding according to the grain production, and the cutting width and height according to the crop, also, the oil control handle scope according to the working load. If there is abnormal sound or accident, should stop the engine and deal with the problems.
- The assistant takes charge of the receipt of the grain. This person should concentrate to prevent accidents. There should be space between the bag (or crate) and the grain exit towards the storage. If there is accident during this process should stop the engine and seal with the problem, and when the machine is still working, it is forbidden to stretch the arm or hand or any other part of the body into the thresher pipe, or it will cause injuries.
- It is required to stop the engine to deal the accidents may happen during the operation.
- When the machine needs to drive between the long distance of two fields, there is no need for the clutch device, because this can reduce the abrasion between the parts.
- It requires experience of operating on fields and training for the operator.
- Do not change the bag when the machine turns the direction or reverses, or it may cause injuries or make the grain drop out from the bag.

2.11.7.4 Maintenance of the Mini-Combine Harvester

- Except everyday maintenance before the work, it should be maintained overall after the work of a quarter of a year.

- This is required to add the fresh lubricant to the transmission shafts, exposed gears, conveyor chains and the cutters, add the grease to the hinge pin.
- Check over the wearing parts: the grain elevator on the header, the cutters on the second threshing cylinder, the movable and fixed cutters, the cover of the crank handle, the thresher belt, the cylinder sieves, the brush and the belts etc. When necessary, repair and change them.
- Check the thin boards: the header plate and the outside exit pipe. When necessary, repair or change them.
- The wrecked or rusty outside parts should be removed off the rust or re-sprayed
- Spray the preservative oil and grease to the cutter unit and the chains.
- Un-tighten the triangular belt and the conveyor chains.
- The storage should be dry, ventilated, should not be in the air (Fig. 2.21 and Fig. 2.22).
- The spear parts should be piled up tightly separated, divided into big parts and small parts. The small ones should be packaged in cases.
- The header should be under laid with two straight and plat wooden blocks indicating to the direction of the elevator conveyor, with fulcrum on the joint strength beneath the header. This is requires stability and little pressure on the cutters.
- Take away the wire from the battery, keeping well, charge it with the other charger or by the machine. This is for preventing the battery from damages.
- Clean out the straw, chaff or grain from inside and outside the machine.
- Check with more frequency while in rainy days or wet seasons.

Fig. 2.21: Cleaning mini combine after harvesting

Fig. 2.22: Covered by polythene after cleaning

2.11.8 Transferring Mini-Combine Harvester from One Place to Another

2.11.8.1 Requirement to transport Mini-Combine

- Every element should be checked whether there is any disordering or crack, all the nuts and bolts whether are connected or fixed well, the frame structure whether is regular, etc. If any problem mention above appears, ought to take measures to do away.
- When starting, the engine should first start up the header.
- If the slope on which the machine drives when loading and unloading, marching at low gear, at the same time, stepping on and fixing the brake pedal (with nuts for low turning round) and with the assistant helping beside.
- When marching on rough path, please make the machine at low speed.
- It is forbidden to drive down at steep hillside at neutral gear. This is for preventing from the header drooping and damaging the dividers.
- Heavy carriage is forbidden during the driving.
- When the distance is longer than 5 km, should transport by truck to avoid abrasion and the accident as shown in Fig.2.23.

Fig. 2.23: Loading mini-combine in a truck for transferring shed to field

2.11.8.2 Special attention to the objects as below when load and unload

- Please use special dock board to load and unload (when the machine is on, it should not be irregular obviously). The width should be 1.2 times of the rubber track, the length 4 times of the height of the board of the truck. It should be skid-proof.
- The hook of the dock board or the bent board (locks the carriage with more than 200mm), aligning to the carriage without obvious interstice.
- The hook and the board should be strong for the machine.
- The loading or unloading places should be flat, and the work should be completed with the assistant and the operator. First step on the brake pedal and fix it on (with nuts for slow turning round). To ensure the safety, before loading and unloading, align the rubber track to the dock board. Do not turn the direction and brake it at this process or it will slip and cause rollover.

- It is forbidden to load or unload in neutral gear. It should be gear one or reverse gear.
- It should be in low rpm, and the engine cannot be stopped during unloading.
- One man on the carriage and one man on the ground where can easily avoid the dangers and operate the machine when load and unload. Nobody is allowed to stand on the machine. The two men should work coincidentally with each other as shown in Figs. 2.24 and 2.25.

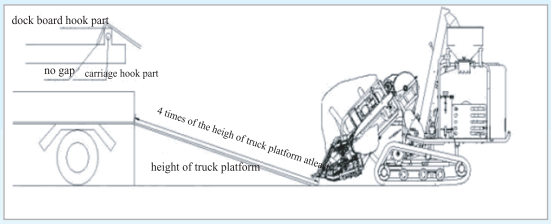


Fig. 2.24: Harvester loading in truck

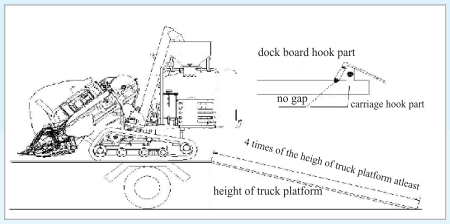


Fig. 2.25: Harvester unloading in truck

2.11.8.3 Carriage of the machine in components

- All big parts should be guarded according to the working condition. Do not place it upside down.
- When need to tie anything to the machine, should tie it to the strong frames, not to the thin parts, belts, shafts or casting parts which are easily get irregular or be damaged.
- The heavy things are forbidden on the thin wall parts, gears or the cutters.

2.11.9 Financial Analysis of Mini-combine Harvester

Description	Amount
Initial fixed investment cost (Tk)	650,000
Machine life (yr)	10
Yearly fixed cost including interest on investment, shelter, tax and insurance (Tk/yr)	110,500
Total harvesting cost for using mini-combine (Tk/ha)	9,880
Total paddy harvesting cost for manual harvesting (Tk/ha)	20,847
Cost saved by mini-combine over manual harvesting (%)	52

Chapter 3

CONSERVATION AGRICULTURE AND IRRIGATION MACHINERY

3.1 Background

The agricultural sector contributes 14.10% of Bangladesh's GDP. Almost 67% of her total population directly engaged in crop production. Out of 66.64 million active labours in Bangladesh, 27.06 million (40.2%) are engaged in agriculture. Evidence indicates a progressive shrinking of rural labour availability, as workers migrate to cities or abroad to earn more wage, particularly in the garments, service, and construction sectors. Cropland availability in Bangladesh is declining by 68,760 ha each year (0.73%) since 1976. However, Bangladesh needs to produce double food from the same piece of land to attain the target of Sustainable Development Goal (SDG) of the United Nations. To mitigate labor shortage, farm mechanization is one of the best option for sustainable crop production. Appropriate farm mechanization has been emphasized as an important policy and development goal in Bangladesh. In this view, Farm Machinery and Postharvest Process Engineering (FMPE) division of Bangladesh Agricultural Research Institute (BARI) has been developed modern agricultural machinery such as high speed rotary tiller, seed planter, bed planter, maize sheller, multi-crop thresher, axial flow pump, solar pump etc. suitable for farmers. To introduce and promote these modern machines among the stakeholders (farmers, operators, small entrepreneurs, mechanics, and manufacturers, etc.) it is needed intensive training and extension work. At this end, BARI is collaborating with the Appropriate Scale Mechanization Innovation Hub (ASMIH)- Bangladesh project of Bangladesh Agricultural University. It is expected that this training manual will play an important role for this purpose.

3.2 Purpose of Training

- To introduce new modern conservation agricultural machinery among the farmers or targeted beneficiary in the project areas
- To provide information about advantages and economic benefits of these modern machines over manual practices
- To provide relevant information and guidelines for the targeted beneficiary about operation, repair and maintenance, safeguarding, business planning of these machines
- To build awareness, skill and knowledge of targeted stakeholders on modern conservation agricultural machinery
- To encourage the youths on entrepreneurship and rural development.

3.3 Expected Outputs

- Stakeholders will become familiar with general aspects of modern conservation agricultural machineries
- Farmers/targeted beneficiary will be informed about the tillage, seed planting surface water irrigation systems with its benefits of these machines
- Operators, mechanics and service providers will be able to operate, repair and maintainance of these machines
- All stakeholders will be informed about co-ordination linkage among beneficiary stakeholders for sustainable use of these modern machines.

BARI SEED PLANTER

3.4 Introduction

For successful crop cultivation, land preparation is very important. Land preparation is one of the major activities to establish any crop. Generally, farmers in Bangladesh grow rabi crops (dry winter) after rainfed Aman (Monsoon) rice with 3-4 numbers of ploughing followed by laddering using two-wheel tractor (power tiller) or four-wheel tractor and hand broadcasting of seeds. This traditional tillage method reduces soil organic carbon at double rate and decreases soil fertility, losses soil moisture, and damages ecological environment. Repetitive tillage requires significant amounts of fuel and energy and results in increased production cost and reduced profit. Again, every crop has its optimum time of sowing/planting. The existing full tillage system for crop planting after Aman rice is being delayed by 10-15 days. This traditional way of land preparation for crop establishment is laborious, time consuming and costly. Delay sowing/planting reduces yield significantly. Mechanical planting/sowing in keep contributes in timely sowing which not only increases yield and cropping intensity but also reduces turnaround time. CA tillage machinery such as strip till (ST) planter, zero till (ZT) planter and minimum till (MT) planter are used for shallow tilling followed by seeding and seed covering in a single pass which saves about 60% fuel. An appropriate seeder machine named PTOS (power tiller operated seeder) or BARI Seeder Machine was developed by Farm Machinery and Postharvest Process Engineering (FMPE) Division of Bangladesh Agricultural Research Institute (BARI) which can utilize residual soil moisture for crop establishment, reduce turn around time, cost reduction and manage crop residue properly. This machine can accomplished three operations in a single pass, shallow tillage (up to 60 mm), placement of seed in a furrow and leveling cum pressing three types of combined tilling operations such as ZT, ST, and MT can be performed with this machine by arranging rotary blades at optimum moisture content of 15 to 30% of soil moisture level. The average field capacity of this machine is 0.09-0.12 ha/h.

3.4.1 Advantages

- It can be manufactured in local workshop
- It can be operated in small land and easily transportable
- Reduce turnaround time
- Seeds can be sown at uniform depth
- Tilled residue-free strip warms quickly
- Well suited for poorly drained soils
- Excellent erosion control
- Soil moisture conservation
- Minimum fuel and labour costs
- Builds soil structure and health
- It can save 30-35% fuel and 30-50% seeding cost
- Yield increases by up to 15-20%
- Environmental friendly as it reduces carbon emission.

3.4.2 Specifications of BARI Seed Planter

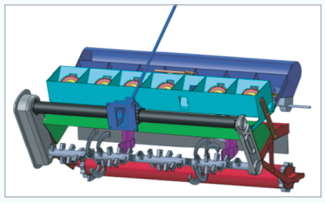
- Dimension : 720 mm×1320 mm×700 mm
- Weight : 167 kg
- Number of rotary blades : 48
- Power requirement : Power tiller (9-12 kW)
- Number of rows : 6 (line number adjustable)
- Row spacing : 200 mm (adjustable)
- Normal working speed : 1-3 km/h
- Working width : 1200 mm
- Normal seeding depth : 50-60 mm
- Type of seed meter : Inclined plate type
- Speed of blade : 450-500 rpm
- Price of the seeder : BDT 190000.00 (US$2375) (With 9 kW Power tiller).

3.4.3 Description of BARI Seed Planter

Seed planter machine has basically two main units:

1. Power unit: Power tiller (9-12 kw) use as driving unit.
2. Seeding unit: Locally made seeder unit hitched with power transmission unit of power tiller.

Power unit



Seeding unit

BARI Seed planter attached with power tiller

Fig. 3.1: View of BARI seed planter

3.4.3.1 Different working parts of Seed Planter

1. Cutter blade
2. Roller
3. Seed box
4. Seed "On-Off" lever
5. Seed tube
6. Roller bar
7. Rotavator chain box
8. Seed metering device
9. Rubber guard
10. Roller bearing box
11. Tillage depth control lever

Table 3.1 Type of inclined plate seed metering devices for different crops and seed rates

Types of crops	Inclined plate type	Seed rate (kg/ha)	No. of row
Wheat	32	120	6
Mungbean	28	24	4
Soybean	20	30-32	6 or 4
Rice	11	7-10	6
Jute	32	5	6
Chickpea	35	35-40	6
Sunflower	9	8-10	2
Maize	9-10	22-25	2

3.4.4 Working Principle

The seeding part is attached with power tiller replacing the rotavator part of the power tiller. This machine consists of 48 numbers of "C" type rotating blades arranged in face to face alternate outside configuration for pulverizing soil at shallow depth with very high speed (450-500 rpm) and having inverted 'T' furrow opener for furrow opening and seed dropping in the furrow properly. Seeds are drilled continuously or at regular intervals in rows and depth of sowing can be maintained. A bar joined with the roller has several holes, moderation of which enables reducing or increasing the depth of ploughing. The power tiller has to be taken at north or south side of the land and seeds have to be poured in the seed-hopper. Special type inclined plate seed metering devices are used for planting of different crops like maize, jute, wheat, pulses and oilseeds directly. Seeds are placed at uniform depth, covered, compacted and maintained uniform population per unit area. Before operating the machine in the field, the sprocket of the seeder has to be attached with the sprocket of the wheel shaft by means of chain. At the beginning of operation, the gear of the rotating blades has to be engaged. The machine has to start operation at a speed of 1.0 to 1.5 km per hour by keeping the power tiller at first or second gear. Blades are arranged in face to face alternate inside configuration and remain in gang at front position of seed furrow opener for tilling (Fig. 3.2). When the machine moves forward, the seed plates

rationally start dropping seeds from the seed hopper. The seeds fall through tubes into the furrows, created by furrow openers. The arrangement and number of furrow openers depend on the line spacing of crop to be grown. It is to be observed whether seeds are being poured in lines properly through plastic tubes. After reaching the end of the land, the seeder needs an U-turn for which the rear part of the seeder has to be raised and started sowing again in the next row. It is to be observed carefully whether the metering device is moving properly or not. This process is continued. In strip tillage method, 15^{o} tip angle rotary blades are used for proper back filling of soil in the furrow. The number of rotating blades is reduced to 24 and each four blades is arranged in face to face inside configuration (Fig. 3.3) so that they remain in gang at the front position of seed furrow opener for tilling in strip 5-6 cm and creating tilt soil just in front of furrow openers and between the two furrow openers the soil remained untilled. Zero tillage can be done by removing the rotary blades (Fig. 3.4 and Fig. 3.5).

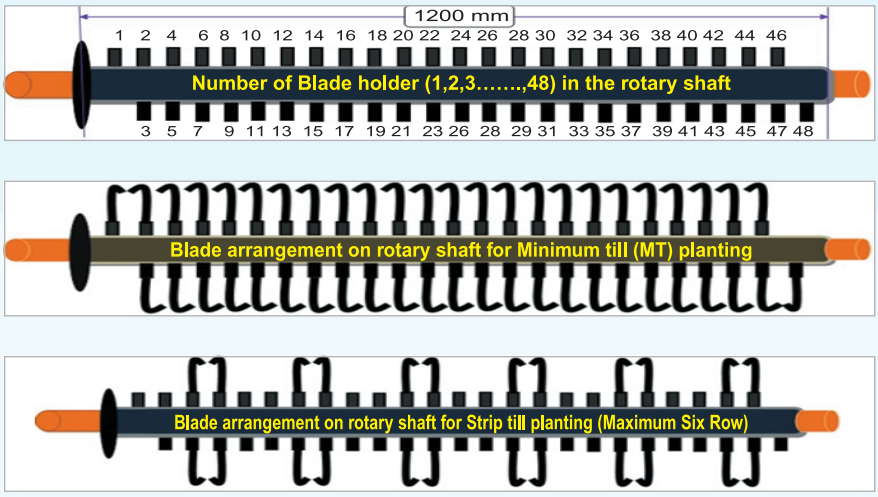
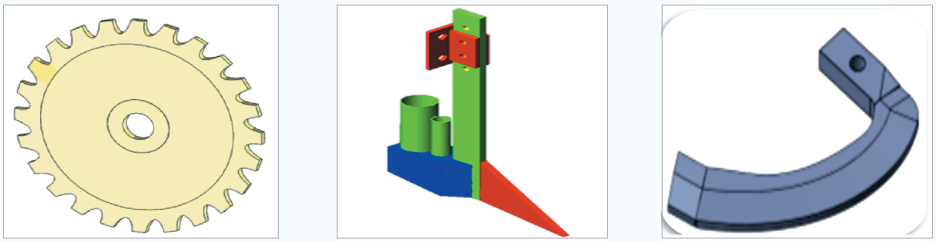


Fig. 3.2: Arrangement of blades of BARI seed planter



Inclined seed metering device | Inverted 'T' furrow opener | 15^{0} strip blade

Fig. 3.3: Seed meter, furrow opener and strip blade of BARI seed planter machine


Zero till planting


Strip till planting


Minimum till planting

Fig. 3.4: Views of different tilling and planting methods using BARI seed planter


Jute


Mungbean


Soybean


Wheat

Fig. 3.5: Views of crop field planted by BARI seed planter

3.4.5 Field Performance

- Crops: wheat, maize, jute, paddy, oil seeds and pulses
- Field capacity: 0.09-0.12 ha/h (20-25 decimal/h)
- Field efficiency: 50-75%
- Operating cost: 2500-4000 Tk/ha (US$ 30-50) by seeder, 5000-6000 Tk/ha (US$ 58-70) by conventional method.

3.4.6 Maintenance

- Seed box must be emptied after field work and roller, blade etc. should be cleaned with water
- Use lubricant in all rotating parts
- Dissemble the seeder from the power tiller and keep the seeder gear box under sunlight, rain free dry shed covering with clean polythene for the next season.

3.4.7 Precautions

- Machine must be stopped for any change during operation
- Don't drive the machine backward during operation.

BARI BED PLANTER

3.5 Introduction

Bed planting adds a new era in modern farming system. It saves natural resources, increases yield, reduces production cost and facilitates different crop management. In Bangladesh, farmers are practicing bed planting for potato, maize, chill vegetables etc. from long ago for protecting their crops from waterlog problem due to heavy shower. They make bed manually and it is very laborious, time consuming and costly. They have limited knowledge about bed planting technology and crops grow better in bed. Considering the above facts, BARI have developed a bed planter (Fig. 3.6) for reducing labor requirement, cost of bed formation and seeding time as well as higher yield and income of farmers.

Fig. 3.6: BARI bed planter

3.5.1 Advantages

- Bed formation and seeding can be done in a single operation
- Operation & maintenance is very easy
- Environmental friendly
- Reduce arsenic absorbstion in crop
- Seed can be sown by bed planter without removing crops residues
- Reduces turnaround time and helps to increase crop intensity in cropping pattern
- Every plants and lines get border effect that increases both growth and yield of crops
- Increase cereal crops yield by 5-20%, pulse crops by 15-35% and fiber crops (Jute) by 10-15%
- Reduces irrigation water by 25-30%, nitrogen fertilizer by 10-15%, seed by 15-20%, tillage costs up to 60%.

3.5.2 Specifications of Bed Planter

- It is made of MS angle bar, MS sheet, MS flat bar, bearing, MS shaft etc
- Overall dimension: 1200×800×720 mm
- Height of bed: 150-200 mm
- Width of the bed: 600-700 mm (controlled)
- Distance between bed to bed: 300 mm wide
- Price: Tk 40,000 (US $475) (without power tiller)
- Weight: 95 kg.

3.5.3 Description of Bed Planter

Bed planter machine has basically two main units:

1. Power unit: Power tiller (9-12 kw) use as driving unit
2. Bed planting unit: Locally made bed planting unit is hitched with power transmission unit of power tiller.

3.5.4 Working Principle

BARI bed planter is attached with power tiller that can till soil, make bed and sow seeds simultaneously in a single pass. Seed can be sown on bed either single or double lines and maintaining seed to seed distance following standard agronomy of different crops. In this bed planter, blades are arranged in face to face inside configuration (Fig. 3.7) remain in gang at front position of furrow opener for tilling and allied in such a way that tilth loose soils are thrown in inner side from left and right sides then form bed (Fig. 3.8). A roller behind the rotating blades lightly presses the loose soil and makes the bed compact and uniform in size and shape. Round aluminum or plastic plates with grooves of varying sizes are mounted within a plate holder which is rotating during power transmission. Machine adjusting, field operation, seed planting process are as similar of BARI Seeder. Both Sifeng and Dongfeng model bed planters are available.

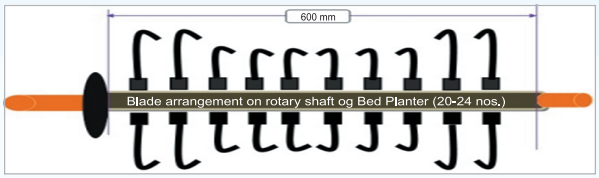


Fig. 3.7: Blade arrangement of Bed Planter

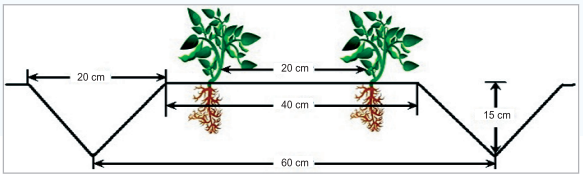


Fig. 3.8: Bed diagram

Fig. 3.9: Operational view of bed planter

3.5.5 Field Performance

- Field capacity: 0.08-0.10 ha/h (20-24 decimal/h)
- Field efficiency: 50-75%
- Operating cost: 2200 Tk/ha (US$ 28) by bed planter, 6000 Tk/ha (US$ 75) for wheat, 15000 Tk/ha (US$ 188) for maize by conventional practice.

Table 3.2 Cost comparison between traditional method and bed planting method

Types of crops	Cost/Bigha (33 decimal), Tk.		Cost savings (Tk.)
	Traditional	Bed planting	
Wheat	750	350-450	300-400
Maize	3200	1000-1200	2000-2200
Mungbean	550	350-450	100-150
Sesame	700	350-450	250-350
Vegetables	900	350-450	450-550

Mungbean

Wheat

Maize

Fig. 3.10: Views of different crop field planted by bed planter

3.5.6 Maintenance

- Seed box must be emptied after field work and roller, blade etc. should be cleaned with water
- Use lubricant in all rotating parts
- Dissemble the seeder from the power tiller and keep the seeder gear box under sunlight, rain free dry shed covering with clean polythene for the next season.

3.5.7 Precautions

- Machine must be stopped for any change during operation
- Don't drive the machine backward during operation.

BARI SOLAR PUMP

3.6 Introduction

Bangladesh has 1.77 million irrigation pumps of which 85% run by diesel. The price of diesel is ever increasing. On the other hand, electricity in our country is insufficient and uncertain. This condition is creating adverse problem to operate irrigation pumps. The extraterrestrial solar irradiance in Bangladesh is 4.0-6.5 kWh and during summer, solar energy is available almost 6 to 9 hours in a day. The price of solar pump is reducing. So, solar energy can be used alternative in Bangladesh where grid electricity is not available. Solar pump is pollution free and environment friendly. To irrigate surface water, a pump of one horse power has been developed. The pump is operated by a 1000 Wp panel (Fig. 3.11). The pump is directly coupled with one horse power DC motor. So, no battery is needed. The pump can run only by solar energy. The pump will not work during night time and cloudy or foggy weather.

Fig. 3.11: BARI solar pump

3.6.1 Advantages

- Centrifugal type solar pump is suitable for surface irrigation
- This pump can lift water from 6.0 m depth
- It is operated by 1000 Wp solar panel
- The pump requires no battery
- Vegetable cultivation is economically profitable using solar pump irrigation

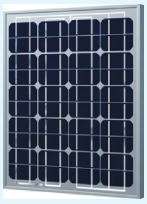
3.6.2 Specifications of Solar Pump

- Water lifting suitability: surface water
- Diameter of pipe: 38 mm (1.5 inch)
- Motor capacity: 800 Watt (1.0 hp)
- Solar panel capacity: 1000 Wp
- Motor type: DC
- Motor rpm: 3500
- Price of solar pump: Tk 80,000 (US$950)

3.6.3 Common Module Technologies

Types of photovoltaic panels and their characteristics are given below:

Table 3.3 Types of photovoltaic panels and their characteristics

Mono-Crystalline	Poly-Crystalline	Amorphous (thin film)
• Silicon mono crystalline • Waver arrangement • Efficiency: 17-20% • Aluminium frame with glass cover • Nominal Voltage: 12/24 V DC	• Silicon poly crystalline • Poly-waver arrangement • Efficiency: 15-18% • Aluminium frame with glass cover • Nominal Voltage: 12/24 V DC	• Silicon amorphous • Surface coating • Efficiency: 6-8% • Standard and flexible framing • Applicable on various materials • Nominal voltage: 12-48V DC
		

3.6.4 Working Principle

The solar panel is made of silicon mono-crystalline chips. It consists of 1000 W photovoltaic cells. The cells capture sunlight and a direct transformation of solar power into electric power is obtained. The panel provides power to a DC motor and the motor is directly coupled to a 1 hp centrifugal pump. No battery is required for this operation. The pump can lift water from 6.0 m depth. The fluid is sucked in axially, due to the rotation effect of the impeller, into the pump body where it is radially accelerated in the vane before being forced out. The shaft is driven by the electric motor. The motor can only use solar energy. The pump will not work during night time or if the sky is cloudy (Fig. 3.12 and Fig. 3.13).

Fig. 3.12: Solar pannel installed with fixed strong structure

Fig. 3.13: Solar pannel installed with auto-tracker structure

3.6.5 Irrigation of Vegetables, Wheat, and Boro Rice using Solar Pump

Irrigation applied using solar pump in drip and furrow irrigation methods for brinjal and tomato cultivation are given in Table 3.4. Drip irrigation method is a water saving method. It is observed from table that the water saving by drip irrigation over furrow irrigation is 56% for brinjal cultivation and yield increase 10.46%. On the other hand, water saving in drip irrigation over furrow irrigation for tomato cultivation is 52% and yield increases 22.39%. So, from result it is observed that irrigation applied using solar pump in drip irrigation method, yield increased 10-20% and water saved 50% (Fig. 3.14 and Fig. 3.15).

Table 3.4 Comparison of water used in drip and furrow irrigations methods for brinjal and tomato cultivation

Irrigation method	Yield of Brinjal		Irrigation of brinjal		Yield of Tomato		Irrigation of Tomato	
	Yield (ton/ha)	Yield increase (%)	Irrigation applied (mm)	Water saving (%)	Yield (ton/ha)	Yield increase (%)	Irrigation applied (mm)	Water saving (%)
Drip	35.58	10.46	233	49.01	51.43	22.39	295	50.83
Furrow	32.21		457		42.02		600	

Fig. 3.14: Pictorial view of tomato cultivation using solar pump

Fig. 3.15: Pictorial view of brinjal cultivation using solar pump

3.6.6 Financial Analysis of Solar Pump for Surface Irrigation of Vegetable and Cereal Crops

Cost items	Tomato	Brinjal	Wheat	Boro rice
Initial investment/cost for pump (Taka)	450000	450000	450000	450000
Depreciation (Tk/year)	20250	20250	20250	20250
Interest on investment (14%) (Tk/year)	3150	3150	3150	3150
Repair, maintenance and shelter (Tk/year)	4500	4500	4500	4500
Fixed cost for solar pump (Tk/year)	27900	27900	27900	27900
Water requirement per season (mm)	610	460	430	1288
Command area (ha) at 60% irrigation efficiency (using hose pipe)	1.06 (2.62)	1.40 (3.45)	3.75 (9.26)	0.58 (1.43)
Land use cost (Tk/year)	23080	34132	43744	6944
Total fixed cost (Tk/year)	50980	62032	71644	34844
Total variable cost (input cost+ interest on operating capital) (Taka/year)	99153	86117	38664	66099
Total cost (Fixed cost + variable cost) (Tk/year)	150133	148149	110308	100943
Yield (t/ha)	38.00	30.00	3.50	4.25
Total production of crop (t)	40.28	42.00	13.13	2.47
Price at harvesting season (Tk/t)	10000	10000	25000	20000
Gross return (Tk)	402800	420000	328250	49400
Net return over total cost (Tk)	252667	271851	217942	-51543
Benefit cost ratio over total cost	2.68	2.83	2.98	0.49

Total investment= Solar pump cost + solar panel cost + Pipe, Fittings etc. cost, Life of pump= 20 Years

3.6.7 Operation & Maintenance

- Solar panel should be installed at shadow free, sunny place so that it can take whole day sunlight
- Solar panel must be mounted with strong structure so that it protects from breakage due to any reason of fall down
- Solar electricity should be carefully used as like as grid electricity
- Instrument and other accessories must be placed keep away from solar panel during electrical wiring with panel
- Solar panel should be cleaned regularly for removing dust and dirt using cloth
- Solar panel should be connected such a way to achieve correct voltage otherwise the motor may burn
- Pump should be fitted very near to the water source
- Make sure that strainer of the suction pipe remains fully submerged in the water
- Be careful that strainer should not touch on the mud or the bottom of the water source
- Make sure animals, children or other obstacles will interfere with the engine or the pump while they operate
- Do not manipulate any of the pump parts while it is running, in case of detecting any problem, stop the motor immediately.

BARI AXIAL FLOW PUMP

3.7 Introduction

The farmers of Bangladesh rely on 1.77 million of centrifugal type irrigation pump of which about 174000 are centrifugal type low lift pump. An axial-flow pump is a common type of pump that essentially consists of a shaft and an axial impeller in a pipe. The propeller can be driven directly by an engine or electric motor in the pipe mounted to the pipe from the outside or by a right-angle drive shaft that pierces the pipe. Axial flow pump is a technology which is generally used for low head surface water lifting in the Philippines, Vietnam and Thailand. This pump is widely used for surface water irrigation, drainage and aquaculture at the water head of 1-3 m. The discharge of axial flow pump is about 2 times higher than that of centrifugal pump of same size. It can save fuel about 40-60% for lifting same volume of water than low lift pump (Centrifugal pump). In this pump impeller is submersed in the water so that no priming is needed during operation. Length of driving shaft as well as hollow pipe may be as long as 7.5 m. To meet the farmers' demand, Bangladesh Agricultural Research Institute has developed three sizes of axial flow pump (76 mm, 102 mm and 150 mm) for low, medium and high discharge. These axial flow pumps can be efficiently used for surface water irrigation, drainage of excess water and aquaculture in fish ponds (Fig. 3.16). Pump should not be operated if the strainer is blocked or if it is vibrating excessively. Pump should be maintained regularly for its smooth operation.

3.7.1 Advantages

- Suitable for surface water lifting at low head (≤ 5.0 m)
- Axial flow pump produces relatively high discharge at low head (≤ 5.0 m)
- It can pump up to 2-3 times more water at 4 m head than centrifugal or radial flow pumps
- Compared to conventional irrigation pumps, axial flow pump required 40-60% less fuel to lift the same volume of water
- Priming is not necessary for axial flow pump like centrifugal pump
- Easy to transfer from one place to another
- It can be easily operated by available power tiller
- Lower price than same size of centrifugal pump
- Operating cost is also cheaper than same size of centrifugal pump.

Axial flow pump

Axial flow pump in operation

Fig. 3.16: Views of BARI axial flow pump

3.7.2 Specifications of BARI Axial Flow Pump

- Axial flow pump is made with locally available iron materials such as MS pipe, MS solid shaft, impeller, MS pulley, bearing, etc.
- Sizes of axial flow pumps are 76 mm (3"), 102 mm (4") and 150 mm (6")
- Length of driving shaft as well as hollow pipe may be as long as 7.5 m
- Small (76 mm), medium (102 mm) and large (150 mm), axial flow pumps are operated by 10.0 hp, 12.5 hp and 14.0 hp diesel engines, respectively
- The discharges of small (76 mm), medium (102 mm) and large (150 mm), axial flow pumps are 15, 26 and 45 L/s, respectively
- Rotating speed of axial flow pump is 1800-1900 rpm
- The prices of small (76 mm), medium (102 mm) and large (150 mm), axial flow pumps are Tk. 15000 (US$188), 20000 (US$250) and 30000 (US$375), respectively
- Weight of small (76 mm), medium (102 mm) and large (150 mm), axial flow pumps are 25 kg, 30 kg and 40 kg, respectively
- Pump efficiency: 80%.

3.7.3 Working Principle

Axial flow pump is used for lifting surface water at lower water head. Axial flow pump, engine, delivery pipe and necessary fittings are taken to the canal of pond. Lower side of axial flow pump with foot valve is submersed in the water. Inlet end of the pump should be at least 30 cm below the water surface and 30 cm above the ground surface (Fig. 3.17). The outlet end of the pump is inclined to the bed of the pond or canal and connecting with delivery pipe. Engine and pump should be properly fixed with ground with poles and ropes. Engine or motor is set with engine with pulley and V-belt. If the pump is operated by power tiller, then pump and power tiller engine is set with V-belt. During setting the pump with engine so that it should be aligned properly. The belt should be properly tightened to get proper speed as well discharge (Fig. 3.18). Before starting the engine, lubricating oil, fuel and water must be checked. All bolts, nuts, clamp greasing in the bearings and bushings and pulley of pump should be checked. Then engine or motorto be started and water will be discharged through the outlet of the pump. During operation, proper pump speed as well as engine speed need to be

selected to get high discharge (Table. 3.5). If any undesirable sound comes from the engine or pump, then engine should be stopped urgently.

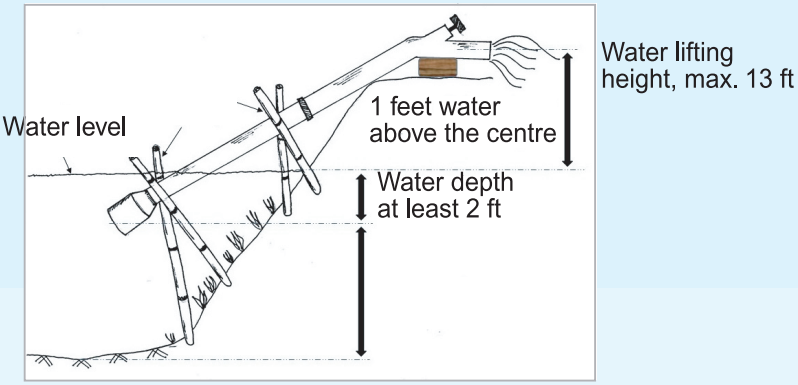


Fig. 3.17: Using Bamboo pillar to reduce vibration and shaft breakage

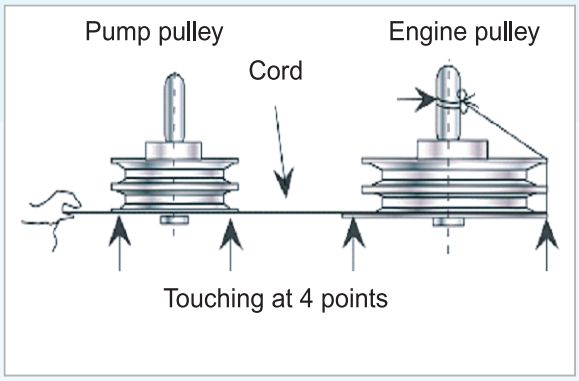


Fig. 3.18: Alignment experiment of pulley with cord

Table 3.5 Engine power, water lifting head and pump rpm

Dimension of AFP	Engine power	Water lifting head	Pump pulley rpm	Engine pulley radius calculation formula
3 inch x 16-20 feet	6-8 Hp	Maximum 16 feet or 5 meter	1700-1800	Engine pulley radius= (Pump pulley radius x Pump pulley rpm)/Engine pulley rpm
4 inch x 16-20 feet	8-10 Hp		1700-1800	
5 inch x 16-20 feet	10-12 Hp		1700-1800	
6 inch x 16-20 feet	12-14 Hp		1700-1800	
8 inch x 16-20 feet	16-20 Hp		1700-1800	

3.7.4 Operation Checklist

- Check that all pre-season maintenance is complete
- Inspect that all drain valves are closed
- Check pumps impellers for wear. Repair if necessary
- Re-pack bushings if necessary and lubricate pump
- Set the pump as close as possible to the water
- Check all nut and bolts and tighten them if necessary
- Make sure that the coupling of the pump is ok
- In case of diesel engine, check oil, fuel and cooling water level
- Pour necessary fuel in the fuel tank through fuel filter
- Make sure that strainer of the suction pipe remains fully submerged in the water
- Be careful that strainer should not touch on the mud or the bottom of the water source
- Before starting the engine, make sure pump and engine are fixed and will not be displaced by the vibrations. A simple structure of bamboo and some ropes can serve for this mechanism
- Make sure animals, children or other obstacles will interfere with the engine or the pump while they operate
- Engine or motor should be start wearing tight dress. Avoid loose dress during operation of pump
- Do not manipulate any of the pump parts while it is running, in case of detecting any problem, stop the engine immediately.

3.7.5 Financial Analysis of Axial Flow Pump

Description	Amount
Purchase price of pump with 9 kw engine and fittings (Tk)	70,000
Economic life of pump (Yr)	5
Average discharge (l/sec)	45
Annual command area (ha)	15
Fuel consumption (l/ha)	1.00-1.30
Depreciation, interest of investment, shelter (Tk/ha)	1,300
Cost of pump operation (Tk/ha)	3,700
Total cost of operation (Tk/ha)	5,000
Traditionally payable charge for irrigation water (Tk/ha)	7,500
Cost saving (%)	30

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The U.S. Government's Global Hunger & Food Security Initiative

Appropriate Scale Mechanization Innovation Hub (ASMIH)-Bangladesh

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