Agriculture Machinery Operator

(Job Role)

Qualification Pack: Ref. Id. AGR/Q1103

Sector: Agriculture

Textbook for Class XI

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PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION, SHYAMLA HILLS, BHOPAL, M.P., INDIA

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(a constituent unit of NCERT, under MHRD, Government of India)

FOREWORD

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF–2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and also contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning.

The NSQF sets common principles and guidelines for a nationally recognised qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities. It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Human Resource Development. This textbook has been developed as per the learning outcomes-based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude. I acknowledge the contribution of the development team, reviewers and all the institutions and organisations, which have supported in the development of this textbook. NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

Dinesh Prasad Saklani
Director
National Council of Educational
Research and Training

New Delhi
February 2022

ABOUT THE TEXTBOOK

An Agriculture Machinery Operator is important Job role in agriculture, for operating agriculture machineries used in different farming processes such as tilling, planting seeds, fertilizing plants, spraying and dusting of plants and harvesting crops and also responsible for carrying out periodical maintenance procedures for the same and making minor adjustments. Agriculture Machinery Operator is responsible for driving, minor repair maintenance and servicing of agriculture farm machinery and other set-ups. The person should be able to work independently on the assignment, be comfortable in performing laborious work, be a good listener, good at following instructions, a cooperative team player and result-oriented, with a positive attitude. Agriculture Machinery Operator is a beginner's level course. On completion of this course, a student can take up an intermediate level course for a job role in the 'Agriculture Sector'.

The textbook for the job role of 'Agriculture Machinery Operator' has been developed to impart knowledge and skills through hands-on learning experience, which forms a part of experimental learning. Experimental learning focuses on the learning process for the individual; therefore, the learning activities are student-centred rather than teacher-centred.

The textbook has been developed with the contribution of the subject experts, vocational teachers, industry experts and academicians, for making it a useful and inspiring teaching-learning resource material for the vocational students. Adequate care has been taken to align the contents of the textbook with the National Occupational Standards (NOS) for the job role so that the students acquire the necessary knowledge and skills as per the performance criteria mentioned in the respective NOS of the Qualification Pack (QP). The NOS for the job role of 'Agriculture Machinery Operator' covered through this textbook are as follows:

1. AGR/N1123: Prepare for training and demonstration.

2. AGR/N1124: Demonstrate the operation of various farm machineries and implements.
3. AGR/N1125: Demonstrate and supervise the repair and maintenance of agricultural machineries and implements.
4. AGR/N1107: Prepare power tiller for operation.
5. AGR/N1108: Operate a power tiller for various farm operations.
6. AGR/N1110: Carry out various operations using power tiller attachments.
7. AGR/N1103: Prepare combine harvester machine for operation.
8. AGR/N1104: Operate the combine harvester machine to harvest grain crop.
9. AGR/N1105: Perform repair and maintenance of combine harvester machine.
10. AGR/N1115: Prepare and operate the reaper.
11. AGR/N1116: Prepare and operate the power thresher.
12. AGR/N1101: Operate tractor for farm operations.
13. AGR/N1102: Perform regular maintenance and basic repair of tractor.
14. AGR/N9903: Maintain health and safety at the workplace.

Unit 1 of the textbook gives an History of Agricultural Mechanization in India. Unit 2 Introduction of Tractor. Unit 3 deals with the Agriculture Machinery and its Operation. Unit 4 focuses on the Operational safety in agriculture machinery.

This textbook could not have been completed without the support of the National Skill Development Agency (NSDA), National Skill Development Corporation (NSDC) and Agriculture Skill Council of India (ASCI).

We extend our gratitude to all the contributors for selflessly sharing their precious knowledge, acclaimed expertise and valuable time, and positively responding to our request for development of the textbook.

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CONTENTS

UNIT 1: HISTORY OF AGRICULTURAL MECHANIZATION IN INDIA

Agriculture farming is one of the most important occupations in our country. More than 65 % population do agriculture cultivation for livelihood. Agriculture practices have transferred with the adoption of improved seed, fertilizer, use of agriculture machines and technologies. The adoption of modern technology has helped the farmers get better yield, timeliness of the operation, and more growth.

Farm mechanization is the process of transferring farm power to farming implements and machinery. It is an important agricultural resource in India, with the potential to alter the lives and economy of millions of people living in rural areas.

Farm mechanization can help farmers produce more high-value crops and improve their quality of life by removing the laborious operations that come with human labour. Increased output advances and benefits to the rural economic cycle. Thus, improving smallholder farmers' economies increases access to input supply chains and integration in modern food systems. This results in higher incomes, which generates new and expanded business opportunities, more value addition, and overall better livelihoods for smallholder families.

Consequently, mechanization in agriculture can make a significant contribution to the long-term growth of global food systems. In the sphere of agriculture, mechanization is the most significant parameter for long-term agricultural development. It aids in boosting production at a lower cost, reducing the deficit, improving the management of high-priced inputs, enhancing total natural resource productivity, and reducing the challenges related to diverse agricultural activities.

India's agricultural situation was completely concealed during the post-independence period. The country was suffering from severe food scarcity and had to rely on imports to feed its people. To cope up with this issue, the “Green Revolution” took place in the 1960s. It involved the adoption of numerous new technologies such as enhanced high-yielding hybrid seeds, chemical fertilizers, the building and extension of irrigation infrastructure, and farmer education.

The "Green Revolution" was shaped by technological achievements such as improved water systems and increased mechanization in agricultural operations. Cereal imports in India were usually minor in the 1970s due to the success of the "Green Revolution," except for catastrophic crop failures in 1979-80, which led to fresh imports of 2.3 million tonnes of food grains in 1981-82.

India reached self-sufficiency by the end of the twentieth century, producing enough food. For example, 212 million tonnes of food grains in 2001-2002. In countries like India, where money is scarce and labour is plentiful, partial

mechanization could be the most effective solution. However, increasing population pressure on land, tiny and fragmented holdings, acute poverty, and farmer ignorance are some of the causes that are preventing agriculture from being mechanized.

In this session, you will learn about basic terminology used in agriculture, the need and role of agricultural machinery. You will also understand the importance of farm mechanization and traditional agriculture machinery.

Important Basic Terminologies: In agriculture, various terms are used during different operations, which are listed below-

- **Tractor:** A vehicle that is used on agriculture fields to pull or carry machinery such as plough, cultivator, harrow, etc.
- **Plough:** A plough is an agricultural tool that is used to loosen or turn the soil before seeding or planting.
- **Ploughing:** The process of cutting, loosening, and turning the soil is called ploughing.
- **Tillage:** It is soil preparation of the agriculture field by various types of mechanical agitation, such as digging, stirring, and overturning.
- **Primary Tillage:** The first soil tillage after the last harvest is the primary tillage.
- **Secondary Tillage:** The tillage operations conducted after primary tillage on the soil to bring a successful tilting of the soil are known as secondary tillage.
- **Seedling:** A very young tree or plant growing out of a seed.
- **Sowing:** The process by which a seed or seedling is planted.
- **Irrigation:** The artificial method of applying water to the soil so that, the crop can grow easily.
- **Weeding:** A process to remove unwanted plants from the land surface.
- **Intercultural operation:** Minor and finer operations carried out on the field, between sowing and harvesting.
- **Harvesting:** The method of cutting matured crops from the fields.
- **Winnowing:** The process of removing chaff/unwanted particles from the grain by using winnower.
- **Threshing:** The process of separating the grain from the crop by using manual or mechanical power.

SESSION 1: NEED AND ROLE OF AGRICULTURAL MACHINERY

In India, farmers have low income per capita due to the low yield per hectare from their holdings. One of the important reasons for low yield is due to the use of traditional technology, manpower as well as animal power. Due to low holding, farmers use traditional equipment like desi plough and this desi plough is operated by bullock, buffaloes, or manually.

Gradually farmers have started using improved farm types of machinery for various agricultural operations such as ploughing, sowing, cultivation, harvesting, and threshing by manual power, animal power, and mechanical power.

Human power: Human beings are the main source of power for operating small tools. They are engaged in doing stationary works like harvesting, threshing, winnowing, chaff cutting, and lifting irrigation water. On average, a man is able of producing 0.1 horsepower energy. Due to urbanization labours are migrating and working in the industries for better wages. There is a shortage of manpower in rural areas.


Fig.1.1: Human Power in Field

Animal power: In animal power, animals such as buffaloes, camels, horses, donkeys, and mules are used for agricultural operations. These animals produce a low amount of power between 0.50 to 0.75 Horsepower. Perhaps, this amount of power is not sufficient to carry out
agricultural operations. Animals can be a cheap source of farm power if raised by the farmers themselves. It becomes the costliest source if the animal has to be brought from some other place.

Fig.1.2: Animal Power in Field

Mechanical power: One of the important sources of farm power is mechanical power, which is available through power tillers, tractors, and engines. Tractors and power tillers are available in various ranges from 15 to 120 and 06 to 12 Horsepower respectively. Due to the high output of power, agricultural operations can be done timely and easily. Most agricultural machinery is operated by the tractor.

Fig.1.3: Mechanical Power in Field

Agricultural Mechanization: Mechanization of agriculture farming means the introduction of a machine in agricultural land for the completion of different operations in farming. It helps quicker, easier and better production of agriculture produce. The use of agricultural machines helps in increasing farm production. Agriculture mechanization is being practiced at various levels of agricultural operations.

Importance of mechanized farming: Mechanization provides-

a) High yield
b) Less expenditure per unit area
c) Timeliness in the farm operation
d) Quick work
e) Less drudgery of labour

Considering these reasons, the use of modern agricultural machinery is adopted for various agricultural operations such as land preparation, ploughing, sowing, intercultural operations, spraying, harvesting, threshing, and so on.

Mechanization is a multi-dimension concept that is widely applied in agriculture. A farmer needs to plant, reap and sow at the right time with the right equipment at the right season for higher productions. Agricultural machinery not only helps to save the time of farmers but also helps in saving inputs like seed, fertilizers, and chemicals of a farm. The advantage of using the farm machine is that they are capable of doing the maximum in minimum time, reducing the cost of farming operations. Even at minimum speed, these farm machines can work twice as fast as human workers. Nowadays, these machines are also being redesigned and upgraded with the upcoming technologies to make them more eco-friendly.

Using agricultural machinery results in an increase in the yield of the crop and the income of the farmer. Farmers can either purchase the agricultural machinery or take them on a rent basis. Nowadays farmers can hire agricultural machinery through custom hiring centers, which are established by agriculture society or government agencies. For example, a big machine like a combine harvester was hired from another place to a remote area for timely completion of operations such as harvesting and threshing. Whereas, now it is easier to hire agricultural machinery through a custom hiring center.

Advantages of Farm Mechanization

1. Land preparation can be done more thoroughly in less time.
2. Heavy and otherwise difficult soils can be ploughed satisfactorily and quite independently of weather and season.
3. The timely completion of farm operations helps in saving more time for planting. Therefore, better seed control and inter-row cultivation are possible.
4. Engine power may be used efficiently for stationary operations of threshing and processing.
5. Multi-cropping is more feasible by minimizing periods during which the land has no crops growing on it, thus maximizing land and water use.

Dis-advantages of Farm Mechanization

1. Higher initial costing of machinery and less annual usage.
2. Tractors might undesirably displace labour that is already under or unemployed.
3. Repair and maintenance of complex engines and machinery are problematic.
4. Operational skills are often undeveloped.

5. Operational supplies and services for fuel and lubricant are quite expensive.

Traditional Agricultural Implements

Traditional agricultural implements can be categorized based on two power sources; human/manual power source and an animal power source.

1. Human/ Manual Power Source

1. **Spade:** A multi-purpose hand tool used to dig pits, to create ridges, furrows, etc. In this tool, the handle is made of a wooden bar and the blade is made of steel.

Fig.1.4: Spade

2. **Khurpa:** A small multi-purpose hand tool used on the farm for intercultural and weeding activities.

Fig. 1.5: Khurpa (Iron)

2. **Hand Weeder:** A very simple hand tool for weeding.

Fig.1.6: Short Hand Weeder

4. **Sickle:** A simple tool used for harvesting crops and cutting the other vegetation.

Fig.1.7: Sickle

5. **Bamboo Sieve:** A hand tool used for cleaning, sieving, and packaging. The sieve or *chhalna* separates dust, stones, and other foreign matters from cereals.

Fig.1.8: Bamboo Sieve

6. **Winnower:** A tool used to separate the chaff from grains using blowing of air.

Fig.1.9: Winnower

7. **Stone Mill:** It is used for grinding and crushing.

Fig.1.10: Stone Mill

2. Animal Power Source

1. **Soil Scoop (Animal drawn):** It is used over short distances in excavating ditches, cleaning drains, and moving soil.

   It consists of – (a) Blade (b) Soil trough (c) Hitching loop (d) Handle

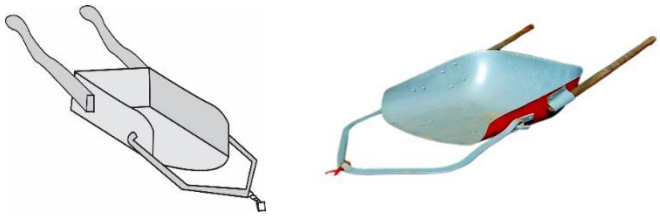


Fig.1.11: Animal drawn soil scoop

2. **Animal drawn plough:** Commonly it is of two types- (a) Indigenous plough and (b) Mouldboard plough

   (a) Indigenous Plough: As a primary tillage implement, it is most commonly used in India. It is also known as 'Desi plough'. The main parts of plough are: Body, Shoe, Share, Handle, and Beam.

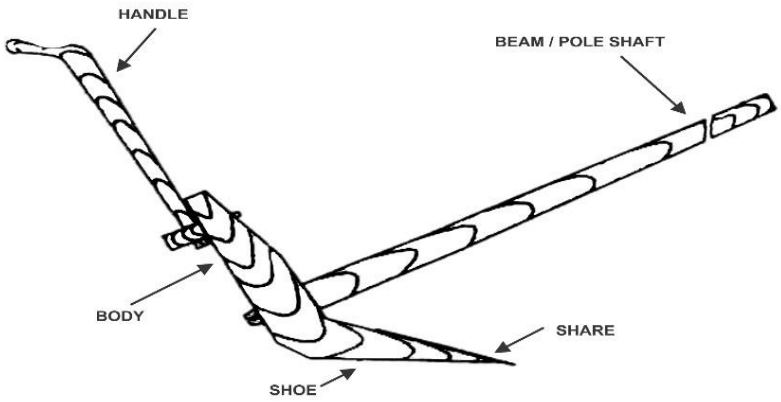


Fig.1.12 (a): Indigenous plough

   (b) Mouldboard plough: The animal-drawn mouldboard plough is thin and small, which ploughs up to a depth of 15 cm, while two larger ploughs are mounted to the tractor and ploughed to a depth of 25 to 30 cm. Mouldboard ploughs are used for turning the soil for better land preparation for farming.

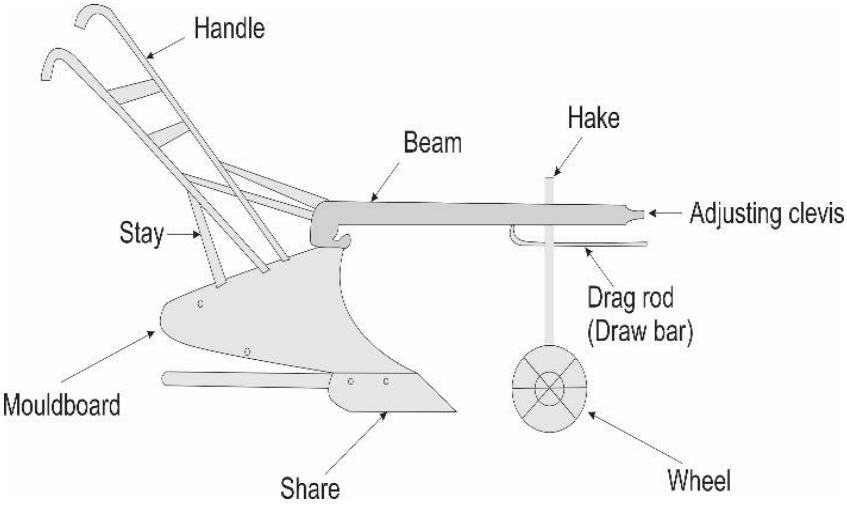


Fig.1.12 (b): Animal drawn MB plough

3. **Animal drawn disc harrow:** When preparing seedbeds, it is used to split clods. It normally has six or eight discs fixed in two groups, with three or four discs in each gang. It mainly consists of- (i) Disc (ii) Gang frame (iii) Scraper (iv) Spacer (spool) (v) Clevis (vi) Gang angle mechanism (vii) Beam (viii) Axle (ix) Middle tine (x) Bearings.

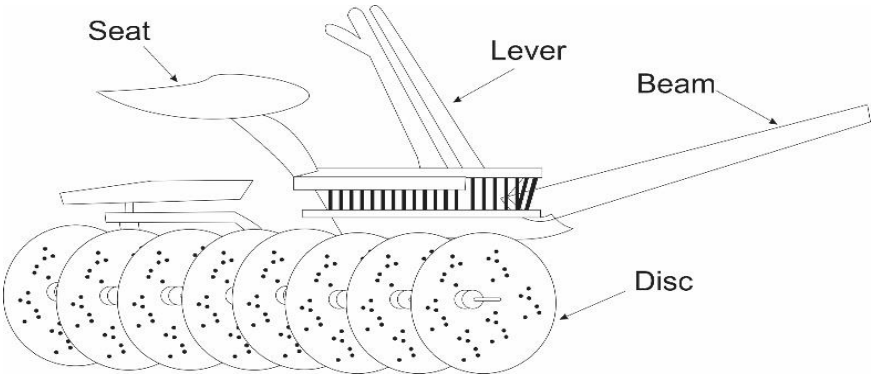


Fig.1.13: Animal drawn disc harrow

3. ***Bakhar* (Blade harrow):** It consists of one or more blades connected to the beam or frame used with a minimum of soil inversion for the shallow working of the soil.

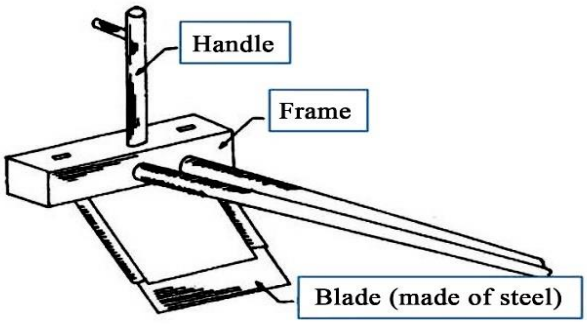


Fig.1.14: Blade harrow

4. ***Guntaka* (*Patela*):** It is an improved kind of blade harrow. It consists of a frame or beam connected to one or more blades. It is mostly used in the preparation of the seedbed and levelling the agriculture field.

5.

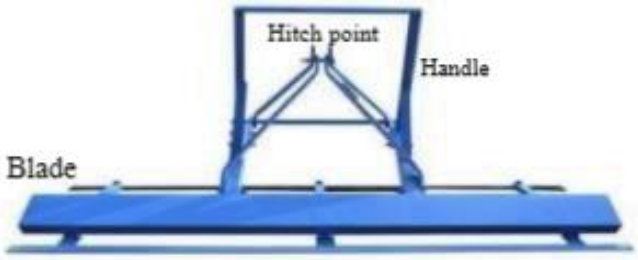


Fig.1.15: Guntaka Harrow

6. **Bullock drawn cultivator:** It is a secondary tillage device, used for intercultural operation at various times. It removes the weed and aerates the soil so that a smooth, loose seedbed is maintained.

Fig.1.16: Bullock drawn cultivator

7. **Bund Former:** It is used by gathering the soil to create bunds or ridges. It consists of- (a) Forming board (b) Beam (c) Handle.

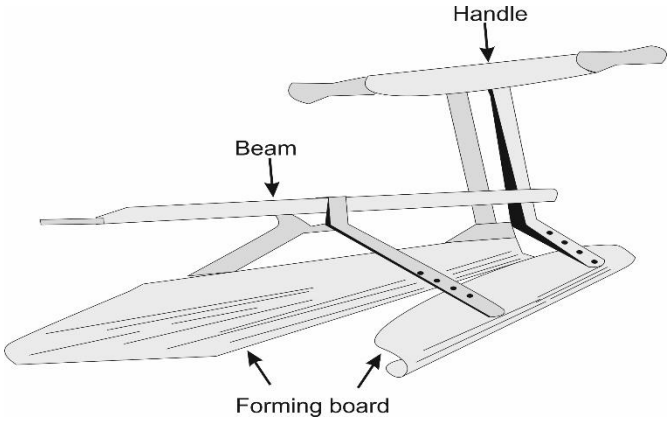


Fig.1.17: Bund former

8. **Animal Drawn Ridger:** It is used to form ridges, needed in well-tilled soil for the sowing of row crop seeds and plants.

Fig.1.18: Animal drawn ridger

9. **Puddler (Animal drawn):** It is used after initial ploughing for the preparation of paddy fields with standing water. Clods are broken up and the soil is churned. It reduces water leaching, eliminates weeds by decomposing, and it is done in standing water between 5 and 10 cm deep.

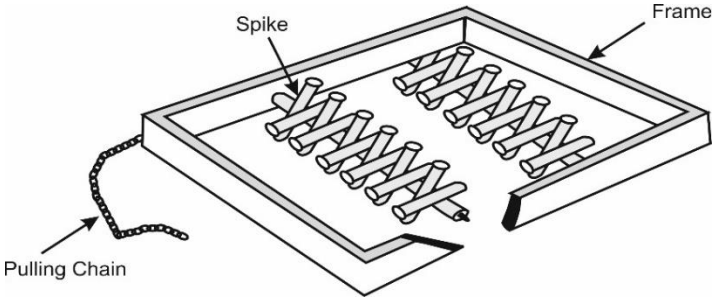


Fig.1.19: Wetland Puddler

10. **Foot-operated sprayer:** A foot-operated implement used for spraying insecticides in the agriculture field and plant etc. It consists of **-** (a) Barrel (b) Pump (c) Pedal (d) Platform (e) Suction hose (f) Spray lance.

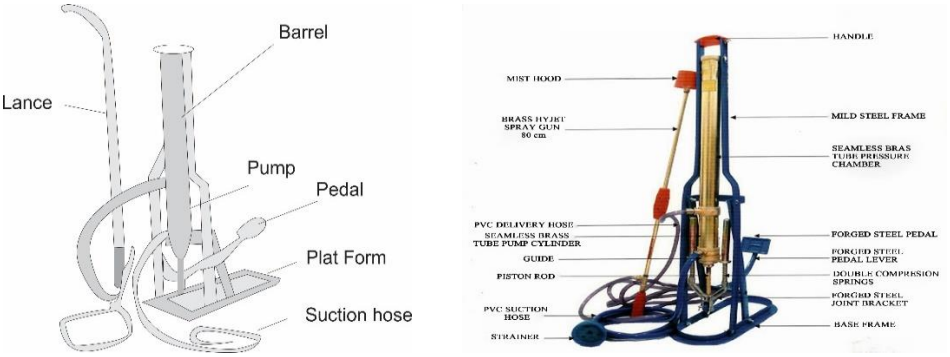


Fig.1.20: Foot-operated sprayer

11. Green manure trampler (Animal drawn): It is an implement that is used in the fields to trample and press the green manure crop. There are two types of tramplers: (a) Slat type (b) Disc type

The main parts of the trampler are - (a) Frame (b) Axle and bearings (c) Disc or slat (d) Footboard (e) Handle

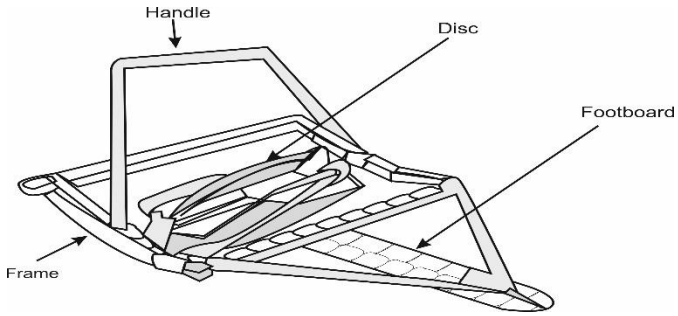


Fig.1.21: Green manure trampler

12. Hand Dibbler: It is a conical tool used for making proper holes in the soil surface so that seeds can be planted. The hand dibbler consists of tapered projections in a frame for making the hole.

Fig.1.22: Hand Dibbler

13.Animal (Bullock) drawn seed-drill: This implement is drawn by a pair of average ox or bullocks for sowing the seeds. There are two types of the bullock-drawn seed drill.

(i) In which seeds are dropped by hand or manual.

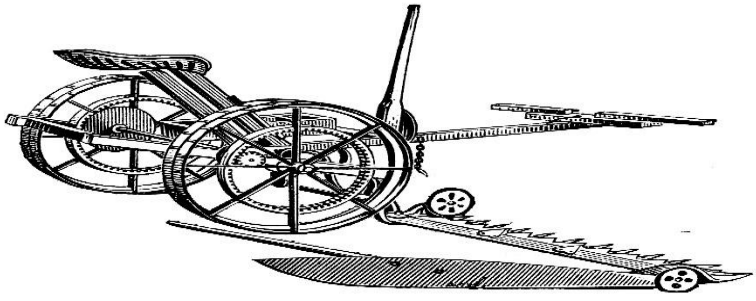
(ii) In which seeds are dropped by mechanically.

Fig.1.23: Bullock drawn seed-drill with metering unit

14. One row jute seed drill: It is a manually controlled implement. It consists of a seed box, a mechanism for seed dropping, and a land wheel.

Fig.1.24: One-row jute seed drill

15.Animal drawn reaper: It is pulled by a pair of animals. It can harvest nearly 5 to 8 cm above the ground. It consists – (a) Frame (b) Cutter bar knife wheel (c) Bearing



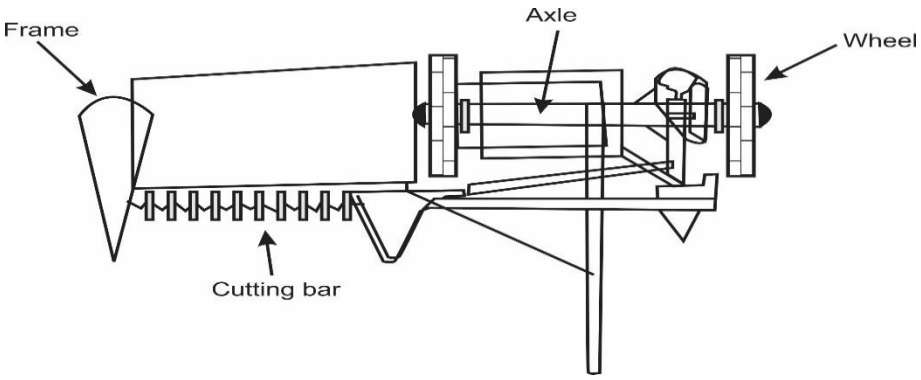


Fig.1.25: Animal drawn reaper

16. Olpad Thresher: An agricultural machinery used for threshing the agriculture produce. This is a very old threshing implement that is simple in operation. It is also known as a wheat crop thresher.

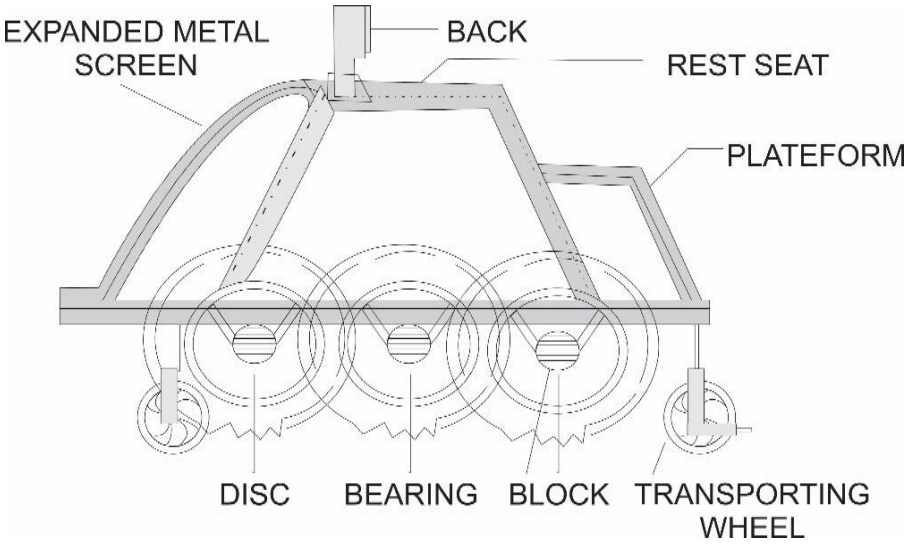


Fig.1.26: Olpad Thresher

17. Pedal-operated paddy thresher: The pedal-operated thresher is used for threshing the agriculture crop by manual power. This thresher is best for paddy crops. It consists of - (a) Cylinder (b) Body frame (c) Axle (d) Drive mechanism.

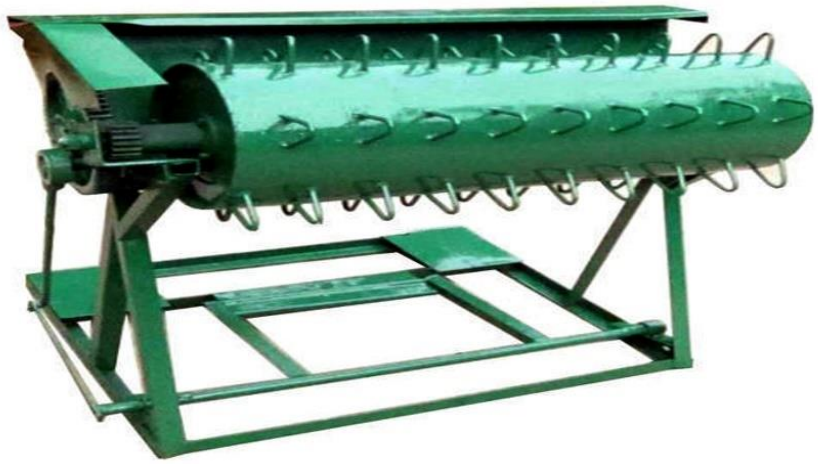


Fig.1.27: Pedal-operated paddy thresher

PRACTICAL EXERCISE

Activity 01: Sketch any two traditional agricultural machineries or implements used in the agriculture field.

Material required:

1. Notebook
2. Pencil
3. Eraser
4. Sharpener

Procedure:

1. Identify the traditional types of machinery available on the farm.
2. List the available traditional types of machinery on the farm for sowing, harvesting, and threshing.
3. Sketch any two traditional types of machinery.
4. Label the parts of machinery.

CHECK YOUR PROGRESS

A. Answer the following

1. Define the role of agricultural machinery in agriculture?
2. What do you mean by agriculture mechanization?
3. Describe the importance of mechanized farming.

4. List the name of traditional agricultural machinery.
5. Define any two traditional agricultural machineries and draw the diagram?

B. Fill in the blank

1. Human beings are the main source of.....for operating small tools and Implements.
2. On average, a man is able of producing ..... horsepower energy.
3. ..... is used for breaking clods while preparing seedbeds.

C. Match the following

1. A multi-dimensional concept that is widely used in agriculture.	A. 
2. It is used to form ridges, required for sowing row crop seeds and plants in well-tilled soil.	B. Farm Mechanization
3. Soil scoop	C. 
4. A simple tool used for harvesting crops and to cut the other vegetation.	D. 
5. It is a conical instrument used to make proper holes in the field.	E. Animal drawn

SESSION 2: DEVELOPMENTS IN AGRICULTURE MECHANIZATION

With the development of agriculture and the adoption of agriculture mechanization practices, a tractor was introduced. In India, the first tractor was brought to India in 1914. From 1950-1960, there were only around 8,000 tractors, which rose to 39,000 units. Engines (petrol, kerosene, and diesel) have been used for post-harvest manufacturing such as floor production, rice milling, grinding, etc.

During the sixties, India went through a serious food crisis and the situation was called 'ship to mouth'. In the latter half of this decade, the Government of India took significant policy decisions to bring about change. The 'government guaranteed' the farmers' procurement of main crops at the minimum support price (MSP). Just about 75,000 tractor units (1 tractor/1800 h) were present.

With the adoption of high yield variety (HYV) crops, demand for irrigation water was created. Farmers started using tube wells, pumps, etc., Whereas, those who were not owning tube-well, pumps bought water from neighbouring farmers at a nominal rate to grow the HYV crops. Thus, the first and most important mechanization in India was groundwater pumping. It was done by using engine and electric motor-driven irrigation pumps.

Farmers purchased threshers for water pumping which was operated by the engine or motor. This was mainly used for wheat crops. Interestingly, earlier the threshers were fabricated by local blacksmiths in small towns. They mostly used locally available materials, especially parts of discarded persian wheels. Farmers either purchased high-capacity tractor operated or electric operated thresher or hired the thresher from neighbouring farmers mostly on a share of production basis.

The mechanization of agriculture in India ensured higher yields and assured prices to farmers. With more profit due to agriculture mechanization, farmers started purchasing different farm machinery and implements.

The intensification of agriculture was assisted by higher inputs of farm power, as well as greater profitability of farming-generated

surpluses that could be spent on capital equipment. With the adoption of HYV seeds, the number of tractors got doubled by 1971, and 96 percent of the tractors were privately owned on farms of over 10 hectares (ha) in size.

By 1980, the number of tractors was more than 500,000 (1 tractor/260 ha), which reached about 4.0 million units (1 tractor/35 ha) in 2010. Currently, India is the largest producer of tractors in the world. The annual production is about 700000

units, out of which around 10 percent units are exported.

Through all these years, the economics of ownership of most tractors had been justified by custom hiring. This was done for both on-farm works and off-farm works such as transport and construction activities. The usage of tractors in transportation activities accounts for more than 50 percent of the average annual use. Many small farmers also started owning tractors due to the opportunity of custom hiring.

Also, over the years, due to rural electrification majority of the irrigation pumps are powered by electric motors. The size of irrigation pumps has increased due to the lowering of the water table in many areas. As the electricity to rural areas is subsidized for agricultural purposes in India, most farmers have either individually or jointly installed tube wells wherever groundwater is available. The number of electric motor-operated pumps increased from 4 million in 1981 to about 25 million in the year 2015. The number of diesel-operated irrigation pumps also increased from 3.3 million in 1981 to about 7 million in 2015. There was a phenomenal growth of farm equipment due to favourable government policies for promoting machinery manufacturing in the private sector. So, here is a list of development in tractors.

Table 1.1: Chronology of tractor's development

S.No.	Tractor developed	Year
1.	The word tractor appeared first on record in a patent issued on a tractor or traction engine	1890
2.	First successful gasoline tractor	1906
3.	First Winnipeg tractor trails	1908
4.	First tractor demonstration	1911
5.	Power take-off	1915-1919
6.	All-purpose tractor	1920-1924
7.	Diesel engine (was used in tractor and pneumatic tires were introduced with clutch and other accessories)	1936- 1937
8.	Manufacturing of diesel tractors on an extensive basis	1950-1960
9.	Four-wheel-drive tractors	1970

Table 1.2: History of tractor industry development in India

S.No.	Tractor developed in India	Year
1.	The first manufacturer of a tractor in India	1960-1961
2.	Escorts tractor	1971
3.	HMT tractor	1973
4.	Pitti and Kirloskar tractor	1974
5.	Harsha tractor	1975
6.	Auto tractor	1981
7.	Universal Tractors	1982
8.	GTCL tractors, M.M Tractors, Sonalika, VST, L&T, Bajaj Tractors	1983-2003

Impact of agriculture mechanization

The impact of agricultural mechanization in India led to the following growth and transformation in agriculture and allied sectors:

- Tractor production, growth, and sales have considerably increased, due to their local production in India. The number of draught animals used in agriculture also declined rapidly over the past decades. The states with high rates of available power per hectare are the ones with higher yields.
- Mechanization technologies were first adopted by the large farmers (over 10 ha farm size) followed by medium-scale farmers (with 4 to 10 ha farm size). The large numbers of such farmers in states like Punjab, Haryana, and western Uttar Pradesh played a critical role in facilitating the creation of viable agricultural machinery and implementing the distribution and services sector. Such farmers were also the ones who were able to provide mechanization and other services to the more numerous semi-medium (2 to 4 ha farm size), smallholder farmers (1 to 2 ha), and marginal.
- The availability of credit at subsidized rates has been catalytic to the rate at which farmers – especially the small and medium scale ones – were able to procure agricultural machinery and implements. In addition, custom hiring of agricultural machinery assures the minimum support prices for the farmers' produce.

- The higher demand for agricultural machinery and equipment led to the development of competitive and viable manufacturing industry. In this sector, India became a leading player and net exporter globally.
- The Government of India provided support services; for research and development, testing and standards check, for human resources development in support of agricultural mechanization.
  The agricultural engineering programmes were instrumental in the success of agricultural mechanization in India. established in the numerous state agricultural universities, and institutes under the Indian Council of Agricultural Research (ICAR).
- Business and enterprise-friendly policies, laws, and regulations encouraged commercial activities and entrepreneurship in farming. The key factors which contributed to the success of agricultural mechanization in the different states of India were input supply, produce handling, processing, marketing, and manufacturing.

Present scenario of agricultural mechanization in different agro-climatic zones/regions

Agro Climatic Zones: The Planning Commission initiated the Agro-climatic Regional Planning Project in June 1988. Under this system, the country is divided into 15 Agro Climatic Zones (Table no.1.3) based on common factors such as soil type, rainfall, temperature, water resources, etc. The separation of these agro-climatic zones assumes importance in planning strategies for agricultural development.

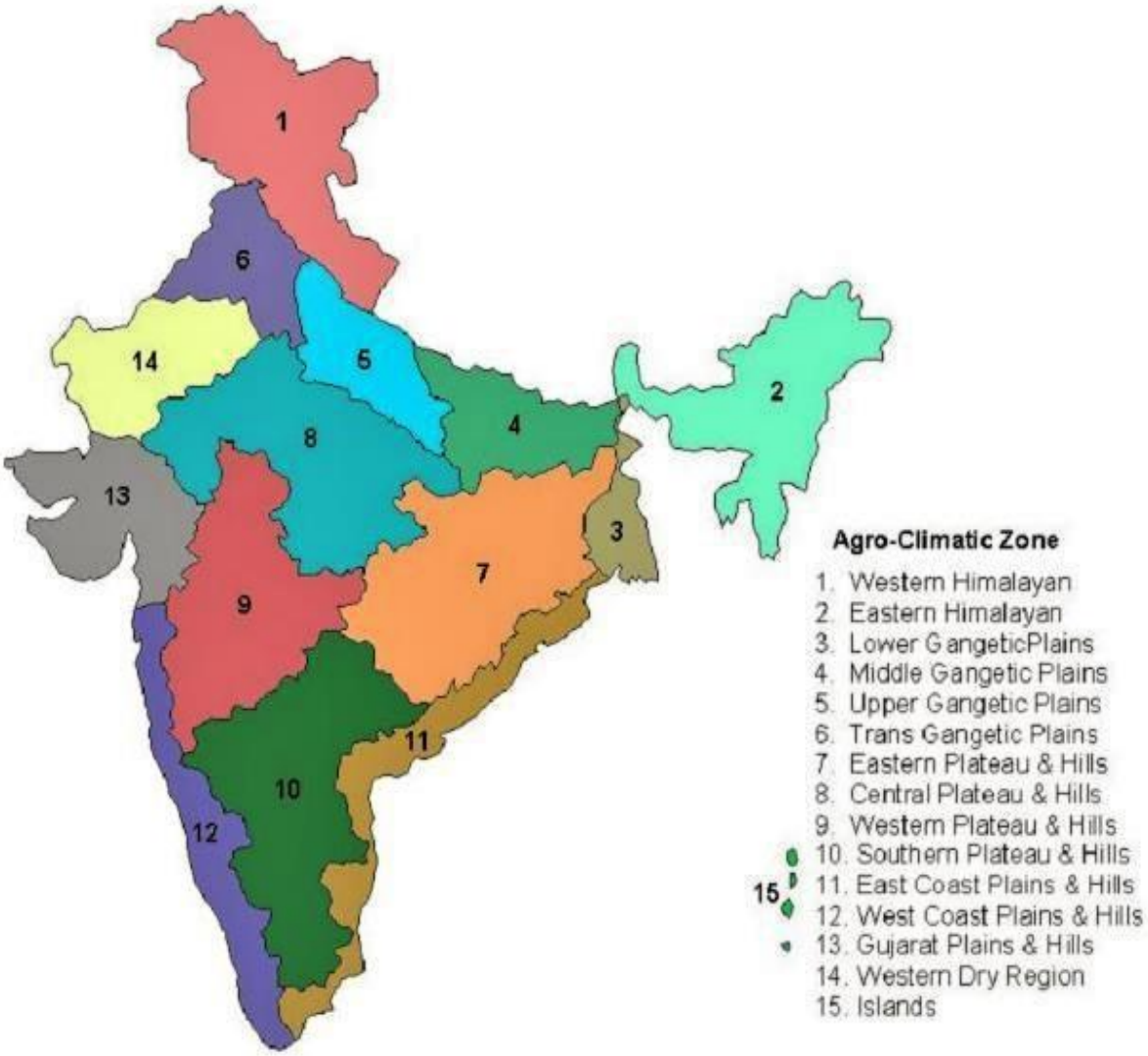


Fig.1.28: Agro-Climatic Zones in India

***Table 1.3: Agro*-climatic zone in India**

S.No.	Regions in India	Name of Tools and Machinery	Area
1.	**Western Himalayan Region**	Small tractor, power tiller, pumping sets, chaff cutter, rotavator, (zero till drills, strip-till drills, roto drills, till-plant machines, raised bed planters, ridge seeder, orchard sprayers, sickles, fruit pluckers, combine harvester, thresher aero-blast sprayers, and vertical conveyor reapers.	Jammu and Kashmir, Himachal Pradesh, and Uttaranchal
2.	**Eastern Himalayan Region**	Khasi spade, power tiller, tractor; MB plough, disc harrow (offset), shallow tube wells, pedal-operated paddy thresher, huller.	Arunachal Pradesh, Assam, Sikkim, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and West Bengal
3.	**Lower Gangetic Plain Region**	Puddler, drum seeder, cultivator, laser leveller, power tiller, rotavator, ridger, sprayer, mist blower, electrostatic sprayer, digger, multi-crop thresher, maize sheller, vertical conveyor reaper, thresher, groundnut planter, and manual/power-operated grader.	West Bengal
4.	**Middle Gangetic Plain Region**	Ploughs, harrow, cultivator, seed/seed-cum fertilizer drill, potato planter, power thresher, tractor trolley, bullock cart, tractor, pump sets, and plant protection equipment.	Uttar Pradesh and Bihar
5.	**Upper Gangetic Plains Region**	Sickle, power-operated weeder, planter/transplanter, combines and harvester, aero blast sprayer, orchard sprayer, and electrostatic-sprayer.	Uttar Pradesh
6.	**Trans-Ganga Plains Region**	Mouldboard plough, tractor-drawn disc harrow, cultivator, planker (mild steel), leveller, soil scoop, bullock drawn seed drill, bullock drawn planter, tractor-operated semi-automatic potato planter, wheel hand hoe, tractor-drawn bund former, knapsack sprayer,	Punjab, Haryana, Chandigarh, Delhi, and Rajasthan

		foot sprayer, reaper, diggers, power threshers, power cleaner and grader, straw baler.	
7.	**Eastern Plateau and Hills region**	**Chhattisgarh:** Puddlers, rotavator, disc harrow, seed drill, wheel hoe, planter, reaper, digger, tubular hand maize sheller, manual rice transplanter, and multi-crop thresher, rotavator, tractor-mounted inclined plate planter, and tractor-drawn vertical conveyor reaper. **Jharkhand:** Digging fork, weeding fork, hand cultivator, pruning secateurs, budding and grafting knife, manual fruit harvester, dutch hoe, garden rake, and weeding trowel. **Chotanagpur region:** Kudali, khurpi, local sickle, spade, animal-drawn ridger plough, animal-drawn seed drill, dutch hoe, japanese paddy weeder, pedal-operated paddy thresher. **Bihar:** Birsa ridger plough, birsa potato digger, MB plough (10 cm size), dutch hoe, grubber, pedal-operated paddy thresher, and improved sickle.	Jharkhand, Orissa, Chhattisgarh, Madhya Pradesh, and West Bengal
8.	**Central Plateau and Hills region**	Bullock drawn mouldboard plough, tractor mounted, mouldboard plough, animal-drawn disc harrow, improved patella harrow, rotavator, tractor mounted, offset disc harrow, improved bakhar blade, duck foot cultivator, tractor-mounted disc harrow (trailed type), animal-drawn land leveller, tractor-drawn land leveller, self-propelled hydro dozer.	Madhya Pradesh, Rajasthan, Uttar Pradesh
9.	**Western Plateau and Hills region**	Bullock drawn mouldboard plough, tractor-mounted mouldboard plough, animal-drawn disc harrow, improved patella harrow, rotavator, tractor-mounted offset disc harrow, improved bakhar blade, tractor-mounted duck foot cultivator, tractor-mounted disc harrow (trailed type), animal-drawn land	Madhya Pradesh and Maharashtra

		leveller, tractor-drawn land leveller, self-propelled hydro dozer, tractor-drawn harrow- cum-patela.	
10.	**Southern Plateau and Hills region**	Transplanter, cono-weeder, self-propelled reaper and thresher/combines, tractor-drawn planter, long handle weeder, power weeder, 3-4 T.D. harvester,, power thresher, rotavator, tractor-drawn planter, power weeder, power-operated ridger/furrower, self-propelled harvester, tractor-drawn seed drill/planter, fodder harvester, multi-crop thresher, tractor-drawn-broad bed former, power sprayer, single row puller, sucker remover, auger digger, harvesting equipment, ridger, single row long-handled weeder.	Andhra Pradesh, Tamil Nadu, Karnataka
11.	**Eastern Coastal Plains and Hills**	Power-operated and bullock drawn improved puddlers, transplanters-manual and self-propelled, cono-weeder, self-propelled reapers, high capacity thresher, combines, power winnower, combination tillage tools, tractor operated equipment, tractor-drawn planter, long handle weeder, power wheel, tractor-drawn 3-4 row harvester, power thresher, grader, power decorticator, rotary tillers, planter (tractor operated), power weeder, off barer and earthing up equipment (mini tractor/power tiller operated), harvester (self-propelled), fodder separator, multi-crop thresher, single row self-propelled/two-row tractor operated vegetable transplanter, improved power sprayers, power tiller operated/ self-propelled boom sprayer, sucker remover, auger digger, tractor/power tiller operated plough, trencher.	Orissa, Andhra Pradesh, Pondicherry, Tamil Nadu

12.	**Western Coastal Plains and Ghats**	Power tiller, operated rotavator, Power-operated, transplanters, direct seeder, cono-weeder, vertical conveyor reaper, combine, thresher, tall tree power sprayer, power tiller operated implement, tree climber, hydraulic operated harvesting ladder, improved dehusking machine, dryer, tall tree sprayer, power weeder, tractor operated harvester, tapioca peeling machine, tractor-drawn rotavator, and planter, power sprayer and dusters, tree crop sprayer, fruit picker(manual), auger digger, plucking tools, pepper grader, electrical-cum-solar powered dryer, small power weeder, tea plucking machine, power tiller operated rotavator, improved leveller, direct seeder (manual), cono weeder, tree climber, foot-operated sprayer, hydraulic operated harvesting ladder.	Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu
13.	**Gujarat Plains and Hills**	Rotavators, zero till drills, strip-till drills, roto-drills, till-plant machines, raised bed planters, ridger planters, and transplanters, aero blast sprayers, orchard sprayers, electrostatic sprayer, power-operated trenchers, angle dozers, drudgers, buck scraper.	Gujarat, Dadra and Nager Haveli, Daman and Diu
14.	**Western Dry Region**	Tractor, power tiller, combine.	Rajasthan
15.	**Island Region**	Sickles, fruit plucker, vertical conveyor reaper, aero-blast sprayer, orchard sprayer, electro-static sprayer, power-operated trencher, angle dozer, drudger, buck scraper.	Andaman Nicobar Islands and Lakshadweep

PRACTICAL EXERCISE

Activity 01: Sketch the Agro-climatic zone of India. Material required:

1. Notebook
2. Pencil
3. Eraser
4. Sharpener

Procedure:

1. Identify the Agro-climatic zones of India.
2. List the Agro-climatic zones of India.
3. Sketch Agro-climatic zones of India.
4. Label the Agro-climatic zones of India.

CHECK YOUR PROGRESS

A. Answer the following

1. Describe the development of agriculture mechanization?
2. What do you mean by Agro-climatic zone?
3. List the Agro-climatic zones of India.

B. Fill in the blank

1. The first tractor was brought to India in ……
2. India went through a serious food crisis and that situation was called ……
3. First Winnipeg tractor trails were introduced in the year…….
4. In the year 1971 …… tractor was manufactured.

C. Match the following:

Regions in India	**Area**
1. Western Himalayan Region	A. West Bengal
2. Eastern Himalayan Region	B. Uttar Pradesh and Bihar
3. Lower Gangetic Plain Region	C. Jammu and Kashmir, Himachal Pradesh, and Uttaranchal
4. Middle Gangetic Plain Region	D. Assam, Sikkim, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, Arunachal Pradesh, and West Bengal

UNIT 2: INTRODUCTION OF TRACTOR

In unit one we learned about the history of tractor and agro-climatic zones in India. And how, the new technology was adopted in agriculture to evolve from human and animal power to mechanical power sources. As human and animal power requires more effort, time, and money, whereas mechanically powered machines give effortless work within a short time and it also requires fewer labours.

In an agricultural field, multiple field operations like land preparation, sowing, intercultural operation, spraying, harvesting, and threshing, etc. are being done with the help of a tractor. Henceforth, importance of the tractor cannot be ignored in the farm mechanization process.

SESSION 1: IMPORTANCE OF TRACTORS IN AGRICULTURE

What is Tractor?

An 'Agricultural Tractor' is a self-propelled vehicle designed to deliver high tractive torque at slow speeds. It consists of two axles, which could be wheeled, track-laying, or semi-track-laying, more particularly designed to pull, push, carry and operate implements and machines used for agricultural work.

Fig. 2.1: Tractor

Importance of Tractor: Importance features of the tractor are elaborated below-

- **Saves time, effort, and resources:** With a tractor, a farmer can cover a larger area of land efficiently in lesser time, and with lesser manpower, hence increasing the yield due to timeliness and efficiency.

- **Multi-purpose usage:** Tractor can be used by a farmer in different farming operations such as land development, ploughing, harrowing, sowing, weeding, plant protection, irrigation, harvesting, threshing, and transportation.

Fig. 2.2 (a): Land development operation

Fig. 2.2 (b): Ploughing operation

Fig. 2.2 (c): Harrowing operation

Fig. 2.2 (d): Sowing (seed) operation

Fig. 2.2 (e): Weeding operation

Fig. 2.2 (f): Harvesting operation

Fig. 2.2 (g): Threshing operation

Fig. 2.2 (h): Transportation

- **Powerful and durable:** A tractor is a powerful machine, which can be used in plain as well as in rough terrain. It has a long economical life if properly maintained.
- **Available in different horsepower range:** In India, it is available in more than 70 horsepower ranges, starting from 7 horsepower. This is why even a small farmer having 2 ha of land can purchase a tractor as per his suitability and economic viability.
- **Opportunity for the custom hiring:** Once all the tasks in which tractor is needed are done, the farmer could give the tractor on rent for extra income. As the annual use of a tractor is very less in India and to come up to breakeven point, from where it is economically viable to own a tractor, small farmers need to use a tractor from custom hiring.
- **Rural transport carriers:** A Tractor with a trailer is used to carry the seed, fertilizer, and other farm input to the field. It is also used in loading the harvested crop to home and the prospective market.
- **Modifies social structure in rural areas:** It saves the farmers from laborious and tedious works on the farms. This is how the pressure on land decreases and the status of the farmers also improves. In general, it could be presumed that farmer sowning a tractor is modern and progressive.
- **Solves the problem of a labour shortage:** It creates jobs for the technical manpower in the village itself. As the labour shifted to industry, the use of tractors replaced human power. It also creates jobs for the operators, technicians, electricians, and engineers in the village.
- **Government loan and subsidy availability:** Bank loans and government subsidies are easily available for purchasing tractors and implements.
- **To motivate the younger generation:** Nowadays, the youth of the rural area are moving to the urban area. As agriculture profession is becoming more attractive with the adoption of modern technology in this field. Therefore, with the modernization of the agriculture sector, the youngsters have an option to choose it as a career.

PRACTICAL EXERCISES

Activity 01: Sketch a tractor and label the parts.

Material required:

1. Pencil
2. Blank white paper
3. Eraser
4. Sharpener

Procedure:

1. Identify the parts of the tractor.
2. Draw the diagram of a tractor.
3. Mention its parts and label them.

CHECK YOUR PROGRESS

A. Answer the following questions

1. Define Agricultural tractor?
2. How to increase the yield of the crop with the use of a tractor.
3. How is a tractor helpful to the farmers?
4. What is the visual difference between a car and a tractor?

B. Fill in the blanks

1. With a tractor, a farmer can cover …… area of land efficiently in ……. time.
2. A tractor is a …… machine that can be used in plain as well as in rough terrain.
3. A small farmer having 2 ha. of land can purchase a tractor, as per his suitability and …….. viability.
4. A tractor with a …….. is used to carry seed fertilizer and other farm inputs to the field.
5. A farmer can use the tractor in different …….. operations such as land development, ploughing, harrowing, sowing, etc.

SESSION 2: TYPES OF TRACTORS

Types of Tractors: Tractors are classified based on uses like crop-wise, soil-wise, and agro-climatic-wise. On the basis of its usage, these can be further classified as agricultural/farm tractors and industrial tractors. To perform the different farm operations efficiently various types of tractors have been designed.

The tractors are classified into three classes; based on the type of construction, type of drive, and purpose.

1. Based on Type of Construction:

(a) Riding Type Tractor: Tractor in which a driver can sit and drive like a general-purpose (four-wheel tractor).

Fig. 2.3: General-purpose four-wheel tractor

(b) Walking Type Tractors: Tractors with which the operator walks along like garden tractors and power tillers.

Fig. 2.4: Power Tiller

2. Based on Type of Drive:

(a) Track Type Tractors: In this type of tractor instead of wheels; tracks are fitted on both sides. These tracks get driven over the sprocket run by the rear axle shaft. The steering gear is not fitted to steer the tractor. The tractor is steered by applying brakes to one track, with the other track moving. These are used for bulldozing or land clearing work.

Fig. 2.5: Track type tractor

(b) Wheel Type of Tractors: These are the most commonly used agricultural tractors. They can run fast and the tyres can absorb a certain amount of field shocks. These can be further divided as:

i. **Two-wheel Tractor:** In this type of tractor engine power is given to rear tyres (also called traction wheel) through transmission. The front tyres which are smaller in size are used as a steering wheel. The track width of both the front and rear tyre on the same axle is adjustable for field and haulage operation. Two-wheel drive tractors are available almost in all ranges in India, starting from 07 hp to 70 hp ranges. These tractors are used for small farms, hilly areas and gardening purposes.

Fig.2.6: Power tiller

ii. **Three-wheel Tractor:** This type of tractor was very popular 15 years back, but now it's replaced by four-wheel tractors. Three-wheel tractors had single or dual wheels fitted at the front end in the center and were considered good for negotiable shorter turns.

Fig.2.7: Three-wheel tractor

iii. **Four-wheel Tractor:** It is the most commonly used tractor. It is also known as all-purpose tractors. Based on available power, these have been classified as-

a) Small tractors – 15 to 25 hp.
b) Medium tractors – 25 to 45 hp.
c) Large tractors – more than 45 hp.

Fig. 2.8: Four-wheel tractor

3. Based on Purpose:

(a) Utility Tractor: It is a specific purpose field tractor that is designed for ploughing driving any other equipment through its P.T.O. (Power take-off) drive. Now it is not manufactured in the country.

(b) All-purpose Tractor: It is designed in such a way, that it can meet practically all the demands for agricultural operations like ploughing, harrowing, leveling, pulling other implements, seed drill, operating threshers, and pumps through its P.T.O. These are connected with the help of three-point linkages.

(c) Orchard Type Tractor: A special type of tractor used in orchards. These are usually very high so that driver could perform all operations on the trees while sitting on the seat. No part of the tractor is protruded outside, so that tractor can go easily in between trees safely.

Fig. 2.9: Orchard-type Tractor

(d) Garden Tractor: These tractors are available in the range of 1 to 10 hp and are very small in size. These are mostly used in kitchen or vegetable gardens.

Fig. 2.10: Garden Tractor

(e) Rotary Tiller: These are walking types of tractors and are used in small fields or on hills where fields are very small in size. These are also used in fields that are at different levels, where ordinary tractors cannot work efficiently. Tined blades are fitted to the tillers to prepare the seedbeds quite effectively by pulverizing the soil. These are also used in rice fields for puddling and other operations.

Fig. 2.11: Rotary Tiller

(f) Earth Moving Tractors: These tractors are heavy, strongly built, and are available in both types: track and tyre. These are used for earth moving work on dams, quarries, and other constructional works.

(g) High Clearance Tractor: Used in certain operations like crop weeding, intercultural, and plant protection which require more ground clearance to avoid any damage to crops.

(h) Industrial Tractors: These tractors are manufactured mainly for specific requirements of industry and airport and used mainly for pulling heavy loads. Instead of a three-point linkage, a drawbar is used for pulling the load.

Fig. 2.12: Industrial Tractor

Horse Power of Tractor

Horsepower (hp) is a unit of measurement for power or the rate at which work is completed usually with an engine or motor output. There are a variety of horsepower specifications and types. The mechanical horsepower (or imperial horsepower), which is roughly 745.7 watts, and the metric horsepower, which is approximately 735.5 watts. One horsepower is roughly 746 watts of power by modern standards, while there are some differences, such as the metric horsepower, which is about 10 watts less. It's also worth mentioning that a tractor's horsepower rating normally refers to the "engine horsepower," which is distinct from the horsepower provided by the power take-off (PTO), which is a lesser figure than the rating.

Agricultural tractors are divided into various horsepower ranges, these ranges help farmers/operators for different uses as well as government subsidy and other marketing purposes:

1. Tractors up to 15 hp.
2. Tractors from 15 hp to 20 hp
3. Tractors from 20 hp to 40 hp
4. Tractors from 40 hp to 70 hp

Selection of Tractor

More than 230 models of tractors ranging from 7 to 70 PTO Horse Power (The PTO Horsepower indicates the amount of power available to run various implements) are produced by more than eighteen manufacturers at present. Farmers often face problems in selecting a tractor that is suitable for all the requirements. The performance of the tractor depends on how the power is applied to the soil and the overall efficiency of operation.

a. **Horsepower of the tractor:** If the tractor is big for the size of the farm, fixed costs increase which directly reduces the profit. However, if the tractor is small, it may take extra time resulting in lower yields and poor crop quality.
b. **Size of landholding and type of operations:** Tractor is used for various field operations starting from land preparation, sowing, irrigation, harvesting, threshing, and transportation work. Out of all the operations, some are difficult and the output in terms of hectares per hour is less than others. Therefore, it is always recommended that while determining the horsepower of the tractor, we should consider the field operation which is toughest and time-consuming, for example - ploughing.
c. **Working time availability:** The time available for completing a particular field operation is another important factor in deciding the horsepower range. In a year if more than one crop is to be grown, then the time available after harvesting of one crop and the seedbed preparation for the second crop is to be calculated precisely based on the previous records. While calculating, availability of time, for the preparation of land one should refer to at least 4-5 years of weather records. Always consider the year in which the worst weather situation was prevailing and thus obtain some calendar days available for various field operations**.**
d. **Soil Resistance:** In different soil conditions the soil resistance varies. In heavy soil it is high and in light soil it is low. An implement that can give a desired depth of operation in light soil at a certain speed will not be able to do the same quantum of work in the same period in heavier soil. In such cases, reduce the speed of the tractor to pull the load at the desired depth. A tractor capable of performing all operations timely for a specified size of the field in light soil will be different in case of heavy soil.

Once the horsepower of the tractor is decided, check the following factors:

i. **Dependable reliable and durable:** The tractor must have a record of less breakdown, and a long overhaul period of its components.
ii. **Less initial, operating, repair, and maintenance cost:** Tractors may have a less initial price, are fuel-efficient, and have less maintenance, the cost of spare parts is comparable and easily available.
iii. **Test Performances:** Check the performance of the tractor in test reports, which is published by Central Farm Machinery Training & Testing Institute, Budni (Govt. of India), in terms of power-take-off (PTO) & drawbar power output, specific fuel consumption, the performance of a hydraulic system, performance of other components, suitability, performance in field and haulage operations.

iv. **Safety and Comfort:** From the CFMT&TI Budni test reports of the tractor, we may also check performance details of noise, vibration, brake, seat, work area, visibility, operating efforts, stability, safety-guards, and provision of roll over protective structure.

v. **Engine Consideration:** Backup torque, specific fuel consumption, and operating speed range are important engine considerations while selecting a tractor**.**

vi. **Transmission system:** The number of gear speeds and gear spacing are important. Even if two tractors have the same horsepower, a tractor with better gear speeds and gear spacing can perform the same task in lesser time.

vii. **Simple to operate, maintain and repair:** The tractor must have easy and few controls, easy accessibility of maintenance/repairs.

viii. **After sales-service:** The dealer must have a good record of prompt and quality service, genuine spare parts, excellent behaviour, and the manufacturer is giving sufficient warranty and free services.

ix. **Brand Image:** The number of tractor and other products in the area. Also take a look at opinion maker and satisfied customer, publicity of the products and organisation.

x. **Standard and optional features:** Whether ballast weight, toeing hitch, pulley, and differential lock are provided with the tractor or having optional features.

xi. **Versatility:** Whether tractor is suitable for dryland, wetland, and haulage work.

xii. **Aesthetics:** Tractors having excellent styling/colour product graphics, finish of casting, sheet metal, light, and instrument panel are liked by the customer.

xiii. **Availability of matching implements:** Whether the implements like a plough, seed drill, cultivators, and other important implements match with the horsepower of the tractor and are available in the market.

xiv. **Resale value:** The tractor is being sold after its use and it has a good second-hand market, so check its resale value in the market.

Table. 2.1: Make and models of tractors available in India

S.No.	Name of the manufacturers	Models
1.	Action Construction Equipment Ltd.	ACE DI 37 XT, ACE DI42 XT, ACE DI350NG4WD, ACE DI350 NG, ACE DI874 NG, ACE DI 47 XT,

	(ACE make).	ACE DI450 NG 4 WD, ACE DI 550NG 4 WD, ACE DI 6565 4 WD, ACE DI 550 NG, ACE DI550*, ACE DI450 NG, ACE DI450*, ACE DI 6565, ACE DI 305 NG.
2.	Adico Escorts Agri equipment's Pvt. Ltd. (Steel track make).	Steel track, Steel track 18.
3.	Agri King Tractor and equipment Pvt. Limited (Agri King Smart make).	Agri King Smart AKT44, Agri King Smart AKT54.
4.	Captain Tractors Pvt. Ltd. (Captain make).	Captain 200DI 4WD, Captain 250DI, Captain 250DI 4WD, Captain 200DI.
5.	CNH Industrial (India) Pvt. Ltd. (New Holland make).	New Holland 3510, New Holland 3230, New Holland 3032, New Holland 3037, New Holland 3230TX, New Holland 4010A, New Holland 3630 TX, New Holland 5500 Turbo super 12+3UG, New Holland 3600-2 All-rounder Plus+, New Holland 3600-2, New Holland3630 TX plus UG 4WD, New Holland 3630 TX A1, New Holland 4710 A, New Holland6010, New Holland 6010 (12+12), New Holland 7500 Turbo super 12+3 UG, New Holland 6510, New Holland 7510, New Holland 6510 12+12.
6.	Escorts Ltd. (Escort make).	Escorts Ltd 439 E1 (Brand Name-Powertrac), Escorts Ltd 434 DS (Brand Name-Powertrac), Escorts Ltd 425 N E1 (Brand Name-Powertrac), Escorts Ltd,26(Brand Name-Farmtrac), Escorts Ltd EURO 45 E5(Brand Name-Powertrac), Escorts Ltd -Powertrac439 DS plus ALT 4000, Escorts Ltd -Powertrac439, Escorts Ltd 60 F2 Farmtrac, Escorts Ltd 45 F9 Farmtrac , Escorts Ltd Euro60 powertrac, Escorts Ltd Euro41 E3 Powertrac, Escorts Ltd Euro 50 Powertrac, Escorts Ltd 6065 F4 Farmtrac, Escorts Ltd Farmtrac 60, Escorts Ltd Euro 47 powertrac, Escorts Ltd Farmtrac 45, Escorts Ltd 45 F25 Farmtrac, Escorts Ltd Farmtrac 6050 F1 Um, Escorts Ltd Farmtrac 6050, Escorts Ltd Farmtrac 6060 UM, Escorts Ltd Farmtrac 6065 UM 4 WD.
7.	Force Motors Ltd (Force make).	Force motors ltd. OX25 Orchard DLX, Force motors ltd. OX25 Orchard mini, Force motors ltd. OX25 Orchard DLX LT, Force motors ltd Sanman 5000, Force motors ltd Sanman 6000, Force

		motors ltd balwan 450, Force motors ltd balwan 400DLX.
8.	Gromax Agri Equipment Ltd (Gromax make).	Gromax Trak star 545, Gromax Shaktiman 45 DLX.
9.	Indo Farm Equipment Limited (Indo farm make).	Indo Farm3035 DI C-Mesh Indo Farm3048 DI C-Mesh.
10.	International Tractors Ltd (Sonalika make).	Sonalika international DI-22 4WD Gardentrac, Sonalika international DI-26Gardentrac, Sonalika international DI-734 FE, Sonalika international DI 35 HDM, Sonalika international DI-30 RX Baagban Super 4WD, Sonalika international DI 730 II FE, Sonalika international DI 740 III CM series, Sonalika international DI-35 SM, Sonalika international DI-35 RX CM plus, Sonalika international DI 750 III HDM, Sonalika international DI750 II HDM s1, Sonalika international DI 60 RX, Sonalika international DI 60 CM series 2 WD, Sonalika international DI 750 III super, Sonalika international DI 47 RX 4WD WL, Sonalika international DI 745 III npower plus, Sonalika international RX Mileage master super, Sonalika international DI 42 HDM, Sonalika international DI47 RX 4WD, Sonalika international DI47 RX Heavy duty, Sonalika international DI Worldtrac 60 RX 4WD, Sonalika international DI20 Garden trac, Sonalika international DI 30 Baagban super, Sonalika international DI740 Super CM series, Sonalika international DI 35 DS CM series, Sonalika international World trac 60 RX.
11.	John Deere India Pvt. Ltd. (John Deere make).	John Deere 5042 D V3, John Deere 5045 D V2, John Deere 5036D, John Deere 5105, John Deere 5036D V2, John Deere 5105 V2, John Deere 5039D, John Deere5039 D V2, John Deere 3038 EN, John Deere 3036EN, John Deere5310 V5, John Deere 5310 V3, John Deere 5060 V2, John Deere5060 E, John Deere 5310 V1, John Deere 5310v4, John Deere 5045 D 4WD V2, John Deere 5050D V7, John Deere 5050 E, John Deere5050 E V2, John Deere5050D V5, John Deere 5050D V4.
12.	Kerala Agro Machinery	KAMCO Teratrac 4W.

	Corporation Limited (KAMCO make).		
13.	Kubota Agricultural Machinery India Pvt Ltd (Kubota make).		Kubota B2741, KubotaA211N, KubotaB2441, Kubota L4508 DD, Kubota L-3408 DD, Kubota MU5501, Kubota MU5501 4WD, Kubota MU 4501, Kubota MU4501 4WD.
14.	Mahindra & Mahindra Ltd (Mahindra and Swaraj make).	Swaraj Division	Swaraj 712 ES, Swaraj 724 XM orchard narrow track, Swaraj742 FE, Swaraj 724 XM orchard, Swaraj735 FE, Swaraj 843 XM, Swaraj 825 XM, Swaraj 834 XM, Swaraj 735 FE JXPDS 540, Swaraj 724 XM, Swaraj 735 XT, Swaraj 735Fee, Swaraj 834 XM PXPDS540, Swaraj, Swaraj 744 FE Swaraj 855 FE, Swaraj744 XM, Swaraj 963 FE ST, Swaraj 963 FE STR, Swaraj 960 FE.
		M&M	Mahindra 215 YUVRAJ , Mahindra JIVO225 DI, Mahindra B275 Di TU MKM, Mahindra255 DI power+, Mahindra YUVo 415DI, Mahindra Yuvo 475 DI, Mahindra415 DI, Mahindra255DIPOWER +OID, MahindraJivo245 DI, Mahindra265 DI MKM, Mahindra475 DI MKM, Mahindra B275 DI TU MKM, Mahindra 475DI MKM DLX , Mahindra575 DI MKM DLX, Mahindra275 DI MKM, Mahindra275 DI TU MKM DLX, Mahindra255 DI MKM DLX, Mahindra Yuvo265 DI, Mahindra Yuvo275 DI, Mahindra 605 DI, Mahindra575 DI Power+, Mahindra605 DI PS , Mahindra Yuvo 575 DI, Mahindra 555DI Power Plus , Mahindra 605 DI4WD S+ Mahindra605 DI MS , Mahindra 575DI MKM, Mahindra Arjun 555 DI, Mahindra585DI Power +,Mahindra 605 DI CAB, Mahindra Yuvo 575 DI 4WD, Mahindra 605 DI MS 4 WD S+, Mahindra 605 DI Super turbo.
15.	Preet Tractors Pvt. Ltd. (Preet make).		Preet3049 Challenger, Preet6549, Preet 955Challanger, Preet4549 Challenger.
	Same Deutz-Fahr India Pvt. Ltd. (Deutz-Fahr make).		Deutz-Fahr Agrolux 45 E, Deutz-Fahr Agromaxx 45, Deutz-Fahr3042E, Deutz-Fahr3035E, Deutz-Fahr3040E, Deutz-Fahr Agrolux 55 E, Deutz-Fahr Agrolux 55 E (12+3) 2 WD, Deutz-Fahr Agrolux 55E 2 WD, Deutz-Fahr Agromaxx 55 4WD Deutz-Fahr Agromaxx 55, Deutz-Fahr Agrolux 50E, Deutz-Fahr Agrolux 50 E 2WD, Deutz-Fahr Agrolux 70 E, Deutz-Fahr Agrolux 70 E 2 WD, Deutz-Fahr Agromaxx 50, Deutz-Fahr Agromaxx 60 4WD, Deutz-Fahr Agromaxx 60 Deutz-Fahr Agrolux 75 E Profiline.

16.	Tractors and Farm Equipment Limited (Eicher and Tafe make).	Eicher	Eicher 188, Eicher242 USJ, Eicher 241 XTRAC, Eicher 368 USJ, Eicher 242 XTRAC, Eicher 242 XTRAC Premium, Eicher 312, Eicher 364, Eicher 380, Eicher 480, Eicher 333, Eicher 485USJ, Eicher 551, Eicher 485 hydromatic, Eicher557, Eicher548.
		TAFE	TAFE MF 1035 V13, TAFE 30 DI orchard plus, TAFE MF 1035 DI Mahashakti V1, TAFE MF 1035 DI V18, TAFE MF 1035DI V1, TAFE MF 241DI PP 4WD, TAFE MF 1030 Mahashakti, TAFE MF 1134, TAFE MF 241 DI, TAFE MF 241 DI, Planetary plus V1, TAFE MF 1035 DI V2, TAFE MF 6028, TAFE MF 5245 DI 4WD, TAFE MF 7250 DI V1.1, TAFE MF 5245 DI MAHAMAHAN, TAFE MF245 Di, TAFE MF9000, TAFE MF9500 2WD, TAFE MF9500 4WD, TAFE MF5245Di planetary plus V1, TAFE MF7250DI power drive power steering, TAFE MF9500.
17.	VST Tillers Tractors Ltd (VST make).		VST Shakti VT180D HS/JAI-4W, VST Shakti MT180/JAI 2W, VST ShaktiMT180 D, VST Shakti MT224-1/AJAI-4W, VST Shakti MT270 Virat 4W, VST Mitsubishi Shakti VT 224-1D94WD).
18.	Trisul Tractors Pvt. Ltd. (Trisul make).		Trisul125 DI.

PRACTICAL EXERCISES

Activity 01: Make a list of different tractors make and model.

Material required

1. Pen
2. Notebook

Procedure

1. Visit the tractor dealer shop.
2. Identify different types of tractors.
3. Makes a list of different make and models of a tractor using newspapers, websites, tractor dealers, government departments.

CHECK YOUR PROGRESS

A. Answer the following questions

1. Define the Horsepower.
2. What is the difference between wheel type and track-type tractor?

3. What is the engine consideration while selecting a tractor?
4. Write the names of five tractor manufacturers along with two models of each manufacturer.

B. Fill in the blanks

1. While calculating, availability of time, for preparation of land one should refer to at least 4-5 years of ……. records.
2. The …… available for completing a particular field operation is an important factor in deciding the horsepower range.
3. The soil resistance in different soil conditions ……. in heavier soil, it is …… and in light soil it is low.
4. The tractor may have ……. initial price, fuel-efficient and having less maintenance and cost of ……. parts are comparable and easily available.
5. In certain crops weeding, intercultural, and plant protection operations are required more …… to avoid damage to crops.

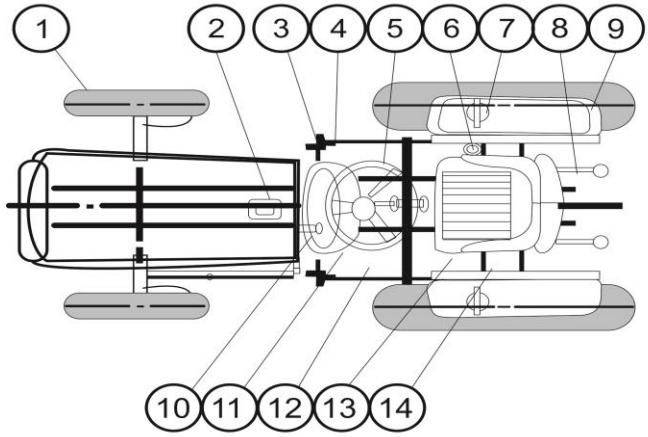
C. Match the following

Column A	Column B
1. For the specific requirement of orchard and horticulture these tractors have been developed.	A. Industrial tractor
2. These tractors are manufactured mainly for the specific requirement of industry and airport.	B. Crawler tractor
3. In this type of tractor, engine power is given to all four wheels to reduce slippage and increase the drawbar pull.	C. Orchard special tractor
4. For heavy earthmoving and construction work these types of tractors are used.	D. Four-wheel-drive tractor

SESSION 3: COMPONENTS AND SYSTEM OF TRACTOR

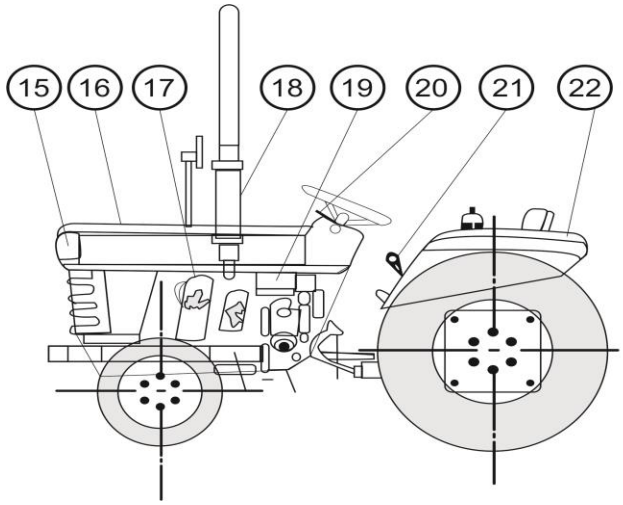
In a tractor, power is generated from the engine which converts the chemical energy of fuel into mechanical energy of power. The engine is called an internal combustion engine because the fuel burns insides the engine. Four-stroke diesel internal combustion engines are used in tractors.

(A) Top view



1. Front wheel
2. Fuel tank cap
3. Accelerator pedal
4. Brake pedal
5. Steering wheel
6. Hydraulic control lever
7. Turn signal lamp
8. Lift arm
9. Rear tire
10. Instrument panel
11. Clutch pedal
12. Step
13. Seat
14. Rear axle housing

(B) Side view



15. Side clearance
16. Engine hood
17. Fan cover
18. Muffler
19. Fuel tank
20. Throttle lever
21. Main speed change lever
22. Fender

Fig. 2.13: Line Diagram of Tractor

A tractor is made of the following main components:

1. IC Engine
2. Clutch
3. Gearbox
4. Differential and Final drive
5. Power take-off
6. Steering system and Front axle
7. Brakes
8. Hydraulic system and Three-point linkage
9. Auto electrical system
10. Intake and Exhaust system
11. Cooling system
12. Fuel supply system
13. Lubrication system
14. Governing System

Let us now learn about different systems of tractor-engine and sub-assembly of engine system

Terminologies related to engine power

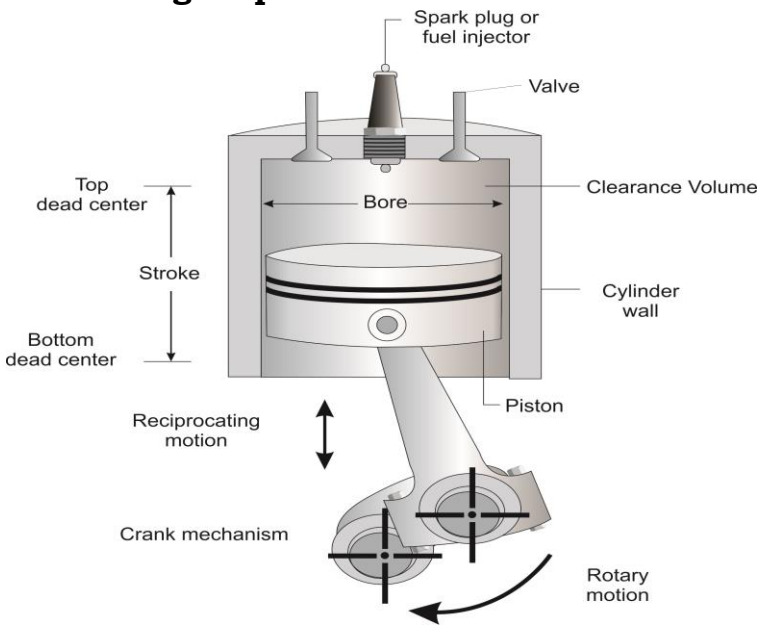


Fig. 2.14: Basic Parts of Engine Cylinder

1. **Bore (d):** Bore is the diameter of the engine cylinder.
2. **Stroke (L):** It is the linear distance travelled by the piston from the top dead centre to the bottom dead centre.

3. **Swept Volume**: It is the volume (A x L) that the piston displaced by one stroke of the piston. Where A is the cross-sectional area of the piston.
4. **Compression ratio:** It is the ratio of the volume of the engine cylinder at the beginning of the compression stroke to that at the end of the compression stroke.

   Compression ratio = Total cylinder volume/clearance volume

   = (Swept volume + clearance volume)/clearance volume
5. **Power**: It is the rate of doing work. One horsepower is equivalent to 4500 kg per minute.
   I. **Indicated horsepower (IHP):** It is the power generated in the engine cylinder and received by the piston. It is the power developed in the cylinder without friction or auxiliary unit.

In the metric unit,

Indicated horse power (IHP) = (PLANX/ (4500 x 2) (for 4 stroke engine)

Where,

P=mean effective pressure (kg/cm^2)

L = stroke length, (m)

A=cross sectional area of piston, (cm^2)

N = engine speed, rpm

X = no. of cylinder

TYPES OF ENGINES

Heat engines can be broadly divided into two types:

a) External Combustion (EC)

b) Internal Combustion (IC)

In an EC engine combustion of fuel takes place outside the engine whereas in IC engine fuel combustion takes place inside the engine. The IC engine is of three types: reciprocating, wankel, and rotary gas turbine. However, the reciprocating type engine is the most commonly used.

The reciprocating engine can be further classified as Compression ignition (CI)/Diesel engine and Spark Ignition (SI)/petrol engine. Suction, compression, power, and exhaust are four main events that take place in the reciprocating engine. In four-stroke engines, these events are completed by two revolutions of a crank shaft or four strokes of the piston. However, in a two-stroke engine, these four events are accomplished in a single revolution of the crank shaft.

Multi-cylinder engines can be classified in different ways on the basis:

1. Cylinder arrangement
2. Valve arrangement
3. Type of fuel used
4. Number of operating cycles
5. Types of cooling
6. Type of ignition

COMPONENTS OF ENGINES

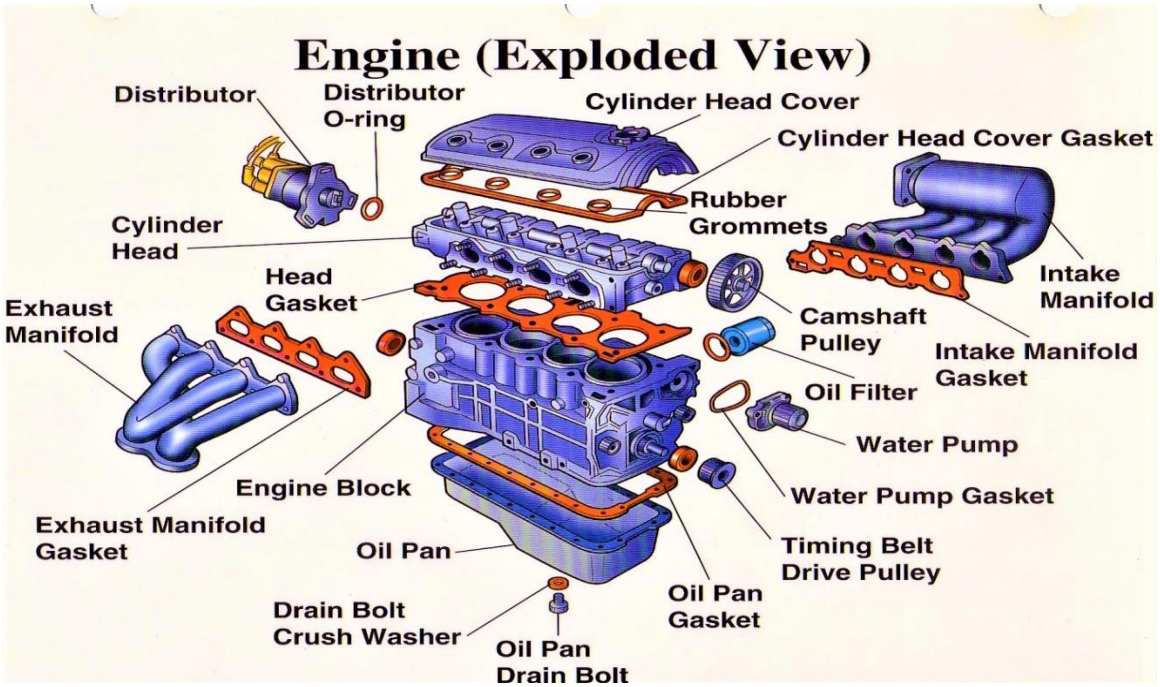


Fig. 2.15: Engine Components

1. **Cylinder Head** is at the top of the engine and houses the valves and has intake and exhaust passages.
2. **Valves** open and close to let fuel in and exhaust gases out of each cylinder.
3. **Camshaft** rotating in the engine block opens the valves by cam action.
4. **Cylinder Block** is the main housing of the engine and supports the other main parts.
5. **Cylinders** are hollow tubes in which the piston works. They may be cast into the cylinder block or made of liners or sleeves.
6. **Pistons** move up and down in the cylinders by the force of combustion.
7. **Piston Rings** seal the compression in the combustion chamber and also help to transfer heat.
8. **Connecting Rods** transmit the motion of the pistons to the crankshaft.

9. **Crankshaft** receives the force from the pistons and transmits it as rotary driving power.
10. **Main bearings** support the crankshaft in the cylinder block.
11. **Flywheel** attaches to the crankshaft and gives it momentum to return the piston to the top of the cylinders after each downward thrust.
12. **Balancers** such as shafts or dampers, if used, balance the vibrations in the engine.
13. **Timing Drives** link the crankshaft, camshaft, and other key parts together to assure that each is doing its job at the right time.

Now, let's try t get familiar with the main components of a tractor

I. IC ENGINE: An internal combustion engine (ICE) is a heat engine in which the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit.

Principle Operation of IC Engine:

1. **Four Stroke Cycle (Diesel Engine):**

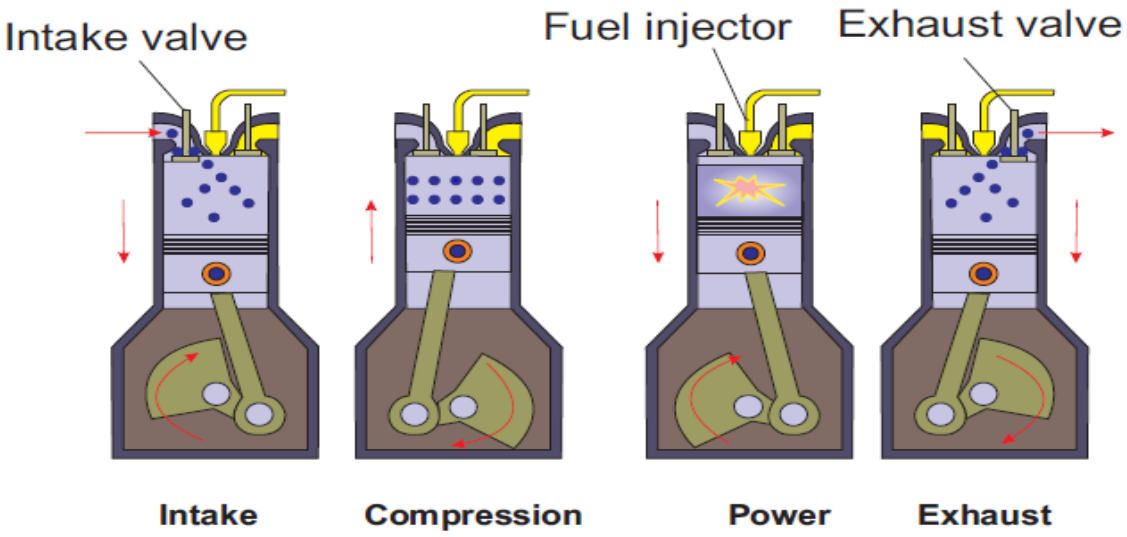


Fig. 2.16: Four Stroke Cycle (Diesel Engine)

In four-stroke cycle engines, there are four strokes which are completed in two revolutions of the crankshaft. These are respectively; suction, compression, power, and exhaust strokes. The working process of these strokes is as follows:
Step 1: Intake or Suction stroke: In this stroke only, inlet (intake) valve is open and the outlet (exhaust) valve is closed.

Step 2: Compression stroke: In this stroke both the intake and exhaust valve are closed and fuel is compressed by the piston.
Step 3: Power stroke: During this stroke, the fuel and air mixture is compressed inside the cylinder. Due to which the piston reaches the upper portion of the cylinder and this produces exhaust gases/power in the cylinder.
Step 4: Exhaust stroke: After the completion of the power stroke the exhaust gases are ready to be released from the cylinder, thereafter the exhaust valve is open but the intake valve remains closed.

VALVE OPERATION

Valve operating mechanism consists of several components such as-

1. Crankshaft gear
2. Camshaft gear
3. Tappet
4. Pushrod
5. Rocker arm

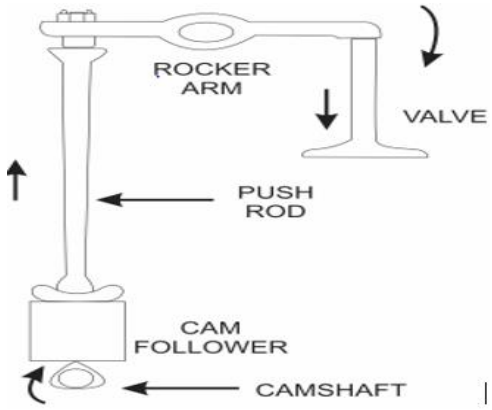


Fig.2.17: Valve Mechanism

VALVE TIMING DIAGRAM

A valve timing diagram is a diagram of crank rotation on which the time of opening-closing of the inlet valve, the exhaust valve is shown in (Fig.2.18).

The valve timing mechanism is concerned with the relative closing and opening of valves and their duration with respect to the cylinder position and the degree of crankshaft rotation. Top Dead Centre (TDC) is the instant when a piston is at the top of its stroke i.e., it is on the point of changing from upward to downward motion. Bottom Dead Centre (BDC) is the instant when a piston is at the bottom of its stroke i.e., it is on the point of changing from downward to upward motion. Theoretically, the intake valve should open on TDC and close at

BDC. Whereas the exhaust valve should open on BDC and close on TDC, but these angles differ in actual practice. Valve timing is a function of speed. For most of the average tractor engines of the four-stroke cycle, the inlet valve opens about 5° before TDC and closes at about 30° after BDC; the exhaust valve opens about 40°before BDC and closes at about 5° after TDC.

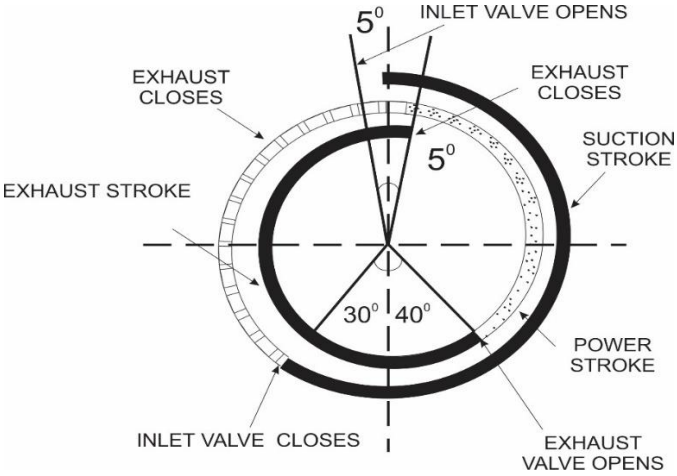


Fig. 2.18: Valve Timing Diagram

Various Systems of Engine

The engine is a very important parts of any vehicle. Every system of the engine must work properly. The various systems in an engine are as follows:

1. Intake & Exhaust System
2. Cooling System
3. Fuel supply System
4. Lubrication System
5. Governing System

1. INTAKE & EXHAUST SYSTEM: These systems are used for the intake and exhaust of gas and fuel. An air intake system consists of pre-cleaners, air cleaners, intake manifold, and hoses.

a. Pre-cleaner: Pre-cleaners are fitted in the upper portion of air cleaners. These are used to remove the large dirt/dust particles from the air before it enters the air cleaner. It works on the centrifugal principle.

Fig. 2.19: Pre-cleaner

b. Air cleaner: There are different types of air cleaners, but two types of air cleaners are used in tractors; Oil-bath type and Dry type. In an oil bath-type air cleaner, air enters through a central tube and moves downward into the oil in a cup at the bottom.

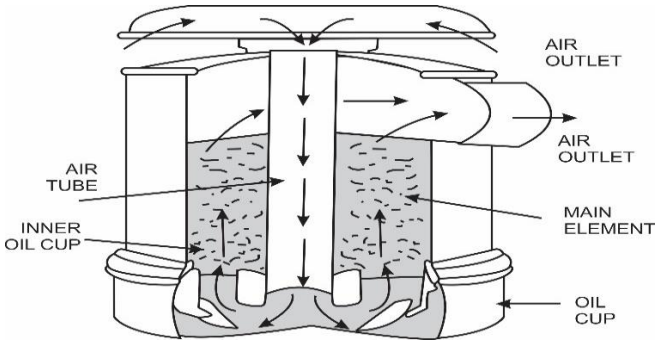


Fig 2.20: Oil bath air cleaner

In dry type air cleaner, there are three main parts: pre-cleaner, cleaning element and main housing.

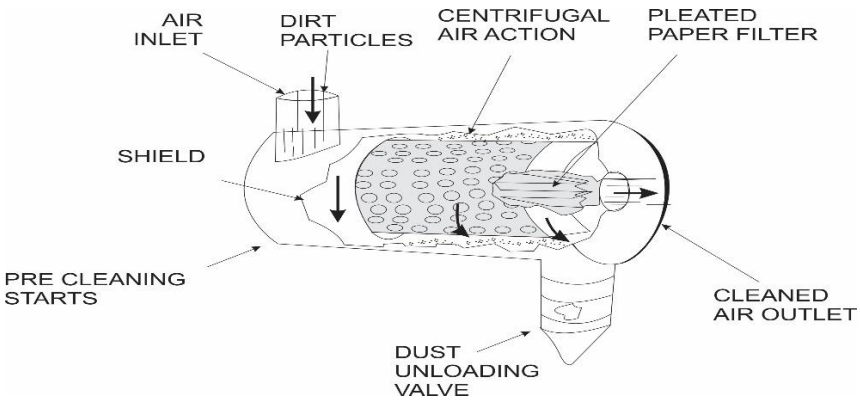


Fig. 2.21: Dry-type air cleaner

c. Intake manifold: It is an enclosure on the side of the engine made up of cast iron or aluminium alloy.

d. Exhaust system: The exhaust system collects the exhaust gases from the individual cylinders, cools them to reduce fire hazards, and reduces their energy levels to provide a low noise engine.

Fig. 2.22: Exhaust System

e. Turbocharger: A turbocharger which is an exhaust-driven turbine, helps to move air into an engine by pressurizing and increasing the density of the air in the intake manifold.

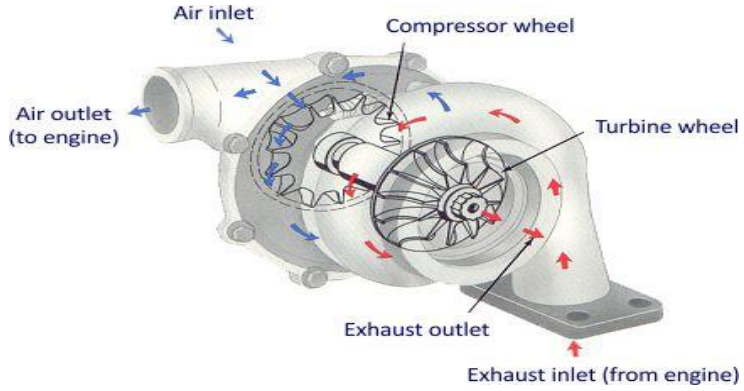


Fig. 2.23: Turbocharger

2. **COOLING SYSTEM:** The purpose of a cooling system in an engine is to dissipate the surplus heat for the protection of engine components, maintain the optimum temperature of the engine, and maintain the lubricating property of the oil for smooth functioning of the engine. There are two types of cooling systems used in tractors engine- liquid cooling and air cooling.
   a. **Air cooling system:** In air-cooled engine heat is conducted from the working component of the engine to the atmosphere directly.
   b. **Liquid cooling system:** In a liquid cooling system, liquid jackets are provided around the engine cylinder or liners. The circulating liquid/coolant in these jackets absorb the heat from the cylinder surface and then the heated water/coolant is cooled by passing through the radiator.

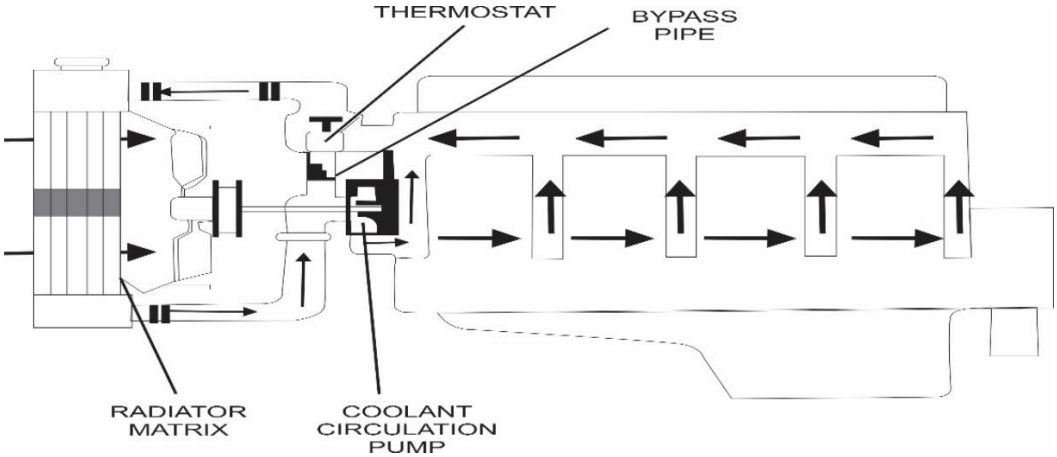


Fig. 2.24: Liquid Cooling System

In the radiator, heat in the coolant is released in the atmosphere with the radiator core and radiator fan. First, the hot coolant moves from the upper tank of the radiator to the lower tank through the radiator core. Then the air spreads inside the radiator, and it transfers the heat of the coolant outside. It is a reservoir for a liquid to operate the cooling system.

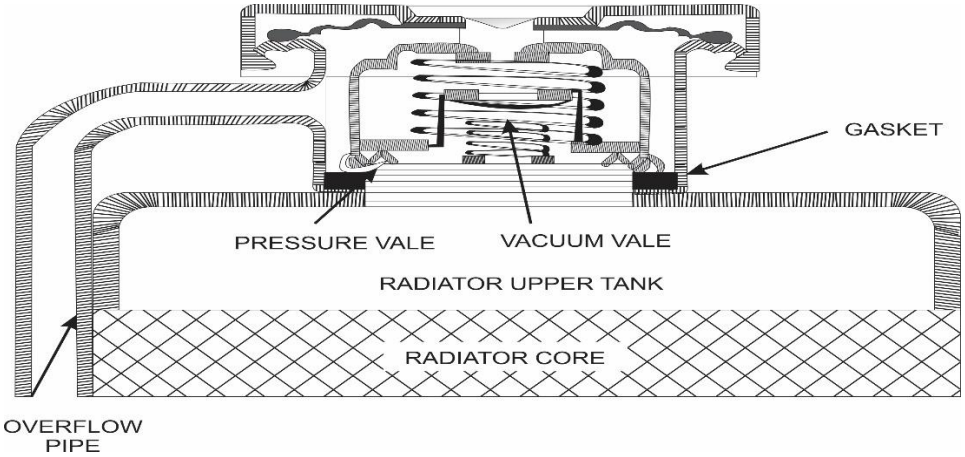


Fig. 2.25: Liquid Cooling System

To circulate the coolant through the system, the centrifugal-type pump draws hot coolant from the engine block and forces it to the radiator for cooling.

3. **FUEL SUPPLY SYSTEM:** In the diesel fuel system, fuel is sprayed directly into the engine combustion chamber where it gets mixed with hot compressed air and ignites. It has the following components:
   - Fuel tank-stores fuel.
   - Fuel feed pump-moves fuel to the injection pump.

- Sediment bowl assembly-collects dust particles.
- Fuel filters-helps clean the fuel.
- Fuel injection pump-times, measures and delivers fuel injection under pressure.
- Fuel injectors-atomize and spray fuel into the cylinders.
- Combustion chambers.

Fuel tank: The fuel tank is made up of a mild steel sheet or fibre sheet of sufficient capacity and suitable shape.

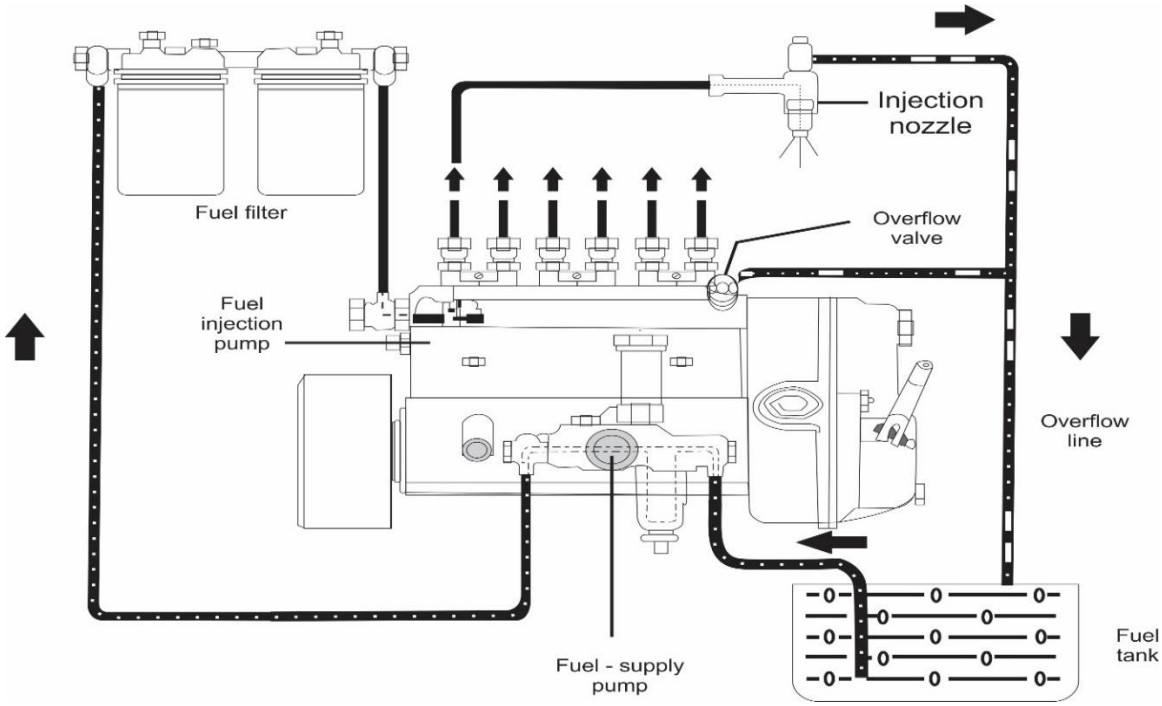


Fig. 2.26: Fuel Supply System

Fuel feed/supply pump: It delivers the fuel from the tank to the injection pump continuously and at a reasonable pressure.

Sediment bowl assembly: It is mounted between the fuel tank and fuel feed pump. It removes the coarse impurities from fuel before entering to fuel supply system.

Fuel filter: A filter present in a fuel line that screens out dirt and dust particles from the fuel, and is normally made into cartridges containing a filter paper. Mostly two-stage filters are used and it consists of the metal element, felt and cloth element, and paper disc.

Fuel injection pump: It supplies fuel to the injectors according to the firing order of the engine. It has a high-pressure pump in it. The fuel injection pump is usually of two types: Multi-element pump and Distributor (rotary) type pump.

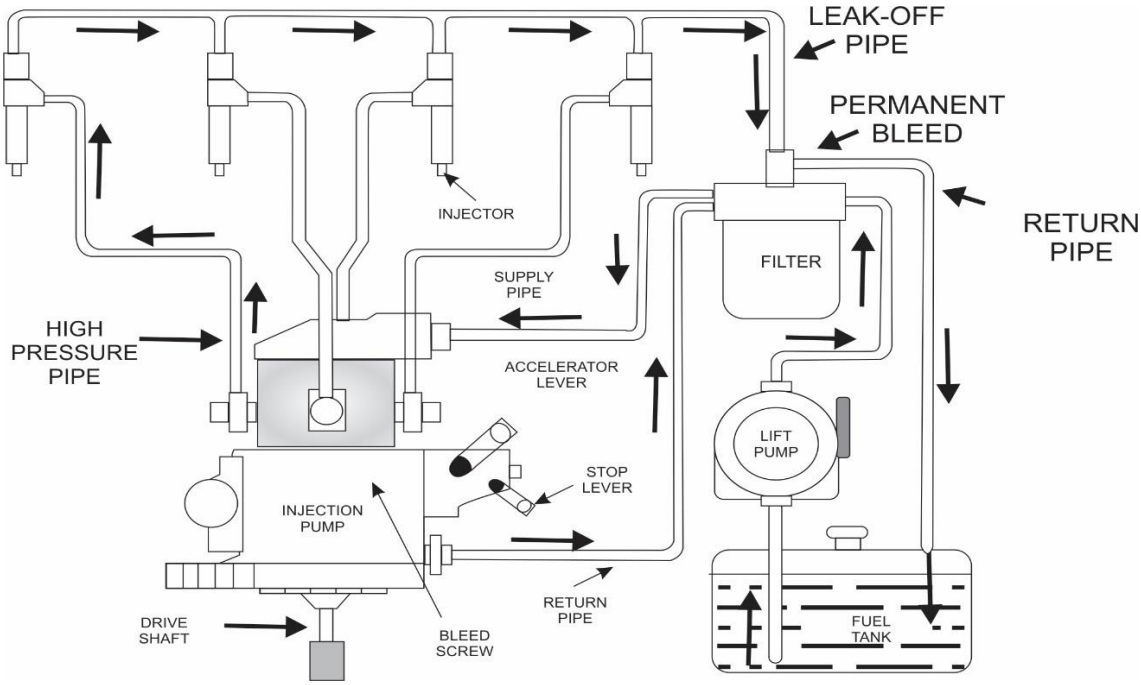


Fig. 2.27: Distributor (rotary) Type Pump

Fuel injector: Fuel injectors deliver finely atomized fuel under high pressure to the combustion chamber of the engine.

Combustion chamber: A Combustion chamber is a space inside the engine, where the combustion of fuel takes place. Combustion chambers are of two types: Direct injection chamber and Indirect injection chamber.

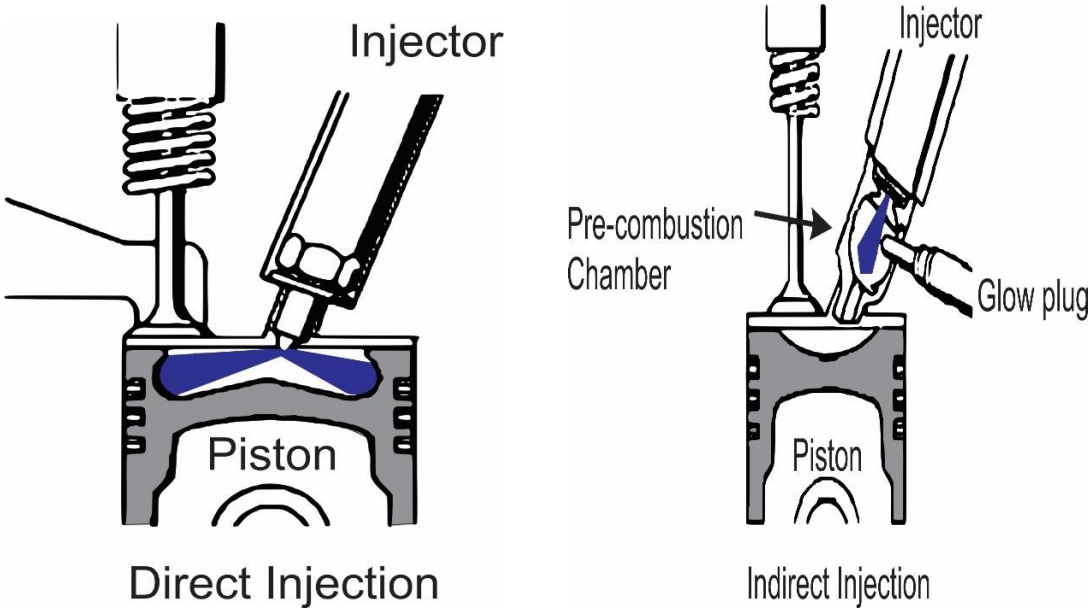


Fig. 2.28: (a) Direct Injection Chamber (b) Indirect Injection Chamber

4. **LUBRICATION SYSTEM:** The lubrication system prevents friction between moving parts of the engine. It supplies adequate lubricating oil to prevent excessive friction. Special additives are added to the engine oil to increase the engine resistance towards corrosion, engine oil film also has a damping effect. In most engines, oil is sucked out of the oil pan by the oil pump. This is a part of the lubrication system:
   - **Oil filter:** It traps the dust, dirt, metal rubbings, and other foreign materials. There are two types of filters that are used:

   1. Full-flow filter: In full flow filters the entire flow of oil is forced through the filter before it reaches the lubrication points.

   2. Bypass filter: To remove almost all pollutants from motor oil, by-pass oil filtration features a secondary filter.

Lubrication Methods: The three main methods of lubrication are as follows:

a. Splash lubrication: In this case, the oil is splashed onto different working parts of the engine using big end bearing caps, small scoops, crankpin webs, or dippers. These dips into the oil at every revolution and oil gets scattered or splashed.

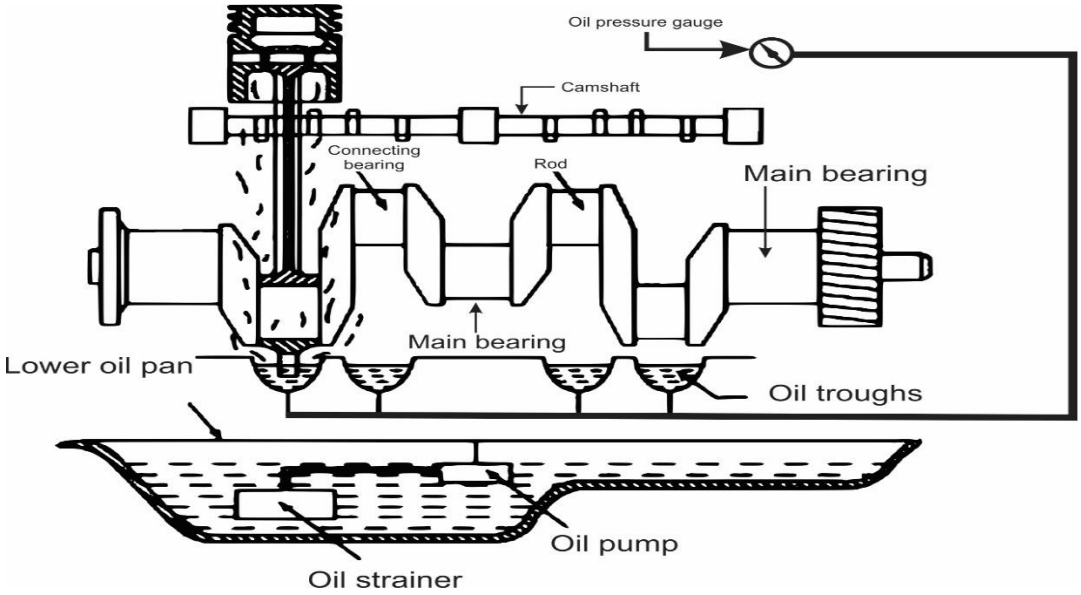


Fig. 2.29: Splash Lubrication System

b. Force feed: A pump draws the oil from the sump in the crankcase, usually through a mesh strainer, and force it at high pressure through the oil lines and filter to the lubrication points. The oil pump delivers oil to the main gallery from

where it passes through drilled holes to the main bearings, camshaft bearing, and partially to the connecting rod bearing.

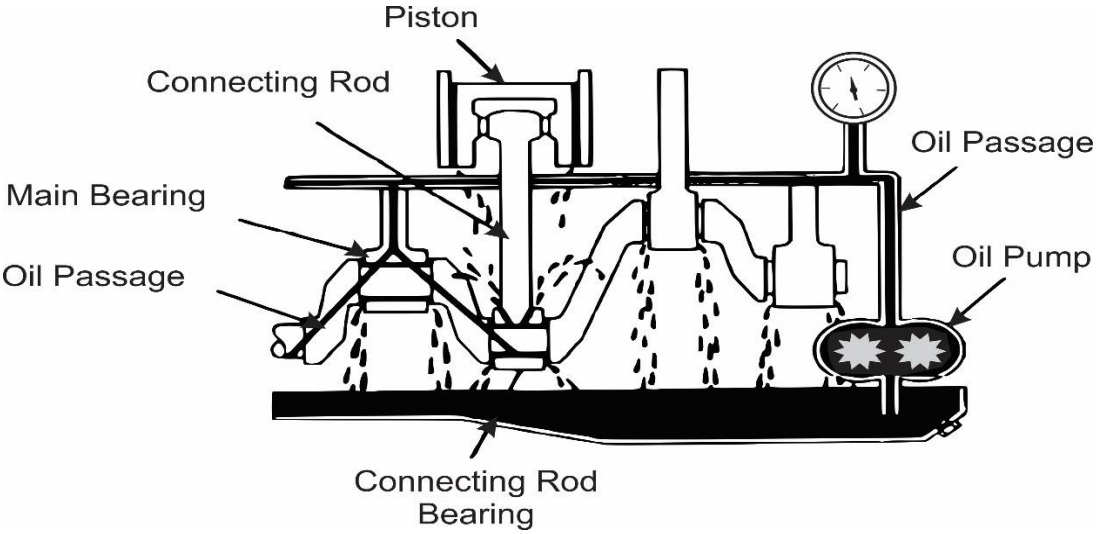


Fig. 2.30: Force-feed Lubrication System

c. Combination of splash and force-feed: In this method combination of both splashes well as force-feed is used. Some parts are lubricated by splash and some by force feed method.

5. TRANSMISSION SYSTEM: The transmission system of the tractor consists of the following components:

1. **Clutch:** To disconnect the engine from the rest of the transmission, so that gear can be engaged or changed. This is how the engine can be brought to a suitable speed before being put on the road.
2. **Transmission/gearbox:** It provides a means of varying the gear ratio between the engine and the rear wheel, it transmits power at multiple speeds and torque.
3. **P.T.O. drive:** It transmits torque from the engine to the PTO spline.
4. **Differential:** It transmits power around the corner to the drive axle and also allows each drive wheel to rotate at a different speed and still propel its load.
5. **Final drive:** It gives the final reduction in the speed and increases torque to the wheels.
6. **Axle:** The shaft and connecting parts, that transmits torque from the differential or final gear reduction to the wheels.
7. **Rear wheels:** The received torque is converted into driving force on interaction with the ground surface.

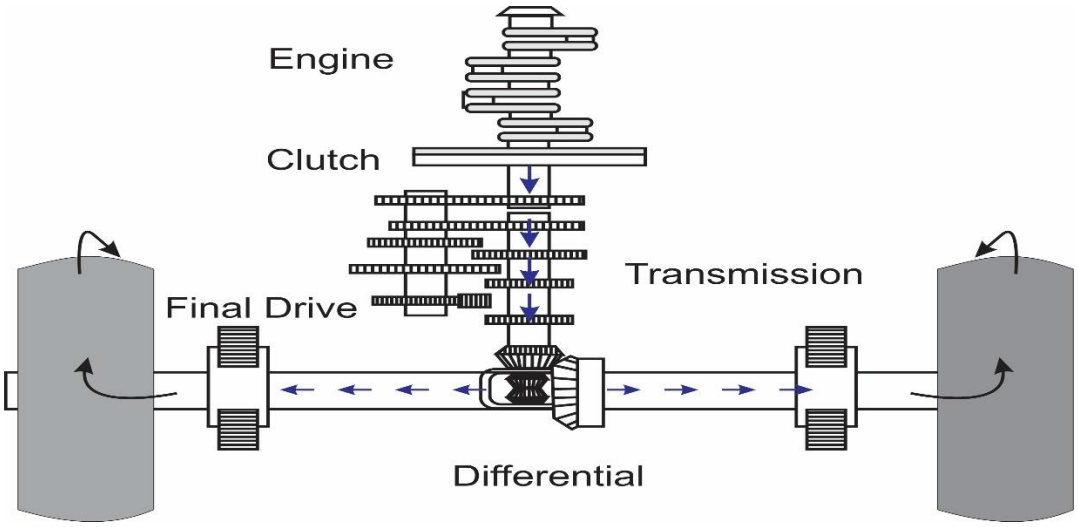


Fig. 2.31: Fuel Supply System

II. CLUTCH SYSTEM

The clutch is a vital link in the power train. It connects and disconnects power between the source (engine) and the receiver (transmission/gearbox).

Working Principle of Clutch: The clutch works on the principle of friction, when one stationary surface is brought into contact with rotating surfaces, the stationary surface also starts rotating. The driving plate or surface is a flywheel that contacts with a clutch plate (made of friction material). The other plate is known as the pressure plate.

Types of Clutches-

1. **Disk and Plate type:** One or more plates are brought together to transmit torque.
2. **Band type:** An outside band is tightened over a rotating part to transmit torque.
3. **Overrunning type:** Engagement is allowed in one direction, but the unit freewheel in the other.
4. **Magnetic type:** A magnetic field holds both the clutch plates together, allowing them to rotate as a unit.
5. **Cone type:** Two cone-shaped parts are engaged to transmit torque.
6. **Expanding shoe type:** An inner shoe is expanded to contact an outer part to transmit torque.

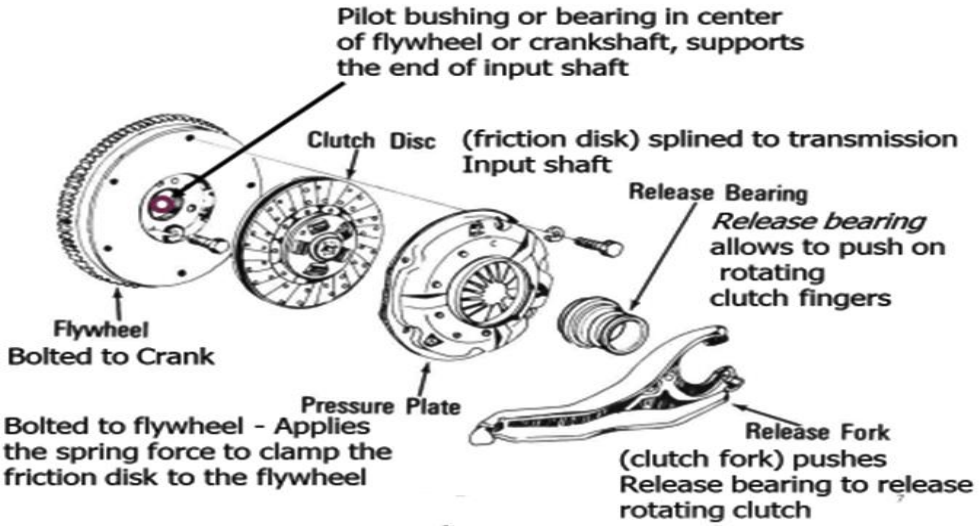


Fig. 2.32: Clutch

Operation when disengaged: When the clutch pedal is depressed, the clutch release bearing moves forward against the operating lever. As the lever pivot, the clutch bolts pull the pressure plate rearward to compress the clutch spring and release the pressure applied to the clutch disk. It separates the driven disk from the flywheel and pressure plate.

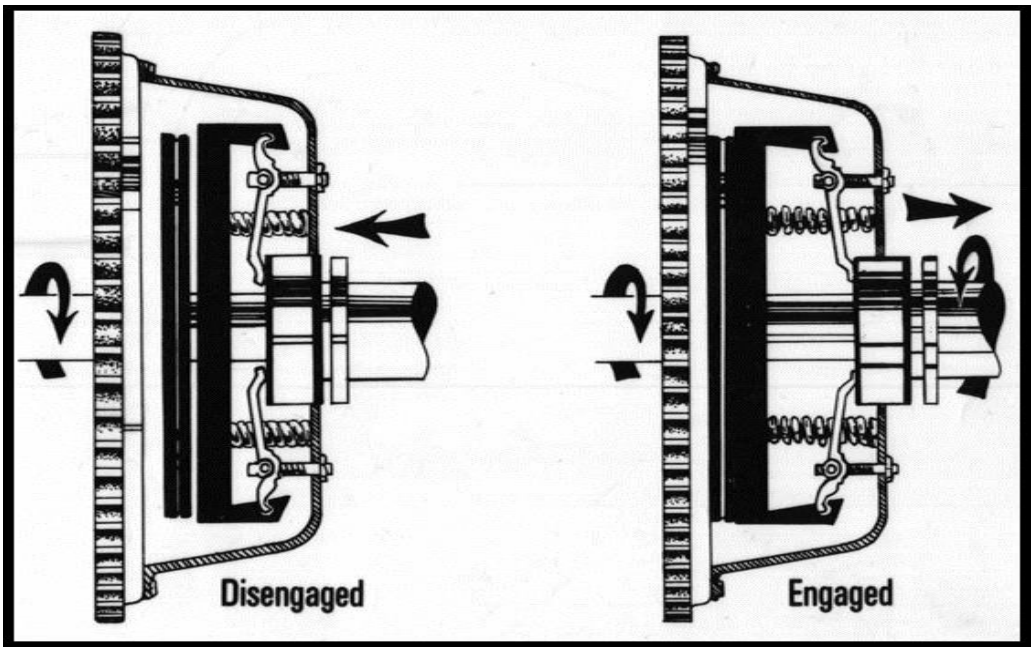


Fig.2.33: Clutch Engaged and Disengaged

Operation when engaged: When the clutch paddle is released, the compressed clutch springs force the pressure plates to move forward to apply pressure to the

clutch disk. Since the clutch bolts are secured to the pressure plate, the operating levers force the clutch release bearing rearward. This allows the plate to clamp the clutch plate against the flywheel again. Now the flow of power is connected between the engine and the transmission input.

III. TRANSMISSION/GEARBOX

It is a set of gear by which the vehicle is operated. Tractor rear wheels operate ata much slower speed than the engine. The gearbox plays important role in speed reduction.

Requirement of the gearbox-

1. To reduce the rpm from the engine before it reaches the wheel.
2. A means to back the tractor by reversing the direction of rotation of drive.
3. To provide the required torque or speed depending on the field requirement or the operation being performed.
4. It provides a neutral position, so that engine and road wheels are disconnected even when the clutch is in the engaged position.

Principle: Any combination of gear wheels using which motion is transmitted from one shaft to another shaft is called a gear train. Consider a smaller gear having 20 teeth is driving the bigger gear having 40 teeth asset. The smaller gear revolves thrice as fast as the larger gear and the gear ratio will be 40:20 or 2:1.

Types of Gears: There are three types of gears-

1. **Straight Spur Gear:** On these, gear teeth are cut straight parallel to the axis of rotation. Usually, one or two teeth of one gear remain engaged with the other gear.
2. **Helical Spur Gear:** On these types, gear teeth are cut obliquely across the perimeter of gear instead of being cut straight.
3. **Herring Bone Gear:** These are double helical gears with reversed teeth angles on the opposite side. This causes the thrust produced by one side to be counter balanced by the thrust produced by the other side.

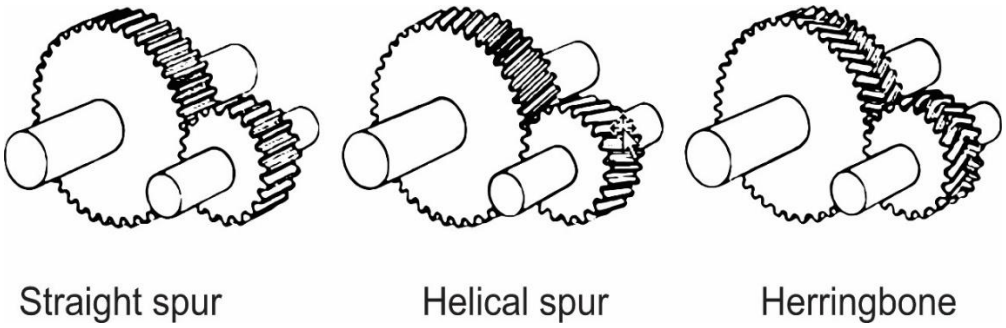


Fig. 2.34: Types of gears

Types of Gear Boxes: In tractors, four types of gearboxes are used-

1. Sliding mesh gearbox
2. Constant mesh gearbox
3. Synchro mesh gearbox
4. Planetary gearbox

1. **Sliding mesh gearbox:** In this type of gearbox the selected main shaft gear is slid over the main shaft to mesh with a corresponding gear on the countershaft.

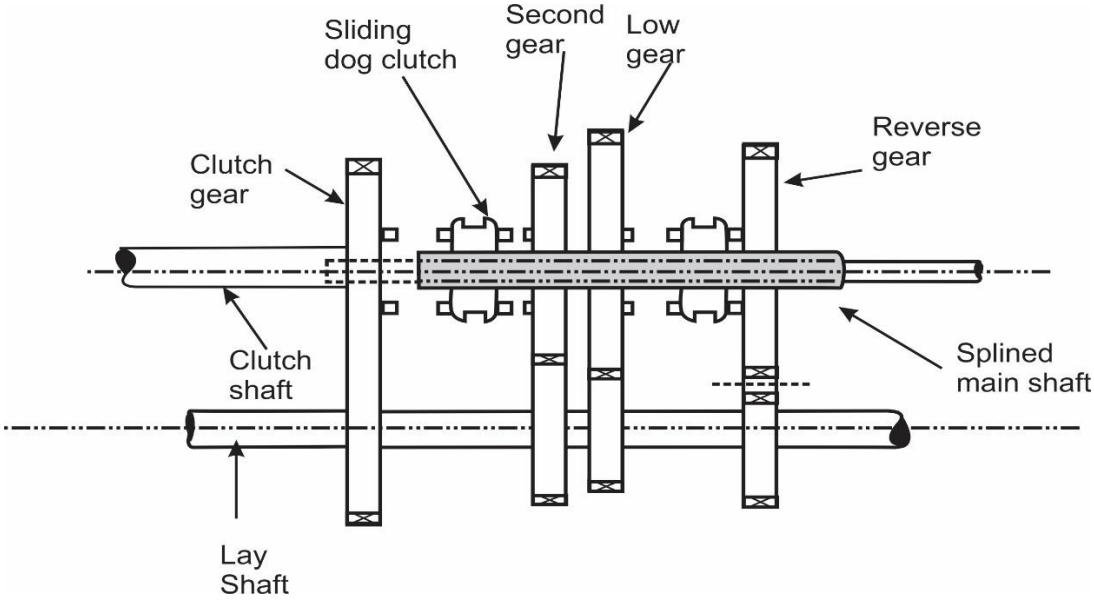


Fig.2.35: Sliding mesh gearbox

2. **Constant mesh gearbox:** Ina constant-mesh gearbox, the gear on the main and countershaft are always in the engaged position. Dog clutches are used to lock different gears to spinning input and output shafts in manual vehicle gearboxes.

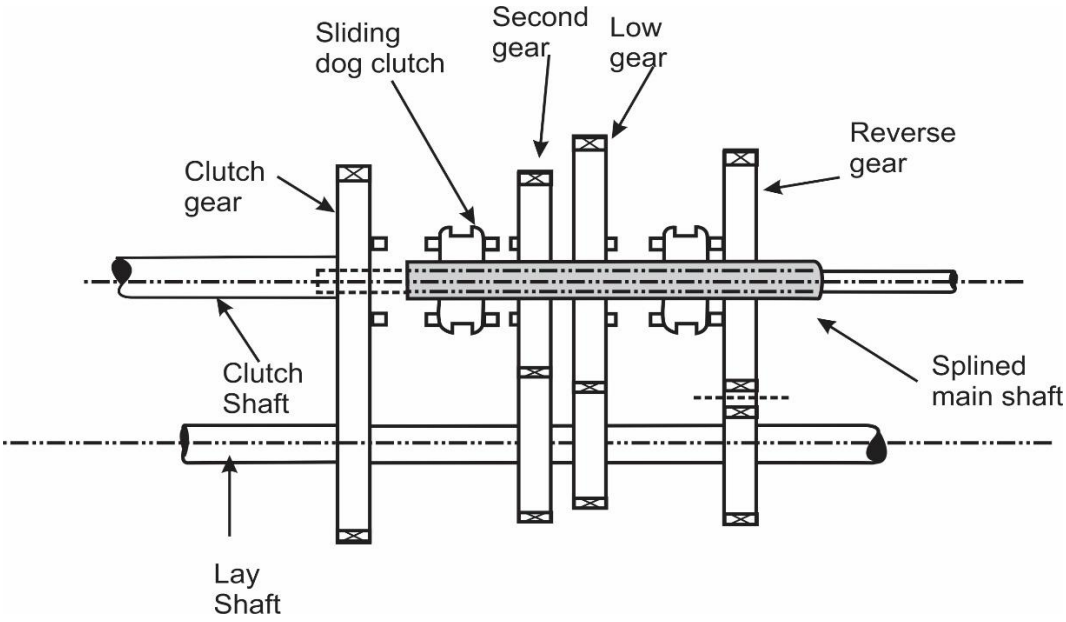


Fig.2.36: Constant mesh gearbox

1. **Synchro mesh gearbox:** Synchromesh is an advancement over the constant mesh gearbox. A synchronizing unit is provided to assist the changing of gear. By matching the shaft speeds before allowing the dog clutch to engage, a synchromesh system provides smooth engagement.
2. **Planetary gearbox**: In this gear system, the planet gear turns on its axis while rotating around the sun gear shaft.

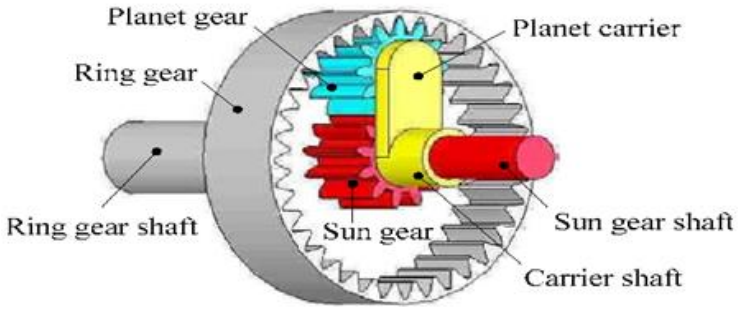


Fig.2.37: Planetary gear

IV. DIFFERENTIAL AND FINAL DRIVE

Let us discuss these in detail-

(a) Differential: While turning, each wheel of a tractor covers a different distance. The inner portion of the rear wheel covers a shorter distance than the outside portion. Since speed is equal to the distance travelled divided by the time

taken to cover that distance; the wheels which travel a shorter distance move at a slower speed. If the tractor did not have a differential, the wheels would have to be locked together and forced to spin at the same speed. This will make it hard for the tractor to turn on one wheel, and may also result in slipping of the tractor.

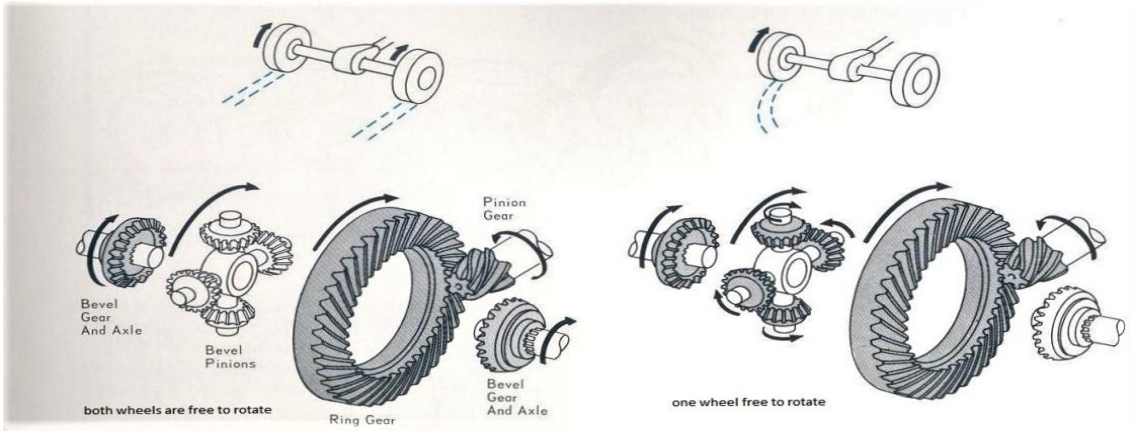


Fig.2.38: Differential

Differential Lock: Differential lock directs the power equally to both wheels by locking out the differential. This prevents the loss of traction when one wheel is slipping. Never use a differential lock when you are turning the tractor.

(b) Final Drive: It gives the final reduction in speed and also increases the torque into the drive wheels. It is fitted near the rear drive wheel of the tractor.

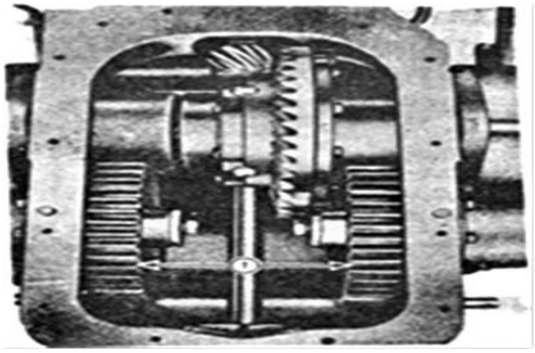


Fig.2.39: Final Drive

Drive wheel: It is a part of the transmission system in the engine. Wheels must be strong enough to support the tractor and withstand the forces caused by normal operation. At the same time, they must be as light as possible, to help keep un-sprung weight to a minimum. A tyre is the key traction point on a vehicle. They are responsible for transmitting power from your tractor to the field. Tyres act as a buffer between the tractor and the road because they carry the full weight of the tractor. The inflation pressure in the rear wheels of the tractor

varies between 0.8 to 1.5 kg/cm^2 and the front wheel varies from 1.5 to 2.5kg/ cm^2.

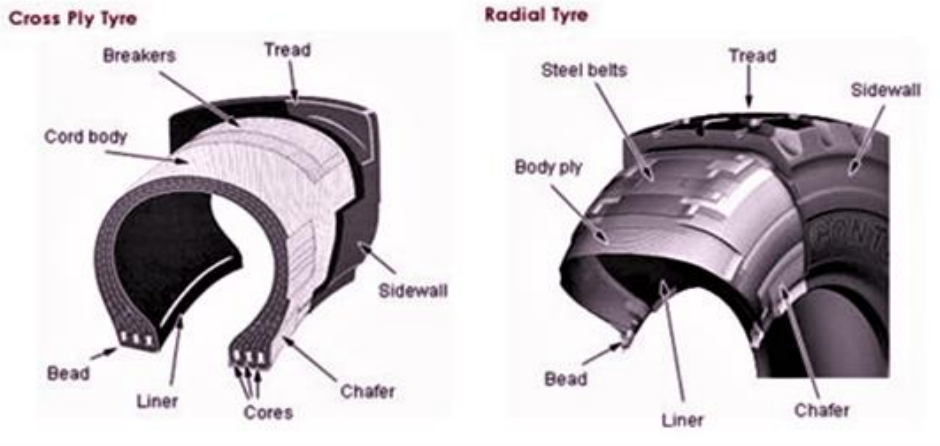


Fig.2.40: Tyre

Ply rating: A tire ply rating is an expression of the tire's strength and capacity; it is more commonly expressed as "load range." It has no longer a direct connection to a tire's construction and several layers.

RIM SIZE: The width and diameter of the rim are in inches. A rim designated 13.6 by 38 would refer to a rim measuring 13.6 inches across the rim flanges and 38 inches in diameter.

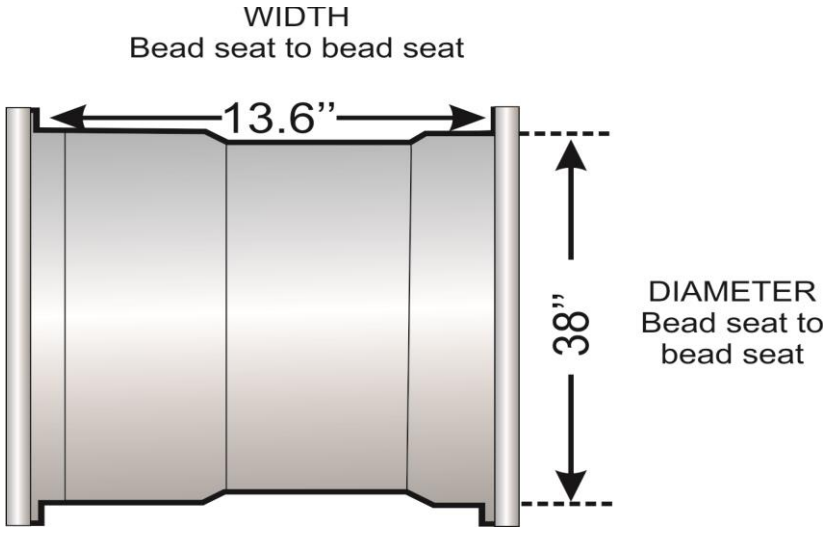


Fig.2.41: Rim Size

Ballasting: When working with heavy tools or high traction, ballasting involves raising the weight of your tractor to improve tyre grip or decrease its centre of gravity. The normal load on traction wheels can be increased by putting water or air inside the pneumatic tyre tube. Filling water in the tube is water ballasting. Generally, the tube is filled up to a maximum of 75% by ballasting.

Track width adjustments: To increase the stability of the tractor on sloppy land, muddy terrain, or inter-cultivation the wheel spacing of the front and rear track can be adjusted as per manufacturer recommendation.

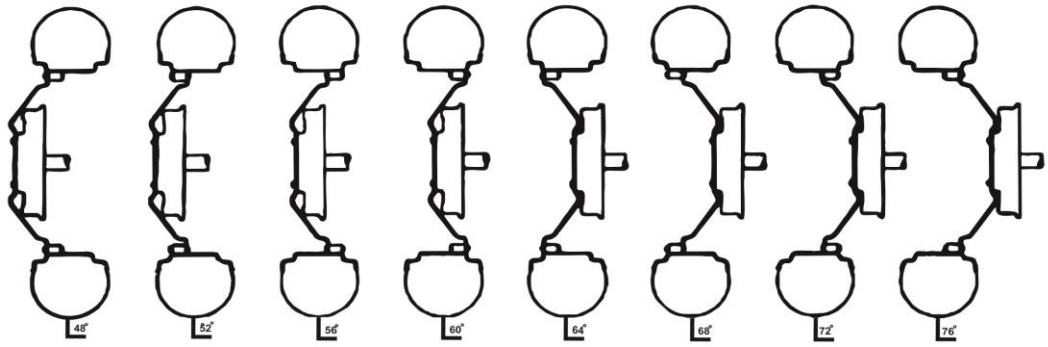


Fig. 2.42: Track width adjustments

V. Power take-off: A tractor is used for a variety of tasks, including threshing crops, pumping water from tube wells, spraying, and operating rotavators and other rotary machinery. Tractors are usually equipped with a power outlet in the back. Power Take-off (PTO) is the name of the power outlet. The gearbox provides power to the PTO shaft. The gearbox's countershaft is frequently extended to the back to serve as the PTO outlet.

Table. 2.2: Characteristics of PTO Types

PTO type	Nominal diameter (mm)	Number and type of splines	PTO rated rotational frequency (rpm)
1	35	6 Straight splines	540
2	35	21 involute splines	1000
3	45	20 involute splines	1000

VI. STEERING SYSTEM AND FRONT AXLE

Let us discuss these in detail-

A. Steering system: The system, governing the angular movement of the front wheels of a tractor is called a steering system. This system minimizes the efforts of the operator in turning the front wheel with the application of leverages.

The function of Steering System-

1. Control of front wheel (sometimes rear wheel) direction.
2. Transmit road feel (slight steering wheel pull caused by the road surface) to the driver's hand.
3. Maintain the correct amount of effort needed to turn the wheels.
4. Absorb most of the shock going to the steering wheel as the tire hits holes and bumps in the road.
5. Allow for suspension action.

Main Parts of Steering System-

1. Steering wheel
2. Steering column
3. Steering shaft
4. Steering drop arm
5. Steering gearbox
6. Pitman arm
7. Radius rod (optional)
8. Steering arm
9. Stub axle
10. Tie rod

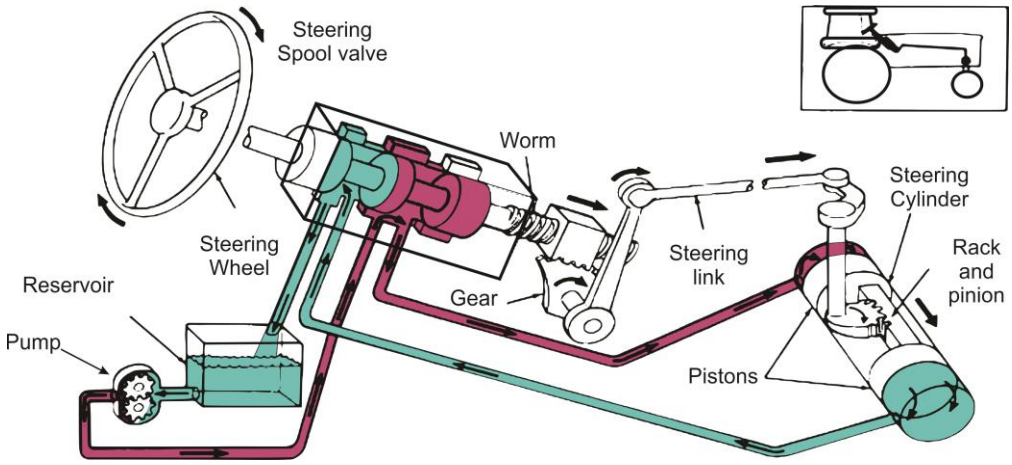
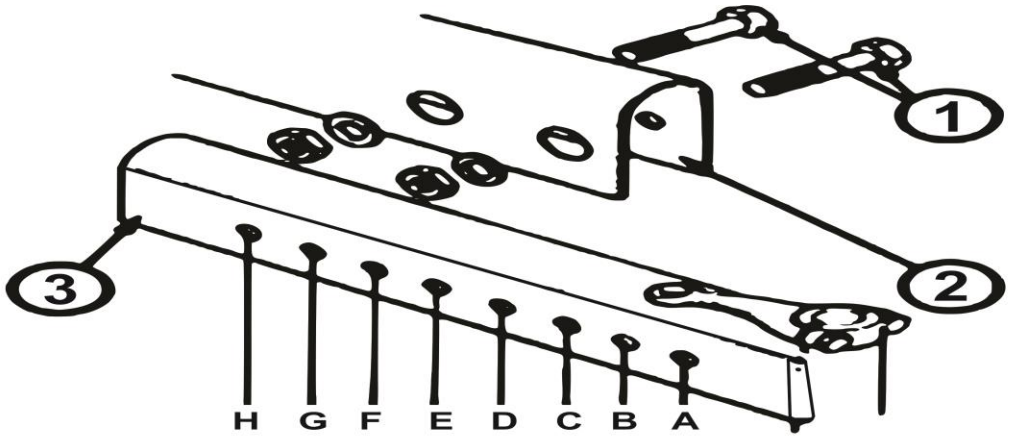


Fig.2.43: Steering System

B. Front Axle: Front axle of the tractor is used to bear the full weight of the front side of a tractor. It's a rigid tubular or I section steel construction pivoted at the centre. To adjust the track width, the front axle has provision to be extended on both sides. It has kingpin, steering arms using which machine can easily be steered.



View of 1. Outer Axle Retaining Bolts; 2. Centre Axle Assembly; 3. Outer Axle Assembly

Fig.2.44: Front Axle

STEERING GEOMETRY: Steering geometry, usually called front end alignment is not only meant checking of toe-in and adjusting the steering linkage. Following items are part of steering geometry play an important role for easy and safe driving.

1. **Camber angle:** The angle between the plane of the wheel and the vertical is called the camber angle.

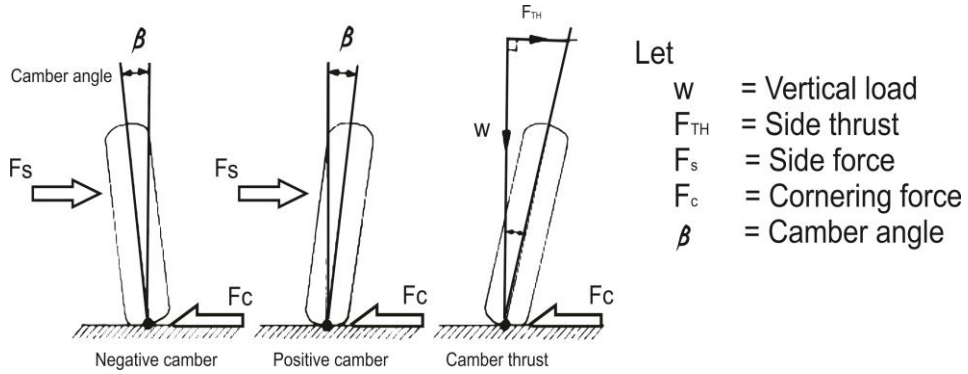


Fig.2.45: Camber Angle

2. **Caster angle:** It is the angle by which the kingpin is set at the back of a vertical line drawn through the centre of the spindle body.

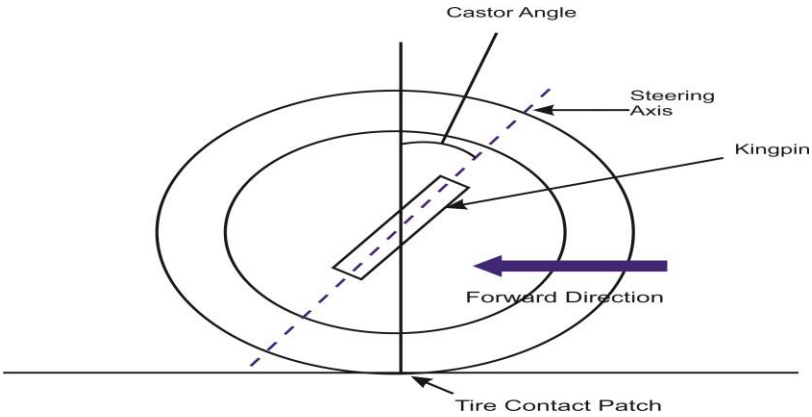


Fig.2.46: Caster Angle

3. **Toe-in:** When the distance of the front wheel at the front is less than the distance at the back of the front wheels, it is called toe-in.

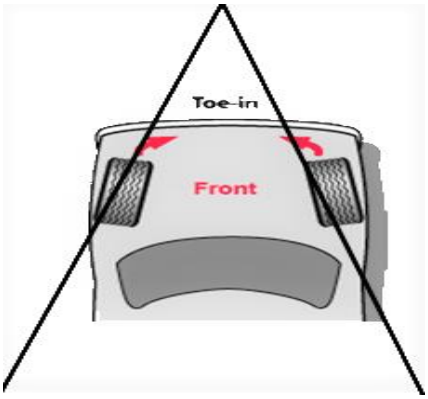


Fig.2.47: Toe-in

4. **Toe out**: When the distance of the front wheel at the front is more than the distance at the back of the front wheels, it is called toe-out.

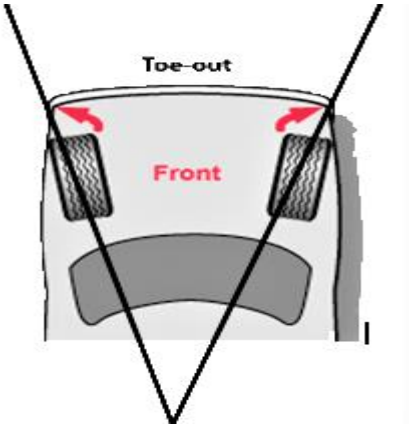


Fig.2.48: Toe out

5. **Kingpin Inclination:** Centre line of the cambered wheel and the centre line of the kingpin join at a point where the tyre is touching the ground. The angle on which the kingpin is inclined is called the kingpin inclination.

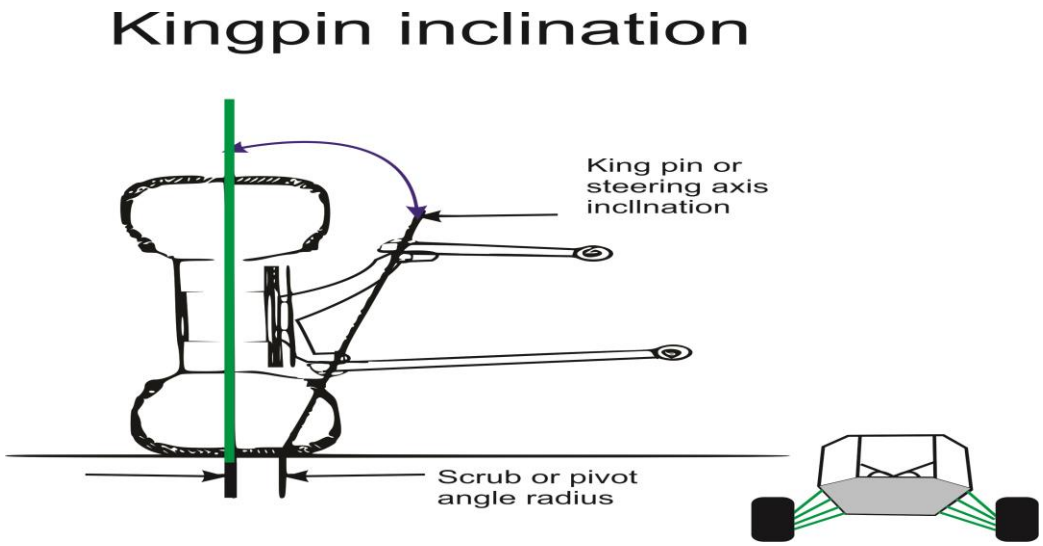


Fig.2.49: Kingpin Inclination

6. **Dashboard:** It is a control unit indicator of the tractor.

Fig.2.50: Dashboard

Table. 2.3: Control/Dashboard

The Control/Dashboard of a tractor generally consists of the following:	
• Engine speed-cum-digital cumulative digital run-hour-meter.	• This meter indicates the engine hour as well as engine revolution per minute.

• Coolant temperature gauge (with the colour zone).	• This indicates the temperature of the coolant of the cooling system.
• Fuel level gauge (with colour zones).	• This indicates the lubricating oil pressure in the system.
• Lubricating oil pressure indicator lamp.	• This indicates the diesel fuel level in the tank.
• Light switch.	• The light switch is for light on or off.
• Main switch.	• When the ignition switch is on, the electric current flows in the electrical circuit.
• Horn push button.	• To push horn.
• Battery charging warning indicator lamp.	• This indicates the charge and discharge of the battery.
• Turn signal indicator & hazard Light indicator.	• Turn and hazard light indicator.
• Turning indicator two-way switch.	• While turning give the indicator.
• Headlight (long beam) indicator lamp.	• Shows whether the headlight is on or off.
• Hazard warning switch.	• To indicate the hazard warning.
• Hand accelerator lever.	• This lever is for increasing or decreasing the speed of the engine.
• Fuel cut-off knob.	• Itis designed to cut the fuel supply to an engine.
• Steering control wheel.	• To steer the tractor.
• Parking brake lever.	• To apply the parking brake.

VII. Brakes: Brake is used to stop or slow down the speed of travel of a tractor by applying frictional forces. Two types of brakes are normally used in tractors- mechanical brakes and hydraulic brakes.

1. Mechanical Brakes: This system is cheap and gives trouble-free service, and is simple to maintain. The mechanical brakes are again classified into two types namely- shoe brakes and disc brakes.

(a) Shoe brakes - These are of two types, namely:

i. Internal expanding shoe brakes
ii. External contracting shoe brakes

i. Internal expanding shoe type: Two brake shoes made of frictional material fitted inside the brake drum are held away from the drum by the means of springs. One end of each shoe is the fulcrum, whereas the other is free to move by the action of a cam that applies force on the shoes. The movement of the cam is caused by the brake pedal through the linkage. The drum is mounted on the rear axle, whereas the shoe assembly is stationary and mounted on the backplate.

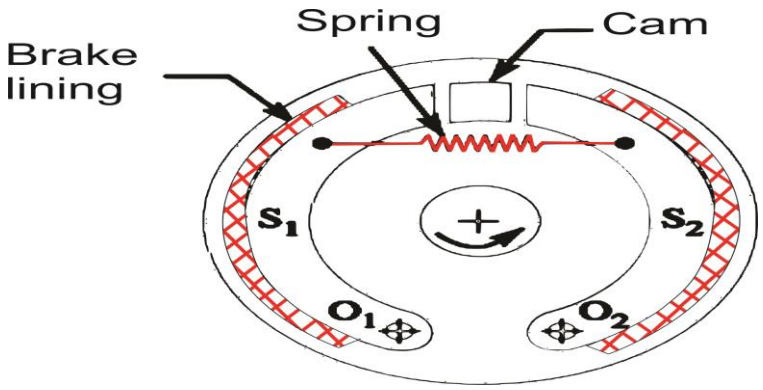


Fig.2.51: Internal expanding shoe type

ii. External contracting shoe type: The brake band directly surrounds the drum mounted on the drive axle. When the pedal is depressed, the band tightens the drum.

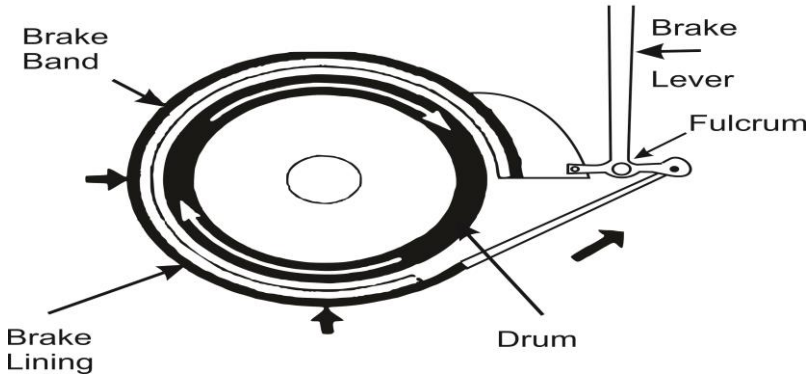


Fig.2.52: External contracting shoe type

(b) Disc brakes - In this system, two actuating plates and two friction plates work as a single unit. The entire unit is fitted in the drum. Balls are fitted in between the non-uniform cavity actuating plates and these plates are attached by the springs. When we press the pedal, the actuating plates expand. Friction

plates have inner splines attached to the outer splines of the moving shaft. When actuating plates expand, they force out the friction plates and friction plates are attached to the moving drum, resulting in the application of the brake.

2. Hydraulic brake: It works on Pascal's law. The brake fluid, which is usually a mixture of glycerine and alcohol, is filled in the master cylinder. When the pedal is depressed, the piston of the master cylinder is forced into the cylinder and the entire system turns into a pressure system. Immediately, the piston of the wheel cylinder slides outward which moves the brake shoes to stop the rotating drum. When the pedal is released, the return spring of the master cylinder moves the piston back to its original position, causing a sudden pressure drop in the line. The retracting springs of the brake shoes bring them to their original position, and the pistons of the wheel cylinder will also return.

VIII. HYDRAULIC SYSTEM AND THREE-POINT LINKAGES

Before the introduction of three-point linkage in tractors, implement like mouldboard, cultivator and harrow etc., were pulled by tractors. Apart from this, a depth control wheel was used for increasing/decreasing the depth.

Hydraulic system is based on Pascal's law, which observed "Pressure applied to a fluid in a closed container is transmitted with equal intensity throughout the liquid and at right angles to the surface of the container".

As per Pascal's law, the basic principle of hydraulics are:

1. Liquid has no shape of its own.
2. The liquid is almost incompressible.
3. Liquid transmits applied pressure in all directions.
4. Liquid provides a great increase in the work.

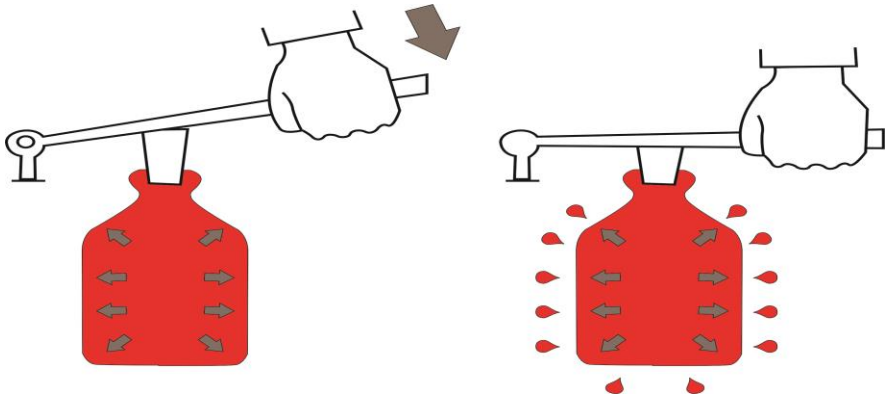


Fig.2.53: Hydraulic Jack

Components of hydraulic system

1. Reservoir: Every hydraulic system should have its oil reservoir though some of the tractor manufacturers build a common reservoir for transmission and hydraulic.

2. Pump: Basically, the purpose of the pump is to push the hydraulic fluid and create flow. Three types of pumps are used in hydraulic systems, hereunder you know about them in figures 2.54, 2.55, and 2.56.

i. Gear type pump

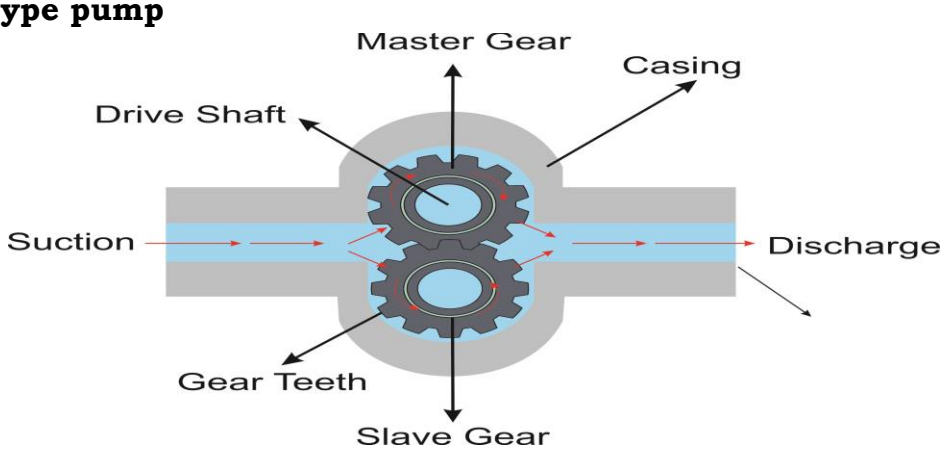


Fig.2.54: Gear type pump

ii. Vane type pump

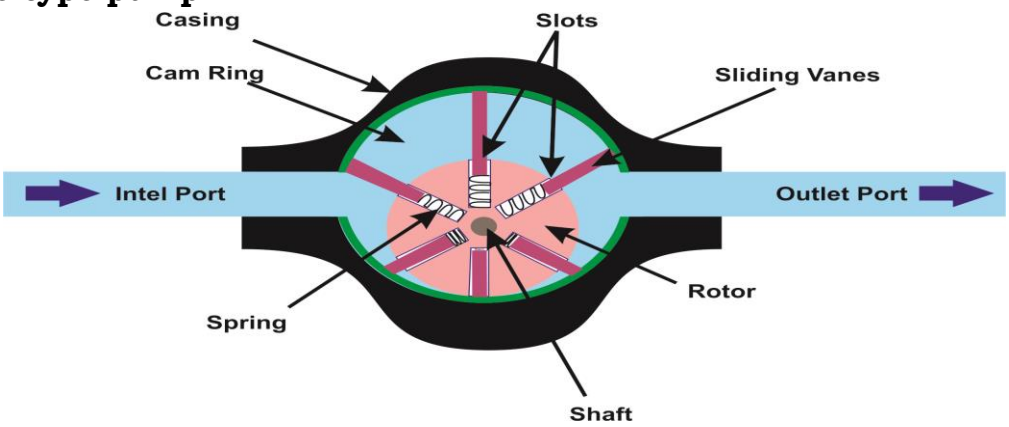


Fig.2.55: Vane type pump

iii. Piston type pump

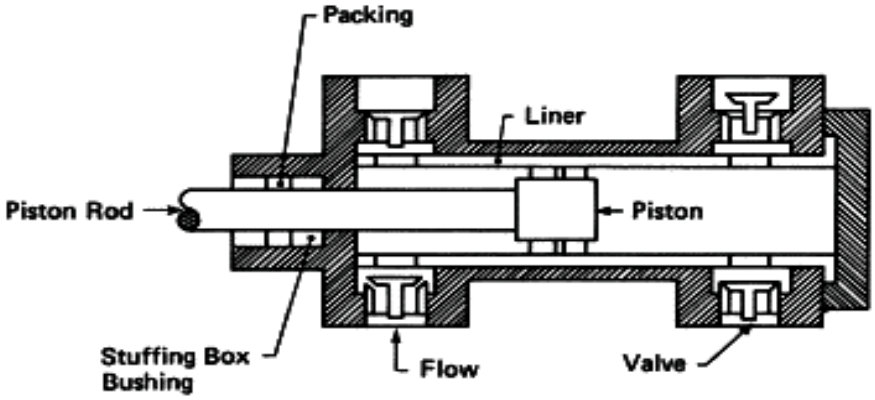


Fig. 2.56: Piston type pump

3. Valves: Hydraulic valves are classified into three categories: -

i. **Pressure controls –** There are different shapes and designs of valves and may be known as pressure relief valve, cylinder safety valve, pump safety valve, unloading valve, feathering valve, etc.

ii. **Flow controls –** There are different shapes and designs of valves and may be known as differential valves, flow rating valves, slow-fast valves.

iii. **Directional controls –** There are different shapes and designs of valves and may be known as spool valve, rotary valve, one-way valve/non-return valve, check valve, control valve, slide valve, etc.

4. Hydraulic Cylinder: Cylinders can be classified as either single-acting or double-acting.

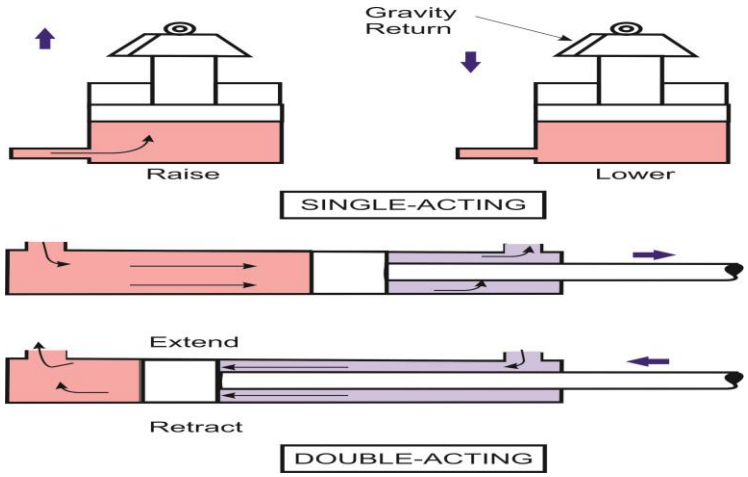


Fig. 2.57: Hydraulic Cylinder

A single-acting cylinder consists of a head-end port that is operated hydraulically in only one direction. Whereas, a double-acting cylinder has ports at both the

head end and rod end. Pumping oil into the head end moves the piston to extend the rod.

Tractor three-point linkage: The tractor hitch system is that essential element of the tractor, which binds prime mover and implement into a single working unit. The tractor or the implement will not perform alone but must work together like two wheels of a cart.

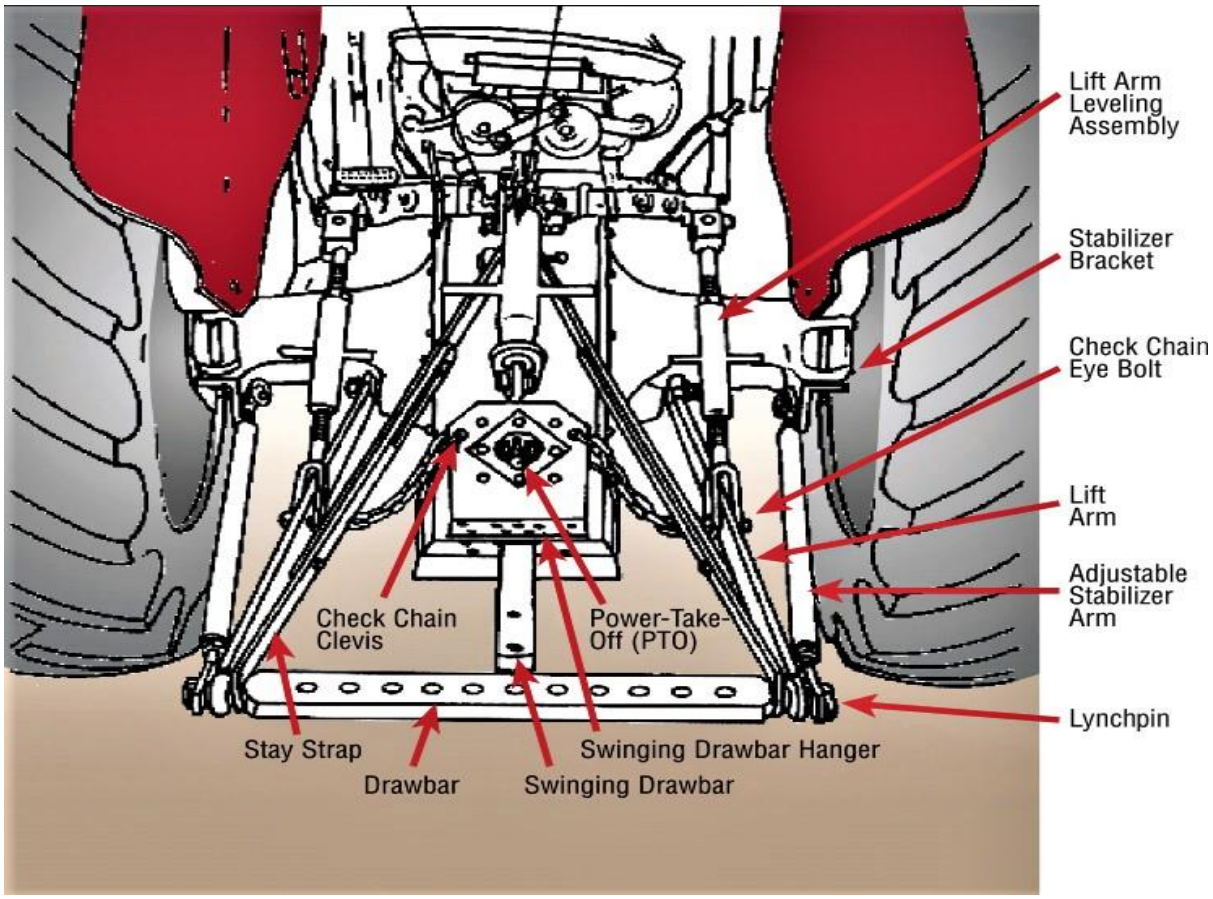


Fig. 2.58: Three-point hitch system of the tractor

The tractor hydraulic system is connected to the implement through three-point linkages, the three points are, two lower links and one top link. Both the bottom link is connected to two lift arms through lift links. The lift arms are directly mounted on a rock shaft which is further connected to the piston rod. So that, every movement of the piston is transferred to the bottom links. The third hitch point is connected through the top link. We can adjust the top link for connecting the implements, and maintaining the level and suction angle of the implement. In some tractors, draft sensing is also carried out through top links, while some tractors are having lower link draft sensing.

IX. TRACTOR AUTO ELECTRICAL SYSTEM

1. Battery: A battery is an electrochemical device that converts chemical energy into electrical energy. Tractors use 12 volts of "lead-acid" batteries. The battery consists of 6 cells and each cell produces approximately 2 volts.

The functions of the battery are:

- A battery supplies power to the starter and ignition system to start the engine. A battery also supplies the extra power, when the vehicle's electrical load exceeds the supply from the charging system.
- Batteries act as a voltage stabilizer in the electrical system. An automotive battery evens out voltage spikes and prevents them from damaging other components in the electrical system.
- It stores the current produced by the alternator and to supply current to critical systems in the event of a power outage.

Battery construction: Batteries are made of five basic components-

1. A polypropylene battery container.
2. Positive and negative internal plates made of lead.
3. Plate separators are made of porous synthetic material.
4. Electrolyte, a dilute solution of sulfuric acid and water.
5. Lead terminals.

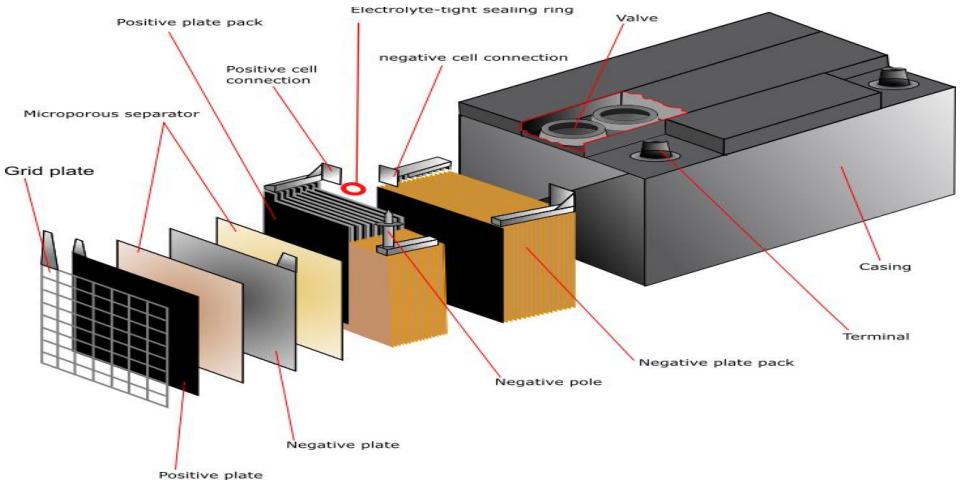


Fig. 2.59: Battery

2. Charging System

Alternator: An alternator operates on the principle when the flux linking a conductor change and an electromagnetic force (emf) is induced in the conductor. In the alternator, conductors are held stationary and a magnetic field

is moved through them. The alternator rotates the magnetic field so that the stationery conductors cut the moving magnetic lines of force. The alternators are fitted with diodes that allow the current to pass from one side only, as such no cut-out relay is required.

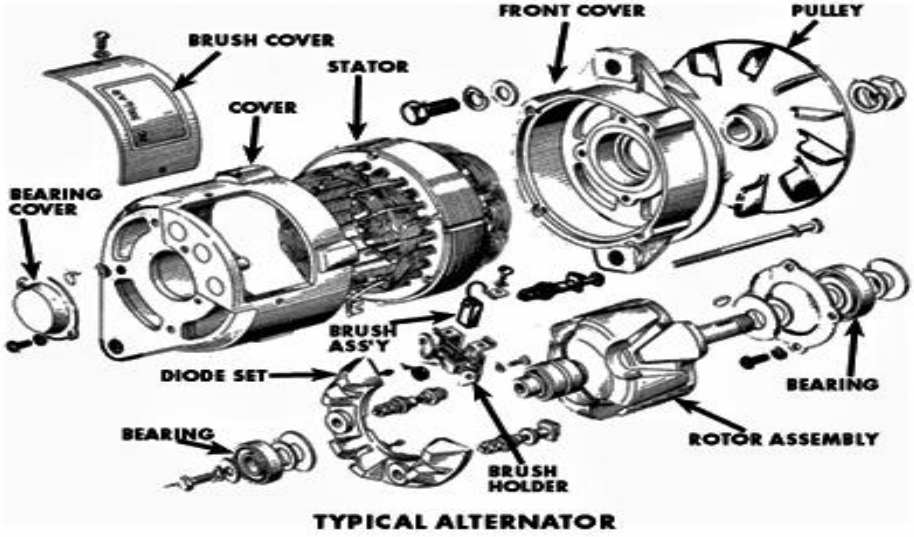


Fig.2.60: Cut view of typical alternators

Components of alternator

i. **Rotor:** The rotor consists of a coil of wire wrapped around an iron core and mounted on the rotating shaft. Current through the wire coil - called "field" current - produces a magnetic field around the core. The strength of the field current determines the strength of the magnetic field. The field current is direct current (DC). In other words, the current flows in one direction only which is supplied to the wire coil by a set of brushes and slip rings. The magnetic field having north and the south pole is produced through a magnet. The rotor is driven by the alternator pulley as the engine runs, hence it's named as "rotor."

ii. **Stator:** The rotor is surrounded by three sets of coils called the stator. The stator is fixed to the shell of the alternator, and it does not turn. As the rotor turns within the stator windings, the magnetic field of the rotor sweeps through the stator windings, producing an electrical current in the windings. Because of the rotation of the rotor, an alternating current is produced.

For example, the north pole of the magnetic field approaches one of the stator windings and coupling takes place, a weak current is produced. As the rotation continues, the magnetic field moves to the centre of the winding, where maximum coupling takes place. Here the induced current is at its peak. As the rotation continues to the point that the magnetic field

is leaving the stator winding, the induced current is small. Thereafter, the south pole attracts the winding, producing a weak current in the opposite direction. As this continues, the current is produced in each winding placed against the angle of rotation of the rotor. The three stator windings are spaced 120 degrees apart inside the alternator which produces three separate sets, or "phases," of output voltages.

iii. **Rectifier:** In a three-face alternator, six output diodes are mounted at the slip ring end of the alternator housing. Out of the six output diodes, three are mounted in a positive plate and three in a negative plate. Both positive and negative plates are separated. The terminal links enable each of the three stator output wires to connect to the different diode in each plate. As the rotor revolves, the diodes convert AC to DC for charging the battery.

iv. **Regulators:** The alternator is controlled by AC voltage regulators, otherwise the alternator may produce too much voltage. The regulator works by placing a resistance in the field circuit which reduces current flow in the alternator rotor.

v. **Self-starter:** The main function of the motor is to start the engine. It is designed to operate for short intervals under great load. It is small in size but produces very high power (hp). A current-carrying conductor is formed in a loop and mounted on a shaft. It causes the shaft to rotate when placed inside a magnetic field which is used to start the engine.

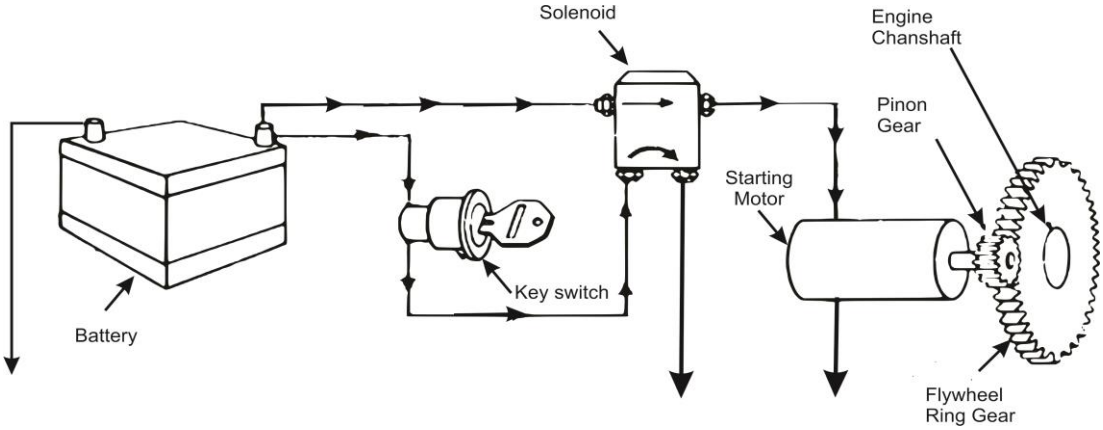


Fig.2.61: Self-starter System

It has five main components namely armature, field coil brushes, end shields solenoid switch, and drive mechanism.

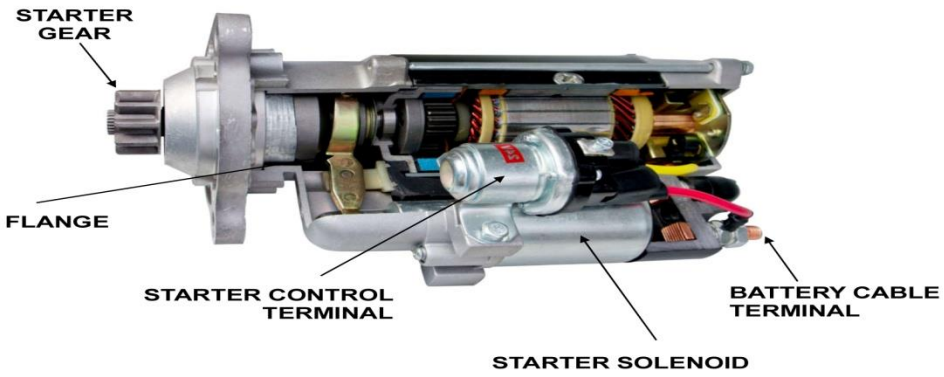


Fig.2.62: Self Starter

The armature coils are mounted on the motor's central shaft (supported with bearings). The field coils are formed into four or more "shoes", placed inside the steel frame of the starter. Brushes are used to create electrical contact to the commutator segments. When current is fed into two of the four brushes, it flows through all the loops of the armature, shoe windings, and outside the other two brushes. This creates a magnetic field around each loop. As the armature turns, the loop moves to a position where the current flow reverses. This constant reversal of current flow allows the armature and field coils to repel each other and spin the motor. As larger is the magnetic force; more current will flow in the coils and therefore more power will reach the motor. On one end of the armature shaft, the drive mechanism is placed which starts the flywheel ring gear.

PRACTICAL EXERCISES

Activity 01: Visit the tractor industries

Material required:

1. Pen
2. Notebook

Procedure:

1. First, take permission from some (as many possible) tractor industries.
2. Visit these tractor industries.
3. Identify all the available tractors.
4. Note down their specifications.
5. Sketch a tractor and label its parts.

Activity 02: Sketch the clutch system

Material required:

1. Pen

2. Notebook

Procedure:

1. First, take permission to visit a tractor workshop.
2. Identify the clutch system visible in the tractor.
3. Note the specifications of different types of clutches.
4. Sketch clutch and label its parts.

CHECK YOUR PROGRESS

A. Answer the following

1. Define the IC engine and write its working principle?
2. Explain valve timing with a neat sketch?
3. What do you mean by lubrication system. Explain different types of lubrication methods.
4. Describe the clutch system and its different types.
5. Explain gearboxes and make neat sketches of different types of gearboxes?
6. Define castor angle, bore, ply rating, stator, and rectifier.

B. Fill in the blank

1. Bore is the ..... of the engine cylinder.
2. ..... directs the power equally to both wheels by locking out the differential.
3. A battery is an ..... device that converts chemical energy into electrical energy.
4. In the Planetary gear system, the planet gear turns on its axis while rotating around the ..... shaft.
5. When the distance of the front wheel at the front is less than the distance at the back of the front wheels, it is called .....

C. Match the following

Column A	Column B
1. The angle between the plane of the wheel and the vertical is.....	A. 
2. It consists of a coil of wire wrapped around an iron core and mounted on the rotating shaft.	B. 

3. It gives the final reduction in speed and increase in torque to the drive's wheels.	C. Camber angle
4. Exhaust system	D. Brake
5. It stops the moving tractor in the shortest possible time and shortest distance.	E. Rotor
6. Pre-cleaner	F. Final drive

SESSION 4: DRIVING TECHNIQUES AND RULES

Driving License and Traffic Signals

To drive a tractor, two-wheeler, or four-wheeler, a person should mandatorily have a driving license. A driving license is an official document certifying the license holder's qualification to drive a tractor, motor vehicle of any category. The Central Government's Motor Vehicle Act of 1989, now popularly known as Central Motor Vehicle Rules (CMVR), states that any person who is operating a vehicle on Indian roads must have a valid driving license issued by the concerned State Government's Regional Transport Office or Transport Authority. Before obtaining a permanent license, one must obtain a learner's license. The minimum age to obtain a driving license in India is 16 years for motorcycles with a power of 50cc or less and 18 years for all other kinds of vehicles.

Types of Driving License

Based on the type of vehicle a person is planning to drive or ride, he/she should apply for one of the following types of driving licenses-

1. **Driving licence for motorcycles without gear:** Apply for this type of driving licence (DL) to drive a two-wheeler that doesn't have gear.
2. **Driving licence issued for light motor vehicles:** Apply for a DL of this kind to drive or ride a two-wheeler with gears or any private motor vehicle like cars, tractors, etc.
3. **Driving licence issued for transport vehicles:** If you plan to drive a heavy motor vehicle for transportation of goods or passengers.

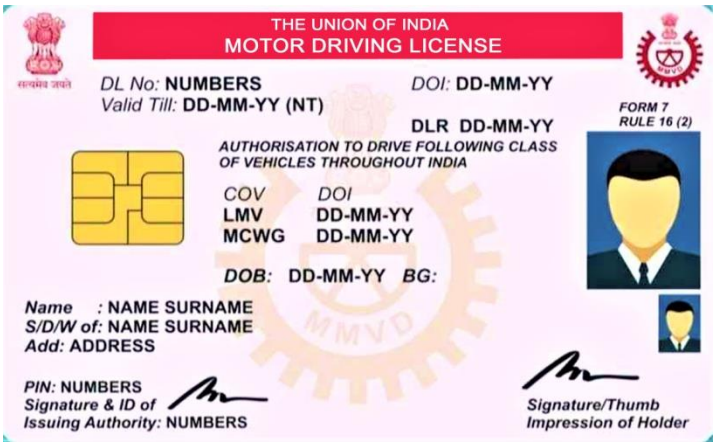


Fig.2.63: Driving license

Documents required for getting a Driving License

Apart from the Aadhaar card, you need to submit the following documents to the RTO.

For age proof, submit any one of these:

- Birth certificate.
- High school passing certificate.
- Attested copy of the passport.
- Certificate issued from the employer, if you are working for state/ central government or a local body.

For address proof, submit any one of:

- Aadhaar card.
- Voter's ID.
- Ration card.
- LIC policy bond.
- Valid passport.
- Employer's certificate issued by local/central or state government.

Other documents necessary to be submitted:

- Application form 4.
- Application form 5 in case of applying for a commercial driving license.
- Original learner's license.
- Three passport size photographs.

How to apply for a driving license through offline mode?

To apply for a permanent driving license via offline mode, a person should follow these steps:

- Visit the nearest RTO and obtain the application form. Alternatively, you can get this form on the official website of the RTO.
- Fill the following details in the form:
  - ✓ Full Name
  - ✓ Father's Name
  - ✓ Residential Address
  - ✓ Educational Qualification
  - ✓ Date of Birth
  - ✓ Place of Birth
  - ✓ Blood Group
  - ✓ Identification Mark
- Submit address proof, passport-size photos, etc.
- Obtain a time slot for the first round of the test. The RTO officers will test your knowledge of traffic rules, regulations, and road signs through an online test.
- Once a person qualifies for the test, a learner's license will be given. Before getting a permanent DL, keep the learner's license for at least 30 days and not more than 180 days.

How to apply for a driving license (dl) through online mode?

To apply for a permanent DL via online mode, follow the below-mentioned process:

1. Visit the website and download the form.
2. Fill in all the details in the printed copy of the form and submit it to the local RTO.
3. Provide all the necessary documents.
4. Get a slot for the driving test.
5. Once this test is clear, a driving license will be allotted within 2 to 3 weeks.
6. The form can be submitted and uploaded online by following the below-mentioned steps:
   - Visit sarathi.nic.in (Government website link)
   - Click on 'Application for new DL'.
   - Click on 'New driving licence'.
   - Enter all the required details and submit all the documents.
   - An application number will be sent.
   - Now, schedule a driving licence test.
   - Appear for the test on the given day.
   - Once this test is clear, a driving license will be allotted within a few days.

TRAFFIC SIGNALS

a. **Regulatory sign**: Most signs under this category come with a round shape. Some of them feature a red border inside with a black symbol on white background, while some others can be depicted in blue circles with white symbols within. These regulatory or mandatory signs indicate rules that should be followed strictly. Otherwise, the driver will be punished and receive a challan for their violation. Not following these signs might affect the traffic flow and cause a serious accident. Refer to table 2.5 to understand in detail.
b. **Cautionary sign:** The signs of this category are usually depicted with the red triangular border with smaller black graphics inside. These signs give warning to the road users about the potential dangers ahead. Example, turn and curve warnings, lane transition warnings, and pedestrian crossing warnings. Even though, there is hardly any regulation or penalty levied on not following them. These signs have a crucial meaning to people's safety. When seeing these warning signs, a driver should pay more close attention and get prepared for the situation. Refer to table 2.6 to learn all the cautionary signs.
c. **Informatory sign:** While the other two types of signs have a particularly important meaning for the safety of the road users, the third category includes signs that provide information regarding the destinations, distance, fuel stations, and other locations. Observing these signs will help you navigate through the complicated traffic system.

Sign Shapes

a. **Round shape:** As mentioned above the round shapes are mostly used for the regulatory signs. Whenever any sign of this shape is seen, one shall pay attention without fail. Follow these signs accordingly or else a fine will be levied for any violation.
b. **Triangle shape:** Triangle shape is mostly used for cautionary signs. Whenever you see a sign in a triangle shape, drive more carefully and pay close attention to the road ahead. However, there is one triangle sign that belongs to the regulatory sign groups. It is the "Give Way" sign with an upside-down triangle shape.
c. **Octagon shape:** This sign is used exclusively for the stop sign. Due to this exclusivity, you will hardly notice any other signs using this shape for other meanings.
d. **Rectangular sign:** Rectangular is used for informational signs. While navigating toward a specific destination, pay attention to the rectangular signs.

CORRECT DRIVING TECHNIQUES

Check-Up Before Starting

Before operating a tractor, operators must do basic maintenance checks. This is necessary to become familiar with the position and operation of each control lever or button. Regular maintenance checks help to keep the machine in good operating order and avoid costly breakdowns during important periods. While purchasing a tractor, go through the operator manual provided by the manufacturer. It gives all the important safety and maintenance tips. Review the safety precautions in the operator's manual regularly. Observe and follow the instructions contained on warning decals attached to the tractor.

Fig.2.64: Pre-starting check-up

Before starting the tractor following checks should be performed-

1. Look for tractor safety issues**.** Walk around your tractor for inspecting it before driving. Loose wheel nuts or bolts may need periodic tightening.
2. Check your tractor's tire pressure. Low pressure in one or more tires may cause instability and create a safety hazard. If you notice that you have low tire pressure, look for air leakage from around the valve stem.
3. Check the engine oil level. Clean the dipstick with a clean cloth and reinsert it fully. Remove and locate oil level. The safe operating range is between two marks on the dipstick.

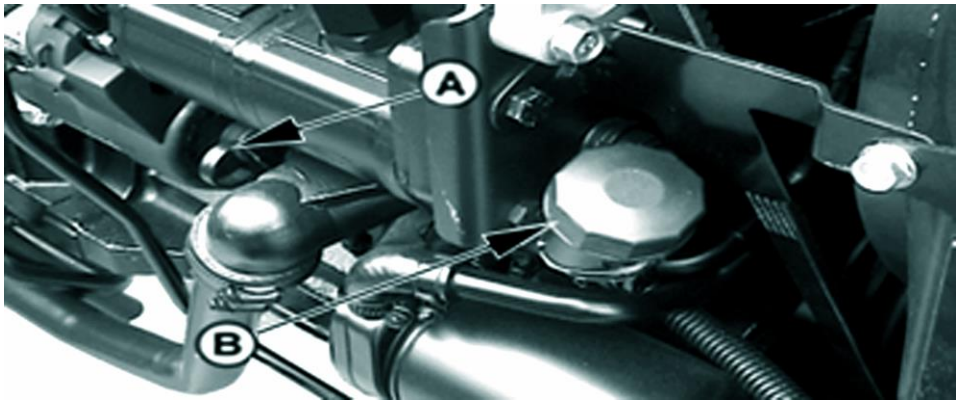


Fig.2.65: (A) Engine Oil Dipstick (B) Engine Oil Filler Cap

4. Drain water and sediment from the fuel filter drain after draining bleed the fuel.

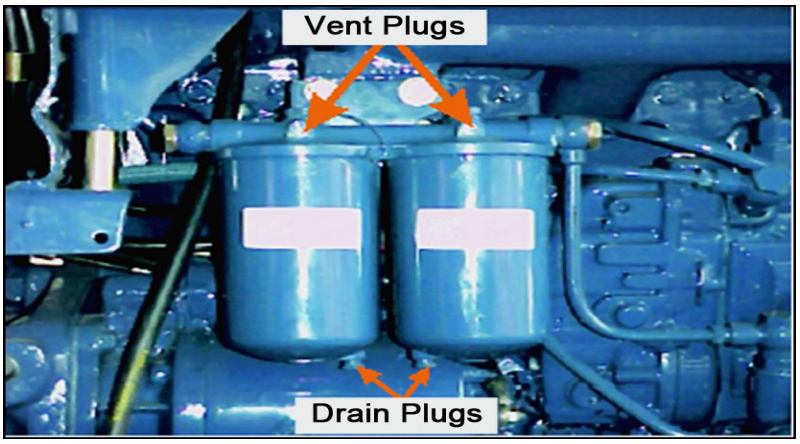


Fig.2.66: Fuel filter

5. Check the cooling system- Check coolant level in the recovery tank and fill it. If a recovery tank is not provided then loosen the radiator cap slowly. To relieve any excess pressure, remove the radiator cap until the coolant is cold**.** Top up the radiator with the coolant, check the fan belt tension.

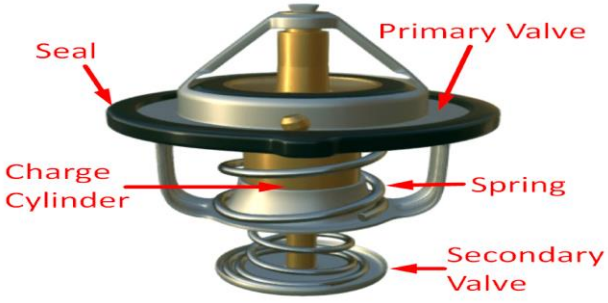


Fig.2.67: Thermostat valve

6. Check fuel gauge to be sure tractor has plenty of fuel.
7. Check battery electrolyte level carefully.
8. Check all of the hydraulic lines and fuel lines, to make sure that they are securely fastened and in good condition. Check hydraulic lines for pinhole leaks
9. Be safe at all times**.** Wear good-quality shoes and keep any long hair tied back. Avoid wearing loose clothing while operating a tractor.
10. Operator's platform area - Examine the area around the seat to make sure it is clear of oil or tools.
11. Lighting/flashers - Check headlights and warning lights/flashers to make sure all of the lights are working and replace bulbs if necessary.
12. Keep small children away from tractors. Tractors are designed to carry only one person-the driver.

Tractor Driving Tips

Starting and stopping the tractor

After completing a pre-starting check of the tractor and doing necessary maintenance, we are ready to start the tractor. Start the engine from the operator's seat only. Never start the engine while standing on the ground. Before starting the engine remember to place the gear shift lever in a "neutral position". Place all hydraulic controls in a neutral position and disengage the PTO. Apply the brakes and depress the clutch pedal, clearing obstructions from the intended path. Push hand throttle, forward off idle position (approximately 1/3 of full throttle). The engine may not start with the throttle pulled completely down. Do not operate the starter more than 20 seconds at a time. If the engine does not start, wait at least two minutes for the starter motor to cool before trying again.

Fig.2.68:(A) Hand Throttle (B) Key Switch

Warm-up engine before working with it. Check all the instruments. Make sure that there is proper oil pressure, the battery is charging, air restriction indicator light showing off.

Fig.2.69: Instrument Panel

For stopping the tractor, apply the brakes evenly and disengage the PTO. Lower all hydraulically powered equipment to the ground, put the gearshift lever in "neutral". Turn the ignition key off and/or cut off fuel for diesel and remove the key to prevent tampering or accidental starting. Pull Manual Fuel Shut-off Knob rearward and hold until the engine has completely stopped.

Fig. 2.70: Hydraulic levers

Always aids the engine to cool down quickly, before the engine stops. This allows the valves and pistons to cool down uniformly. Make sure that the parking brakes are locked.

Fig.2.71: Fuel Shut-off Knob

When operating on the road

Tractors, operated on the public highways must be equipped with Slow Moving Vehicle (SMV) emblems and lights that meet the (Central Motor Vehicle Rules)

CMVR standards. If a tractor-trailer is attached to a tractor, the trailer must have a slow-moving emblem (shown in Fig:2.72) near the rear tail lights.

Fig.2.72: Slow Moving Vehicle (SMV) Emblem

Before operating the tractor on the highway be sure tail lights are flashing and turning properly. Before going forward open the parking brake lock.

Fig. 2.73: Brake pedals

When the tractor is running on the road at speed both the brake should be locked. Shift to a low gear, before descending a steep hill to improve the control on the tractor with little or no braking. Reduce engine speed by controlling the fuel supply before applying tractor brakes. The tractor should be operated at a lower speed when a load of attached equipment is higher than the tractor. Heavy towed or rear-mounted implements may start swaying in transport. Excessive swaying will result in loss of steering control. Drive slowly and avoid quick turns of the steering wheel. When operating a tractor, avoid sharp turns and high speeds. High speeds, coupled with rough ground and narrow wheel settings increase the chance for a rollover. Make turns slowly and at wide angles.

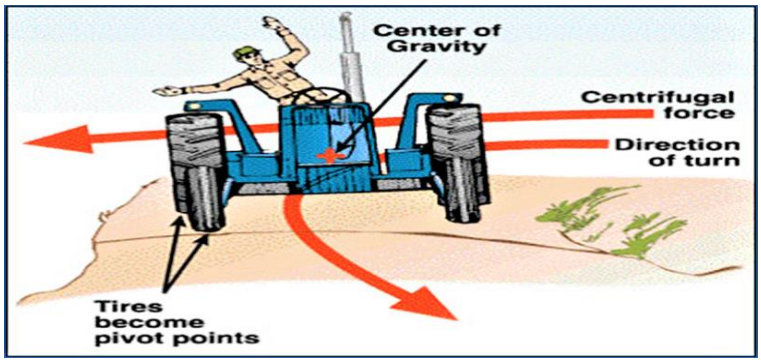


Fig.2.74: Tractor turning condition

Keep tractors and implements away from irrigation ditches and embankment edges to avoid tractor upsets. Keep wheels spread wide whenever possible, this can be done by track setting. A tractor will overturn sideways much easier if the wheels are close together. Edges may be weak and break from the weight of the equipment. If you get stuck, do not tie a fence post or any other object to the tyre for traction. It may tip the tractor over, as it tries to overcome the hump or the post may be thrown up behind the tractor hitting the driver. The best solution is to have another tractor pull you out. Do not put your foot over the clutch pedal while operating the tractor. Release the clutch slowly especially while going upside. Don't disengage the clutch while going downhill, it may be dangerous. Hitch height should be such that the weight transfer is on the optimum side, i.e., hitch height should not be high enough to start front lifting in the tractor at the same time. It should not be very low so that not enough of the weight is transferred on the rear wheels. This will lead to inadequate weight transfer and lesser traction as a result.

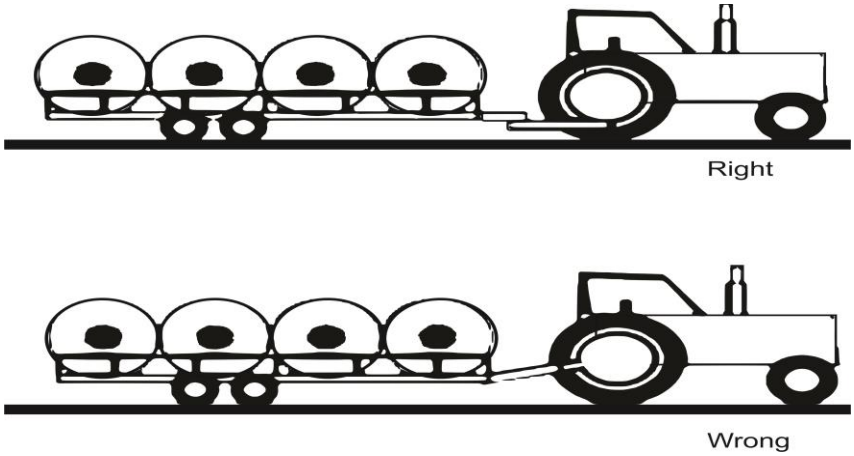


Fig.2.75: Weight balance condition in tractor trolley

With ROPS (**Rollover protective structure**) & a seat belt, the operator has an excellent chance of being contained in the protective zone and surviving a rear rollover. If ROPS is provided in the tractor, use a seat belt.

While operating in the field

Before going to the field, check the tractor and implement. Ensure that the implement is securely hitched and that tyres are properly inflated. Upon reaching the field, check if the field conditions are suitable for the assigned task. At the field unlock the brake pedals, so that wheels can stop separately and improve turning ability. Do not change gears when the tractor is moving. Ensure the PTO shaft is covered. While operating a 4-wheel drive tractor, engage the front drive in the field. Select the operating gear. In a dry work situation, a good

starting gear condition is either 3rd low gear or 1st high gear. Mostly all the field operations are undertaken at ground speeds between 4-8km/hr. In a wet situation, the gear selection may be lower. Set the throttle to mid-range using the hand throttle and slowly release the clutch. At the same time lower the implement into the soil. Then, increase throttle setting to full throttle using the hand throttle control. Foot throttles should only be used for transport situations. If the implement is operating at the desired depth and the engine cannot hold its engine rpm then select a lower gear. When operating on slopes, avoid sudden starts and stops. Operate up and down the slope on steep slopes, not across the slope. Slow down when changing directions. Do not operate where the machine could slip or tip. Stay alert for holes, rocks, and roots in the terrain.

The tractor should be using 70% to 80% of its maximum power when the tractor and implement are correctly matched. When operating at ground speeds of 7 to 8 km/hr, this indicates a permissible rpm drop of not more than 10% of the full non-loaded engine speed. For example, if the full-throttle unloaded engine speed is 2500 rpm, then the loaded speed should not drop below 2300 rpm. If the engine speed drops by more than 200 rpm select a lower gear or lighten the load. Ballast the tractor when operating tillage implements to avoid the slip. The normal load on traction wheels can be increased by putting it inside the pneumatic tyre tube. Generally, the tube is filled up to a maximum of 75% by the ballasting material and rest with the air at the rated air pressure.

Never hitch to the axle or other high point. Hitch towed loads only to the drawbar and at the manufacturer's recommended height. When using the three-point hitch, add front weights necessarily to maintain stability and prevent steering problems. Disengage the Power Take-Off (PTO) when it's not in use. Use the PTO shield whenever equipment is in use. Do not use a tractor for a job it wasn't designed for. The tractor was designed as a source of power to do fieldwork.

Importance of Log Book

A tractor logbook is a document, where all the information about the tractor is recorded. This includes information such as the name of the machine, purchase year, hour’s works, fuel log and average consumption of fuel per hour, lubricants consumption service logs, spare parts used. A tractor logbook is important because it speaks a lot about the health and upkeep of a tractor. Tractor owners list out the amount spent on a tractor -services like air filter change, wheel alignment, tire pressure, battery change, etc. along with the date on which the

service was done. Looking at this, the owner can determine the upcoming or pending tractor services. Apart from the services, it helps keep the record of expenses incurred on the tractor.

1. General Information of Tractor/Equipment

Below mentioned points are included in this section:

- **Name of tractor**
  a) Model
  b) Serial number
  c) Year of purchase
  d) Purchase price
- **Engine**
  a) Make
  b) Model
  c) Serial No.
- **Fuel Injection pump**
  a) Make
  b) Model
  c) Serial Number
- **Starting system**
  a) Make
  b) Model
  c) Starter motor power rating
- **Battery**
  a) Make and Number
  b) Rating
- **Tyres**
  a) Front size and make
  b) Rear size and make
- **Fuel and lubricants capacity**
  a) Engine oil
  b) Gearbox, rear axle, rear final drive, and service brakes oil
  c) Hydraulic
  d) Steering housing
  e) Fuel tank

2. Date-Wise Information

The second section gives the daily information about the tractor. It is better if to top-up the fuel tank of the tractor at the beginning of every month so

that the monthly average of diesel consumption can be calculated. Average fuel consumption in litre/hr is the total diesel used in a month divided by actual working hours. Similarly, keep eye on engine oil consumption. Any sudden increase in engine oil consumption should be taken seriously for wear of engine components. Records of servicing usually remind us about the upcoming servicing schedule. It is a good practice to keep an inventory of some fast-moving parts like fan belts, hose pipes, filters, etc.

Table. 2.8: Daily information of tractor

Date	Tractor starting time	Closing time	Actual working hours	Numbers of hours idle due to repair/ maintenance	Numbers of hours tractor is used	Diesel used	Engine oil /other oil used	Services maintenance details	Spare parts used

a) Fuel level in the fuel tank at the starting of a month in litres.
b) Fuel level in the fuel tank at the closing of a month in litres.
c) Total fuel issued during the month in litres.
d) Total fuel consumed during the month in litres.
e) Total engine working hours during the month.
f) Average fuel consumption in litres/hour.

Table 2.9: Details of Servicing and maintenance

Name of equipment			Contact details of Manufacturer		
Serial number			Name of the operator		
Name of the manufacturer of equipment			Date of purchase		
Date of servicing	Progressive working hours	Nature of job performed during Servicing	Expected date of next servicing	Working hours since the last service	Remark

PRACTICAL EXERCISES

Activity 1: List the document required for acquiring a tractor driving license.

Materials required:

1.Pencil
2. Notebook

Procedure:

1. First, go to the RTO office or go through the website.
2. Note down the document required for a tractor driving licence.

Activity 2: Draw traffic signals sign.

Materials required:

1.Pencil
2.Blank white paper
3.Sketch pen set.
4.Compass box

Procedures:

1. First, go to the RTO office or go through the website.
2. List the different types of traffic signal signs.
3. Sketch the traffic signal signs.

Activity 3: Make a list of necessary precautions to be taken while driving a tractor.

Materials required:

1. Pencil
2. Notebook

Procedure:

1. First, read the tractor manual.
2. List out the precautions that should be taken during driving a tractor.

CHECK YOUR PROGRESS

A. Answer the following question

1. What are the types of traffic signs? Draw any five-traffic sign and write their purpose.
2. Before starting the tractor, some essential check-ups are done. List down any five-essential check-ups.
3. What is the importance of hitch height, during pulling a trolley?
4. Write five safety precautions, while travelling on highways.
5. What is the importance of a logbook in a tractor?

B. Fill in the blanks

1. The minimum age to obtain a driving licence in India for the tractor is……. years.
2. Always start the tractor engine from the ……only.
3. A tractor ……is a document where you record all the information about a tractor.
4. Most field operations are undertaken at ground speeds between ……km/hr.
5. Do not change ……. when the tractor is moving.

SESSION 5: PREVENTIVE MAINTENANCE

What is Preventive Maintenance?

Preventive maintenance is a type of proactive maintenance that includes adjustments, cleaning, lubrication, repairs, and parts replacements. It is done to keep the tractor and agricultural machinery in good order and reduce unscheduled downtime and major repairs.

Maintenance is the regular and periodical care of the machine helping us to work well, safe and long trouble-free life. Maintenance is not repairing of machine. Preventive maintenance is a schedule of planned maintenance action aimed at preventing breakdowns and sudden failures. The primary goal of preventive maintenance is to prevent the failure of equipment before it occurs. It is designed to preserve and enhance equipment reliability by replacing worn components before they fail.

Objectives of preventive maintenance

a) To reduce failures: for obtaining maximum availability when needed
b) To save on operating cost: for minimizing repairing cost
c) To prevent an accident: for ensuring the safety of the worker
d) To improve the working condition: for quality of product/output

Activities of preventive maintenance

a) It includes equipment inspection & checks.
b) Cleaning and servicing.
c) Periodical care and adjustments (lab & Field)
d) Partial or complete overhauls at a specific period
e) Coolant / Water, Oil changes, and lubrication wherever required.
f) Record of equipment deterioration, to know the right time to replace or repair worn parts before they cause a system failure.

Long term benefits of preventive maintenance

a) Improved machine system reliability.
b) Decrease the cost of replacement.
c) Decrease machine down time.
d) Better spares inventory management.

Checking of engine oil

Check the oil level with the cold engine. Never operate the tractor, if the oil level is above the maximum level mark or below the level mark on the oil level dipstick.

Operating the engine under these conditions causes a loss of power, excessive fuel consumption, overheating, and damage to the engine.

1. Park tractor on level terrain.
2. Shut engine 'OFF'.
3. Wait for some time.
4. Remove oil level dipstick.

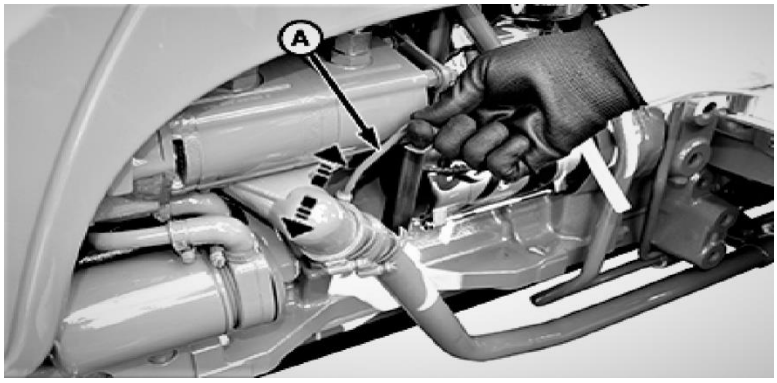


Fig.2.76: Preventive check-up (A) Dipstick

5. Clean oil level dipstick.
6. Insert oil level dipstick into the engine and remove it again.
7. While checking the oil level, the dipstick should be held horizontally and the oil level should be in the region between the minimum and maximum marks.
8. If the oil level is below the minimum mark, add the specified engine oil via fill port.

Checking of brake oil

If the tractor is provided with a hydraulic brake, it is necessary to check brake fluid as per the maintenance schedule. Steps for checking brake fluid-

1. Clean the top of the reservoir carefully.
2. Open the top of your brake fluid reservoir.
3. Look to see where the fluid level lies; make sure that the brake fluid level is within half an inch or so of the cap.

Checking of tyre pressure

The pressure within the tractor tyre is never constant. It can change depending on the load, outside temperature, degree of tyre wear and its usage, type of soil, etc.

As the tyre moves along the uneven farmland, the shoulders and lugs may get impacted by abnormal wear. To avoid the heating up of structural materials,

use the rubber components and nylon parts to separate the tyres from shoulders and lugs. So, reducing the pressure helps preserve the soil. If the pressure is too low, it will cause premature wear to the tyre's internal structure.

An over-inflated rear farm tyre contacts only at the center of the crown and results only in one lug touching the ground at the contact patch. Due to this, every alternate lug slips past. The lug which comes in contact with the road wears faster. Usage of proper inflation pressure will help improve this condition.

The inflation pressure in the rear wheels of the tractor varies between 0.8 to 1.2 kg/ cm^2 (12 to 18 PSI) depending upon its application. In tillage application it is 0.8kg/cm^2; while for haulage application it may kept 1.2 kg/cm^2. To check the tyre pressure, unscrew the cap on the air valve of the tyre. Now, push the tyre pressure gauge firmly onto the tyre valve. Look at the pressure reading on the gauge.

Gear oil

To check the transmission oil, follow these steps-

- Park the tractor on a level surface and turn off the engine.
- Remove and clean the small gauge (dipstick) with a cloth.
- Reinsert and remove the gauge and hold it tilted to check the oil level.
- In case of a low level, replenish the oil.

Coolant in the radiator

Follow these steps to check the coolant in the radiator-

- Park machine safely.
- Allow the engine to cool.
- Check recovery tank coolant level.
- Remove recovery tank cap, if necessary, to add coolant.
- Add pre-diluted coolant or specified ratio of anti-freeze and water.
- Install and tighten the recovery tank cap.

Fan Belt Adjustment

The fan belt should be checked for correct tension and wear, normally the wear occurs inside of the belt. Too much tension may cause alternator and water pump bearing failure and belt wear. Too little tension will cause a decrease in alternator output and belt wear. To check the belt tension, either use a belt

tension gauge or press in the middle of a free span. The width of the free span should be 12 to 18 mm.

Periodical Maintenance of Tractor

The tractor plays a significant role in agriculture. It requires adequate and timely maintenance, to keep it working for a long time at a minimum cost. Read the operation and maintenance manual given by the tractor manufacturer and follow the procedures mentioned in it.

1. Daily / every day (After 10 hours of work)

1. Clean the tractor and its implements.
2. Check oil levels in different assemblies after parking with the tractor on a horizontal surface. Top up, if necessary, when the engine is cold.
3. Top up the fuel tank, if necessary, preferably in the evening, after the day's work to avoid condensation.
4. Clean the radiator. Remove dust and dirt accumulated in the core and top up the cooling system with clean water.
5. Make sure that the tension of the V-belts driving the alternator and the fan is in accordance with the manufacturer's recommendations.
6. Check the tightness of the fuel, oil, and water pipes and hoses, cleaners, fillers and drain plugs to avoid leakage.
7. Make sure that the inflation of the front and rear tyres is in accordance with the manufacturer's recommendations.
8. Check the electrical units. Make sure that the ends of the cables are properly connected to the terminals
9. Lubricate the tractor in accordance with the manufacturer's recommendations. Lubricate the front wheel hub bearing after puddling operation.
10. Check all ball joints of the steering linkage. Make sure that the bolts and screws of the front axle, wheel hubs, wheel discs, and wheel weights are tight.
11. Check all the fastening bolts and screws to make sure that they are tight.
12. Start the engine and ensure that: a) the engine runs smoothly without knocking and any abnormal noise, b) the oil pressure gauge is registering sufficient pressure, c) the warning lights are functioning properly, and d) the alternator is generating proper current.
13. Engage the hydraulic lift and check the movement of the lifting arms and three-point linkage.

2. After 50 hours of work

1) Repeat the daily maintenance.
2) Check the elasticity of the fan belt under the pressure of the thumb. It should stretch upto a degree of 12 & 18 mm.
3) The water stored in the fuel filter should be drained out by the drain plug.
4) Check the water level of the battery. If water is found below the limit, fill it with distilled water.
5) Clean battery terminals, vent plug holes and apply petroleum jelly or vase line.
6) Apply grease to the clutch shaft and bearings, bearing of the fan, hub of the front wheel & tie rod, throttle-control lever, alternator bearing, etc.
7) Remove sediments from the air-pre-cleaner bowl. If the dirt in the oil bath gets settled up to 5 mm, it should be cleaned & filled with fresh engine oil. In the case of dry-type air cleaners, cleaning the outer filter is recommended by the manufacturer.
8) Check and adjust the brakes for proper operation. When brakes are correctly adjusted, it is possible to press the brake pedals by approximately 3/4"(19 mm) before brakes are applied.
9) Check and adjust the engine clutch. A clutch will operate for a longer period unless the driver has been operating the tractor with his foot resting on the clutch pedal. The clutch pedal should be adjusted to give a free play of 10-15 mm. The setting is obtained by adjusting the screw until the required measurement is obtained.
10) For a new engine, change engine oil.

3. After 200 hours of work

1) Repeat the 50 hours of maintenance.
2) Change the engine oil. To do so, keep the tractor in the start position for a while and then switch it off to heat the entire oil. Now, drain out the oil through the drain plug and fill fresh and clean oil of the right grade.
3) In case the oil filter is made of paper, element, cloth, etc. change them. Clean the metallic oil filter.
4) Check the free play of clutch and brake. Adjust it according to the operation and maintenance manual of the tractor.
5) If it is advised to clean the primary diesel filter, (in the manual supplied with the tractor) clean it or change it.
6) Clean and check the battery.
7) Inspect and adjust alternator/fan belt.
8) Inspect drawbar support.
9) Check the cooling system for leaks.

10) Lubricate draft link support shaft bushing.
11) Adjustment of hand-operated clutches.

4. After 400-500 hours of work

1) Repeat the 200 hours of maintenance.
2) Change the other element of the diesel filter.
3) Check and tighten all hoses and hose clamps.
4) Get the injector and diesel pump checked either by an authorized dealer or an experienced mechanic.
5) Contact your authorized dealer or an experienced mechanic for the inspection of the valve.
6) Replace transmission with hydraulic filter.
7) Test or replace engine coolant thermostats.

5. After 1000 hours of work

1) Repeat the 500 hours of maintenance.
2) Change steering box oil.
3) Decarbonize cylinder head, piston top, and combustion chamber.
4) Grind valve seats if necessary.
5) Check water pump bearing.
6) Check alternator and starter brushes.
7) Wash front wheel bearing with diesel. Repack with grease.
8) Check tappet clearance. Adjust, if necessary.
9) Change transmission oil and clean drain plug.
10) Inter-change front wheel.
11) Flush cooling system.

PRACTICAL EXERCISES

Activity 1: Study of operator's manual of a tractor.

Material required:

1. Pen
2. Notebook
3. Operator's manual of tractor

Procedures:

1. First go through the tractor operator's manual.
2. List out the procedure and rules for driving a tractor.

Activity 2: Check engine oil level

Material required:

1. Cloth piece
2. Dipstick
3. Engine oil

Procedure:

1. First, park the tractor on level terrain.
2. Then, 'OFF' the engine and wait for some time.
3. Remove oil level dipstick then clean oil level dipstick.
4. Insert oil level dipstick into the engine and remove it again.
5. While checking the oil level the dipstick should be held horizontally and the oil level should be in the region between minimum and maximum marks.
6. If the oil level is below the minimum mark, add the specified engine oil via fill port.

Activity 3: Check fan belt tension

Material required:

1. Fan belt tension gauge/scale

Procedure:

1. First, stop the engine.
2. Then, check the belt tension either by using a belt tension gauge or pressing in the middle of a free span the free span should be 12 to 18 mm.

Activity 04: Check coolant level in the radiator.

Material required:

1. Cloth piece
2. Coolant

Procedures:

1. First, park the machine safely and allow the engine to cool.
2. Check recovery tank coolant level.
3. Remove recovery tank cap, if necessary, to add coolant.
4. Add pre-diluted coolant or specified ratio of antifreeze and water.

Activity 05: Check tyre pressure.

Material required:

1. Tyre
2. Tyre pressure gauge

Procedures:

1. First, check the tyre pressure.
2. Then, unscrew the cap on the air valve of your tyre.
3. Then, push the tyre pressure gauge firmly onto the tyre valve.
4. Now, look at the pressure reading on the gauge.

Activity 6: Make a list of periodical schedules and items of maintenance of tractor.

Material required:

1. Pen
2. Notebook

Procedures:

1. First, read the operator's manual of a tractor.
2. List out the periodical schedule and items of maintenance of a tractor.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is preventive maintenance?
2. What are the objectives of preventive maintenance?
3. What activities are carried out in preventive maintenance?
4. What are the long-term benefits of preventive maintenance?
5. How much inflation pressure is recommended in tractor tyres in different field conditions? What happens, if we keep low inflation pressure or high inflation pressure in tractor tyres?

B. Fill in the blanks

1. Inflation of the front and rear tyres should be kept in accordance with the ……. recommendations.
2. The water stored in the fuel filter should be drained out by the …… plug.
3. Too much tension in the fan belt will cause…… and water pump bearing failure and belt wear.

4. While checking the oil level the dipstick should behold ……. and the oil level should be in the region, between …….and maximum marks

C. Match the following

Column A	Column B
1. It is a type of proactive maintenance that includes adjustments, cleaning, lubrication, repairs, and parts replacements.	A. 0.8 to 1.2 kg/ cm^2
2. The inflation pressure in the rear wheels of the tractor.	B.12 & 18 mm.
3. Check the elasticity of the fan belt under the pressure of the thumb. It should stretch to a degree of ….	C. Periodical Maintenance
4. To keep it working for a long time at a minimum cost, requires adequate and timely maintenance.	D. Preventive maintenance

UNIT 3: AGRICULTURE MACHINERY AND ITS OPERATION

Various types of agriculture machinery are used in the agriculture field. The field preparation for seed sowing with tillage operation, the implement is also known as primary tillage as well as secondary tillage machines.

SESSION 1: PRIMARY TILLAGE EQUIPMENT

1. Primary tillage equipment: The primary tillage is the field operation after the last harvest. Primary tillage is used when the soil is wet or after the crop harvest.

A. Mouldboard Plough

The mouldboard plough is the most common tillage implement, ranging from the simplest type for animal traction, up to the highly advanced, large ploughs for tractors with 250 hp or more. The mouldboard plough is a typical soil tillage implement. It emerged from the traditional, wooden plough which was used in agriculture for ages. Over the years, iron and steel got introduced as tool-making materials, used for making implement like share and mouldboard. This also helped in changing from breaking to inverting the soil.

The advantage of using the mouldboard is that a layer of soil is separated from the underlying sub-soil and is inverted. Thus, any vegetation or manure present on the surface is buried under. A soil layer is brought to the surface, where it is exposed to the action of weathering agents and other implements. As a result, the soil gets pulverized. Heavier mouldboard ploughs can work even in very hard soils. Ploughing is essentially a method of dry farming that involves turning over the soil with a manual or automated plough to make the land receptive to water, plantings, and nutrients.

Types of Mouldboard Plough

Tractor drawn mouldboard ploughs are of two types:

1. Fixed Bottom (or One Way) Mouldboard Plough: Fixed bottom ploughs throw the soil in one direction, usually to the right (Fig.3.1). Its main components are mouldboard, share, land side, frog, shank and plough accessories, and hitch system. The share and share points are made from high carbon steel or low alloy steel. Both are hardened and tempered to suitable hardness.

Fig. 3.1: Tractor drawn 2-Bottom MB Plough

The working of the plough is controlled by a hydraulic system lever and three-point linkage. Its bar point makes it suitable to break the hardpan of the soil. The functions of various parts of a plough are briefed as follows:

- **Beam:** A single horizontal bar to which the plough units are attached.
- **Standard:** Connects the plough body with the beam.
- **Share:** Makes a horizontal incision, cutting the bottom of the furrow.
- **Mouldboard:** Lifts and turns the furrow.
- **Landside:** Aligns the plough by pressing against the unploughed ground.
- **Frog:** Connects various parts like mouldboard, share, and landside.

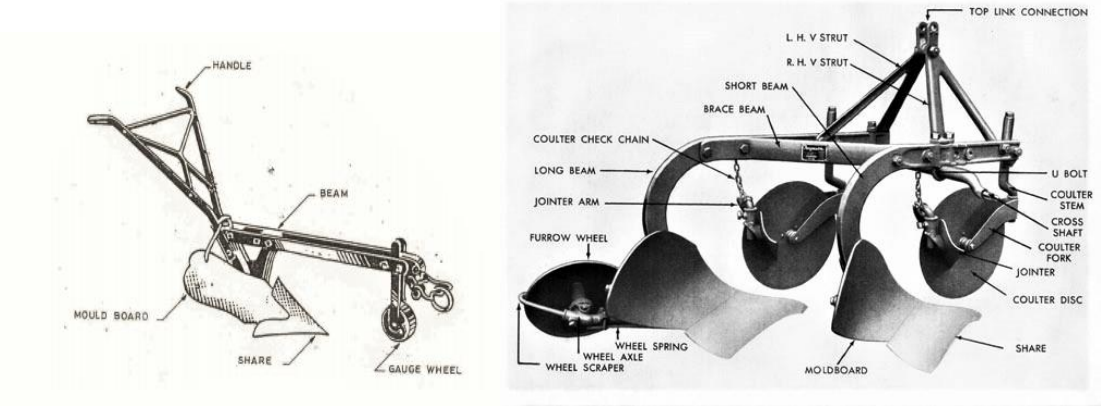


Fig. 3.2: Plough Accessories

There are mainly three accessories used on plough bottoms viz. jointer, coulter, and gauge wheel. The jointer is a small irregular piece of metal having a shape similar to ordinary plough bottom. It looks like a miniature plough. Its main function is to cut and turn over a small ribbon-like furrow slice directly in front of the main plough bottom. It is set to cut 40-50 mm deep. This furrow slice is inverted so that all trash on the top of the soil is completely turned down. Coulter

is used to cutting furrow slices vertically from the land ahead of the bottom and leaves a clear wall. It also cuts trashes covered under the soil.

In general, the coulter should be set about 50 mm shallower than the depth of ploughing. To obtain a neat furrow wall, the coulter is kept 20 mm outside the landside of the plough. It may be a rolling or sliding type. A rolling coulter is a round steel disc suspended on a shank and yoke from the beam. Mostly plain rolling coulters of 300-450 mm diameter are used. The sharpened edge of the coulter may be smooth or notched. It can be adjusted up-down and sideways. The up-down adjustment controls the depth and sideways width of the cut. The gauge wheel helps in maintaining the depth of cut under different soil conditions. It is usually placed in a hanging position.

For proper penetration and efficient operation, some clearance is provided in the mouldboard plough and that is called "suction". The suction is of two types viz. vertical and horizontal suction (Fig. 3.3). Vertical clearance is the maximum clearance under the landside and the horizontal surface. Vertical suction is measured at the joining point of share and landside. It helps in maintaining the depth of the cut. Horizontal suction is the clearance between the landside and the furrow wall. It helps in maintaining the width of the cut. Mouldboard plough needs 3-5 mm vertical clearance (vertical suction) and about 5 mm side clearance (horizontal suction).

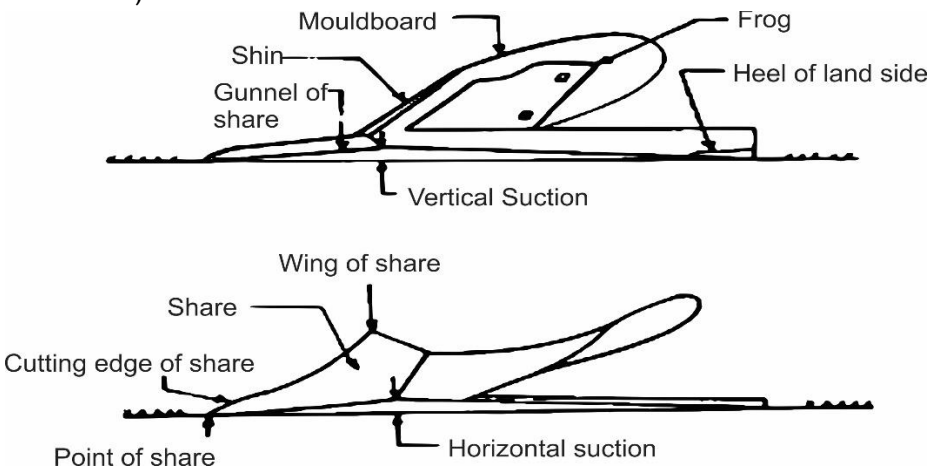


Fig. 3.3: Horizontal and vertical suction mouldboard plough

2. Reversible Bottom (or Two Way) Mouldboard Plough

The bottoms of reversible bottom ploughs (Fig.3.4) are designed in such a way that the right-turning bottoms can be quickly and easily swapped out for a set that turns the soil to the left. As a result, as the furrow reaches its end, the plough is raised, rotated, and returned across the field, ploughing into the

furrows that have just been dug. There are no dead furrows, uneven ground, or sunken patches with reversible ploughs.

Fig. 3.4: Tractor Drawn 2-Bottom Reversible MB Plough

Table 3.1: Advantages and Disadvantages of One-way and Two-way Ploughs

Advantages	Disadvantages
One-way Plough	
1. Cheaper to buy.	1. Dead and back furrows are unavoidable.
2. Relatively simple to adjust.	2. Careful layout of field necessary.
3. Wear only on (replaceable).	3. Width of individual lands not more than 60 m.
4. Large forces transferred via upper link (to activate hydraulic control system).	4. More attention is necessary during secondary tillage.
5. More ploughs can work (offset) behind each other.	5. Large headlands are necessary.
6. A simple way of mounting tools at the rear.	6. Plough does not easily penetrate in dry soils.
	7. Contour-line ploughing on slopes is seldom possible.
Two-way Plough	
1. Big savings in time on small fields.	1. More expensive as the two-way plough (2-3 times).
2. Laying out of the fields in lands is not necessary	2. Heavy construction, causing a strong relief of the front axle load of the tractor.

3. A level surface can be created.	3. Swivelling mechanism is subject to wear.
4. Contour ploughing on slopes is possible.	4. Symmetrical adjustment (of both sets of bodies) is difficult.
	5. Weight limits the total number of bodies.

Classification of MB Plough based on hitching with tractor

Tractor-operated implements may be classified as mounted, semi-mounted, and trailed. The mounted implements are completely controlled by the tractor's hydraulic lift using the three-point linkage. With the semi-mounted type, the weight of the implement is carried on a rear transportation wheel. The trailed type of implement is attached to the tractor's drawbar. Depending on the type of plough, the principle of attaching the implements with the source of power varies. In general, the aim is to make the best use of the source of power (animal or tractor).

(a) **Trail-type ploughs** are fitted with wheels to control their depth. These ploughs are not linked to the tractor's hydraulic system - the only link is the drawbar (hitch bar). They produce only a small additional load on the tractor's rear axle. Hitching (linking) and unhitching are quick and easy but they can be transported (to and from the field) at low speeds. Only they may cause problems on small fields (e.g., in irrigated farming) because of the limited area for maneuvering.

(b) **Semi-mounted ploughs** are hitched at their front to the 3-point linkage system (or to the lower links) of the tractor. The plough is supported at the rear by a furrow wheel, which is often hydraulically operated. This plough often has four or more bottoms. It keeps too much weight off the tractor's front axle, especially when using heavy ploughs with a large clearance between the bodies. The semi-mounted plough's design allows for more bodies than the mounted plough.

(c) **Mounted ploughs** with up to five bodies are typically attached to the tractor's 3-point linkage system. Quick-coupling systems are simple to install. Tractors with free-link operation of the hitch system can carry the plough during transport work, which is supported by a gauge wheel when in use. With automatic depth or draught control, the plough is never supported by wheels. During operation, a large part of the forces acting on the plough (including its weight) is transferred to the rear axle of the tractor (less slippage). To ensure that the steering of the tractor is not over-affected by the considerable lessening of the load on its front axle care should be taken.

Shapes of Mouldboard

Different soils require differently shaped mouldboard. Accordingly, many types of ploughs are available either standard or special-purpose types. The main types of the mouldboard are mentioned below:

(a) General-purpose: A slow-turning, flat mouldboard is twisted along the surface of this type. It creates nearly unbroken furrow cuts. It produces enormous clods with a rough surface, necessitating several secondary cultivations to provide a suitable seedbed. It can work in depths of up to 20 cm and work at speed of up to 4-6.5 km/hr.

(b) High speed: The upper portion of these mouldboards has less curvature. At a speed of 6.5-11 km/hr., this plough performs admirably.

(c) Semi-digger: This is twisted along its length and has a concave surface. It can be used to plough up to 25 cm deep. This plough requires less secondary cultivation.

(d) Digger: The digger's body is twisted along its length and has a more concave surface. At depths of roughly 30 cm, it produces broken work.

(e) Slatted: This plough type is used for very sticky soils. The surface is slatted so that it scours better in difficult soil conditions such as loose, sticky soil and waxy clay (Fig.3.5).

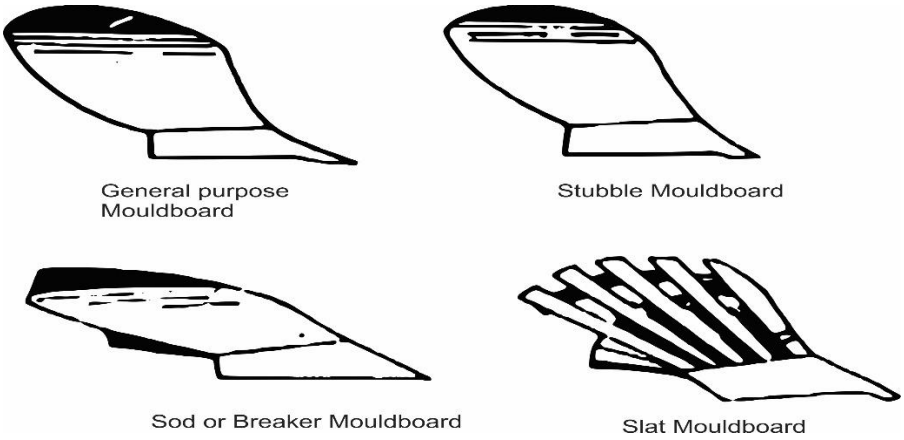


Fig.3.5: Different types of Mouldboard

(f) Stubble: This type is broader and bent more abruptly along the top edge. It is best suited to work in soil, that has been cultivated from year to year. It is called stubble because the stubble of plants from the previous crop is still on the land. Choosing a given type of plough body depends upon the soil type, topography, the required inversion, and speed.

Terminology

The important terms frequently used in ploughing operations are as follows (Fig.3.6):

Furrow: It is a trench formed by an implement in the soil during the field operation.

Furrow slice: The mass of soil that is cut, lifted, and thrown to one side is called furrow slice.

Furrow wall: It is an undisturbed soil surface by the side of a furrow.

Crown: The top portion of the turned furrow slice is called 'Crown'.

Back furrow: A raised ridge left at the center of the strip of land when ploughing is started from the center to the side is called 'back furrow'. When the ploughing is started at the center of the field, the furrow is collected across the field, and while returning back another furrow slice is lapped over the first furrow. This raised ridge is named as 'Back furrow'.

Dead furrow: An open trench left in between two adjacent strips of land after finishing the ploughing is called 'Dead furrow'.

Head land: While ploughing with a tractor, a strip of unploughed land is left at each end of the field is called 'Head land'. At the end of each trip, the plough is lifted until the tractor and the plough has turned and is in position to start the return trip. The size of head land is about 6 meters for two or three bottom tractor plough and one meter more for each additional furrow.

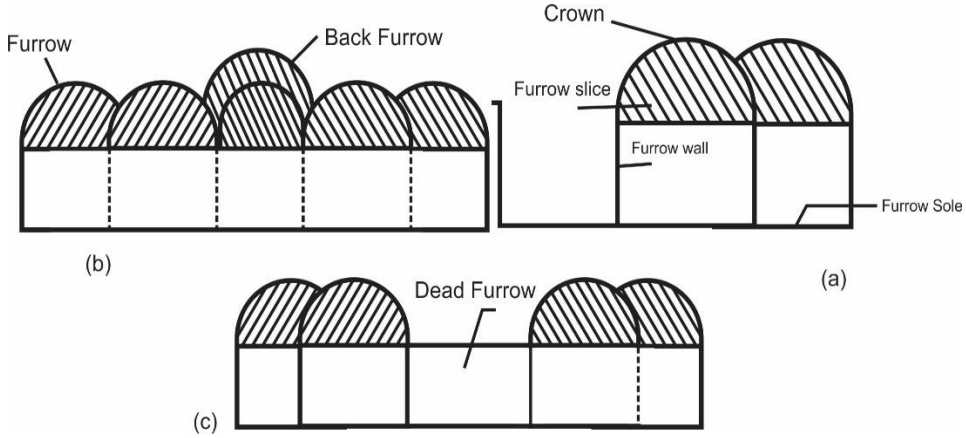


Fig.3.6: Schematic of furrow made by a plough

Methods of Ploughing

Always make furrow from the right-hand side. There are two methods of ploughing:

Gathering: Whenever a plough works round a strip of ploughed land, it is known as gathering (fig.3.7 (a))

Casting: Whenever a plough works round a strip of unploughed land, it is known as casting (Fig.3.7(b))

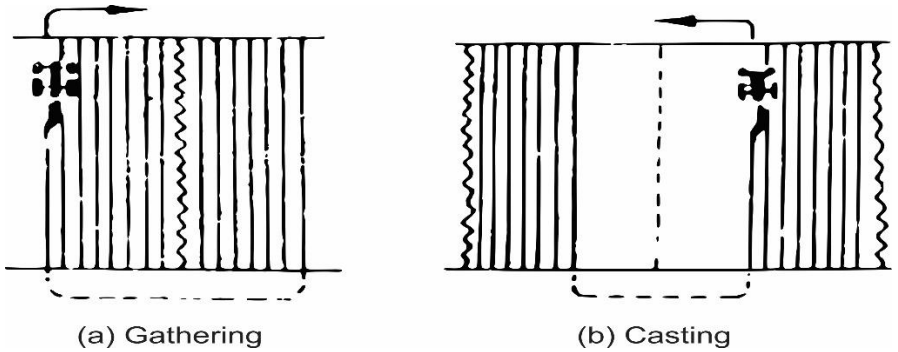


Fig.3.7: Gathering and Casting Operation Pattern

Casting or gathering alone is usually inefficient for ploughing a field. The following are some of the most common tractors ploughing techniques.

Continuous ploughing method

The continuous ploughing method (Fig.3.8) is regarded very convenient and economical under typical conditions. This is a common approach in which the tractor and plough are never idle for more than three-quarters of a land width along the headland and are never turned in a region less than a quarter land width. The headland is initially designated, and the first ridge is set up at three-quarters of a land width from the side in this technique (Fig. 3.8. a). The other ridges run the entire length of the field. Between the first ridge and the side land, the operator begins ploughing.

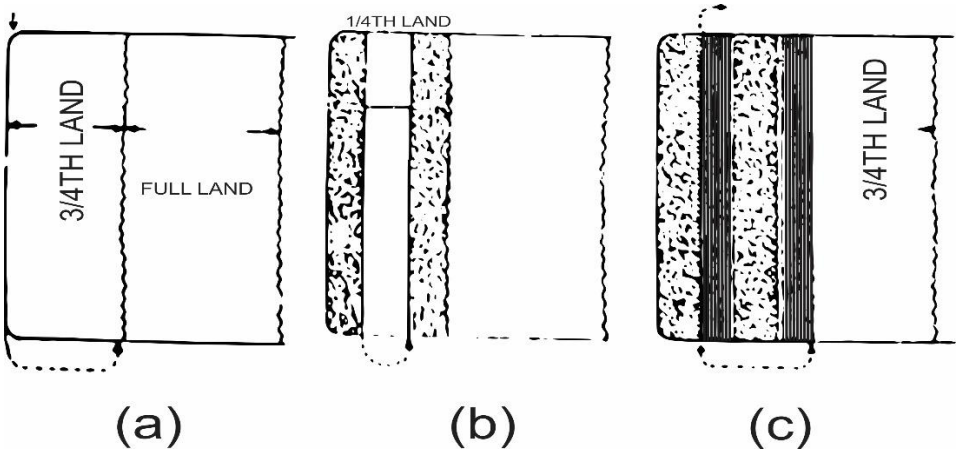


Fig.3.8: Continuous Ploughing Method

The continuous ploughing method (Fig.3.8) is regarded very convenient and economical under typical conditions. This is a common approach in which the tractor and plough are never idle for more than three-quarters of a land width along the headland and are never turned in a region less than a quarter land width. The headland is initially designated, and the first ridge is set up at three-quarters of a land width from the side in this technique (Fig. 3.8. a). The other ridges run the entire length of the field. Between the first ridge and the side land, the operator begins ploughing. The remaining three-quarters of the land can be treated in the same way as the first three-quarters. This procedure is done for each of the other lands in the field.

Round and round ploughing

In this method, the plough moves round and round in the field. This system is adopted in the conditions, where ridges and furrows interfere with cultivation work. The ploughing of the field can be started in two ways.

a. Starting at the centre: A small plot of land is marked in the middle of the field and it is ploughed first. After that, the plough works around this small plot and the entire plot is completed. Although this is not an economical method.

b. Starting at the outer end: The tractor starts ploughing at one end of the field and then moves on all the sides of the plot and comes gradually from the sides to the centre of the field. Wide diagonals are left unploughed to avoid turning with the plough. There are no back furrows in this method. Conventional ploughing is usually done by this method.

One Way Ploughing

This system requires the use of a special type of plough known as a reversible plough or one-way plough. Such a plough turns furrows to the left or right. After the headland has been marked, the operator ploughs along with a straight side landmark. At the end of the first trip, he turns his tractor in a loop and returns down the same furrow. No dead and back furrows are left in the field. In gently sloping fields, this method is suitable.

How to determine the size of a plough (Fig.3.9)

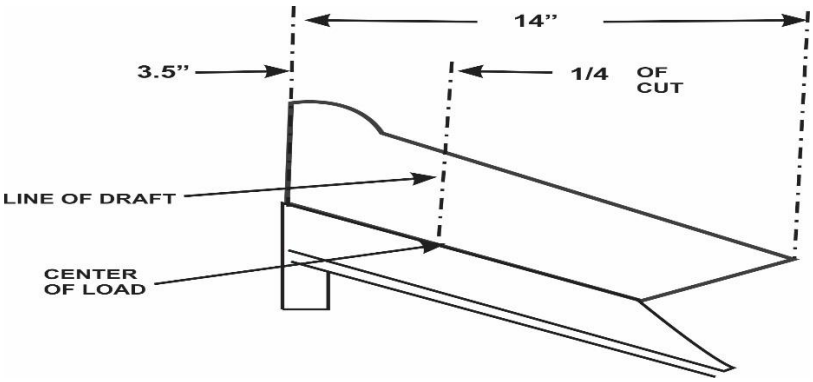


Fig.3.9: Measuring size of plough

i. Stand facing one of the plough's mouldboard assemblies so that the curve of the mouldboard is toward you.
ii. Identify the plough share along the bottom front edge of the mouldboard. The plough shares meet and cuts the soil as the mouldboard plough is pulled, directing the soil onto the curve of the mouldboard above it. The plough shares of modern mouldboard ploughs are bolted to the mouldboard and replaceable to allow for the wear.
iii. Measure the bottom edge of the plough share from the front tip of the plough share edge to the back tip of the plough share edge using a measuring tape or stick. You are measuring the forward and widest edge of the ploughshare. For example, you measure 14 inches (355.6 mm) from the bottom front tip to the bottom back tip of the ploughshare edge. This is a 14-inch (355.6 mm) bottom plough.
iv. The size of the mouldboard correlates to the size of the furrow. Thus, a 14-inch mouldboard will cut a 14-inch furrow.

How to set up a Mouldboard Plough

Setting up a mouldboard plough involves getting the ploughshare and coulter to the desired depth. It also means getting the plough adjusted so that the ground it turns over is level.

- Prepare the tractor and make sure that it has the proper weights to counterbalance the weight of the plough. If you have a fully mounted plough, the tractor needs weights on the front to balance the weight of the plough mounted on the rear side (back).
- Adjust the tractor's wheel width so that the right rear wheel runs in the furrow of the plough. This setting depends on the number of bottoms or plough

shares in a plough. Check the operator's manual of the plough for specific settings.

- Attach the plough to the tractor. If the plough has a three-point hitch, back the tractor up to the plough and secure the three connections. Raise the plough to move it. If the plough uses the tractor's hydraulic system, connect the hitch pin as well as the hydraulic lines. Raise the plough with the hydraulics.
- Check that all the bolts are tight and secure on the plough. With a new plough repeat this step after a couple of hours of plough operation to make sure nothing has worked loose.
- Align the coulter to the mouldboard. These rolling blades make it easier for the mouldboard plough to turn the earth over. Set them in line with the mouldboard and about 2 inches (50.8 mm) in front of it. The cutter wheels should provide a clean cut just to the left of the landslide. The depth should cut through the trash but not tear it up. Torque the coulter's fastening bolts in place once the coulter is in position.
- Level the plough: Set the plough into the ground and plough a short distance. With the plough still in the ground, check to see if the plough frame is level. If it's not, use the tractor's lift-arm crank to level the plough. If the plough isn't at correct level from front to back, use the top link of the three-point hitch to adjust it.
- Lock the tractors stabilizer (sway) bar or lift-arm the plough should be adjusted. This lessens the plough's movement from side to side while in operation.

Field Operation with Mouldboard Plough

Ideally, the best ploughing techniques not only turn over the soil but pulverize and loosen the depth up to 10 inches (254 mm) below the surface. The kind of plough to be used is determined by the size of the field and the type of soil. Proceed as follows:

i. Start the first round on a long side of the field. Lower the plough into the ground and run the tractor at a speed recommended by the plough manufacturer. Drive in a straight line so that the furrows turn evenly. If possible, use an object in the distance as a visual reference to keep the first line straight.
ii. Raise the plough at the end of the row on time to have enough room to turn. Go to the other long side of the field and plough another straight row. If the field is very big, then divide it into sections.

iii. Return to the first row that is already ploughed. With the right wheel in the furrow left by the first pass, plough another straight row. Once the initial passes are complete, you have the furrow to use as a guide. Repeat this process until ploughing in the field is finished. The furrow from the last pass, or dead man furrow, is going to be lower than the rest. Plough over that furrow one last time to even the ground.
iv. Choose the right ploughing pattern. Using a circuitous pattern means starting from the outside edge and working your way inward in the shape of the field. Circuitous patterns are used primarily with mouldboard ploughs. Headland patterns are formed by making parallel lines back and forth and are the most efficient way to handle large tracts of land. Gathering patterns begin at the center and work their way out. These are good for making drainage ditches along the edges of the field, but they require finding an accurate center.

Fig. 3.10: Field operation of MB Plough

Performance Measurement

The important parameters to be observed to get an idea about the performance of the plough is as follows:

A) Rate of work: In this, the performance of plough can be judged in the following ways:

i. Width of cut: For determining the width of cut, an average of 5 runs should be taken. The measurement of composite width should be taken at a minimum of 5 equidistant places in the direction of travel and average working width should be determined.

ii. Effective field capacity: The actual output term of the area covered per hour is expressed as the effective field capacity. In calculating the effective field capacity, the time consumed for real work and that lost for other activities such as turning, adjustments, etc. should be taken. Time for refueling should be deleted because usually filling up before starting the test can make refueling unnecessary except for especially large fields. It can be calculated as:

$$\textbf{Ee} = \frac{A}{T_P + T_N}$$

Where,

Ee = Effective field capacity (ha/h)

A = Area covered (ha)

TP = Productive (h)

TN = Non-Productive (h)

(Non-productive time is the time lost for turning and adjustments etc. excluding refueling and machine trouble)

iii. Field efficiency: The field efficiency is the ratio of effective field capacity to the theoretical field capacity expressed in percentage.

$$\textbf{Et} = \frac{WS}{10}$$

Where,

Et = Theoretical field capacity

W = Theoretical width of Implement (m)

S = Speed of operation (km/h)

$$\textbf{Field efficiency (η)} = \frac{E_e}{E_t} \times 100$$

For most of the tillage operations, field efficiency ranges between 75-90 %.

iv. Slippage: The slippage of tractor drive wheel occurs most during the ploughing operations. The distance covered by the tractor in a given number of drive wheel revolutions decreases with the wheel slip. Therefore, in the case of tractor or power tiller operated to implement the wheel slip affects the speed of operation and thereby the effective field capacity of the implement. The wheel slip is determined as under and expressed in percentage.

$$\textbf{Wheel slip (\%)} = \frac{N_L - N_o}{N_L}$$

Where,

NL and NO are total no. of the revolutions at the load and no load respectively for the marked test run.

B) Quality of work: In this, the performance of plough can be figured by following these ways:

i) Depth of cut: The vertical distance between furrow sole and ground level is referred to as depth of cut. To obtain an accurate result, the depth should be measured at a minimum of 10 places and its average was taken.

ii) Soil inversion: Soil inversion is the process through which the furrow slice is inverted. The inversion characteristics can be measured by the weed count method. In this method, the number of weeds/stubbles present are counted before and after ploughing by placing a square frame of 30 cm x 30 cm or 50 cm x 50 cm randomly at a minimum of 5 locations in the field. The soil inversion is expressed in percentage.

$$\textbf{Soil inversion (\%)} = \frac{W_B - W_A}{W_B} \times 100$$

Where,

W_B = No. of weeds present per unit area before the operation

W_A = No. of weeds present per unit area after the operation

iii) Soil Pulverization: Soil pulverization is the breaking of soil into small aggregates resulting from the action of tillage forces. The mean mass diameter (NMD) of the soil aggregated is considered as the index of soil pulverization and can be determined by the sieve analysis of the soil sample through a set of standard test sieves (IS: 460-1982). Sieving provides a simple means for measuring the range of clod size and relative amount of soil in each size class.

C) Draft measurement (For mounted type plough)

The draft can be measured by two tractors and a dynamometer. An implement is mounted on a tractor (A) and then it is towed by another tractor (B) through a dynamometer. Measure the draft when the tractor A is in neutral gear condition but implement is in operating condition and again when the implement is in the lifted position. The difference between the two readings gives the draft requirement of implement.

Draft power requirement for the operation of the implement can be calculated by the following formula:

$$\textbf{Power (matric hp)} = \frac{Draft(kgf) \times Operational\ speed\ (m/s)}{75}$$

2. Disc plough

Disc plough is a perfectly round, concave disc sharpened on the edge used for cutting the soil (Fig.3.11). Disc ploughs are suitable for areas where the soil conditions do not permit the operation of mouldboard ploughs to a good advantage. The plough is used for the following jobs:

- Primary tillage in rough, dry, and hard soils,
- Seedbed preparation,
- Ploughing land containing stones and roots,
- Working in soils with heavy vegetation growth and large amounts of plant residue,

- Ploughing in regions with a high risk of erosion,
- Ploughing on sticky, waxy soils and soils which tend to form plough soles,
- Land clearance and ploughing between rows of the trees.

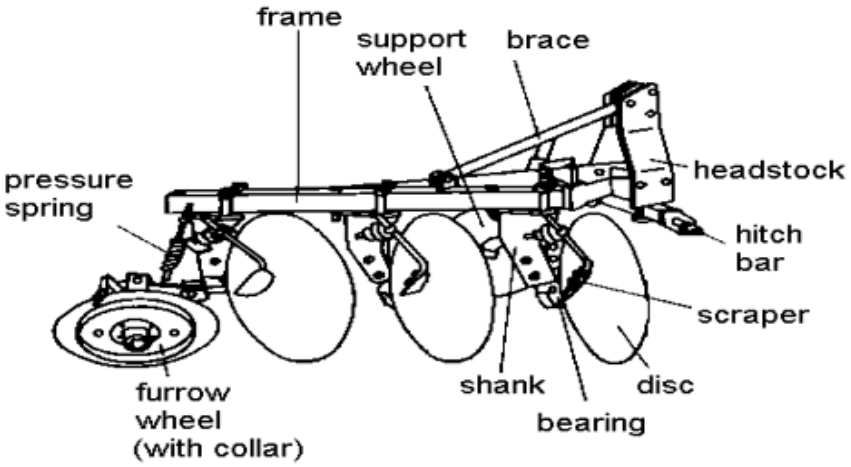


Fig. 3.11: Disc Plough

The mouldboard ploughs cannot penetrate into hard soil; disc ploughs can ride over rocks. Nevertheless, there is little difference between mouldboard and disc ploughs as regards effect, maintenance, reliability, power requirements, and total tillage costs.

Table 3.2: The comparison between mouldboard and disc ploughs

Criteria	**Disc plough**	**Mouldboard plough**
Inverting	Medium	Good
Mixing	Medium	Hardly
Crumbling	Medium/good	Medium
Burying of long stubble	Not completely	Completely
Plough sole compaction	Little	By landside less by share
Susceptibility for damage by roots and stones	Little	More
Possible fields of use	Heavy, dry, stony soils forest soils	Clean fields
Durability	High	Medium
Weight	High	Lower
Draught requirement	High	High

Penetration by disc ploughs creates problems on dry heavy soils. Penetration can be achieved only with a suitable high load (up to 500 kg per disc by adding weights). Unlike the mouldboard ploughs which have to be protected by special mechanisms and suitable shares. The disc ploughs roll over roots and stones, thus preventing the damage. A constant working depth is very hard to maintain. It is also difficult to keep to a straight line of travel. Generally speaking, the soil is tilled less intensively and with less inversion than with a mouldboard plough.

Sticky soils cause fewer problems. The discs rarely have to be sharpened or replaced since their rotation produces a long cutting edge. The advantages & disadvantages of disc ploughs in comparison to the mouldboard plough are:

Table 3.3: Disc plough's advantages & disadvantages in comparison to MB plough

Advantages	Disadvantages
• Only partial inversion of the soil, so that the plant residue is left on the surface, thus reducing the erosion risk and water losses by evaporation. • The mixing action on loose soils. • Rolls over obstacles so that hardly any breakage occurs. • Lower risk of choking (sugarcane, cotton, maize). • Fewer problems with sticky soils. • Hardly any smearing of the furrow bottom (plough sole). • The wear is spread over the entire circumference of the disc (2 m of cutting edge on discs with a diameter of 65 cm). • The discs are self-sharpening. • Easier adjustment.	• Penetration is difficult in the hard soils. • Heavy weight (and consequently, high prices). • Greater lifting capacity required from the tractor's hydraulic system. • Furrow wheel is needed for controlling the depth and lateral movement. • Not usually suitable for the slopes owing to the strong lateral forces. • The plough's weight may cause compaction of the furrow bottom. • Less efficient weed control. • The soil surface is not properly levelled after ploughing (irrigated fields).

Functioning of Disc plough

Unlike the mouldboard plough, a disc plough will not penetrate the soil on its own rather it needs a heavy load. The soil is not carried over the surface of the

disc (as with a passive share in the mouldboard plough) therefore, there is less scouring (rubbing). The disc is rotated by the soil reaction. It lifts and deposits the soil not with a winding but with a pouring tumbling movement.

Fig.3.12: Field operation by Disc plough

When combined with the differences in the acceleration force is exerted on the soil. This force increases from the center towards the edge. This movement causes the disintegration, mixing, and loosening of aggregated soil. In case of the cohesive soils, this movement may produce deposits of clods along a lateral axis, thus forming the unwanted "rabbit holes". The furrow slices which are formed in these soils are difficult to be crumbled by the secondary tillage operations. Consequently, the standard of the tillage depends to a large extent upon the type and condition of the soil. Like the mouldboard plough, the disc plough leaves an open furrow.

There is less likelihood of forming a plough sole with a disc plough because:

- The disc plough tears rather than cuts, so no cutting surface can develop (the tillage horizon is corrugated);
- There are no landsides and heels on the mouldboard plough which produce further smearing and compaction.

In the case of compactable soils, however, the total weight of the heavy plough may cause compaction over a thicker layer (5-10 cm) below the furrow bottom. The large discs require less draught and cut through the plant residue more satisfactorily.

Types of Disc Ploughs: There are two types of disc ploughs:

I. Standard disc plough: The standard disc plough consists of a series of individually mounted, inclined disc blades on a frame supported by the wheels.

- The discs are tilted backward at 15-25^{o} to the vertical (Fig.3.12).

- The plane of the disc face is angled at a 42-45^{o} horizontal angle from the direction of travel (Fig.3.13).
- The disc diameter ranges from 60-85 cm.
- The disc concavity - the spherical radius ranges between 45 and 62.5 cm.
- The discs are placed on the antifriction bearing.

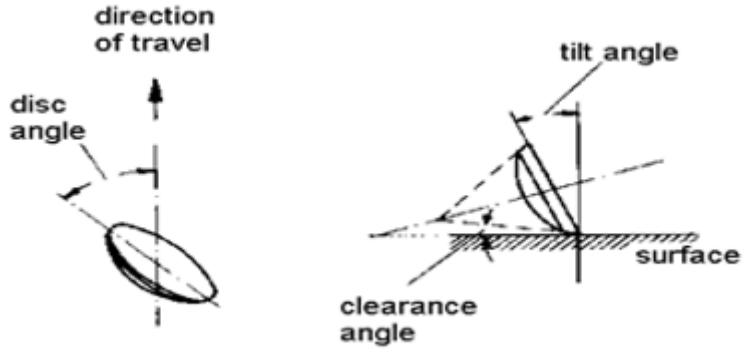


Fig. 3.13: Disc and Tilt angle

II. Vertical Disc Plough: These discs are uniformly spaced along a common axle (or gang bolt) through a spacer spool. It is used for shallow ploughing (7-10 cm) and mixing the stubble with the soil.

- The discs are smaller in diameter (50-60 cm).
- The entire gang rotates as a unit.
- The width of the cut ranges from 90 cm to 6 m.

Classification of Disc plough based on types of hitching with tractor

The tractor drawn disc ploughs are designed in one of the following forms as (definition same as given for mouldboard plough types):

- **Mounted (integral):** The mounted implements act as an integral part to the tractor and are lifted hydraulically.
- **Semi-mounted (semi-integral):** The semi-mounted disc ploughs can be lifted hydraulically and supported on support wheels.
- **Trailed (drawn):** The trailed disc ploughs have a land wheel attached to the rear for support and provide a lifting mechanism.

Description of the Implement and Tools

From what was studied in the earlier discussions, we can realize that the disc ploughs are very heavy implements equipped with between one and eight concave discs. The working depth is 25-40 cm. Each disc is mounted on its shank (standard) with a bearing (frog). The shanks are mounted on a sturdy steel frame diagonally in the direction of travel.

The disc angle and tilt angle are adjusted on the frog bearing and can be adapted to the field conditions. The diameter of the disc's ranges from 560 to 810 mm. The disc's concavity is defined as the depth of the center about the edge, in the range between 60 and 120 mm. An opening in the center of the discs is used to mount a tapered roller bearing which can be adjusted by a castle nut to prevent too much play. The dimensions (diameter, thickness) of the discs are usually given in inches and are interrelated based on a specific ratio.

The discs are made of specially treated manganese silicon steel which is very resistant to wear. The hardness is comparable to that of plough shares and may be as much as 600 HV (Vickers Hardness). The direction of the disc rotation is always in the direction of travel since they are driven by the slice of soil moving along the concave inner side of the disc. Mounted ploughs are usually equipped with a rear furrow wheel.

Disc plough accessories: The disc plough accessories are provided as attachments to improve plough performance and quality of work. Some of these are:

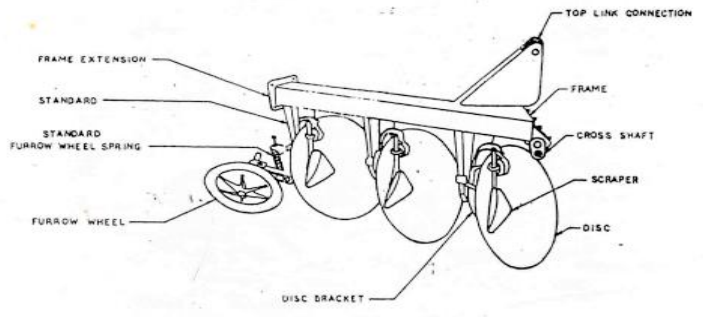


Fig. 3.14: Disc plough accessories

- **Scrapers:** These tools are shaped like hoes or small mouldboards provided to remove (scrap off) the soil from sticking on the disc and improve the inversion.
- **Additional weight:** Since the disc plough cannot penetrate deep into the soil, an additional weight is added to the frame (or weight box) to force the plough into the ground for penetration.
- **Furrow wheels:** Front and rear furrow wheels are provided with the disc ploughs to absorb the side forces of the soil. The furrow wheels are angled up to 45 degrees from the surface and are equipped with a collar. These wheels absorb at least part of the lateral forces exerted by the soil. With this wheel arrangement, however, a trailed type plough will always tip over when making a right-hand turn. So, the plough should always be turned to the left.

- **Depth adjustment:** Depth adjusting mechanism is provided to change the depth of operation by adjusting the angle between the frame and the land wheel axis.

Power Requirement: The power requirement of a disc plough, like the mouldboard plough, depends on such factors as the specific soil resistance, weight, dimension, and shape of the implement, and speed. Owing to its heavy weight the draught required (per volume unit of soil moved) for a disc plough is more or less the same as for a mouldboard plough despite the rolling action. When more concave discs are used to obtain better crumbling the draught requirement will increase with the degree of curvature.

This requirement depends to a large extent upon the soil conditions as the discs are driven by the soil resistance and movement. The power requirement is generally 15-20 kW per plough per disc. At the 5.5 km/h working speed of the disc plough, a capacity of 0.4 ha/h can be expected for each meter of working width.

Adjustments and Operation: Like the mouldboard ploughs, disc ploughs also require various adjustments as discussed below:

(a) Working Depth: The working depth is maintained mainly by the weight of the plough. The disc and tilt angle strongly influence the depth control and must be adjusted to the soil conditions. The following settings may be used:

Table 3.4: Disc and tilt angle settings for disc plough

Soil	Tilt angle (vertical)	Disc angle (horizontal)
Hard	03^0 - 20^0	45^0 - 50^0
Cohesive	10^0 - 25^0	43^0 - 48^0
Loose	15^0 - 30^0	40^0 - 45^0

Every plough's disc angle, as well as the tilt angle on many of them, may be modified (frequently in gradations). When the disc is tilted, an angle of clearance should be allowed to prevent constraint upon the disc's tearing action and possible smearing of moist soil. The wider the tilt angle, the less freedom is left for the disc angle because, otherwise, the back of the disc may scour against the furrow wall (more power required and more wear caused).

(b) Working Width: There are only a few possibilities of changing the working width. The width can be adjusted by:

- Changing the angle disc angle,

- Adjusting the furrow wheels,
- Adjusting the disc-mounting clamps on the frame.

As stated, the cutting width of each disc can be changed by altering the disc angle. Horizontal and lateral forces must be absorbed by the slanting furrow wheels. For trailed type disc ploughs these forces should also be absorbed by the gauge wheels running on the undisturbed soil; as little as possible should be absorbed by the tractor body (to avoid side draught). Collars on the furrow wheels improve the guidance of the plough.

The correct setting of the tractor's front and rear track widths is most important for guiding the plough and for determining the cutting width of the front discs. This is particularly important in case of reversible ploughs.

PRACTICAL EXERCISES

Activity 01: Make a list of mouldboard plough.

Material Required:

1. Pencil
2. White paper/notebook
3. Eraser
4. Sharpener

Procedure:

1. First, visit different agriculture fields or farms.
2. Then, identify different types of MB plough used in that field.
3. List out different types of MB plough.
4. Draw a neat sketch and label it.

Activity 02: Sketch disc plough.

Material Required:

1. Pencil
2. White paper/ notebook
3. Eraser
4. Sharpener

Procedure:

1. First, visit the different agriculture fields or farms.
2. Identify the disc plough used in that field.
3. Note down the specification of the disc plough.
4. Draw a neat sketch and label it.

CHECK YOUR PROGRESS

A. Answer the following questions:

1. What is tillage and its objectives?
2. Explain the traditional plough.
3. Describe the parts of a mouldboard plough and their functions.
4. Describe the parts of a disc plough and their functions.
5. Compare the advantage and disadvantages of mouldboard and disc plough?
6. What are the technical features of mouldboard and disc ploughs?

B. Fill in the blank

1. Trail-type ploughs are fitted with wheels to control their ……
2. The …… helps in maintaining the depth of cut under different soil conditions.
3. Soil pulverization is the breaking of soil into ……, resulting from the action of tillage forces.
4. The disc angle and tilt angle are adjusted on the …… and can be adapted to the field conditions.
5. An open trench left in between two adjacent strips of land after finishing the ploughing is called ……

C. Match the following:

Column A	Column B
1. These implements act as integral parts to the tractor and are lifted hydraulically.	A. Semi-mounted
2. Effective field efficiency (Ee) is -	B. Trailed (drawn)
3. The disc ploughs can be lifted hydraulically and placed on support wheels.	C. $\frac{N_L - N_o}{N_L}$
4. Wheel slip (%) is indicated by-	D. $\frac{A}{T_P + T_N}$
5. Field efficiency (η) is -	E. Mounted (integral)
6. These disc ploughs have a land wheel attached to the rear for support and provide a lifting mechanism.	F. $\frac{E_e}{E_t} \times 100$

SESSION 2: SECONDARY TILLAGE EQUIPMENT

Secondary tillage: The secondary tillage uses a variety of harrows, rollers, or pulverisers, mulching and fallowing tools. To boost the seedbed by increasing soil pulverisation, preserving moisture by destroying weeds, and cutting crop residues. There are the following secondary tillage equipment's:

A. Rotavator: It is a primary cum secondary tillage equipment. In a single pass of the rotavator, a better seedbed and soil pulverisation achieved. It can be used in both dry and wet environments.

The preparation of wheat fields after harvesting the paddy crop is quite difficult in the heavy soils. Due to crack development in the soil, the implement like mouldboard plough, disc plough, and cultivators, etc. do not work properly as there is a tendency of the lifting of big clods. And the upper layer of the soil is not always loosened to the desired extent, nor is the proper mixing of different layers achieved. Frequent operation with the conventional implement has to be performed for the preparation of seedbed for the sowing of wheat crop. In addition, the stubble of rice crops creates problems especially when the crop is harvested with the combine harvester. It requires a high amount of energy input (20-30%) for the tillage operation.

Rotavator helps to obtain specific benefits of early seed bed preparation. This is done soon after harvesting of paddy crop for sowing wheat, and after harvest of the wheat crop for sowing of paddy. This, not only requires low energy in the tillage operation but also mixes and incorporates the stubbles of the previous crop thoroughly in the soil. This improves the physical properties of soil and hence result in increased crop yield. As an ideal seedbed is prepared with the use of a rotavator, it facilitates the sowing of wheat by seed-cum- fertilizer drill without any operational problems. The rotavator (derived from rotary cultivator), also known as Rotary plough or tiller is a power-take-off (PTO) driven implement useful for quick seedbed preparation and soil tillage (Fig.3.15). Rotavator is very effective in chopping crop residue or sod and incorporating it into the soil or incorporating fertilizer, mulches, manure, or other amendments into the soil. They are used in gardens, landscaping, and site-specific agricultural applications; and mainly to obtain a quick seedbed, for clearing weeds, and breaking up large clods.

Studies conducted throughout the world indicate that the rotavator prepares well-puddled soil which reduces the basic infiltration rate of water. It also results in saving in irrigation water during the initial 15-20 days of transplanting. It is quite effective to prepare seedbeds in dry as well as wet conditions.

Working Principle

The PTO shaft drives the rotor, and as the rotor turns, the blades on the rotor are rotated at high speed and break up the soil as the machine is drawn along. Soil is tilled as the rotating blades (tines) penetrate and stir the soil. Blades incorporate crop residue or soil amendments and pulverize the soil to a fine tilth.

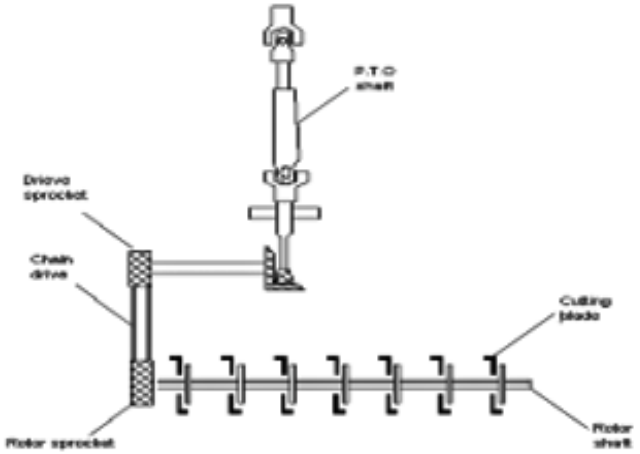


Fig. 3.15: Rotavator plough

Constructional Details

Rotavator consists of a steel frame, a rotary shaft on which blades are mounted, a power transmission system, and a gearbox. The blades are of L-type, made from medium carbon steel or alloy steel, hardened and tempered to suitable hardness. The PTO of the tractor drives the rotavator. The rotary motion of the PTO is transmitted to the shaft carrying the blades through the gearbox and transmission system. The speed of the rotor is kept at about 210 rpm for a rated PTO rpm of 540 rpm of a prime mover. One or two operations of this implement are sufficient for good pulverization of soil depending upon soil and crop conditions. It is not meant for sandy soil.

Fig.3.16: Rotavator and its major parts

The principal parts of the rotavator are:

1) Rotor shaft
2) Adjustable curved flats (skid)
3) Rotatory/rotating blades

Hitching system

4) Gear box assembly
5) Chain drive or Gear drive assembly
6) Rotor assembly
7) Metal shield
8) Rack (for skid adjustment)
9) Trailing board

Adjustable curved plates (Skids) on both the sides are used to change the working depth according to the need and situation. Rotavators are available in different sizes of 0.83-1.455 m width for 25 to 60 hp tractors. The size of the rotavator is expressed in the width of the cut. (Table 3.5)

Table 3.5: Selection of the Rotavator according to tractor hp

S.No.	Tractor (hp)	Working width (mm)	Weight (kg)
1.	25-35	836	230
2.	35-40	1042	260
3.	40-47	1248	280
4.	50-60	1455	310

The reason behind the popularity of rotavators amongst the farmers is the benefits it offers over the traditional method of land preparation. These benefits are as follows:

a) After harvesting the previous crop, soil can be prepared in a short period for the next crop and the soil moisture content can be used effectively.
b) Soil pulverization with the rotavator is better than the traditional implements.
c) Cost of operation is less as energy, time, and fuel requirement is less.
d) It destroys the weeds, stubbles of paddy, sugarcane, maize, cotton completely and cuts previous crop residue into fragments, and buries it into the soil, which in turn increases the soil fertility.
e) It can be used effectively for intercultural operation in horticultural crops and puddling in paddy cultivation.

f) As the direction of rotation of rotavator blades and the wheel of a tractor is the same, the rotational energy of the blades helps the tractor to move ahead which in turn reduces tyre friction.
g) With a rotavator 1.5 to 2.0 hectares of land can be prepared in a day of 8 h working schedule.

OPERATION AND ADJUSTMENT

Before each use, perform the maintenance as per the user manual.

- Follow the information on safety training, preparation, starting and stopping safety, operational safety, transport safety warning sections of the user manual.
- With the rotary tiller (rotavator) positioned on a level ground, adjust the tractor lift arms so that when it is lifted, the rotor arm remains parallel to the ground.
- With the rotary tiller attached to the tractor, raise and support the tiller with suitable blocks. Adjust the skids, located on the sides of the tiller. The adjustment bolts for both right and left sides should be positioned in the same adjustment hole. This allows the tiller to till the same depth on each side. Adjust the back plate with regulating chain until the desired mulching effect is found.
  (**Note:** Never attempt to adjust the rotary tiller when the tractor is moving)
- Raise the tiller and remove the blocks. Lower the tiller to the ground.
- With the tractor at idle RPM and the tiller lifted off of the ground, engage PTO and slowly advance the throttle to 540 PTO RPM. (NOTE: A rotary tiller is designed to run at 540 PTO RPM only.)
- Select a low gear for the tractor and begin to move forward. Tractor ground speed is to be controlled by gear selection only and not engine speed. As the tractor moves forward, slowly lower the tiller down. Allow the tiller tines to gradually engage the ground.
  (**Note:** Do not allow the tractor engine or rotary tiller to bog down or stall. This causes undue wear and tear on the tiller and tractor. If this continues to happen reduce the ground speed and raise the tilling depth of the rotary tiller. Never attempt to remove objects from the rotor bar until the tractor has been shut down and the tiller tines have completely stopped.)
  Warning: Never travel at a fast ground speed while sitting on the tiller, this could damage it. Never attempt to turn the tractor or travel in the reverse with the PTO engaged and the tiller in the ground. Always raise the tiller out of the

ground when backing up or attempting to turn. Failure to do so may cause damage to the tiller.

- After each use clean all debris from the tiller tines. Replace any missing or illegible safety decals. Inspect for any damaged or worn parts and replace them before next use. Store the rotary tiller in a dry environment.

Fig. 3.17: Field Operation with Rotavator (Dry Condition)

Fig. 3.18: Field Operation with Rotavator (Wet Condition)

Table 3.6: Trouble Shooting of a Rotavator		
PROBLEM	**POSSIBLE CAUSE**	**POSSIBLE REMEDY**
• Gearbox overheating.	• Low on lubricant.	• Fill the proper level.
	• Improper type lubricant.	• Replace with the proper lubricant.
	• Excessive trash build-up around the gearbox.	• Remove trash.
• Soil texture too coarse.	• Ground speed is too fast.	• Decrease the ground speed.
	• Levelling door too high.	• Lower levelling door.
	• PTO speed too slow.	• Increase PTO speed
	• Soil too wet.	• Wait until the soil dries.
• Soil texture is too fine.	• Ground speed is too low.	• Increase the ground speed.
	• Levelling door too low.	• Raise the levelling door.
	• Shallow working depth.	• Increase the depth using the skids.
• Skips or leaves crop residue.	• Badly worn or bent tines.	• Replace worn/bent tines.
	• Ground speed is too fast for conditions.	• Reduce the ground speed.
	• Slip clutch slipping (if unit so equipped).	• Reduce load.
• Overheated side supports.	• Grass/soil build-up on ends of the rotor.	• Clean rotor.
	• No lubrication on side support or side transmission.	• Check oil in the chain drive box and lubricate the outer side bearing.
• Tines balling up with soil.	• Worn or bent tines.	• Replace tines.
	• Tines incorrectly installed.	• Install correctly.
	• The rear levelling door is too low.	• Raise door.
	• Tractor speed too fast.	• Reduce the ground speed.
	• Soil too wet.	• Wait until the soil dries.
• Work depth differs on the two sides of the tiller.	• Side skids set at different heights.	• Adjust skids to the same height.

• Tines clog frequently.	• Soil too wet.	• Wait until the soil dries.
	• Excessive forward speed.	• Reduce ground speed.
	• Grass/weeds too tall to be worked.	• Cut grass/weeds beforehand.
• The gearbox is noisy.	• Rough gears.	• Run in or change gears.
	• Worn bearings.	• Replace bearing.
	• Low oil in the gearbox.	• Check level and add oil.
	• It may be normal on a new machine	• Allow time for break-in.
• Gearbox leaking.	• Damaged oil seal.	• Replace seal.
	• Bent shaft.	• Replace oil seal and shaft.
	• Shaft rough in the oil seal area.	• Replace or repair shaft.
	• The oil seal was installed wrong.	• Replace seal.
	• Oil seal not sealing in the housing.	• Replace the seal or use a sealant on the outside diameter of the seal.
	• The oil level is too high.	• Drain oil to the proper level.
	• Hole in the gearbox.	• Replace gearbox.
	• Gasket damaged.	• Replace gasket.
	• Bolts loose.	• Tighten bolts
• Tillage depth is insufficient or the tiller will not penetrate the ground.	• Skid shoes need adjusting.	• Adjust skid shoes.
	• Tines installed backward.	• Correctly re-mount tines with cutting edge toward the direction of rotation.
	• Tiller carried by the tractor.	• Lower tractor 3-point arms.
	• Insufficient power.	• Increase tractor engine RPM.
	• Tallgrass/weeds wrapped on the rotor.	• Clear rotor and tines. Cut, burn, or defoliate long material before tilling.
	• Worn or bent tines.	• Replace tines

	• Ground too hard.	• Set tiller for shallow penetration, then deepen progressively (make several trips). • Wait for rain. • Slow forward tractor speed.
	• Tiller climbs out of the ground and propels the tractor forward.	• Till at shallower depth and then deepen progressively. Tractor too small – use a larger tractor or add weights.
	• Tiller at wrong attitude.	• Adjust top link of 3-point hitch to correct tiller attitude.
	• Excessive forward speed.	• Reduce ground speed.
• The machine makes an intermittent clicking noise.	• Loose parts.	• Check that all nuts and bolts are properly tightened.
	• Chain damaged.	• Replace damaged chain link.
	• Gearbox gear tooth damaged.	• Replace damaged gear.
• Excessive vibration and/or machine jumps over the ground.	• Wrong PTO RPM.	• Place PTO lever in 540 RPM position.
	• Excessive trash wrapped on the rotor.	• Remove the trash.
	• Broken or worn blades.	• Replace the blades.
	• Incorrectly mounted blade/blades with dull side cutting first (blades on backward).	• Correctly remount the blades.
	• Damaged or bent main rotor.	• Replace rotor shaft.
• PTO vibrates.	• Worn universal joint.	• Replace universal joint.
	• The machine lifted too high.	• Lower machine and readjust tractor

	• Excessive trash wrapped on the rotor.	• 3-point lift stop.
	• PTO driveline bent.	• Remove trash.
	• PTO driveline hitting the front of tiller or swinging drawbar.	• Replace PTO driveline. Adjust machine lift height and/or remove drawbar.
• The rotor will not turn.	• PTO not engaged.	• Engage PTO.
	• Broken drive chain.	• Repair drive chain.
	• Driveline shear bolt sheared.	• Replace the shear bolt.
	• Clutch slipping.	• Reduce load (slow forward speed).
	• Rock or stump wedged between tine and housing.	• Adjust the clutch. Remove the material wrapped or wedged.

OPERATIONAL SAFETY

All operators of this equipment must read and understand the entire manual, pay attention to safety and operating instructions, and before using.

Keep all helpers and bystanders at least several hundred feet from an operating rotary tiller. Only properly trained people should operate this machine. The majority of the accidents involve entanglement on the driveline, injury of bystanders by the objects thrown by the rotating tines, and operators being knocked off the tractor. Accidents are most likely to occur with the machines that are loaned or rented to someone who has not read the owner's manual and is not familiar with a rotary tiller.

- The rotary tiller is designed for use only on tractors with the power take-off (PTO) turning at 540 RPM.
- Install and secure all guards and shields before starting or operating. The tiller tines, driveline guards and tractor, shields should be used and maintained in good working condition. They should be inspected carefully, at least daily, for missing or broken chain links, shields, or guards. (Worn items must be replaced at once to reduce the possibility of injury).
- Disengage power-take-off (PTO) and place the transmission in neutral before attempting to start the engine.
- Many varied objects, such as wire, cable, rope, or chains, can become entangled in the operating parts of the tiller. These items could then swing outside the housing at greater velocities than the tines. Such a situation is

extremely hazardous. Inspect the cutting area for such objects before tilling. Remove any like objects from the site.

- Never allow the tilling tines to contact such items. Never assume that an area is clear. Always Check!
- Always stop the tractor, disengage PTO, set be a brake, shut off the tractor engine, remove the ignition key, lower implement to the ground, and allow rotating pieces to come to a complete stop before dismounting the tractor. Never leave the equipment unattended while the tractor is moving.
- Never place hands or feet under tiller with tractor engine running or before you are sure all motion has stopped. Stay clear of all moving arts.
- Do not reach or place any part of your body under equipment until it is blocked securely.
- Do not allow riders on the rotary tiller or tractor at any time. There is no safe place for any riders.
- Do not operate unless all personnel, livestock, and pets are several hundred feet away to prevent injury by thrown objects.
- Never operate the tractor and rotary tiller under trees with low hanging limbs. Operators can be knocked off the tractor and then run over by the rotating tines.
- The rotating parts of this machine have been designed and tested for rugged use. However, they could fail upon impact with heavy, solid objects such as steel guardrails and concrete abutment. Such impact could cause the broken objects to be thrown outward at very high velocities. To reduce the possibility of property damage, serious injury, or even death, never allow the tilling tines to contact such obstacles.
- Stop the rotary tiller and tractor immediately upon striking an obstruction. Turn the engine off, remove a key, inspect and repair any damage before resuming the operation.
- Pass rotary tiller diagonally through the sharp dips and avoid sharp drops to prevent “hanging up” tractor and rotary tiller. Practice will improve your skills in maneuvering on rough terrain. Always cut down slopes, never across. Always check the tractor manual for proper use on slopes.
- When using a unit, a minimum 20% of tractor and equipment weight must be on tractor front wheels. Without this weight, the tractor could tip over, causing personal injury or death. The weight may be attained with a front-end loader, front-wheel weights, ballast in the tires, or front tractor weights. When attaining a minimum of 20% of tractor and equipment weight on the front wheels, do not exceed the ROPS weight certification. Weigh the tractor and equipment. Do not guess or estimate.

B. Cage wheel: Movement of machine over the wet and loose terrain involves difficulties associated with a higher level of energy consumption. Rice is a major food grain crop grown in different parts with varying levels of mechanization. Traditional practices of rice cultivation rely on man and animal power but the dependency on the animate source of power is reducing with time due to the benefits of mechanization. To utilize the benefits of mechanization, improved and appropriate energy conservation devices are prerequisites. This is more relevant for the mechanization of typical wetland rice fields of Southeast Asia including India. The conversion of engine power of tractors and power tillers into useful work for the cultivation of wetland is very low due to the low load-bearing capacity of loose soil. This makes the mechanization of wetland cultivation energy inefficient. Different types of traction devices or cage wheels have been designed and are used in different parts of the world.

Tractors and power tillers are mainly used as a mechanical source of drawbar power required for cultivation. These machines with pneumatic tires can perform well on-road and off-road hard surfaces. In wetland conditions the pneumatic tires become inefficient due to higher slip. For this, a special wheel called cage wheel is fitted either with a tire or alone to improve the traction in wetland conditions. Infirm good soil condition, the traction can be improved significantly just by adding more weight to the tractor drive wheel. Internal friction(ø) is very low in wet loose soil conditions, resulting in an increase in drive wheel weight. It is not possible to improve traction efficiently unless the traction device is able to remove loose surface soil and gain hold on relatively firm soil. For increased traction in the wetland, a specific traction device called as a cage wheel is necessary.

The cage wheel is an important traction improvement device in wet puddle soil conditions. During machine operation in the field, there are several losses such as poor surface layer trafficability, higher energy consumption, fuel consumption, soil hardpan, plant debris, and so on. The cage wheel, in particular, provides a floating effect to the power tiller and tractor in wet paddy fields, in addition to puddling the soil. The use of a suitable cage wheel allows well puddle condition and energy-saving operation in the wetland.

C. Cultivator: Cultivator is an implement for inter-cultivation operation with laterally adjustable tines to work between crop rows. This can be used for field preparation and for sowing with seeding attachment. The cultivator stirs the soil and breaks the clods (Fig.3.19). The tines fitted on the frame of the cultivator comb the soil deeply in the field. Cultivators are primarily the type of tillage implements that are used after the crop has come up a few centimeters above the ground. Destruction of weeds is the primary function of a cultivator. The following are a few important functions of a cultivator.

a) Intercultural operations of the field.
b) Destroy the weeds in the field.
c) Aerate the soil for the proper growth of crops.
d) Conserve moisture by preparing the mulch on the surface.
e) To sow seeds when it is provided with sowing attachments.
f) To prevent surface evaporation and encourage rapid infiltration of rainwater.

Fig.3.19: Cultivator operation in the field

Different designs of tines are being used for cultivators (Fig.3.19). Depending upon soil working conditions different types of sweeps and shovels are used as soil working elements (Fig.3.20). The two types of tractors mounted cultivators are shovel type and sweep type. The width of operation depends on the horsepower of the tractor. In the Madhya Pradesh region, sweep-type cultivators are more common which are commercially known as duck foot cultivators.

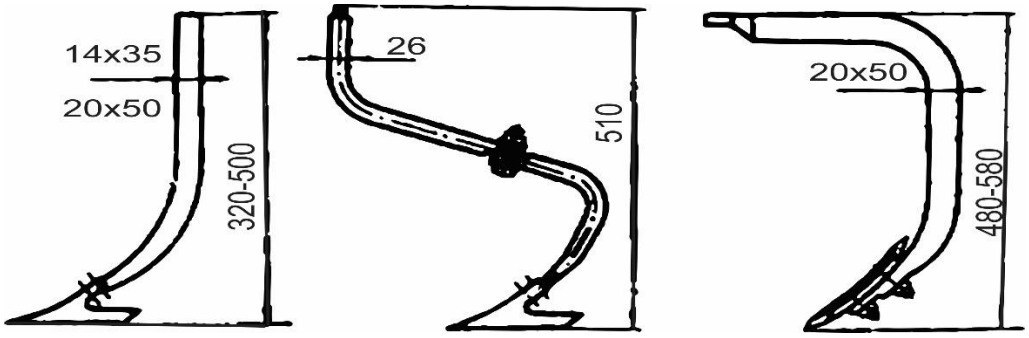


Fig.3.20: Different design of tines for tractor-drawn cultivators

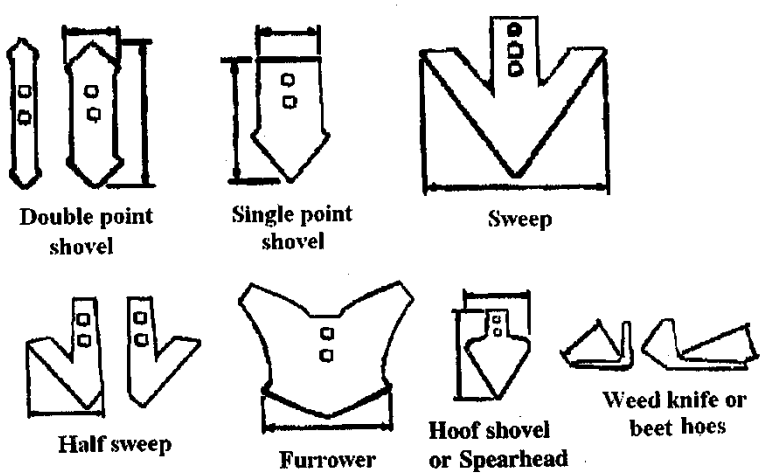


Fig.3.21: Different designs of sweeps and shovels

Usually, tractor-drawn cultivators are of two types, depending upon the flexibility and rigidity of tines: i) Cultivator with spring-loaded tines ii) Cultivator with rigid tines.

1. Spring Tine Cultivator: A tine hinged to the frame and loaded with a spring, so that it swings back when an obstacle is encountered. Each of the tines of this type of cultivator is provided with two heavy pre-tensioned coil springs to ensure minimum movement. The springs operate when the points strike roots or large stones by allowing the tines to ride over the obstruction, thus preventing the damage. On passing over the obstruction, the tines are automatically reset, and work continues without interruption. The tines are made of high-carbon steel. The shovels for this cultivator are made of heat-treated steel for longer life. The implement is mounted type and is controlled by the hydraulic system of the tractor. The cultivator may be fitted with 7, 9, 11, 13 tines, or more depending upon the requirements. These cultivators are used for seedbed preparation both in dry and wet soils. This type of cultivator is particularly recommended for soils which are embedded with stones of stumps. It is also used for intercultural operation by adjusting the tines in wider row crops and for puddling purposes.

Fig.3.22: Spring Tine Cultivator

2. Rigid Tine Cultivator: Rigid tines of the cultivator are those tines which do not deflect during work in the field. It consists of a mainframe made of a box section, rigid tines, U-clamps, and shovels. The clamping of tines helps in adjusting the distance between them according to crop rows. The shovels are made from medium carbon steel or low alloy steel, hardened and tempered to suitable hardness. The shovels are mounted on the tines with fasteners and can be replaced easily on wearing or becoming dull. The depth of operation is controlled by the hydraulic system of the tractor. It is mainly used for loosening, aerating the soil and preparing seedbeds. This cultivator is useful for subsoil cultivation and it eliminates the need for ploughing in hard soils.

3. Duck Foot Cultivator: The duck foot cultivator (Fig.3.23) is a type of rigid cultivator. It consists of a box-type steel rectangular frame, rigid tines, and sweeps. The sweeps are triangular similar to the foot of the duck hence it is called duck foot cultivator. The sweeps are made from high carbon steel and joined to tines with fasteners, which makes them replaceable after being worn out or becoming dull. The tines are made of mild steel and are flat and forged in shape. According to requirement, the number of sweeps can be reduced. The depth of operation is controlled by the hydraulic system of the tractor. This cultivator is popular in black cotton soils. It is mostly used for primary tillage operation for shallow ploughing where as in hard soils, for destruction of weeds, and the retention of soil moisture.

Fig.3.23: Duck Foot Cultivator

Table 3.7: Technical specifications (Important Major specifications)

Type of cultivator	Tractor Mounted
• Mainframe	• Square section 65x65x6 mm
• No of tines	• 7-13
• Type of tines	• Vertical shape, with footplates
• No of shovels	• 7-13
• Power required	• 45 hp tractor
• Working depth	• 125 mm
• Working capacity	• 0.5 ha/hr
• Weight approx.	• 200-300 kg

Preparation and setting of cultivators

a) Select the cultivator to be used according to the type of soil and field conditions (pre-tilled or not). For heavy soils; rigid types cultivators are used and for light soils; spring tine cultivators are used. Make a visible inspection of the selected cultivator before going to the field. Replace all the worn-out parts of the cultivator with a new one. Check for the loose bolts and nuts.
b) Select the size of a tractor that matches the cultivator. Generally, a 35 hp tractor is used with 9 tine cultivators in light soil, while in heavy soil same tractor is used with 7 tine cultivators.
c) Provide an adequate front-end ballast for stability of the tractor.
d) Carry out all the daily and periodic maintenance of the tractor.
e) The cultivator should be properly hitched to the tractor. While hitching, approach the tractor to the cultivator, connect the lower links to the relevant pivots and connect the top link.
f) Adjust the position of the cultivator until it is perfectly horizontal.
g) Lift the cultivator slightly above the ground and adjust the side-to-side level so that all the shovels have the same clearance.

Operation and adjustments of cultivator for optimal performance

The cultivator may be used for breaking up the compacted soil, working loose soil, and cultivating between row crop. To improve the traction, use wheel weights/tire chains.

1. The safe operation of this machine is the responsibility of the owner/operator. The operator should be familiar with the field cultivator, tractor and all safety practices before starting operation.
2. Never let anyone stand between the rear of the tractor and the implement while the tractor is backing up to connect to the implement. Always stand the side of the tractor till it complete stops.
3. Attaching the field cultivator to the tractor increases the overall length of the working unit. Allow additional clearance for the implement to swing while turning.
4. Check for ditches, stumps, holes, or other obstacles that could upset the tractor or damage the cultivator.
5. For proper operation, level the field cultivator by adjusting the tractor linkage. It will assure that the cultivator run at a level.
6. The tractor 3-point hydraulic lift system should be set to transfer most of the field cultivator's weight and draft to the tractor to maximize the traction.
7. The deeper you operate the cultivator; more tractor horsepower and traction will be required.
8. Up to 25-35 kg of concrete block or wooden block or other weight may be strapped or tied to the cultivator frame to improve penetration. Before adding weight, the cultivator should be attached to the tractor's hitch.
9. In very hard soil or dry conditions (or with a small tractor), it may not be possible to operate the cultivator at a desired depth. In these cases, it may be necessary to make several passes. (Increase the depth with each pass until the desired depth is reached.) The best "shattering" action will be realized at a forward speed of 4 to 6 km/h. It is not recommended to exceed 8 km/h as it will only increase fuel consumption, required horsepower, wear on the tractor and implement.
10. Do not make turns with the field cultivator in the ground. Damage to the cultivator will occur. Always raise implement and lower after the turn is made.
11. Do not attempt to operate the field cultivator when the soil is wet. Wet soil will not shatter or break-up and will compact the soil.
12. While making passes across a field, operate the field cultivator diagonal to the direction of the first pass.
13. If the points of the field cultivator are reversible, when the first point wears back, remove the bolts, reverse the point and reinstall the bolts.

14. Do not let the point wear back so that wear occurs on the lower shank body.

Measurement of the performance of cultivator

The main objectives of the performance test are obtaining reliable data on the implement such as work capacity, operating quality, field efficiency, and adaptability to various field conditions. The important parameters to be measured and observed during the performance test of the cultivator are as follows:

a) Working width: It is calculated by multiplying the number of tines to the tine spacing.
b) Depth of cultivation: The vertical distance between the furrow sole and ground level is referred to as depth of cut. To obtain an accurate result, the depth should be measured at a minimum of 10 places and its average was taken.
c) Weeding efficiency: It is the ratio of the number of weeds destroyed per unit area to the number of weeds present before operation per unit area expressed in percentage.

$$Weeding\ efficiency = \frac{No\ of\ weeds\ destroyed\ per\ unit\ area}{No\ of\ weeds\ present\ before\ operation\ per\ unit\ area}\ X\ 100(\%)$$

d) Plant damage: It is the number of plants damaged per unit area.
e) Actual operating hours.
f) Time spent turning at the headland.
g) Time spent for adjustment of an implement.
h) Actual travelling speed: It is the actual working speed of the tractor in the field.
i) Theoretical field capacity: It is the rate of field coverage of the implement, based on 100 percent of the time at the rated speed and covering 100 percent of its rated width.

$$Theoretical\ field\ capacity\ (ha/h) = \frac{Width\ (m)\ x\ Speed\ (m/h)}{10000}$$

j) Effective field capacity: It is the actual area covered by the implement, based on its total time consumed and its working width.
k) Field efficiency: It is the ratio of effective field capacity and theoretical field capacity expressed in percentage.

$$Field\ efficiency = \frac{Effective\ field\ capacity}{Theoretical\ field\ capacity}\ X\ 100(\%)$$

l) Fuel consumption: It is the fuel consumed by the tractor for the operation of the implement per hour per hectare. It is expressed in liter/h/ha.

m) Percentage of wheel slip: Slippage of tractor drive wheel occurs during all field operations. The distance covered by the tractor in a given number of drive wheel revolutions decreases with the wheel slip. Therefore, in the case of a tractor or power tiller operated to implement the wheel slip will affect the speed of operation and thereby the effective field capacity of the implement. The wheel slip is determined as under and expressed in percentage.

$$Wheel\ slip\ (\%) = \frac{N_L - N_o}{N_L}\ X\ 100$$

n) Draft: It is the horizontal component of the pull, parallel to the line of motion.

$$D = P\ Cos\ \theta$$

Where,

D = Draft (kgf)

P = Pull measured by a dynamometer (kgf)

θ = Angle between the line of pull and the horizontal (degree)

Draft power requirement for the operation of the implement can be calculated by the following formula:

$$Power\ (PS) = \frac{Draft(kgf) \times Operationalspeed(m/s)}{75}$$

Safety Precautions

1) Don't leave the tractor seat when the tractor is in motion.
2) Don't leave the tractor engine running.
3) Never operate on steep slopes without maintaining proper tractor stability.
4) Don't sit on the cultivator when it is in operation.
5) The operating speed of the tractor should not be above recommended speed.
6) The working depth of the cultivator should not be above recommended depth.
7) Always carry a medical kit on the tractor.
8) The operators should carefully read this manual to know the operating features and safety matters that require attention.
9) Check the cultivator completely; it should not be used until it is in good technical condition.
10) Cultivating is forbidden during turns or when in reverse.
11) While the cultivator is working, no one is allowed to sit or stand on the cultivator or nearby, failure to do so can cause serious injury or even death.

12) During operation, if abnormal noise occurs. Stop the tractor immediately and determine if the implement has hit an obstruction or the mechanical equipment requires repair. If the cultivator requires a repair, stop the cultivator immediately and service before putting it back into operation.
13) As the cultivator is an implement operated by the tractor's power, the operator should drive with caution and be ready to cut off the power freely to avoid any accidents.

D. Disc Harrow

Disc harrows are the implements used in the secondary tillage operation for levelling the ground, crushing the clods, stirring the soil to create a smooth seedbed for plant growth and prevent or destroy weeds. In some conditions, it is used for covering the seed when the broadcasting method of seeding is employed. They are seedbed finishing implements. They are lighter duty than disk ploughs and generally use smaller blade diameters and narrower spacing between blades. The basic component of the disc harrow is a concave disc, while a disc plough consists of a smaller diameter and curvature. A number of these discs are mounted on an axle to constitute a 'gang', and several gangs may be mounted together to make a disc harrow. Disc blades are available in two forms: Plain and Cut-away.

- **Plain discs** are round, smooth-edged, concave discs.

Fig.3.24: Plain disc

- **Cut-way discs** have notched or scalloped edge.

Fig.3.25: Cut-way disc

Cut-way discs penetrate better than plain discs, therefore these are recommended for the front gangs of tandem disc implements.

Disk harrows (Fig.3.26) are used for secondary tillage including weed control, incorporation of fertilizers and herbicides or pesticides, breaking up surface crusts and clods, and mixing and levelling the top few inches of soil. Unlike the disc plough, the angle of individual discs on the disc harrow is fixed, but the angle of the gang may be set in the direction of travel. The greater the angle set, the greater the pulverization of the soil.

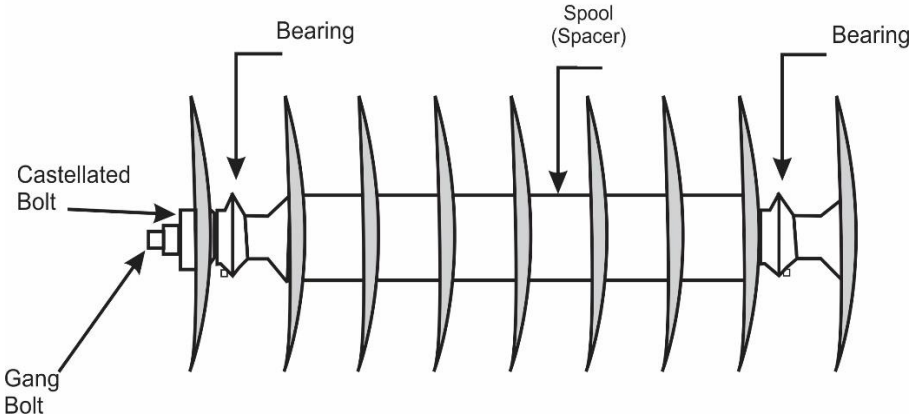


Fig.3.26: Disc Harrow

Types of disc arrangements

Based on the arrangement of discs, the three types of disk harrows are:

- Single action
- Double action
- Offset

(a) Single Action Disk Harrows: It consists of two gangs of disks placed end-to-end which throw the soil in opposite directions (Fig.3.27. a). The cutting width for single-action disc harrows may range from 1.2 to 6.0 m. Sizes wider than 3.6 m have end sections that fold over on the main harrow, so that it can pass through gates. The cutting width may also exceed 6.0 m.

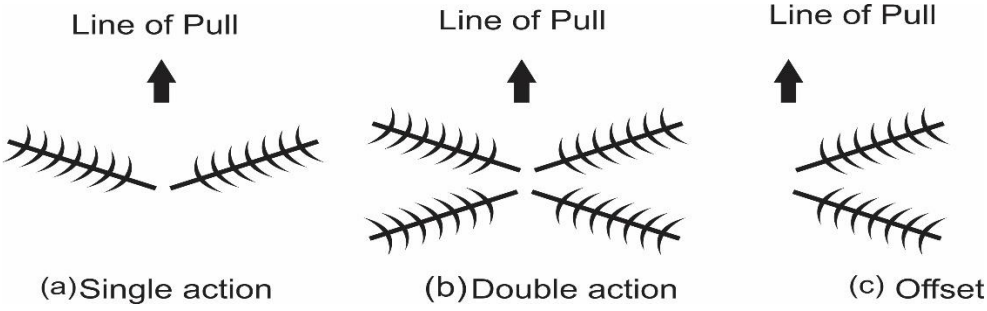


Fig.3.27: Disc Harrow Arrangements

(b) Double Action Disk Harrow: It is often called tandem harrows have two opposed front gangs, like a single action harrow, and two opposed rear gangs following behind the front gangs (Fig.3.27. b). It is so arranged that the discs on the front gangs throw the soil in one direction (usually outward) and the discs on the rear gangs throw the soil in the opposite direction. Thus, the soil is tilled twice with each pass and is left almost levelled as compared to single-action disking.

The conventional four-gang tandem (double-action) power-lifted disc harrow has a fixed angle construction. The sizes in width of cut may range from 1.5 to 7.6 m. Typically, its width ranges from 1.5 to 3.3 m.

(c) Offset Disc Harrows: It is positioned to be operated in an offset position to the tractor (Fig.3.27.c). This arrangement enables the tractor to work beneath fruit tree crops in orchard farms and operate a harrow under limbs near trees, while the tractor runs out beyond the limbs.

The offset double-action mounted disc harrow consists of two gangs of discs arranged in a fixed angle frame, so that one gang runs behind the other. The rear gang may be set to run directly behind the front gang, giving a double disking to the soil or it can be adjusted sidewise to run in the right or the left as desired. There is provision to level the harrow sidewise and for increasing or decreasing pressure on either side of the harrow. The harrow can also be adjusted to regulate the penetration of the rear gang. A change in hitch can also cause the harrow to run to either right or left of the tractor. Mounted offset harrows are available in widths up to 6.3 m. The typical size range is 1.3 to 9.1m.

There are special heavy-duty disk harrows built to chop up on pasture lands and excessively heavy crop residues in sugar cane fields. They are suitable for deeper harrowing of heavy soils. The heavy-duty harrows are usually equipped with a cutaway or notched-edged disk blades. They are available in both single and double-action types.

Types of tractor attachments

The disk harrows are available in sizes suitable for any tractor. In general, there are two classes of disk harrows. These are:

- Trailing disk harrows
- Mounted disk harrows

(a) Trailing Disk Harrows: These are hitched to the drawbar of the tractor and pulled by the tractor.

Generally, the trailing-type disk harrow cannot be lifted off the ground for turns. The harrow is equipped with transport wheels and a remote-control hydraulic lift. These wheels may serve as gage wheels.

(b) Mounted Disk Harrows: These are attached (hitched) to the three-point linkage and hydraulic lift system. Different manufacturers have given different names to the mounted disk harrow, such as direct connected, pickup, and lift type.

As the mounted disk harrow is generally a unit assembly with fixed-angle construction, it can be lifted with hydraulic power lifts, backed into corners, and used close to fences and along ditches or borders. The hydraulic control permits adjustment of the discs to desired depths. Most of the regular two-gang single-action mounted disc harrows are of the heavy-duty type.

Components of Disc Harrow

A Disc harrow consists of several components like a disc plough. These include the discs, disc gangs, harrow frames, standards, bearings, bumpers, scrapers, weight boxes, and levelling devices.

(a) Discs: Round, smooth-edged discs are used on most disc harrows. Special harrows are equipped with discs having a cut-way, notched, or scalloped edge. Where there is too much residue to be cut, cut-way discs are recommended for the front gangs. The disc blades in a narrow range from 40.6 to 71.1 cm in diameter. The disc with 45.7-61.0 cm sizes is popular for regular farm use. Heavy-duty disc harrows are equipped with discs ranging from 66.1 to 71.1 cm in diameter. The discs for harrows are made of high-grade heat-treated steel. They may also be spherical or cone-shaped. They may be sharpened from the inside or outside.

(b) Disc Gangs: Gangs for disk harrows may consist of three-to-thirteen-disc blades assembled on a long bolt or arbor. The spacing between discs may ranges from 15.2 to 22.29 cm for light-duty harrows and 25.4 to 31.8 cm for heavy-duty harrows. The disc blades are held an equal distance apart by a spool-shaped casting.

Some trailing, double action, and offset disc harrows are equipped with remote control, double-action hydraulic cylinders. The hydraulic cylinder is used both to angle the gangs for operation and to straighten the gangs for turns, the crossing of grass-ways in fields, and transportation.

(c) Harrow Frame: Each gang of discs has a strong rectangular or tubular frame supported above the gangs by standards that rest on axle bearings. The gang frames of a double-action harrow are connected by linkage arrangement that, in

most cases, permits adjustment of the angle of the gangs to obtain varying degrees of soil penetration.

(d) Bearings: Light-weight disk harrows generally have two bearings per gang, while heavy-duty harrows may have several bearings per gang. These bearings consist of a specially designed spacer spool around which is bolted malleable cast iron housing. A wood bushing can be used between the spool and the housing. The spool on many harrows is made of white, chilled cast iron and serves as the moving part of the bearing.

(e) Bumpers: A half-moon-shaped cast iron plate placed on the convex side of the disk at the end of the gang. It absorbs all the sidewise pressure in the frame, standards, bearings, and the gangs are allowed to bump together against the bumper plates.

(f) Scrapers: Scrapers are placed on the disc harrow to clean and remove soil that may stick to the concave side of the disk blades.

(g) Weight boxes: A box-like framework is often provided on the frame so that the weights can be placed on the harrow gangs. In some cases, specially shaped iron weights can be attached to the harrow frame. The weights assist the harrow in penetration.

Depth of Operation of Disk Harrows

There are several factors within the harrow itself will influence the depth to which it will penetrate the soil. They include:

- The angle of the disk gang,
- The weight of the harrow,
- The sharpness of the discs on the gangs,
- The size of the disks,
- The concavity of the discs,
- The angle of the hitch.

All these factors are incorporated within the harrow itself. However, other factors that influence the depth of penetration have nothing to do with the harrow. These conditions of the soil are the amount of moisture, whether ploughed land or unploughed land, the amount of trash on the soil, and the amount of organic matter that may be in the soil.

PRACTICAL EXERCISES

Activity 01: Make a list of secondary tillage equipment's.

Material Required:

1. Pen
2. Notebook

Procedure:

1. First visit an agriculture field or farm.
2. Identify the secondary tillage equipment's.
3. List out the secondary tillage equipment's available in farm.
4. Make a sketch of secondary tillage equipment and label it.

Activity 02: Draw the sketch of disc harrow arrangement.

Material Required:

1. Pen
2. Notebook

Procedure:

1. First visit an agriculture field or farm.
2. Identify the different types of disc harrow.
3. List out the different types of disc harrows available in the farm.
4. Draw different types of disc harrow and label it.

CHECK YOUR PROGRESS

A. Answer the following questions:

1. What do you mean by weeding efficiency?
2. What is rotavator and explain their working principle?
3. Write the importance of cage wheel.
4. Describe the cultivator and their types?
5. Define disc harrow and brief their components?
6. Write the operation and adjustments of cultivator for optimal performance.

B. Fill in the blank

1. Cage wheel is an important traction improvement device in ..... soil condition.
2. The ..... tiller is designed for use only on tractors with the power take-off (PTO) turning at 540 RPM.

3. A cultivator is an implement for ..... with laterally adjustable tines to work between crop rows.
4. A half-moon shaped cast iron plate placed on the ..... of the disk at the end of the gang.
5. The duck foot cultivator is a type of ..... cultivator.

C. Match the following:

Column A	Column B
1. It is calculated by multiplying number of tines to the tine spacing.	A. Draft
2. It is the ratio of effective field capacity and theoretical field capacity expressed in percent.	B. Spring tine cultivator
3. The cultivator are those tines which do not deflect during the work in the field.	C. Working width
4. A tine hinged to the frame and loaded with a spring so that it swings back when an obstacle is encountered.	D. Rigid tine cultivator
5. It is the horizontal component of the pull, parallel to the line of motion.	E. Field efficiency

SESSION 3: SOWING, PLANTING, TRANSPLANTING, FERTILIZER EQUIPMENT

A. Seed-cum-Fertilizer Drill

The seed drills fitted with fertilizer dropping attachments are called seed-cum-fertilizer drills. They deliver both the seeds and fertilizers simultaneously in an acceptable pattern. Seed cum fertilizer drill has a large seed box which is divided lengthwise into two compartments, one for seed and another for fertilizers distribution.

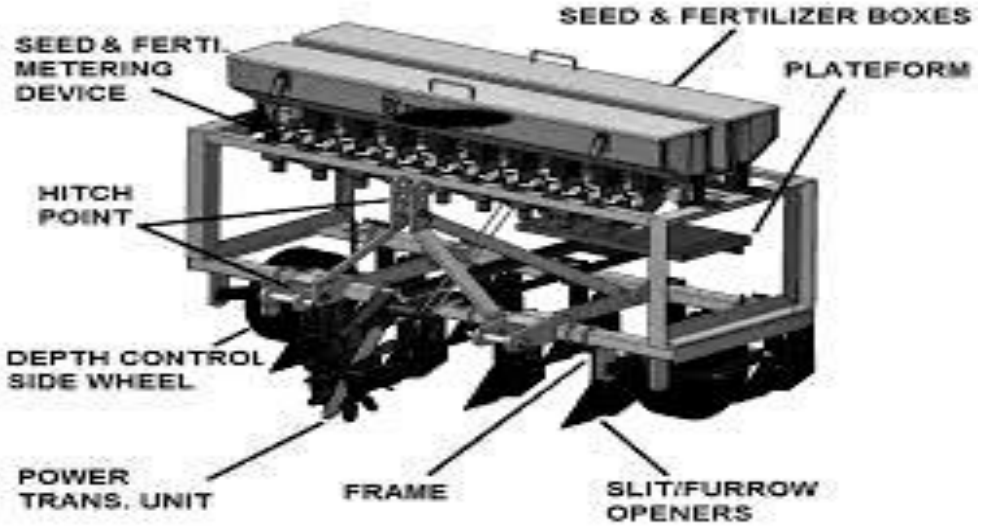


Fig. 3.28: Seed cum fertilizer drill

Functions of Seed-cum-Fertilizer Drill

Except for broadcasters, all seed drills are required to perform all of the following mechanical functions:

- To carry the seeds and fertilizer in separate compartments.
- Metering the seeds and fertilizer at the required rate and/or at the equal interval,
- Opening the furrow into which seeds and fertilizer are placed to the proper depth,
- Depositing (or placing) the seeds and fertilizer in the furrow in an acceptable pattern,
- Cover the seeds and fertilizer and
- Lightly compressing (compacting) the soil around the seed fertilizer.

Principal parts of Seed-cum-Fertilizer drill

To accomplish the above functions, all sowing machines have some components in common with minor differences. The principal parts of a planter are:

a) **Seed box (hopper):** Used for storing the seed & Fertilizer.
b) **Furrow openers:** That opens the furrow.
c) **Metering device:** That picks seed and fertilizer from the hopper.
d) **Seed & Fertilizer delivery funnels:** That transfers the seed from the hopper to the seed tubes.
e) **Seed tube:** That transports the seeds to the furrow and some system for covering the seeds and compact the soil.
f) **Transport wheels:** To drive the metering (feed) mechanism. Land wheels also provide a means to regulate (control) the depth of seeding.
g) **Seed covering devices:** For covering the seeds and compacting the soil around the seed.

I. Furrow openers

Seed drills and planters are provided with furrow openers that open a furrow in the soil for the placement of seeds at uniform depths and spacing (Fig.3.29). The depth at which seed is placed into the soil depends, on the crop species and soil moisture level. In dry areas, seeding depth depends on the rate at which the moisture-drying front descends in the soil. This rate depends on the evaporation of surface soil water and the rate at which seedlings grow or emerge. Furrow openers should form a neat groove in the moist soil zone with minimum soil disturbance, to avoid mixing the top dry soil with the underlying moist soil at seed level. Excessive moisture in the soil causes a smearing action reducing the growth of seedlings. The soil aggregate size is determined by the degree of seedbed preparation and the crop residue; the proper aggregate size avoids the clogging of furrow openers.

(a) Rotating type: The rotating type includes single- and double-disc furrow openers. Single disc openers are widely used on seed drills for cereals. This type of furrow opener cuts a furrow in the soil and pushed the furrow slice to the side, thereby causing disturbance to the top layer of the soil. Disk-type furrow openers work well under many soil conditions. The boot for the seed tube is placed behind or at the side of the discs. For improved penetration, discs are loaded with the springs, which apply a downward force. Double disc furrow openers are rigged with two plane discs, which are mounted on axles at an inclination and are positioned such that they form a V-groove in the soil. The seed tube boot is located between the two dices. The furrow soil is pushed downwards and

sideways to form a groove. Penetration is achieved by applying force using springs and a hydraulic cylinder. Double disc openers work well under many soil conditions; push less soil to the sides compared with single disc openers and easily cut trash on the soil surface.

(b) Fixed type openers: There are the following types of fixed type openers: -

i. **Shoe coulter type:** It is a shoe-type opener with a V-shaped cutting edge. The shoe coulter is made from chilled cast iron and is replaceable. The shoe has a bevelled edge curved backward. It cannot penetrate deep into the soil and is good for shallow seeding. It maintains uniform depth and works well under normal soil conditions. The seed tube boot gets clogged when operated on sticky soils. This type is widely used on grain drills.

ii. **Hoe type:** A pointed hoe digs according to the set furrow depth. It lifts and pushes the topsoil towards the sides and forms a V-shaped groove. Standard size hoe blades are mounted on the rigid or spring-loaded types, which are fixed to the frame of the machine. This type operates well under a wide range of soil conditions but not in fields with many types of stubble.

iii. **Runner type:** The sword-shaped furrow opener with a sharp edge cuts a neat furrow in the soil with minimum disturbance. It works well in a clean seedbed and is used mostly for shallow seeding. Due to its length, it compacts the bottom of the furrow. The runner-type opener is a backward-inclined blade and is widely used for planting maize and other crops, which are seeded at shallow depth.

iv. **Shovel type:** The shovel type opener is a narrow-pointed shovel. Small 100 mm-sized shovels are used on animal-drawn units. The leading edge of the opener is a sharp-pointed triangle. The opener is bolted to the standard for easy replacement. At the rear is a boot with one or two small tubes for seed and fertilizer delivery. The length of the shovel varies from 100 mm to 250 mm. At the rear portion of the boot, a notch is provided to prevent dry soil from rolling back over the seed. Shovel-type openers are easier to fabricate compared with disc-type openers.

v. **Shoe type:** This type of opener, drop seeds, and fertilizer simultaneously in separate bands at the same depth. Its boot is protected at the top and bottom by metal plates to prevent clogging. Inclined plats guide the fertilizer and the seeds to the sides of the furrow wall. The seed and the fertilizer are placed 50 mm from each other. The central plate in the boot creates two compartments- one for seed and one for fertilizer. The wet soil can stick to the sidewall of the boot but not to the delivery ends of the seed or fertilizer tube. Fertilizer is usually placed in a band at the side of the seeds at equal depth. The furrow opener makes a narrow-shaped groove in the soil. The length of the shoe helps in compacting the bottom of the furrow.

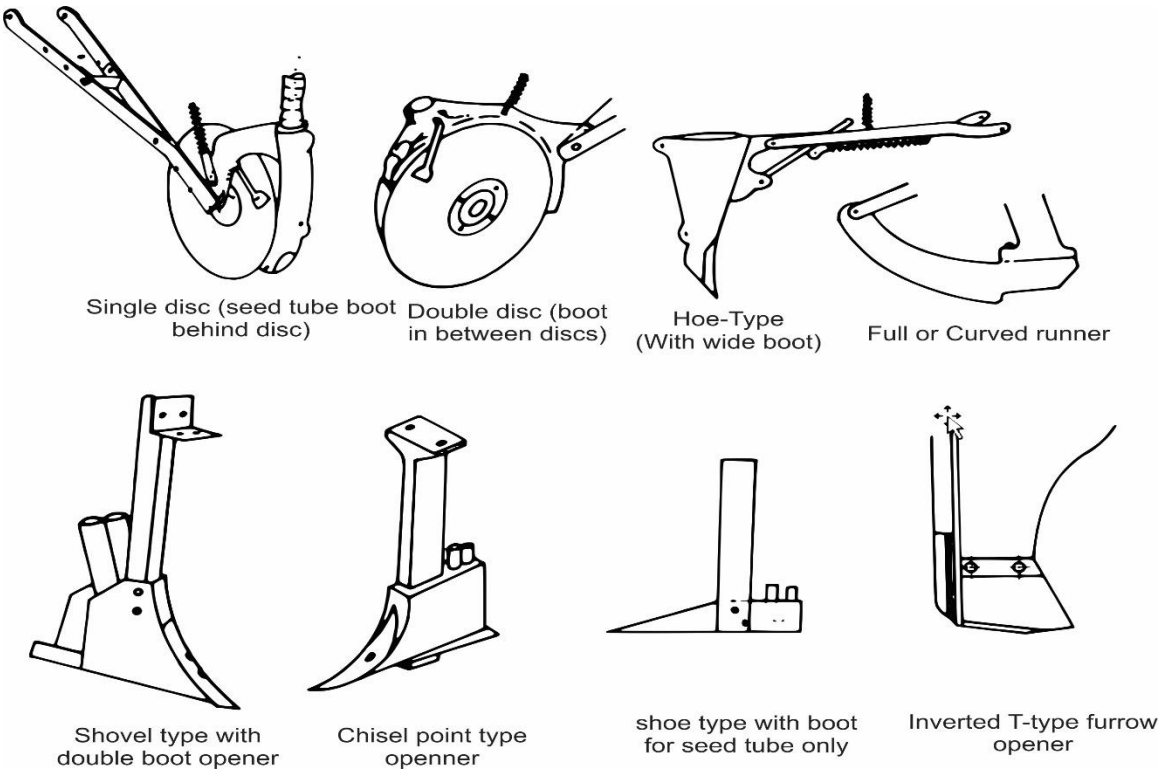


Fig. 3.29: Types of furrow openers used in seed cum fertilizer drills and planters

vi. **Inverted–T furrow opener:** The Inverted-T furrow opener was developed for direct sowing of seeds under upland soil conditions. The furrow opener makes a narrow slit, does not cause too much soil disturbance, and promotes plant emergence under no-tillage conditions. The furrow openers should be selected according to soil and depth of seed placement.
   a. For trashy, stony, and light to medium soils, shovel-type openers are used. The depth of seed placement from 50 to 100 mm is achieved with these openers.
   b. The small shoe or shovel-type openers are also used for shallow (20 to 50 mm deep) placement of seeds in dry farming areas.
   c. Shoe-type openers with single or twin boots are used for sowing in heavy and medium soils for seed placement at 20 to 70 mm depth in the soil.
   d. Runner type opener is widely used for placement of seeds at a shallow depth where soil disturbance required is minimum. The soil cover over seed is also less.

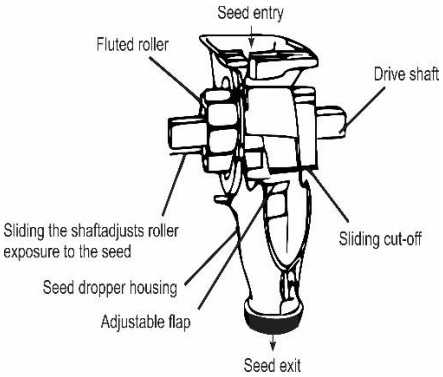
II. Metering Devices (Mechanism)

Seed metering is picking the desired amount, number, or size of a seed to be planted on a given point, line, or area. The metering mechanism allows the seed drill to control the spacing between seeds dropped on the same row or ridge, as well as to control the spacing between two consecutive rows of seeds.

1) **Fluted roller seed metering:** A fluted roller rotates just below the seed box and draws seed from the bottom of the box into the top of seed tubes. In a simple type, the rollers are fluted over only half their length and can be moved laterally so that either the plain or the fluted portion, or a part of each, is in contact with the seed. This provides a simple regulation of the seed rate; for no seed is delivered by the smooth part of the roller.

   This mechanism is widely used in seed drills. It is capable of handling various crops, like wheat, chickpea moonbeam, pigeon pea, soybean, and sorghum. Fluted rollers can be manufactured from different materials, like cast iron, aluminium and plastic. The seeding rate is adjusted by varying the exposed length of flutes which are in contact with seed and by increasing or decreasing the speed of the rollers. Generally, variation in seeding rate is achieved by adjusting the exposed length of the flutes in the seed cup with the aid of a calibrated sliding lever. For accurate movement of the fluted roller, a screw-type sliding arrangement is used in designs. For different sizes of seeds, an adjustable spring-loaded baffle plate is provided. When fully opened, it helps in emptying the seed from the seed feed cup. The fluted roller is a simple, low-cost, trouble-free device suitable for bulk metering even for granulated fertilizers. It is used for metering sensitive seed by rotating it in the reverse direction in which case, seed contact against the baffle plate is avoided.

   An improved design of the fluted roller has spiral-shaped flutes. The spiral-shaped fluted roller distributes the seeds more evenly compared with the straight fluted rollers.



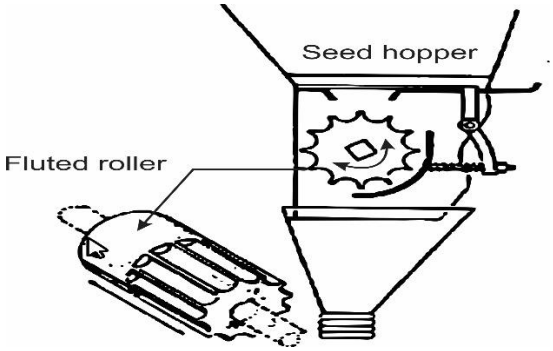


Fig. 3.30: Fluted Roller Seed Metering

III. Seed Delivery Mechanism

This mechanism connects the hopper and furrow opener. It delivers (conveys) seeds from the bottom of the hopper to the furrow opener then to the furrow through a seed tube. On corn planters, the seed tube is a simple round or rectangular tube connecting the hopper and the furrow opener. For hill drop planters it contains valves. On check row planters there is a valve at the top of the tube just below the hopper where the hill is accumulated, and another valve at the bottom of the tube to drop the hill into the furrow.

IV. Covering Device

Covering devices cover the seeds at optimum depths and firmness of the soil following seed dropping into the furrow. A covering device should place moist soil in contact with the seeds and press the soil firmly around the seeds to cover them to the proper depth. The soil is then left directly above the row loose enough to minimize crusting and promote easy emergence. Among the many types of covering devices employed on seeders are drag chains, drag bars, scraper blades, steel press wheels, disk hillers, and various combinations of these units.

1. **Drag type or fixed type covering unit:** In the grain drills, the shallow soil covering devices used are drag chains, spring types, and drag bars. These devices allow satisfactory emergence. After sowing, a wooden plank or levelling bar dragged over the field to cover the furrows. Drag-type devices mostly cover the seed with surface soil to maintain uniform depth and reduce field roughness. They do not compact the soil because they are wide and light.
2. **Rotating type:** The Covering discs, which rotate are commonly used on seed drills and planters. The rotating compacting devices used are the open center, cast iron press wheels. Experiments have shown that such wheels have positive effects on seed emergence. Wheels of different shapes, such as the

flat face, round face, soil rubber wheel pneumatic wheel with small lugs, and concave shaped solid rubber wheel or wheels with central ribs, are used for difficult soil conditions. A rubber wheel is advantageous because no soil builds upon the wheel, thus reducing seed displacement in the furrow. The cast-iron, flat rim wheel, V-grooved wheels, and open-center concave type disc wheels are cheap, yet have satisfactory performance.

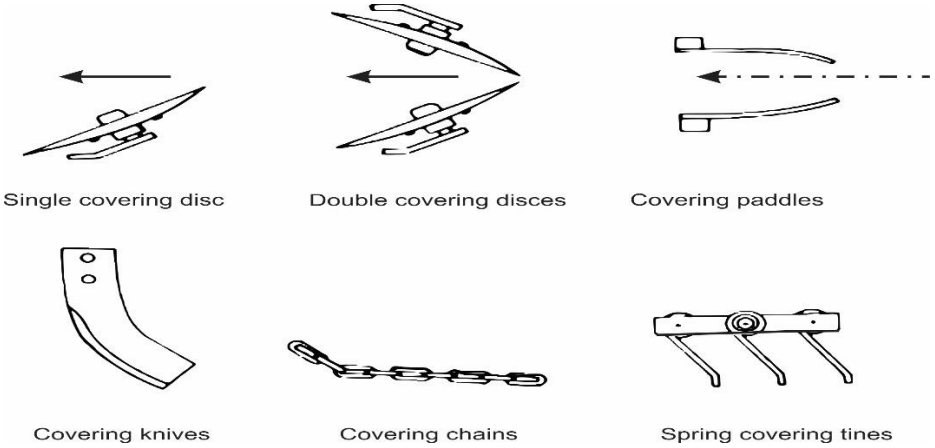


Fig.3.31: Types of Soil covering devices

V. Drive Wheels

The type of drive wheel to be used on drills depends on the ground conditions. When the ground wheel carries the weight of the machine as well as the seeds and fertilizer stored in the boxes, the load on the wheel is sufficient to enable the power transmission from the wheel to the metering devices. The power requirements for driving metering devices are low. The power derived from the wheel can be calculated using principles of soil mechanics.

Two types of wheels are used: pneumatic and rigid steel wheels. Rigid steel wheel is mostly used because of their low cost, low maintenance, and long life. The steel wheel can be categorized into three types (Fig.3.32):

(a) Plain wheel
(b) Lugged wheel
(c) Pegged wheel
(d) Press wheel

a) Plain wheel: Plain wheels used on seed drills and planters have widths varying from 75 to 100 mm, diameters varying from 400-700 mm, and number of spokes ranging from eight to twelve. This type of wheel runs smoothly. The wide rim provides good contact with the soil surface and

develops efficient traction for the drive mechanism. This type is mostly used on light soils since the operation is adversely affected on wet clay soils.

b) Lugged wheel: To develop better traction or grip on the soil, small lugs are provided on the periphery of the wheel the lugs are 25 mm in height and are welded at an angle of 20-25^0 with the axis of rotation to reduce slip. The lugs are welded at and greater than zero and closed to reduce wear, vibrations, and rolling resistance. Tractor-mounted seed-cum-fertilizer drills which are developed as attachments to cultivators are provided with heavy lug wheels that are pivoted at the frame. The lugs are welded at close spacing and at zero degree to develop more traction. The diameter ranges from 350 to 450 mm.

c) Pegged wheel: Pegged wheels are suitable for use under wet or sticky soils, where plain, lugged or even pneumatic wheels fail to work. The rim of the wheel is 25 to 40 mm wide and the spokes are extended 75 to 120 mm beyond the rim. The diameter of the wheel ranges from 500 to 800 mm. The number of spokes, which varies from 12 to 30, depends on the side of the wheel. The spokes are usually made of mild steel round bars or flat bars pointed at the end. The motion of a given point on the wheel follows a cycloid path. The spokes enter the ground vertically and leave the surface upwards. Hence, soil coming in contact with the peg is pushed downward but not taken upwards.

The wheels, which drive the metering devices, should be loaded or equally balanced. In the case where the floating type wheel is used, slip varies from 20-25%. Loading the wheel with a spring to keep it in continuous contact with the ground reduces the slip to 10-12%.

Fig.3.32: Types of ground drive wheels

d) Press wheel: Press wheels push some soil into the furrow, compact the soil around the seed, facilitating the rise of capillary moisture, and also act as a gauge wheel that holds furrow openers at a constant depth. The soil must be pressed around the seed but not above the seed. This is because too much

compaction above the seed may lead to seedling emergence problems if the soil should tend to crust. Press wheels usually follow the covering device.

VI. Calibration of the seed drill

Laboratory testing of a seed drill to determine the rate of seed delivery is called calibration of a seed drill. This is done to ascertain whether a seed drill delivers the seed following the recommended seed rate or not. If any discrepancy is found between the seed delivery of the drill and the recommended seed rate, then the seed metering mechanism is adjusted to deliver the correct seed rate. This method avoids the difficulty of setting the seed delivery rate of the seed drill in actual field conditions. Before the calibration checks are made, the machine should be in condition to go to the field tyre inflation pressures, row spacing should be checked for the recommended level.

The following steps are involved in calibrating the seed drill:

i) Jack up the seed drill and mark a reference point on the ground wheel.

ii) Measure the diameter of the ground wheel. Let us say it is "D", meter.

iii) Measure the working width of the drill of planter let us say it is "W", meter,

W= n x d

Where,

n = number of furrow openers

d = distance between two furrow openers (m)

iv) Workout the circumference of the ground wheel (π x D).

v) Find the length of the strip of land (L) for an area of 1/25 ha taking the width of sowing as cover 1/25 ha, L = (1 /25) x 10000 $m^{2)}$ x 1/w, meter = 400/W, (1 ha = 10000 m^2).

vi) Determine the number of revolutions (N) of the ground wheel of the seed drill required to cover a strip of length L meter L = π x D X N = 400/W meter N = 400 π x D/W revolutions per minute.

vii) Jack the seed drill so that the drive wheel turns freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help count the revolutions of the drive wheel.

viii) Fill the seed in the seed hopper. Place a container/polythene bag under each boot for collecting the seeds dropped from the hopper.

ix) Set the seed rate control adjustment for maximum position and mark this position on the control for reference.

x) Engage the clutch and rotate the ground wheel for N revolutions (N = 400 π D/W).

xi) Weigh the quantity of seed collected in the container and record the observation Ws kg.
xii) Calculate the seed rate in kg/ha.
xiii) Calculation: Seed collected for an area of 400 m^2 = Ws kg.
xiv) Seed rate per hectare = (10000 X Ws) / 400 kg/ha.

If the calculated seed rate is higher or lower than the desired rate of selected crop, repeat the process by adjusting the seed rate control adjustment till the desired seed rate is obtained.

Fig.3.33: Adjustment of seed rate

VII. Maintenance and service (Seed drill & Planters)

A well-maintained and properly adjusted seeding machine gives trouble-free service for a long time. It also helps in timely completion of the operations. The following important points may be kept in mind for the maintenance and repair of various components of the seeding machines.

- Seed and fertilizer boxes should be thoroughly cleaned as these may rust very fast due to environmental moisture. This will damage the boxes and machine will not be useful for the next crop sowing season.
- In fertilizer metering mechanism, fertilizer settles on its parts due to environmental moisture which may cause obstruction in free and uniform flow of fertilizer. Large particles also cause hindrance in the mechanism. Therefore, this system requires special attention as follows: After seeding a crop, fertilizer should be removed from the box and the whole system should be cleaned with the help of a brush or cloth.
- If the system is jammed due to corrosion and rusting, the cell of the fertilizer feeder must be removed and cleaned. All the plastic tubes/ pipes should be properly open. The lever on both sides of the fertilizer box should move easily. This helps in the proper metering of fertilizer.

- Keep the chain and sprockets clean and lubricate all the joints of moving components at the beginning of each season and thereafter every operation. Apply oil periodically to all hinge points.
- Furrow openers are attached to the mainframe with the help of U-bolts. The furrow openers wear out or twist very fast. Therefore, these should be repaired frequently. The worn-out ones should be removed /replaced as and when required.
- Check all the nuts and bolts and tighten the loose bolts. Missing bolts or nuts must be replaced.
- Bend the welded parts if any cracks are noticed at the joints.
- Clean the machine thoroughly, after completing the work.

B. Conservation drills

Wheat sowing by the conventional methods (Traditional Seed Drill) requires large number of tillage operations to prepare a fine seedbed after paddy harvesting. Generally, 6-8 or even more tillage operations are required which costs both time and money for the farmers. Moreover, shortage of time after paddy harvest to wheat sowing creates uncertainty and delay in the sowing operation which results in poor crop yields.

In this method, the farmers also burn the straw in the field to make their field ready for sowing in the short time available for wheat sowing after paddy harvesting. To solve these problems conservation drills have been developed which follow a zero-tillage system. Zero tillage is the process where the crop seed is sown through a conservation drill machine, without prior land preparation and disturbing the soil where previous crop stubbles are present. Zero tillage not only reduces the cost of cultivation, but also reduces the soil erosion, crop duration, irrigation requirement, and weed effect which is better than tillage. Zero tillage (ZT) is also known as 'No-Tillage or Nil Tillage'.

Advantages of Conservation Drills

- Timeliness in sowing (7-8 days earlier than traditional).
- Saves 60-75 liters of diesel per hectare which results in saving natural resources and environment.
- 30-40% less infestation of weeds.
- Saves up to 10-15% water during first irrigation.
- Early (two days) and uniform germination helps in better plant growth than traditional.
- No crust formation after rains. Hence, no effect of rains on germination.

- Improvement in crop yield.
- Improvement in soil structure and fertility.
- No lodging of crops at the time of maturity in case of heavy rains and winds.
- The machine is simple and easy to operate.

Construction details: The most common conservation drill being used in India is known as the Zero-till drill (Fig.3.34).

Fig.3.34: Zero-till seed-cum-fertilizer drill and component

The Zero-till drill machine is operated by a 35 hp tractor and consists of a tubular steel section frame on which other parts are mounted.
Various parts of the zero-till drill as shown in the figure (Fig.3.34) are;

- Seed and fertilizer box made of mild steel sheet.
- Fluted roller metering mechanism for seeds and fertilizer mounted on the bottom of seed and fertilizer box.
- Two depth control wheels for controlling the sowing depth.
- Inverted-T type furrow openers made of medium carbon steel with high-speed steel tip in the front for opening narrow slits in untilled soil.
- Ground drive wheel having lugs on its circumference and acts as a power source to drive the metering mechanism of the drill and power transmission system.

The most important part of the drill is its furrow openers (Fig.3.35) which have wear-resistant high-speed steel cutting edge (share) and sides laid with welding beads of hard facing electrodes to reduce the wear. 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 welded all-round the nose, tip, and sides to reduce wear and tear. A 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.

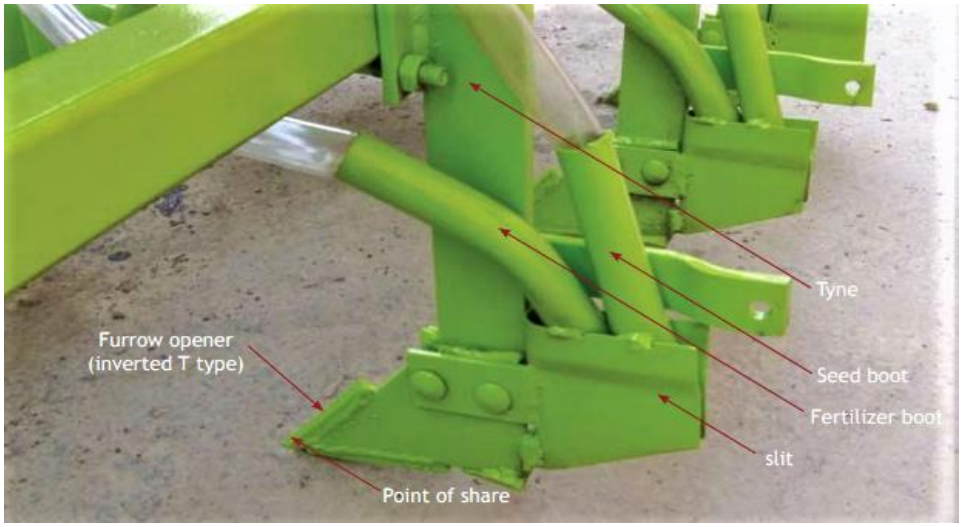


Fig.3.35: Field operation of Zero-till drill

The zero-till drill is operated in the field when the soil moisture is about 24-27 % and the stubble height of the previously harvested crop is not more than 15-20 cm.

- For operation, the zero-till drill is calibrated for metering of the required quantity of seed and fertilizer based on the area to be sown.
- For operation, the seed and fertilizer are filled to about three fourth of the hopper capacities in respective hoppers and the drill is transported to the field with the tractor.
- The depth control wheels are adjusted by raising them according to the depth for placing the seed and fertilizer in the soil, the range is 5 to 7.5 cm.
- The zero-till is drawn by the tractor at a speed of 2.5 to 3.00 km/h.
- With the forward movement of the tractor, the ground drive wheel in contact with soil starts rotating. It transmits the motion to the seed and fertilizer metering mechanism through the auxiliary shaft. The motion is transmitted through a set of chains and sprockets.
- The fluted rollers mounted in seed and fertilizer-metering mechanisms expel the desired number of seeds and fertilizer, which may remain uncovered under high soil moisture conditions due to inadequate soil backflow into the furrow.
- In such conditions, a lightweight plank is hinged behind the drill to cover the seeds and fertilizer and gently press the furrow wall for better seed-soil contact.

Tips for safe & efficient operation of conservation drill

During the field operation, one should consider the following points:

- When tilling and seeding back and forth across the plot, like the seed- drill up so that 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 the hole of the furrow opener. If the tractor is backed up while the seed-drill is operating, the 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 seed-drill through the hydraulic system. Turn the tractor when it's about 2.5 meters away from the end of the plot. After turning, again bring down the seed-drill with the hydraulic system.
- Lift the seed-drill through the hydraulic system when the implement crosses a ridge or is in motion. 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/ fertilizer, wash the mud, and weeds from the seed-drill.

Table No. 3.8: Troubleshooting of conservation drill

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

• Seed/fertilizer is not dropping from furrow opener.	1. The seed/fertilizer box is empty. 2. The furrow opener or seed delivery tube is blocked by soil/mud or fertilizer/seed delivery pipes bent. 3. The fertilizer fluted roller is blocked. 4. The drive wheel does not touch the ground. 5. Broken chain/sprocket.	1. Refill the seed/fertilizer box. 2. Clean soil out of the opener and/ or seed delivery tubes. 3. Clean the fluted rollers. 4. Lower down the hitch to get the drive wheel in contact with the ground surface. 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 fairly level ground and then level all the furrow openers with the help of the top link/ right lower link of the tractor.

i) Maintenance

The seed drill should be properly serviced and maintained. It should be checked before use to ensure that all the nuts and bolts are tightened and 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 the free flow of seed and fertilizer. Chains should be adjusted and lubricated. 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 sowing season, the machine should be properly stored.

ii) Machine storage

Before storing the seed drill for long duration, 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. 'DO NOT' leave any 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 could choke the fertilizer metering system. Keep the appropriate tools with the machine during storage to ensure that they will be available when needed again.

C. Rice Transplanter

A rice transplanter is a specialized transplanter use to transplant rice seedlings in the field.
A common rice transplanter comprises:

- A seedling tray like a shed roof on which mat type rice nursery is set.
- A seedling tray shifter that shifts the seedling tray like a carriage of typewriters.
- Multiple pickup forks pick up a seedling from mat type nursery on the seedling tray.
- Put the seedling into the field as if the seedling were taken between human fingers.

The transplanters can be classified based on power source as:

- Manual
- Animal drawn
- Power tiller mounted (Single Axle or Two-Wheel)
- Tractor mounted
- Self-propelled (Double Axle or Four-wheel)

Transplanters can also be classified based on the type of nursery required, as:

- Root washed seedlings type and
- Soil-bearing seedlings type

In the root-washed seedlings type transplanter, the nursery is raised in a conventional way on moist or puddled soil. At the time of transplanting the nursery is manually uprooted and the roots are washed and then shaken by hand to remove the soil. After this the seedlings are fed to the trays of the transplanter. The root-washed seedling-based mechanical rice transplanter have not been found viable because of high labour requirement with this machine and no net labour saving over the manual transplanting.

Transplanting of uprooted seedlings by female labourers is the most arduous operation in rice cultivation due to their half-bending body posture. A person puts 2-3 seedlings per hill in the puddled soil at a depth of 30-50 mm.

Fig.3.36: Rice Transplanting Process

The person moves in backward direction with a bending posture on the puddled soil. On an average, a worker can transplant only 0.016 ha/day. A worker inserts his/her fingers 3,50,000 times in puddled field to transplant one hectare of land.

This operation is highly labour intensive and results in low plant density leading to lower yield. Timely transplanting is affected by the scarcity of labour during peak season. Delay in transplanting results in a decrease in rice yield. Manual transplanting of paddy requires 300- 350 man-h/ha, which is roughly 25% of the total labour requirement of rice production. Mechanical weeding by weeders is also not possible due to random placement of seedlings during manual transplanting.

Only mat-type nursery-based transplanters have a scope for adoption. For the soil bearing, mat type, seedlings type transplanters, the nursery is raised in trays/frames on a soil and manure bed of uniform thickness. After the seedlings grow for about 22 days the roots form a mat, which can be lifted out of the trays by hand and placed on the transplanter trays.

In the transplanters, the seedling mats are placed in seedling trays and at the time of transplanting, these seedlings are picked up by the fork, which takes the seedlings from the seedling mat and brings them near the soil/water surface. At this position, a lever hits the soil near the seedling's roots and the root portion of seedlings enters the puddled soil due to its momentum. When the fork enters the puddled soil, the seedlings are held by the soil while the fork is withdrawn. Thus, the planting mechanism always remains out of puddled soil. The cleaning action of the knockout lever also helps in improving the picking of seedlings by the fork.

1. **Manually operated rice transplanter:** It is a manually operated rice transplanter suitable for transplanting mat-type rice seedlings in puddled soils in rows. Available in 2-row, 4-row, and 6-row sizes.

Fig.3.37: Manually operated rice transplanter

2. Self-Propelled Walking Type Rice Transplanter (2-wheel)

Fig.3.38: Self-Propelled walking type rice transplanter (2-wheel)

3. Self-propelled riding type rice transplanter (three-wheel)

A self-propelled riding-type rice transplanter suitable for transplanting mat-type seedlings. It is an 8-row riding type machine fitted with a 5 hp single-cylinder, air-cooled diesel engine which powers the front wheel (Fig.3.39). The drive wheel receives power through V-belt, cone clutch, and gearbox. A propeller shaft from

the gearbox provides power to the transplanting mechanism mounted over the float. The float facilitates the transplanter to slide over the puddled surface. The tray for keeping mat type nursery in 8- rows is moved sideways by a scroll shaft mechanism. It converts rotary motion received from the engine through belt-pulley, gear, and universal joint shaft into linear motion of a rod connected to the seedling tray. It consists an auto-reversing mechanism to reverse the direction of movement of the tray after it reaches the extreme position at one end. Fixed fork with knock-out lever-type planting fingers is moved by a four-bar linkage to give the designed locus to the tip of the planting finger. The planting mechanism is operated by a separate crankshaft and connecting rod system with a seedling pusher. It transplants seedlings from mat-type nurseries in eight rows in a single pass. The effective field capacity of the machine is 0.14-0.20 ha/h.

Fig.3.39: Riding Type - Self Propelled Rice Transplanter (three-wheel)

D. Potato Planter

The planting of potatoes is labour intensive and full of fatigue and time-consuming operation. Its mechanization can reduce the input costs, increase work efficiency, augment cropping intensity, and hence farmer's benefit. Potato planting in large parts of the country is done manually which results in varying and non-uniform plant growth. It requires a large labour force in field preparation and planting, besides is less time-efficient due to unavoidable drudgery and competing demand for labours.

The potato planter (Fig.3.40) is a two-row planting machine which consists of a mainframe consisting of a three-point hitch and a toolbar on which hopper, metering mechanism; ground drive wheel, furrow openers, and ridges are mounted. The planting fingers are mounted on a circular notched disc as shown in figure 3.41. There are two such discs in the machine, one disc for each row. While in operation, these discs rotate on their axle, which gets power from the ground drive wheel through the chain-sprocket arrangement. Provision is kept for changing plant spacing by changing two auxiliary sprockets in the power transmission system.

The hopper of the potato planter can be loaded with 200 kg tuber. An agitator is also provided in the hopper to prevent any clogging. The spring-loaded fingers are actuated with the help of cam lobs provided in the center of metering disc. Fingers open due to cam action at picking point and releasing point and remain close in between. Due to gravity flow, tubers in the hopper get stucked in the spring-loaded fingers when they are open. They remain stucked as the finger closes, till it reaches the delivery point. Here they get released automatically in the soil as the fingers open again. The tubers thus metered fall in the furrow created by the furrow opener. The depth of operation of the furrow opener is adjustable. On the backside of the machine, three ridgers are provided which covers the tubers falling in the furrow by making two ridges as shown in Fig.3.41.

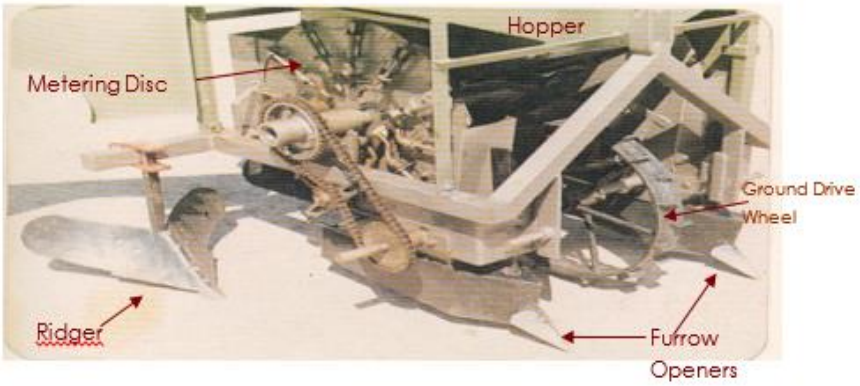


Fig.3.40: Two-row semi-automatic potato planter

Fig.3.41: Potato planting using semi-automatic potato planter

Operation of Potato Planter

1. Calibration: The planter should be lifted clear off the ground and obtain a horizontal level in lifted condition. Set the planter as per the instruction of the manufacturer and fill the hopper with graded potatoes. The step-by-step procedure is as follows:

a) Measure the distance between two adjacent furrow openers. Check inters furrow opener distance, if necessary, adjust to the recommended value. Count the number of furrow openers. Now, the nominal width of coverage (W) can be calculated as:

$$W = N \times d$$

Where, N = Number of furrow openers, and
d = distance between two adjacent furrow openers

b) Measure the diameter of the drive/ground wheel (D), and calculate the circumference (L).

$$L = \pi \times D$$

c) Area sown in one revolution of the drill (A) can be obtained as:

$$A = W \times L$$

d) Now drive the metering mechanisms by turning the ground/drive wheel at a speed which is recommended for the field operation. The number of revolutions (n) to be taken by the ground wheel in one minute at the recommended speed (S) during the stationary calibration, can be calculated as:

$$n = (S \text{ in meter/min}) / (L \text{ in meter})$$

e) Rotate the drive/ground wheel for 'n' times in one minute at a constant speed. Collect the seeds and fertilizer dropped from each outlet. Weigh them and record them on the datasheet.

f) Calculate the seed rate in kg/ha and record it on the datasheet. The number of revolutions to sow one hectare (R) = 10000/A. Seed collected from all N outlets in n revolutions = P kg, (say). Hence, Seed rate (S) can be calculated as:

$$S = (P \times R)/n$$

g) Variation from the specified seed rate per hectare at that particular setting, should not exceed 7%.

h) Variation from the average seed rate in each tube, should not be more than 5%.

Field Operation of Potato Planter

- Before the operation the top link of the tractor is first adjusted, so that the furrow openers and ridgers are levels.
- The machine has provision to adjust the depth of the furrow openers. These have to be adjusted according to field conditions to ensure maximum yield.
- A level seedbed with a good soil tilth and optimum moisture availability is to be prepared for operating the planter.
- Initially operate the planter without seed filling to ensure proper depth adjustment and formation of smooth ridges. If the planter makes uneven

ridges, adjust the spacing and width of ridgers by adjusting the butterfly flaps (Fig.3.42 a).

- The machine has a provision to change plant spacing by changing two auxiliary sprockets in the power transmission system.
- After filling the tubers in the hopper, the potato planter should be operated at a speed of 2.5-3.5 km/h. The machine gives an optimal performance with regards to plant-plant spacing and proper covering of planted seeds (Fig.3.42b).
- Two main factors contribute to planting accuracy: seed size distribution and planter speed. Other minor factors influence how accurately a planter places seed pieces, but paying particular attention to these two main factors will help optimize seed placement.
- Planters that are properly adjusted and operated correctly should place 75 percent or more of the seed pieces within the desired spacing.
- A common planting depth is 6 inches. It may be tempting to plant seed pieces deeper than this to reduce the number of green tubers, however, deeper planting may cause a yield reduction in some varieties.

Fig.3.42 (A): Formation of proper ridges while planting

Fig.3.42 (B): A view of well-planted field

Safety precautions for planter

- Do not try to over tighten the fingers, chain as it may break.
- Do not operate at speed and depth higher than recommended as it may result from a severe breakdown.
- Do not stand on the machine during operation.
- Do not make adjustments when the machine is in operation.
- Do not use intoxicants like liquor, opium, etc., while working with the machine.
- Do not wear a loose dress, bangles, watch, etc., while working with the machine.

E. Cotton Planter

Several factors influence the field emergence of seed and field plant population. Such as the quantity of seed planted, the viability of seed, treatment of the seed with chemicals to kill soil micro-organisms, use of fuzzy seed or delinted seed, planting depth, type of soil, moisture content of the soil, types of seed dropping mechanism, size of cell in planting plate, level of seed in seed hopper, distribution of the seed, type of furrow opener (runner or shovel), the width of furrow opener, prevention of loose soil getting under seed, uniform seed coverage, type of covering device, pressing or firming the soil around the seed, type of press wheel or device, placement of fertilizer to seed at planting time, type of seedbed, time of planting with the season, and experience and skill of the operator. The scattering of seed results in unevenly sown hills, which require additional work to thin or transplant later. It is generally known that the scattering is caused mainly by improper design of the metering device, seed tube, and seed release height. The lesser seed release height and straight short seed tubes reduce the scattering. Inclined cell type cotton planter (e.g., Bt. cotton) places desired quantity of seed without scattering at regular intervals within the rows. Therefore, metering devices for the cotton planter hold desired quantity of seed per hill and drop them on the ground at almost equally spaced intervals.

Planting of cotton and other bold seeded crops like pulses are generally done by inclined cell type planters where row to row as well as the plant-to-plant distance is essential for seed saving and better crop production. The seeds are sown in line at the depth of 30-40 mm with two seeds per hill maintaining the desired spacing between row and plants. This technique results in uniform plant spacing, seed depth and helps further the mechanization of intercultural farming operations that reduces the total cost of cultivation. In inclined cell plate type planter, seed sowing produced more consistent row to row distribution of seeds and reduction in plant stand variability.

Constructional Details

The machine consists of a mainframe, ground wheels, seed and fertilizer hoppers, furrow openers, power transmission system, and three-point hitch, Fig.3.43. A). The metering of Bt. Cotton seed is done with the help of inclined cell plates, Fig.3.43. (B). A view of the cotton crop sown by Bt. cotton planter is given in Fig.3.43. (C). The seed metering mechanism was lowered down near to ground level to avoid scattering of seeds. Fertilizer is metered with the help of fluted rollers. The ground wheel provides drive to the metering shafts through the sprocket and chain arrangement. The depth of planting can be adjusted by lowering or raising the ground wheel.

Fig.3.43. (A) View of Bt. cotton planter

Fig.3.43. (B) View of inclined Cell type plate used for sowing

Fig.3.43. (C) A view of cotton crop

PRACTICAL EXERCISES

Activity 01: Make a list of sowing types of equipment

Material Required:

1. Pen
2. Notebook

Procedure:

1. First, take the permission of the farm owner.
2. Then, identify the sowing types of equipment.
3. List down the sowing types of equipment.
4. Sketch sowing equipment's and label it.

Activity 02: Make a list of planting/transplanting types of equipment

Material Required:

1. Pen
2. Notebook

Procedure:

1. First, take the permission of the farm owner.
2. Then, identify the planting/transplanting types of equipment.
3. List down the planting/transplanting types of equipment.
4. Sketch planting/transplanting equipment's and label it

CHECK YOUR PROGRESS

A. Answer the following questions:

1. What do you mean by seed-cum-fertilizer drill?
2. Explain the working principle of seed-cum-fertilizer drill?
3. What is a conservation drill and write their constructional detail?
4. Describe a rice planter and its transplanting process.
5. Draw the sketch of potato planter.
6. How to calibrate the potato planter?

B. Fill in the blank:

1. The soil aggregate size is determined by the ……of seedbed preparation and the crop residue.
2. Pegged wheels are suitable for use under ……. soils.
3. A rice transplanter is a specialized transplanter used to transplant rice …… onto a paddy field.
4. The seed metering mechanism was lowered down near to ground level to avoid ……. of seeds.

C. Match the following:

Column A	Column B
1. This equipment is used to open the furrow.	A. Metering device
2. It is used to pick the seed and fertilizer from the hopper.	B. Seed covering device
3. This help to transports the seeds to the furrow, and some system for covering the seeds and compact the soil.	C. Seed tube
4. This device is used for covering the seeds and compacting the soil around the seed.	D. Furrow opener

SESSION 4: PLANT PROTECTION EQUIPMENT

Use of the chemicals for controlling insects, pests, fungus, virus, and other parasites or weeds which adversely affect plants growth is an important aspect of modern agriculture. It is still a very effective control method for most insects, pests, weeds, and diseases, despite intensive research into alternative methods. Farmers often tend to use a large number of pesticides than required. This causes a higher loss of pesticides (nearly one-third of pesticides applied to crop on the ground as well as drift). It requires more time for application and adds to health hazards, ecological and environmental destruction.

All chemicals are poisonous substances and they can cause harm to all living things. Therefore, they must be very judiciously used. The main purpose of the chemical application technique is to cover the target with maximum efficiency and minimum effort. To keep the problem under control, with minimum contamination of non-targets. The application techniques ideally should be target-oriented so that safety to the non-targets and the environment is ensured. Proper equipment and technique of application are vital to the success of chemical control operations.

Chemical Spraying

The spraying techniques are classified as high volume (HV), low volume (LV), and ultra-low volume (ULV), according to the total volume of liquid applied per unit of ground area. Initially, a high-volume spraying technique was used for pesticide application but with the advent of new pesticides, the trend is to use the least amount of carrier or diluent's liquid.

Fine droplets are required to control insects, pests, or diseases and bigger size droplets for application of herbicides, etc. The greater the number of fine droplets produced by the device, better will be deposition on the target area. The size of the droplet is important as it affects the drift and penetration distance of droplets towards the target. Hence a compromise is to be made to prevent drift, achieve wide coverage of plant or target area, and more penetration. The optimum droplet sizes are indicated below:

Table 3.9: Optimum Droplet sizes for different targets

Target group	Droplet size (microns)
1. Flying insects	10-15
2. Insects on foliage	30-50
3. Plant surfaces (limited drift)	60-150
4. Soil application (no drift)	250-500

Spraying is employed for a variety of purposes as follows:

a. Herbicides application - against weeds
b. Fungicides application - against fungal diseases
c. Insecticides application - against insects
d. Pesticides application - against pests
e. Nutrients application – for plant health & vigor

Types of Plant Protection Equipment

Different designs of plant protection equipment have been developed for different types of applications and field and crop conditions. The equipment for chemical spraying may be broadly classified based on the form of chemical being applied i.e., dust/powder (duster) or liquid (sprayer). Manually operated hydraulic sprayers viz. knapsack sprayers, twin knapsack sprayers, foot sprayers, hand compression sprayers; air carrier sprayers such as motorized knapsack mist blower cum duster (LV), and centrifugal rotary disc type sprayers are especially suitable for spray applications in crops. The present trend is to apply concentrated pesticides using low and ultra-low volume sprayers. Complete knowledge of the equipment is necessary to develop the desired skill of operation, to select and estimate the number and type of equipment needed to treat the crop in minimum time, and to optimize the use of the equipment.

1. Sprayer

For sprayers, water is the carrier in most cases. The chemicals can be in powder, granules (which need mixing with water), or liquid form which may or may not need dilution by water. Generally, chemicals, when mixed can form one of the following:

- **Solution:** When a chemical is completely dissolved then mixed in the solvent (carrier).
- **Suspension:** Chemicals (powder) remain floating in the water and need constant agitation.
- **Emulsion:** Chemicals disperse in water but do not dissolve.

Functions of Sprayer

A sprayer is a machine used to apply fluid in the form of droplets. The main functions of a sprayer are to:

- Break the liquid into droplets of the required size.

- Distribute them uniformly over the surface or space to be protected.
- Regulate the amount of insecticide or pesticide to avoid an excessive application that might prove harmful or wasteful.

Desirable Qualities of a Sprayer

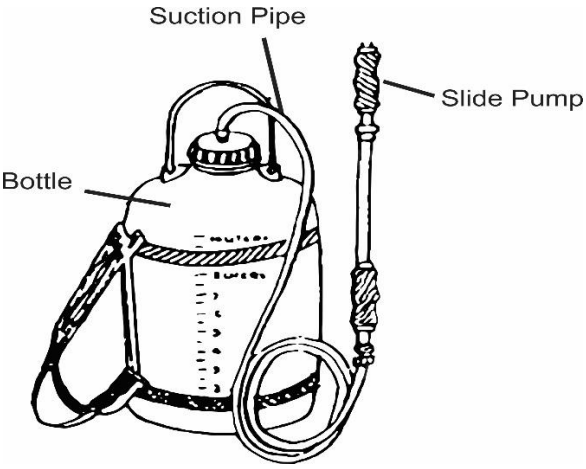
A sprayer would fulfil the following desirable qualities:

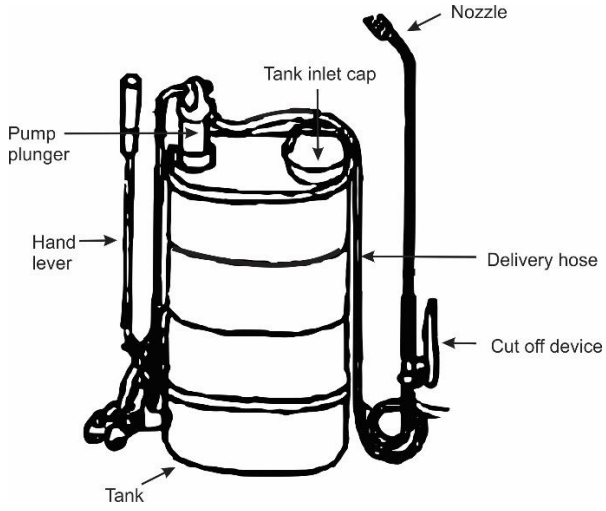
a) The sprayer should produce a steady stream of spray materials in the desired fineness of the practice so that the plants to be treated may be covered uniformly.
b) It should deliver the liquid at sufficient pressure so that it reaches all the foliage and spreads entirely over the sprayed surface.
c) It should be light yet sufficiently strong, easily workable, and repairable.

Types of Sprayers

Sprayers can be classified based on the size of the operation as:

a) Manually operated (can be hand or feet operated),
b) Carried manually but power operated,
c) Tractor operated (Boom sprayers),
d) Aircraft sprayers.





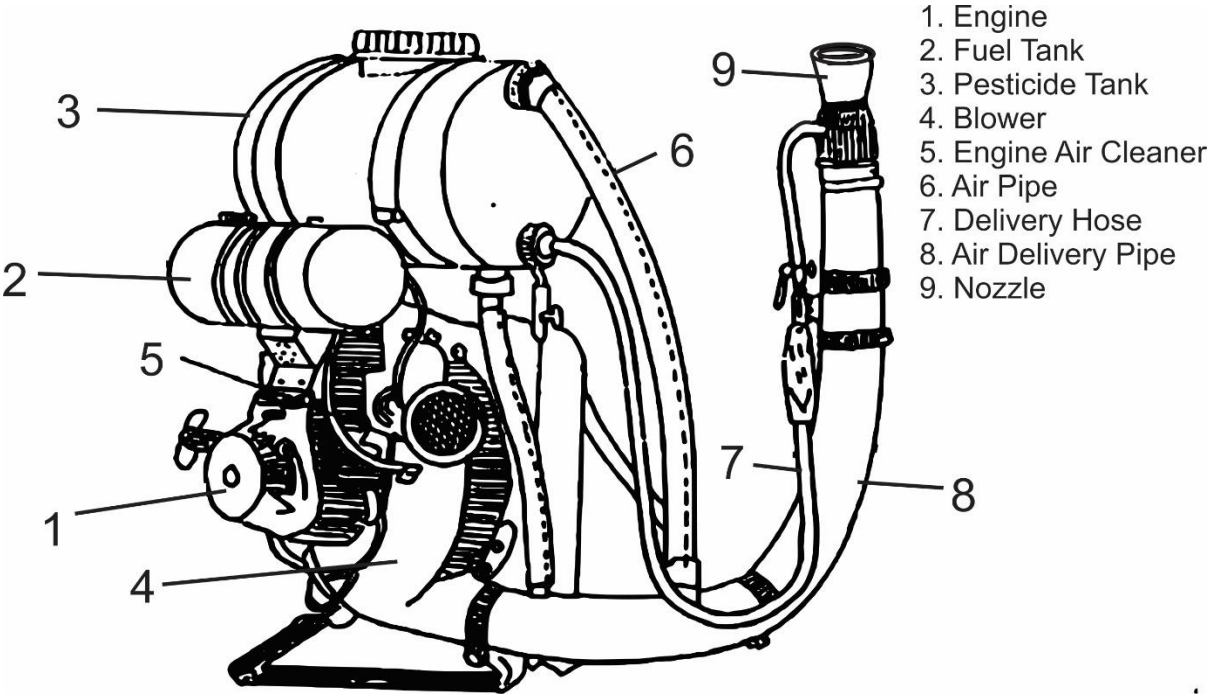


Fig.3.44: (a) Hand Spray (b) Knapsack Spray (c) Power-operated Spray

Sprayer components: The sprayer has the following essential components:

a) Tank: It carries and stores the chemicals, and is usually made of non-corrosive material (Plastic or fiberglass).

b) Pump: It imparts the correct pressure to the liquid carrier and, with the appropriate nozzle, delivers the liquid at the required rate.

c) Nozzle: All important mechanism that breaks the spray liquid into the desired size of droplets and discharges the chemical at a given rate and in droplets of the correct size. Nozzles vary to the rate of discharge, the angle of spray, and the type of spray pattern.

Additional components comprise one or more of the following;

- **Pressure relief valve:** To set and maintain the required pressure.
- **Pressure gauge:** To monitor pressure.
- **Boom or lance:** To which the nozzles are attached.
- **Control valve or cut-off device:** To regulate the flow of the liquid chemical.
- **Filters:** To ensure free flow by trapping unwanted material.
- **Agitator:** Used for mixing the chemical.
- **Air chamber:** To keep air that serves to pressurize the chemical and be sprayed.
- **Strainer:** To filter the solution.

A. Rocker Sprayer

Utility: For spraying of plant protection chemicals on tall trees like coconut, areca nut, and other trees and crops like sugarcane, rubber plantations, vineyards and field crops, vegetable gardens, flower crops, orchards, etc.
Features: The rocker sprayer assembly is mounted on a wooden board and consists of a single or double-acting piston pump, an air chamber, spray lance, long suction line fitted with a strainer, and delivery line assembly. It is a long lever high-pressure sprayer designed for operation with one or two lances. These are 600 to 900 mm long and fitted with a gooseneck bend and nozzle. The metallic components coming in contact with the chemicals are made from brass alloy. During operation the sprayer is held to the ground by the foot of one operator, who also operates the long lever in a rocking motion facilitating the sucking of liquid from the inlet pipe submerged in the chemical storage tank. The other person holds the lance and directs the spray chemical to the target. If two lances are used, then it may require, in all three persons for the spraying operation. With a jet spray gun or bamboo lance, the chemical can be sprayed to a height of up to 10 m.

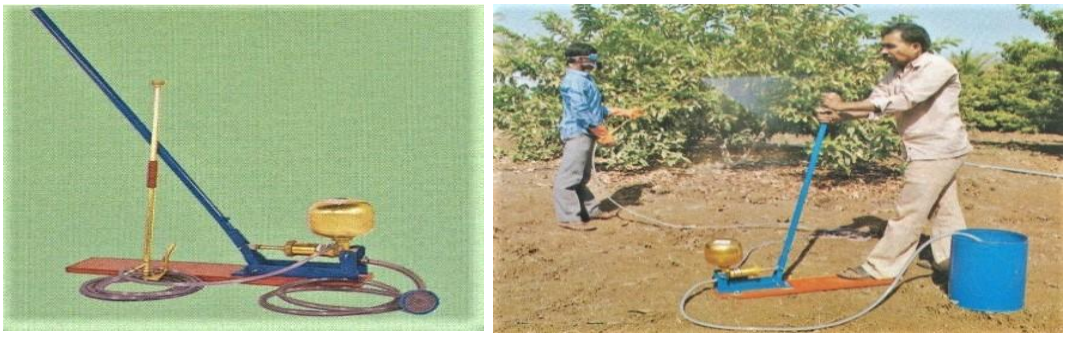


Fig. 3.45: Rocker Spray

B. Foot Sprayer

Utility: The foot-operated sprayer is suitable for orchard and tree spraying.
Features: The sprayer consists of a steel frame with a pump, pump barrel, foot lever mounted on it, and suction hose, delivery hose, and spray lance which are connected through shut off valve, gooseneck bend, and adjustable nozzles. Two strong springs are provided to retract the foot lever to its original position after each pumping stroke. It has a provision for attaching two spray lances, to achieve higher field capacity. The pump barrel, lance and spray nozzle are made from brass alloy. The pump of the sprayer is worked by operating a pedal lever by the foot of the operator. It requires two persons to work. The spray liquid is kept in a bucket or container and it is sucked by a suction hose through a filter (strainer)

due to piston movement. A suitable ball valve is provided in the piston assembly to serve as the suction valve. The liquid from the pump cylinder is then delivered into a pressure chamber where the pressurized liquid reaches the hydraulic nozzle. A minimum two-person team is required to work on this machine. Hydraulic pressure of 10 kg/cm^2 can be achieved which is necessary to protect the jet of spray to the tall trees simultaneously from two spray nozzles.

An adjustable type hydraulic nozzle (Triple Action Nozzle) is generally used which can generate different types of spray patterns viz., fine spray (hollow cone), medium spray, and coarse spray (jet). The fine and medium spray are suited for low-height orchards; jet spray is necessary for tree spraying. The spray jet can reach at 15-20 feet height. For spraying taller trees an extra extension like a bamboo lance may be used to gain an additional height of 8-10 feet.

Fig. 3.46: Foot Sprayer

C. Knapsack Sprayer

Utility: Knapsack sprayers are the sprayers with shoulder straps useful for back mounting. These are used for spraying insecticides and pesticides on small trees, shrubs and field crops.

Features

Knapsack sprayer consists of a lance with a shut-off valve, hand lever, a pump, and an air chamber permanently installed in the tank. The tank capacity may vary between 9 to 22.5 liters. The pump of the sprayer is operated by moving a hand lever up and down one hand while the other hand holds the cut-off device for spraying purposes. Continuous pumping helps in maintaining a uniform pressure and thereby uniformity in spraying.

Fig.3.47: Knapsack Sprayer

D. Power Sprayer

Utility: The power sprayers are suitable for spraying in orchards, tea and coffee plantations, rubber plantations, vineyards, and other field crops. Tall trees up to a height of 15 meters can also be sprayed with it.

Features

The power sprayers are high-volume spraying machines good for large-scale applications in orchards, tree crops and suitable for covering a larger area. These are high-capacity power-operated hydraulic sprayers and consist of a power unit to drive the pump, piston or plunger pump, pressure gauges, pressure regulators, air chamber, suction pipe with strainer, delivery pipes fitted with a lance, gooseneck bend, and nozzles. The source of power is an engine or electric motor. A pressure regulator is used to control the pressure in the discharge lines and a by-pass from the pressure regulator is used for hydraulic agitation in the spray tank. High pressure like 400 psi can be built up and a large spray discharge rate like 30 L/min. can be obtained. The engine or electrical motors with 3-5 horse power capacity provides power to the sprayer.

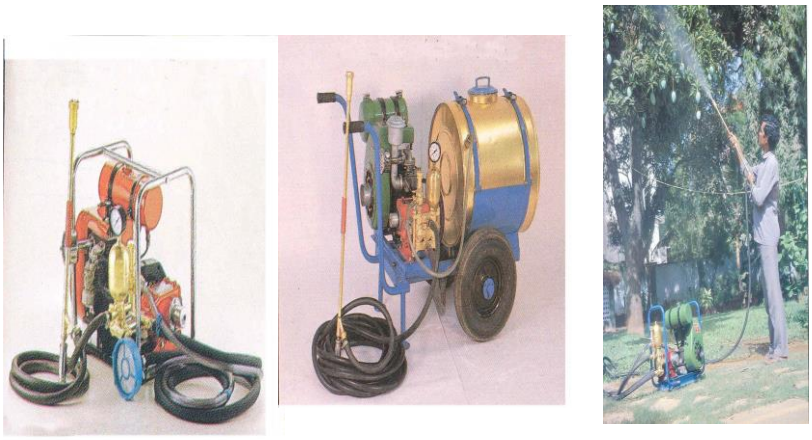


Fig.3.48: Power Sprayers

The complete assembly is mounted on a stretcher-type frame or wheelbarrow for easy transportation. The number of lances may vary from 1 to 6 depending upon the model. In some models, there is a built-in storage tank of fiberglass having a capacity of 100 liters, while in others a separate storage tank is required in which the suction pipe of the sprayer remains submerged. The spray pattern can be adjusted by adjusting the nozzle or selecting the appropriate nozzle.

E. Motorized Knapsack Mist Blower

Utility: It is used for spraying in orchards, coffee farms and tall crops.

Features

A motorized knapsack sprayer is also called as mist blower. It is a low volume (LV) sprayer in which a nozzle (gaseous energy) is used for the fine breakup of spray liquid. The motorized knapsack mist blower has a small two-stroke petrol/kerosene engine of 35cc to which a centrifugal fan is connected. The fan produces a high-velocity air stream. The force of escaping air at high velocity is utilized to shear down the spray liquid into fine spray droplets. The spray droplets are then blown away from the nozzle outlet. The blast of air disperses the droplets over a wide area and helps penetration of spray into the crop canopy. The gyrating movement of droplets in the canopy improves the under-leaf depositing of the spray particles.

Fig.3.49: Motorized Knapsack Mist Blower

The spray tank also has a compartment for fuel and the engine-fan unit is mounted on a common frame, which fits the back of the operator. The tank is made of plastic. The spray liquid flows due to gravity and suction created at the tip of the nozzle, thus remaining in the air stream. Some models of the sprayers have a roller pump for pumping the spray liquid into the discharge hose and have a tall tree spraying attachment. These sprayers have shear-type nozzles. The control valve for the spray liquid is opened gradually and adjusted for the desired flow rate. The spray liquid that falls in the air stream gets sheared and upon coming in contact with the atmosphere a mist is produced.

Care and Maintenance of Sprayer

The sprayers need care and maintenance before and after use.

After Use Care of Sprayer:

a) After spraying, dip the suction hose into fresh water and run the sprayer for a few minutes to clean it. Then lift out the suction hose and run the machine for another few minutes to exhaust the water.
b) Before stopping the prime mover, turn the pressure regulator to make the pressure zero.
c) After spraying, check the machine to see that no screws are loose.

Proper care and maintenance of sprayer increases the life of the machine and gives efficient service. The following are a few important cares to be observed:

a) All washers and packings should be soaked in oil or water before use.
b) The end of the nozzle should be unscrewed and cleaned before starting the work.
c) When spraying is over the sprayer should be operated for some time with clean water to remove sediments from the pressure vessel and discharge tube. To keep the sprayer serviceable, it should be thoroughly cleaned.

2. Dusters: Duster is an equipment used to apply a crop protection chemical in powder form. A duster is a simpler, less troublesome machine than a sprayer and no water is needed, but the weather must be calm for dusting. Duster consists of the following components:

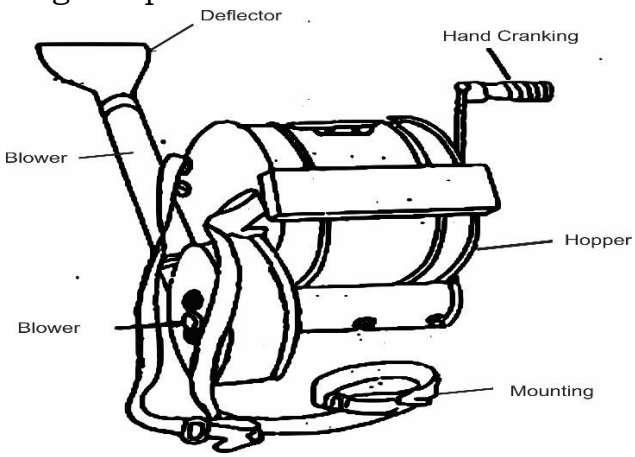


Fig. 3.50: Duster

- **Hopper:** It serves to store the chemical;
- **Agitator:** It is provided within the hopper to keep the dust moving freely to prevent caking;
- **Metering mechanism:** an adjustable orifice.
- **Delivery blower:** This creates an air stream that carries the powder to the target. A duster can be manually operated or powered. The manually operated one can be shoulder mounted or belly-mounted. Dusters can also be ground ridge dusters and aircraft dusters. While dusting is in operation the prevailing wind direction should be used to carry the dust to the target.

A. Hand Rotary Duster

Utility: Suitable for application of chemicals in powder form for controlling pests and diseases in the nursery, vegetable gardens, field crops, tea and coffee plantations, poly houses, and warehouses.

Features

The hand rotary duster is either shoulder-slung type or belly-mounted. The shoulder-slung models are better balanced when the dust hoppers are filled. But it becomes inconvenient to operate in crops like sugarcane and cotton. The belly-mounted type can be used in such situations. The duster consists of a hopper, fan/blower, rigid/flexible discharge pipe, reduction gearbox, rotating handle, shoulder straps, and metering mechanism. The hopper is either made of plastic or aluminium. The hopper made from mild steel sheet is coated with anti-corrosive material for longer life. This type of duster makes use of a fan or blower to flow a large volume of air at high speed. The dusting powder is fed into the stream of air and blown from the outlet tube. The fan or blower rotates at high speed by hand cranking handle, which is geared to it. The higher gear ratio and better blower design provide easy cranking and a good volume of air is emitted. The dust hoppers are generally cylindrical and are provided with an agitator, feeders, and dust metering mechanism. A hand rotary duster can discharge dust powder from 0-150 g/min and displace air about one m^3/min at 35 RPM. Such machine can treat 1 to 1.5 ha/day.

Fig.3.51: Hand Rotary Duster

Care and Maintenance of Dusters:

a) The duster should be thoroughly cleaned before and after use with a suitable brush.
b) The hopper should be filled with dust about half of its capacity.
c) The lid of the hopper should be closed during the operation.
d) Before storing the duster after use, the dust from the fan box, suction piper, and hopper should be thoroughly blown out and the agitation shaft is oiled while cranking.
e) The agitator parts and dust feed should be occasionally checked for blockage by foreign matters.

Table 3.10: Do's and Don'ts for Safe use of Chemical Pesticides by the Farmers

A. WHILE PURCHASING

Do's	Don'ts
• Purchase pesticides/bio-pesticides only from registered pesticide dealers having valid license. • Purchase only just the required quantity of pesticides for a single operation in a specified area. • See approved labels on the containers/packets of pesticides. • See batch number, registration number, date of manufacture/expiry on the labels. • Purchase pesticides well packed in containers.	• Do not purchase pesticides from footpath dealers or un-licensed person. • Do not purchase pesticides in bulk for the whole season. • Do not purchase pesticides without an approved label on the containers. • Never purchase expired pesticides. • Do not purchase pesticides whose containers are leaking/ loose/unsealed.

B. WHILE HANDLING

Do's	Don'ts
• Keep pesticides separate during transportation. • Bulk pesticides should be carried tactfully to the site of application.	• Never carry/transport pesticides along with food/fodder/other eatable articles. • Never carry bulk pesticides on the head, shoulder, or back.

C. WHILE PREPARING SPRAY SOLUTION

Do's	Don'ts
• Always use clean water. • Use protective clothes viz., hand gloves, face masks, cap, apron, full trouser, etc. to cover the whole body. • Always protect your nose, eyes, ears, hands, etc. from the spray solution. • Read instructions on pesticide container labels carefully before use. • Prepare the solution as per requirement. • Granular pesticides should be used as such. • Avoid spilling pesticides solutions while filling the spray tank. • Always use the recommended dosage of pesticide. • No activities should be carried out which may affect your health.	• Do not use muddy or stagnant water. • Never prepare spray solution without wearing protective clothes. • Do not allow the pesticide/its solution to fall on any body parts. • Never avoid reading instructions on the container's label for use. • Never use left-out spray solution after 24 hours of its preparation. • Do not mix granules with water. • Do not smell the spray tank. • Do not use overdose which may affect plant health and the environment. • Do not eat, drink, smoke, or chew during the whole operation of pesticides.

D. SELECTION OF EQUIPMENT

Do's	Don'ts
• Select the right kind of equipment. • Select right-sized nozzles. • Use a separate sprayer for insecticides and weedicides.	• Do not use leaky or defective equipment. • Do not use defective/non-recommended nozzles. Do not blow/clean clogged nozzles with the mouth. Instead, use a toothbrush tied with a sprayer. • Never use the same sprayer for both weedicides and insecticides.

E. WHILE APPLYING SPRAY SOLUTIONS

Do's	Don'ts
• Apply only recommended dose and dilution. • Spray operation should be conducted on a cool and calm day. • Spray operation should be conducted on sunny days in general. • Use recommended sprayer for each spray. • Spray operation should be conducted in the wind direction. • After spray operation, the sprayer and buckets should be washed with clean water using detergent/soap. • Avoid the entry of animals/workers in the field immediately after spray.	• Never apply over-dose and high concentrations than recommended. • Do not spray on hot sunny days or strong windy conditions. • Do not spray just before rains and immediately after the rains. • Emulsifiable concentrate formulations should not be used for spraying with a battery-operated ULV sprayer. • Do not spray against the wind direction. • Containers and buckets used for mixing pesticides should never be used for domestic purposes even after thorough washing. • Never enter the treated field immediately after spray without bearing protective clothing.

F. AFTER SPRAY OPERATION

Do's	Don'ts
• Leftover spray solutions should be disposed of at a safer place viz. barren isolated area. • The used/empty containers should be crushed with stone/stick and buried deep in the soil away from water sources. • Wash hands and face with clean water and soap before eating/smoking. • On observing poisoning symptoms give the first aid and show the patient to the doctor. Also, show the empty container to a doctor.	• Leftover spray solution should not be drained in or near ponds or water lines etc. • Empty containers of pesticides should not be re-used for storing other articles. • Never eat/smoke before washing clothes and taking bath. • Do not take the risk by not showing the poisoning symptoms to the doctor as it may endanger the life of the patient.

G. DURING STORAGE

Do's	Don'ts
• Store the pesticides away from house premise. • Keep pesticides in original containers. • Pesticides/weedicides must be stored separately. • Where pesticides have been stored, the area should be marked with warning signs. • Pesticides are stored away from the reach of the children and live stocks. • The storage places should be well protected from direct sunlight and rain.	• Leftover spray solution should not be drained in or near ponds or water lines etc. • Empty containers of pesticides should not be re-used for storing other articles. • Never eat/smoke before washing clothes and taking bath. • Do not take the risk by not showing the poisoning symptoms to the doctor as it may endanger the life of the patient.

PRACTICAL EXERCISES

Activity 01: Make a list of sprayers

Material Required:

1. Pen
2. Notebook

Procedure:

1. First, visit the shop or farm.
2. Then, take permission from the shop or farm.
3. Identify the different types of sprayers.
4. List down the available sprayer.
5. Sketch sprayers and label them.

Activity 02: Make a list of dos and don'ts for the safe use of chemical pesticides.

Material required:

1. Pen
2. Notebook

Procedure:

1. First, visit the pesticides shop.
2. Then, take permission from the shop or farm.

3. Identify the available pesticides.
4. Then, read the user manual on pesticides.
5. Note down the dos and don'ts for the safe use of chemical pesticides.

CHECK YOUR PROGRESS

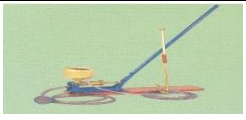
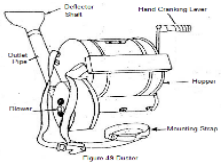
A. Answer the following question

1. Explain the term sprayer and write their types.
2. What do you mean by chemical spraying?
3. Describe the rocker sprayer?
4. Write the difference between foot and knapsack sprayer.
5. Write the importance of the power sprayer.
6. Describe the duster and their types?

B. Fill in the blank

1. Sprayer is a machine used to apply fluid in the form of .....
2. The ..... operated sprayer is suitable for orchard and tree spraying.
3. Tall trees up to a height of ..... can be sprayed with a power sprayer.
4. Duster is the equipment used to apply a crop protection chemical in ..... form.

C. Match the following

Column A	Column B
1. Rocker sprayer	A. 
2. Foot sprayer	B. 
3. Duster	C. 
4. Motorized Knapsack Mist Blower	D. 

SESSION 5: IRRIGATION PUMPS

The irrigation pumps are used to pump water from a lower to a higher level. Hence the water flows through channels to the fields requiring irrigation (lift operation) or to raise it to the required pressure head; so that it can be sprayed on the fields through the piping system (sprinkling). The pump used for irrigation include centrifugal, deep well turbine, submersible, and propeller pumps. Turbine, submersible, and propeller pumps are special forms of centrifugal pumps. However, their names are common in the industry.

Here, the term centrifugal pump refers to any pump that's above the water surface and uses a suction pipe. Before selecting an irrigation pump, one must make a careful and complete inventory of the conditions under which the pump will operate. The inventory must include:

- Source of water (well, river, pond, etc.)
- Required pumping flow rate
- Total suction head
- Total dynamic head

The source of water is either surface water or well water, usually the local geology and hydrologic conditions determine its availability. However, the type of irrigation system, distance from the water source, and size of the piping system will determine the flow rate and total dynamic head.

Types of Pumps used in Agriculture

Water pumps are widely used for the irrigation of crops. These are the machines that move liquids or gases from one place to another through mechanical force. Pumps carry the water from a region of low pressure to high pressure by increasing the pressure of the fluid and giving it the strength to flow against the gravitational force. Pumps are made of hardened metals or alloys like stainless steel, chromium, nickel, etc. They can be operated by electrical energy, wind energy, manual power, etc. They are of great importance in agriculture as they are the prime devices to provide irrigation to the crops.

Different types of pumps available for irrigation. Some of them are designed specially to suit a specific need for irrigation in agriculture.

Types of Pumps in Agriculture

The pumps are classified into two major types – Positive Displacement Pumps and Dynamic Pumps.

1. **Positive Displacement Pumps:** A positive displacement pump displaces or pushes the water from one place to another by virtue of mechanical energy. It has two sides – a suction side and a discharge side. The fluid goes into the suction valve and comes out through the outlet valve. They use the reciprocating, rotary, or linear motion of the piston to trap a fixed volume of fluid in a compartment inside the pump which is then transferred or discharged outside through nozzle. It operates by simultaneously filling the chamber with the fluid and then displacing it.

   A fixed amount of fluid is displaced in each working cycle of the pump; thus, they are also called 'Constant Volume Pumps'. A safety valve should be used in this type of pump because it deals with extremely high pressure of fluids. They are usually operated manually. They cannot be used to pump water from deeper water table levels. They can be used for all types of crops.

Fig.3.52: Positive Displacement Pump

Advantages of Positive Displacement Pumps

1. They can deliver very high pressures (around 800 bar).
2. They can handle fluids of high as well as low viscosity. The rate of flow increases with the increase in viscosity of the fluid.
3. Their efficiency is high (more than 90 %).
4. The rate of flow remains constant irrespective of change in pressure.
5. They are very durable and inexpensive.
6. They can handle air or gas contamination in the liquid flow.

Disadvantages of Positive Displacement Pumps

1. They require protection from over pressure.
2. They have a complex design when compared with centrifugal pumps.
3. They require high maintenance, but it is not expensive.

Applications of Positive Displacement Pumps

1. They can be used to irrigate the field.
2. They can be used to pump spray paints, oils, and high force washing.
3. They can be used for the transportation of oil or gas in pipelines.
4. They can be used in the manufacture of chemicals.
5. They can be used to transport slurry of wastes in waste treatment plants.

2. Dynamic Pumps

A dynamic pump is a high-velocity pump. It increases the kinetic energy of the flow by mechanical motions, which then leads to the flow into the discharge pipe. Centrifugal pumps are a major sub-category of dynamic pumps. These types of pumps can even work with saline water or sandy water. They are usually fitted with filters to remove the solid contaminants. They can be used with all types of crops. Different types of dynamic pumps are as follows:

A. Centrifugal pump

Fig. 3.53: Centrifugal Pump

These pumps are the most commonly used type for irrigation practices. A centrifugal pump moves the fluid through the pump by virtue of rotatory motion. An impeller is the main device that rotates and draws the fluid inside the pump. Centrifuge pump is always immersed in water, and its rotation transfers the kinetic energy to the fluid from the motor. Due to this kinetic energy, the fluid moves through the pump and departs through the discharge valve. They are usually operated by electrical energy. This electric energy can be availed from the natural sources like solar, wind, hydro energy, etc.

The following pumps fall under the category of centrifugal pumps:

(i) Submersible pump: A submersible pump is installed below the surface of water. It consists of waterproof elements. They are used in a well, lake, or pond. They do not require priming and very efficient.

Submersible pumps can be single-staged pumps or multi-staged pumps (a combination of many single-staged pumps). These pumps are usually operated by electrical energy. They can be operated by the solar energy, wind energy, hydro energy, etc. They can be used when the level of the water source is shallow.

Fig.3.54: Submersible Pump

(ii) Turbine Pump: Turbine pumps are also installed underwater. They have high efficiency, similar to submersible pumps. They can be used with wells, lakes, or ponds. The most common type of turbine pump is a vertical turbine pump. Turbine pumps are usually operated by electrical energy. They can be operated by solar energy, wind energy, hydro energy, etc. They can be used when the water level is low.

(iii) End-suction Centrifugal Pumps: They are the most commonly used type of centrifugal pumps. All the portable types of pumps including booster pumps are end-suction centrifugal pumps. They are often connected with a rotating motor. These pumps are not suitable to use when the water source is situated lower than 4 feet from the pump. These are usually operated by electrical energy. They can be operated by solar energy, wind energy, hydro energy, etc. They can be used when the water level is moderately deep.

(iv) Jet Pump: A jet pump or a hydraulic lift can lift water from a water source, which is situated very low from the level of the pump, but they have a lower flow rate. They are used to pump water from a river or a deeper water body. They are usually operated by electrical energy which is availed from solar energy, wind energy, hydro energy, etc. These can be used to pump out water from a very deep-water source.

(v) Floating Pump: A floating pump is a normal centrifugal pump that is connected to a floating object. They are used to pump water from the surface of a lake or a pond. They generally make use of submersible pumps. They are usually operated by electrical energy which is availed from solar energy, wind energy, hydro energy, etc. They can be used to pump water from a shallow water body.

Advantages of Centrifugal Pumps

1. They have a relatively simple design.
2. There are no chances of leaks in the pumps.
3. There is less loss due to friction.
4. They are inexpensive.
5. There is almost no noise.
6. This pump has almost 100 % efficiency.

Disadvantages of Centrifugal Pumps

1. The rate of flow is dependent on the pressure, and the pump works only at a certain pressure level.
2. The rate of flow decreases when high viscosity fluids are used.
3. It requires a constant flow of fluid; otherwise, a gas bubble may form and it stops pumping.
4. It requires priming.
5. Ferrous particles in a liquid can cause corrosion of the impeller.

Applications of Centrifugal Pumps

1. They are the most commonly used type of pumps in irrigation.
2. They can pump harmful and risky liquids.
3. They are used in mining, petrochemical industries, and domestic appliances.
4. In the hydraulic control system.
5. Used by fire-fighters.
6. Used to pump water into tanks on residential buildings.

B. Submersible Pumps

A submersible pump is a turbine pump close-coupled to a submersible electric motor, as shown in the figure.3.55. Both pump and motor are suspended in the water, thereby eliminating the long driveshaft and bearing retainers required for a deep-well turbine pump. Because the pump is above the motor, water enters the pump through a screen between the pump and motor.

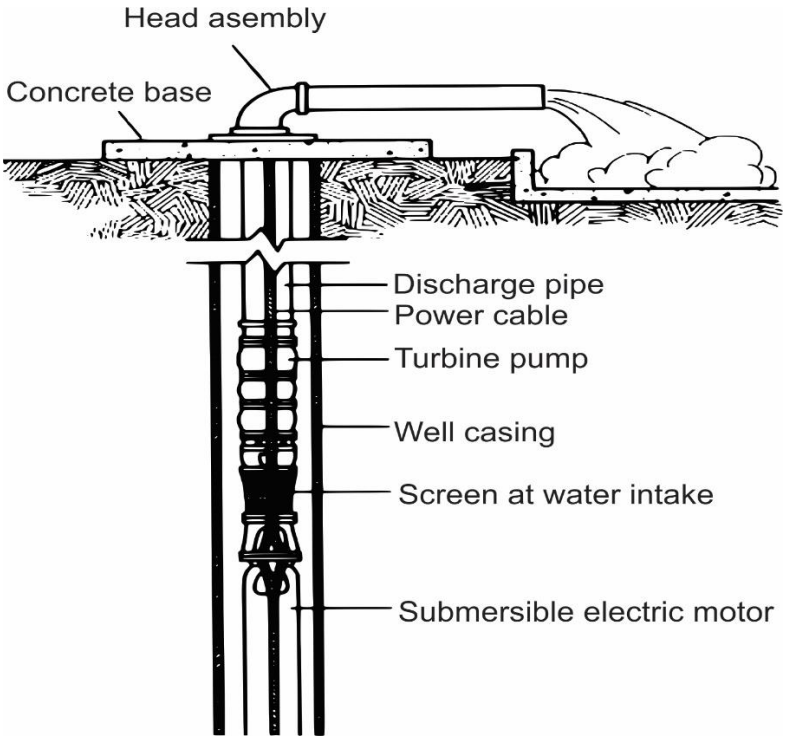


Fig. 3.55: Submersible Pump

The submersible pump uses enclosed impellers because the shaft from the electric motor expands when it becomes hot and pushes up on the impellers. If semi-open impellers were used, the pump would lose efficiency. The pump curve for a submersible pump is very similar to the curve for a deep-well turbine pump.

Submersible motors are smaller in diameter and much longer than the ordinary motors. Because of their smaller diameter, they are lower-efficiency motors than those used for centrifugal or deep-well turbine pumps.

Submersible motors generally are referred to as dry or wet motors. Dry motors are hermetically sealed with high-dielectric oil to exclude water from the motor. Wet motors are open to the well water, with the rotor and bearings operating in the water.

Pump Selection Criteria

The selection of an irrigation water pump is entirely based on the relationship between pump efficiency and the TDH (Total Dynamic Head) the pump will provide at a specific flow rate. As shown before, these parameters also are the basis of the pump characteristic curve. Use Table 3.11 to narrow the selection of a pump type for a broad range of flow rates and total dynamic heads.

Table 3.11: A chart showing the most desirable pump types to use for a given range of flow rates and total dynamic heads.

Gallons per minute	TDH (feet)		
	50 or less	**50 to 500**	**500 or more**
0 to 300	Propeller Centrifugal	Centrifugal vertical turbine submersible	Centrifugal vertical turbine submersible
300 to 5000	Propeller	Centrifugal vertical turbine submersible	Centrifugal vertical turbine submersible
5000 or more	Propeller	Centrifugal vertical turbine submersible propeller	Centrifugal vertical turbine

Table 3.12: Factors to consider in selecting an Irrigation Pump.

Pump Type	Advantages	Disadvantages
Centrifugal pump	1. High efficiency over a range of operating conditions. 2. Easy to install. 3. Simple, economical and adaptable to many situations. 4. Electric, internal combustion engine or tractor power can be used. 5. Does not overload with increased TDH. 6. Vertical centrifugal may be submerged and not need priming.	1. Suction lift is limited, needs to be within 20 vertical feet of water surface. 2. Priming required 3. Loss of prime can damage pump. 4. If the TDH is much lower than design value, the motor may overload.
Vertical turbine pump	1. Adapted for use in wells. 2. Provides high TDH and flow rates with high efficiency. 3. Electric or internal combustion power can be used. 4. Priming is not needed.	1. Difficult to install, inspect and repair. 2. Higher initial cost than a centrifugal pump. 3. To maintain high efficiency, impellers must be adjusted periodically.

	5. It can be used where water surface fluctuates.	4. Repair and maintenance more expensive than for centrifugal.
Submersible pump	1. It is used in the deep wells. 2. Priming is not required. 3. It can be used in crooked wells. 4. It is easy to install. 5. Smaller diameters are less expensive than comparable-sized vertical turbines.	1. It is more expensive in large sizes than deep-well vertical turbines. 2. Only electric power can be used. 3. It is more susceptible to lightning. 4. Water movement past motor is required.
Propeller	1. It has simple construction. 2. It can pump some sand. 3. Priming is not required. 4. Efficient at pumping very large flow rates at low TDH. 5. In this electric, combustion engine and tractor power can be used. 6. Suitable for portable operation	1. It is not suitable for suction lift. 2. It cannot be valve back to reduce flow rate. 3. Intake submergence depth is very critical. 4. It limited in low TDH (Less than 75 feet).

PRACTICAL EXERCISES

Activity 01: Visit the agriculture field/farm

Material Required:

1. Pen
2. Notebook

Procedure:

1. First, take permission from farm owner.
2. Then, visit the field/farm.
3. Identify the available pumps.
4. List out the pumps that are available.
5. Make a sketch and label it.

Activity 02: Draw the sketch of submersible pump

Material Required:

1. Pen
2. Notebook

Procedure:

1. First, take permission from farm owner.
2. Then, visit the field/farm.
3. Identify the submersible pump that are available.
4. List out the specification.
5. Make a sketch and label it.

CHECK YOUR PROGRESS

A. Answer the following question

1. What is irrigation pump?
2. Write the importance of irrigation pump in agriculture?
3. Difference between the centrifugal pump and submersible pump.
4. Write the selecting criteria of vertical turbine and propeller pump?

B. Fill in the blank

1. Irrigation pumps are used to pump water from a ……. to …… level.
2. A positive displacement pump displaces or pushes the water from one place to another by virtue of …… energy.
3. A dynamic pump is a …… pump.
4. An …… is main device that rotates and draws the fluid inside the pump.

C. Match the following

Column A	Column B
1. This pump is used when high efficiency over a range of operating conditions.	A. Jet pump
2. This pump is used in crooked well.	B. Propeller pump
3. It can be used to pump out water from a very deep-water source.	C. Centrifugal pump
4. This pump is used efficiently for pumping at large flow rates with low TDH.	D. Submersible pump

SESSION 6: HARVESTING AND THRESHING EQUIPMENT

Harvesting and threshing is an important operation in the farming. This can be done either manually or with the help of power operated machinery. Harvesting of field crops continues to be one of the most labour-intensive operations in agricultural production system. The mechanical devices used to harvest wheat crop and up to some extent paddy are becoming popular especially in Northern India to minimize the field losses resulting from shattering, unfavourable weather conditions and pilferage.

Traditional method of harvesting

The harvesting of crops is traditionally done by the manual methods. Harvesting of major cereals, pulse and oilseed crops is done by using sickle whereas tuber crops are harvested with country plough or spade. Trials made with scythes and cradles for harvesting grain crops have not been successful in India, as they were heavy to work with and caused shattering of grains. All these traditional methods involve drudgery and take long time.

Mechanical Harvesting Equipment

Timeliness of the harvest is of prime importance. During the harvesting season, often rains and storms often cause considerable damage to the standing crops. Rapid harvest facilitates extra days for land preparation and early planting of the next crop. The use of machines can help in harvesting at proper stage of crop maturity and reduce drudgery and operation time. Considering these factors nowadays improved harvesting tools, equipment, combines are being accepted by the farmers. Mowers operated manually or with engine power sources are also used to a limited extent for harvesting forage crops. For groundnut, potato and root crops which have to be lifted and separated from the soil, digging prongs or blades serve the purpose; and for gathering these crops many kinds of tines or rakes are used.

Requirements of field and crops for mechanical harvesting

The following criteria must be met before mechanical harvesting equipment can be used successfully.

i. Field must be fairly levelled without undulations to facilitate smooth operation and uniform stubble length.
ii. For small reapers and binders, crops must be grown in rows.
iii. Field efficiency of harvesting machines is high in large fields.
iv. Water control in rice fields is essential to ensure that the fields are drained and are relatively dry at harvest time.

1. Vertical Conveyer Reaper

A vertical conveyor reaper–cum-windrower can cut the crop and lay it in the form of windrow for easy picking. It consists of a conventional cutter bar assembly, crop row dividers with star wheels, covers, pressure springs and vertical conveyor belts (Fig. 3.56). Cutter bar is given reciprocating motion by the crank wheel. Crop row dividers with star wheels enter the standing crop and help in lifting, gathering and guiding the crop towards the cutter bar.

After the crop is cut, it is held in a vertical position during its passage by means of pressure springs and star wheels. Vertically held crop is then delivered towards the right side of machine in a windrow perpendicular to the direction of movement of machine with the help of lugged conveyor belt. The gearbox and windrower are coupled to the drive shaft of the prime mower. The output shaft transmits power to the shaft driving the lugged flat conveyor belts and a crank is attached at the lower end of the output shaft to operate the cutter bar through connecting rod. The serrated blade cutter bar with standard knife guards is fitted. The top lugged conveyor belt drives the star wheels on the crop row dividers. Pressure springs are fitted below the star wheels between the conveying platforms to keep the cut crop in upright position while it is being conveyed out of the machine. The power in case of power tiller units is transmitted through an intermediate shaft to the gearbox on windrower either by belt or by shaft drive. In tractor-mounted reaper, the power to the gearbox is transmitted from PTO shaft through gearbox by a long shaft running beneath the tractor body to the front and with the help of universal joint and telescopic shaft which is connected to the gearbox. Lowering and raising of reaper is carried out with the help of hydraulic system of a tractor. In case of power tiller, the machine pivots on the power tiller wheels. With the help of the handle of power tiller, the cutter bar can be raised or lowered.

A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops. It can also be used for harvesting of soybean and other similar crops. Power tiller operated reaper can be operated with a 5-6hp engine, whereas, tractor operated reapers (Fig. 3.58) can be operated with 25-35 hp tractor. Width of cut is about 1.6 m in power tiller reaper, and about 2.05 m in tractor operated reapers. Power tiller and tractor-front mounted vertical conveyer reaper windrower can cover about 0.2 ha/h and 0.4 ha/h, respectively.

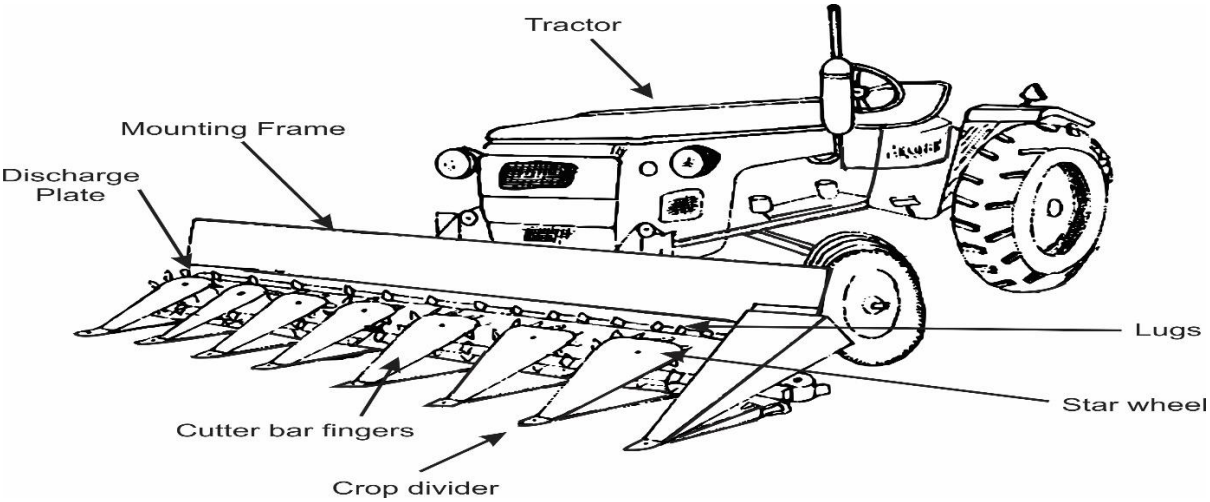


Fig.3.56: Tractor front mounted vertical conveyer reaper

Fig.3.57: Self-propelled vertical conveyor reaper-cum-windrower

Fig.3.58: Tractor front mounted vertical conveyor reaper-cum- windrower

2. Reaper-Binder

A reaper-binder, is a farm implement that was improved upon the simple reaper. In addition to cutting the small-grain crop, a binder also 'binds' the stems into bundles or sheaves. These bundles are usually then left in the field, to allow the grain to dry for several days before being picked up and threshed.

Constructional features of the reaper binder: The riding type self–propelled vertical conveyor reaper binder is powered by a 9 kW, single cylinder, water cooled diesel engine having a rated engine speed of 3000 rpm. It is provided with four pneumatic wheels; two driving wheels in the front having agricultural tread pattern tyres and two steering wheels at the rear having automotive tyres. Other systems include clutch, brakes, steering, hydraulics, and power transmission. An operator's seat is available to make the machine riding type. The harvesting system include crop row dividers, star wheels, standard cutter bar having 76.2 mm pitch of knife section, vertical conveyor belts and wire springs. The effective cutter bar width is 1.2 m. The crop row dividers enter the standing crop and the star wheels guide the crop towards the cutter bar and help in slightly lifting the crop after it is cut, and in turning it at right angle, prior to its conveying by the lugged conveyor belt.

Fig.3.59: Reaper-Binder

Table 3.13: Troubleshoot of Reaper-Binder

Reaper-Binder Trouble Shooting			
S. No.	**Part**	**Problem**	**Adjustment**
1.	**Reel**	i) Does not rotate. ii) Improper gathe ring of crop.	i) Check tension of reel belt. Reel by hand to ensure that the drive pulley key and belt are secured. ii) Adjust height according to height of crop.
2.	**Cutter bar**	i) Unsatisfactory cutting.	i) Reduce the forward speed. ii) Correct the registration. iii) Sharpen the knife sections or replace if worn out. iv) Check the drive belt tension. If loose, tighten.
3.	**Binding & tying mechanism**	i) Broken or torn twine. ii) Loose or untied knot. iii) Frequent untied bundles. iv) Improper cutting of twine.	i) Remove the twine and clean the needle eyelet and pliers. Reduce tension on twine under the tension plate through fly-nut. ii) Tighten the twine disc with the help of spring-loaded screw-bolt provided for the purpose. iii) Adjust the spring tension and smooth face of pliers by emery paper. Use twine of uniform 'Thielman'.
4.	**Conveyor**	i) Bundles keep collecting on conveyor. ii) Conveyor slackened & bundles not conveyed at regular internal.	i) Check the tension or the v-belt over the conveyor roller pulley. ii) Tighten the concaves conveyor with help of the sum buckles provided.
5.	**Bundle size**		i) Increase or decrease the size of bundles by increasing or decreasing the tension of trigger. For this the trigger spring is hooked on to different holes provided.

3. Thresher

Threshers are the most important component of the farm mechanization. The operation of detaching the grains from the ear head, cob or pod is called threshing. It is basically the removal of grains from the plant by striking, treading or rupturing. If threshing is not done timely, all efforts made by farmers and inputs given to crop goes wasted. Traditional method of threshing by animal is very slow. It gives low output. The threshing can be achieved by three methods: Rubbing action, Impact and Stripping.

Types of Power Threshers

1. According to crops being threshed
   - Single Crop
   - Multi-crop
2. According to functional components
   - Drummy
   - Regular (Through-put)
   - Axial flow
3. According to types of threshing cylinder
   - Syndicator
   - Hammer Mill or Beater type
   - Spike tooth type
   - Rasp bar type

Power wheat thresher (Fig. 3.60) is a machine, which threshes the wheat crop and performs other functions such as:

- Feed the harvest crop to the threshing cylinder.
- Thresh the grain out of the ear head.
- Separate the grain from the straw.
- Clean the grain.
- Make 'bhusa' suitable for animal feeding.

Functional Components of Threshing Unit: A power thresher essentially consists of feeding unit, threshing unit, cleaning unit, power transmission unit, main frame and transport unit (Fig. 3.60). The operation of conveying the cut crop into threshing unit is known as feeding. Normally, one of the two types of feeding units 'throw-in-type' or 'hold-on-type' are used in the power threshers. In 'throw-in-type' feeding unit, the cut crop is pushed into threshing cylinder,

where as in 'hold-on-type' the heads are only pushed into the cylinder and straw is manually or mechanically held. Throw-in-type feeding device is quite common in the threshers, which may be a feeding hopper or feeding chute.

1) **Feeding Hopper:** In this type of feeding device there is a hopper placed on the top of the threshing cylinder. Generally, hopper type of feeding units has a rotating star wheel mechanism between the hopper and threshing drum to facilitate the uniform feeding of crop to the drum. The initial cost of this system is high, hence is mostly used on a large thresher e.g., axial flow thresher of large capacity.
2) **Feeding Chute:** The crop is fed manually into these machines through a feeding chute.

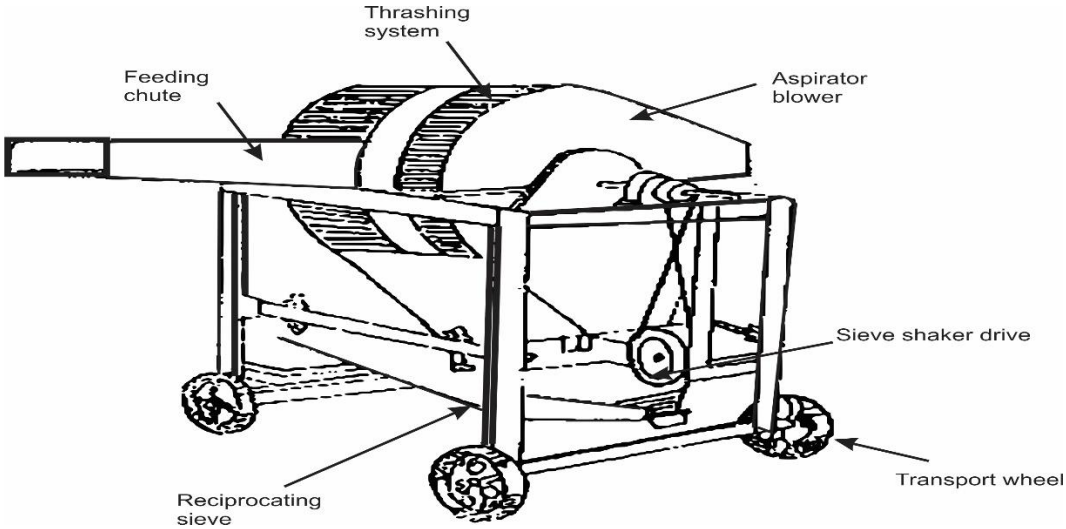


Fig.3.60: Details of wheat thresher

3) **Threshing Unit:** The threshing is accomplished by the impact of the rotating pegs mounted on the cylinder, over to the ear heads, which force out the grain from the sheath holding it. In the threshing of wheat crop, the straw is also bruised and broken up by the impact, thus converting it into 'bhusa' (straw). Threshing unit mainly consisting of a cylinder and concave. There are different types of threshing cylinders such as:
    - Spike tooth/peg type cylinder
    - Rasp bar type cylinder
    - Angled bar type cylinder
    - Wire loop type cylinder
    - Cutter blade or syndicator type cylinder
    - Hammer mill type cylinder

- **Spike tooth type cylinder:** In this type of threshing drum there is a hollow cylinder made out of mild steel flat. Over its entire periphery, a number of spikes/pegs of square /round bars or flat iron pieces are welded or bolted. Now days, in most of the threshers, round peg with adjustable length are used. These spikes are staggered on the periphery of the drum for uniform threshing. The crop is fed along with the direction of motion of the rotating drum. The spike tooth cylinders are available in various sizes. A spike tooth cylinder with spikes of flat front and streamlined back has lower energy consumption.
- **Rasp bar type cylinder:** In this type of cylinder, the slotted plates are fitted over the cylinder rings in such a way that the direction of slot of one plate is opposite to another plate. This type of cylinder is commonly used in threshers. It gives better quality of straw (bhusa) and it can be used for a wide variety of crops viz.-wheat, paddy, maize, soybean etc.
- **Wire loop type cylinder:** In this type of threshing drum, there is a hallow cylinder over which a number of wooden or mild steel plates are fitted. On these plates, number of wire loops is fixed for threshing purposes. This type of cylinder is common in the manually operated paddy threshers. Holding the bundle against the loops of revolving cylinder does threshing of paddy crop.

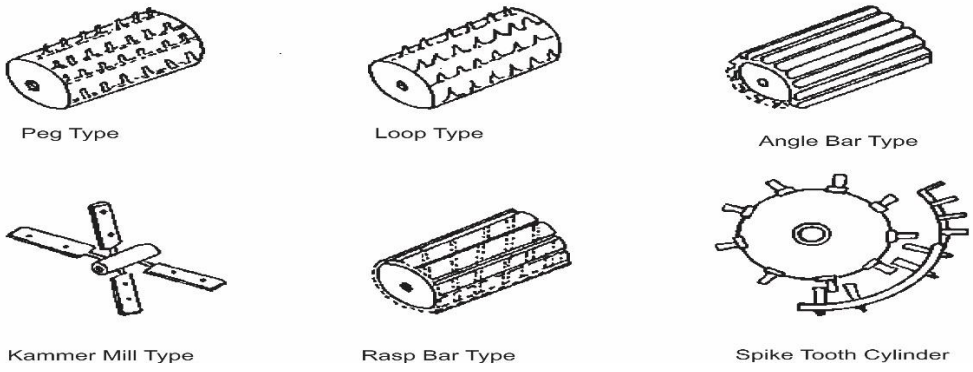


Fig.3.61: Different types of threshing cylinders

- **Cutter blade type cylinder:** It consists of 2-4 chaff cutter blades mounted on the radial arms of a flywheel. The rim of flywheel is corrugated to provide additional rubbing action. This type of cylinder performs satisfactorily in the moist crops. In the Moist crops, using spike tooth or hammer mill type cylinders may results in frequent choking, over loading etc. The device is becoming quote popular in the large capacity wheat

threshers such as 'Harambha thresher'. This type of thresher is generally provided with position feed roller and endless conveyor belt.

- **Hammer mill type cylinder:** It uses beaters to do the required job of threshing. The shape of this type of cylinder is different from the above-discussed cylinder. The beaters are made of flat iron pieces and are fixed radically on the rotor shaft. Generally, feeding chutes are used with hammer mill type threshing cylinder. The cut crop is fed perpendicular to the direction of motion of rotating beaters. This type of thresher requires more power as compared to spike tooth type of thresher.

4) **Concave:** Cylinder and concave together makes the threshing unit. It separates the grain from the crop and removes grain from the straw. Concave is provided in the thresher to hold the fed crop inside the threshing chamber and allows only grain and small amount of chaff to pass through it. The threshing takes place only in this space. It is a curved unit, made of iron steel or iron bar, fitted near the threshing cylinder. The clearance between cylinder and concave is adjustable, depending upon the size and type of grain. The concave clearance for wheat is 5 to 13 mm and for paddy is 5 to 10 mm. As the concave clearance is reduced, the threshing efficiency increases but losses increase and vice versa. The concave clearance at the inlet is less as compared to outlet. There are different types of concaves, which are used in thresher.
    - **Screen type concave:** It is made of mild steel (MS) rod. It is semi-circular in shape and sometimes also made with wires. The screen allows the material after threshing to pass through its perforation.
    - **Perforated concave:** In this, perforations are made in a mild steel sheet. The concave is closed from both the ends by iron sheet. The size of perforation is made as per the size of grain of a crop.
5) **Cleaning Unit:** This unit is provided to separate the grain from chaff. It further uses sub units, like aspirators or blowers, sieves and sieve shaking mechanisms to separate out grains from chaff. The thresher that is provided with aspirator unit is usually called aspirator type thresher. Those threshers fitted with blower which blows air in horizontal direction is called drummy threshers.
6) **Blower or Aspirator:** After threshing unit carries out threshing, the cleaning and separation of straw from grain is required. The fan is generally installed on the main shaft over which cylinders, flywheel and driven pulley are mounted. Fan lifts/sucks the lighter material chaff and other plant portion and throws it away from the out let. Rest of the separation-cum-cleaning is done by screen with its oscillating motion.

7) **Screen:** Most of the power threshers are equipped with two screens. Top screen is provided so as to pass the grain to second screen and chaff is taken out from it. Other screens sieve out the smaller grain or weeds seeds and delivers the cleaned grain towards outlet. The size of screen hole is selected on the basis of grain size. These screens are effective when kept under oscillation.
8) **Shaking Mechanism:** The screens are oscillated or shaken with a crank attached to the screen. This crank is powered from the main axle either by belt or by rod. The circular motion of the main shaft is converted into oscillating motion of the screen, which shakes it and separates the grain from other foreign material and chaff. The separating effectiveness depends on the frequency of strokes of crank, which is adjustable.
9) **Power Transmission Unit:** Threshers are usually powered with the tractors and sometimes with electric motors or diesel engine also. After installing the thresher into the threshing floor in the field, tractor PTO shaft is coupled with a flat pulley. A corresponding matching pulley of appropriate size is provided over to the thresher main shaft. These pulleys are connected with a proper rating of flat belt and thresher is operated. Blower fan is provided into the main shaft of the thresher, which rotates and does the required job. The screens are oscillated with the help of a v-belt and a crank wheel, powered with the main shaft of thresher. A heavy flywheel is also provided on the main axle of the thresher. It is very important part of any thresher. It is provided to store the energy to supply continuously and equally to the entire threshing cylinder. It is made up of cast iron, and fitted on one end of the main shaft of the thresher.
10) **Main Frame:** A very strong frame is provided in the thresher on which all the functional parts are attached. The frame is usually made of heavy angle iron sections. It should be strong enough to sustain vibrations of the machine, during its operation in the field.
11) **Transport Wheels:** Thresher is provided with the wheels at its legs, so that transportation can be easily done. These wheels are made mostly with cast iron but new and large capacity threshers are equipped with pneumatic wheels for better performance during the transportation.
12) **Thresher Adjustment:** The following adjustments can be done on a stationary power thresher:
    - **Cylinder and Concave Clearance:** In order to get cleaned grains and proper threshing, it is very important to set proper clearance between tip of cylinder and concave. On an average, concave clearance is kept about 25 mm at the mouth, 10 mm at the middle and 15 mm at the rear end. Start operating the thresher, by keeping proper recommended speed, and

check if any grain is left in the ears. If it is so, reduce the concave clearance gradually, until drum is threshing cleanly. Too close concave setting is likely to crack some of the grains.

- **Cylinder Speed:** The drum of the thresher should be rotated at a proper speed for better threshing and cleaning efficiency. Normally, manufacturers specify the cylinder speed for different crops. The cylinder speed can be checked using tachometer. Operator should check the speed occasionally under load for proper functioning of the thresher. The cylinder peripheral speed for wheat is kept between 1520 to 1830 m/min and for paddy between 370 to 920 m/min.
- **Fan Adjustment:** Fan(s) fitted on the thresher must provide proper amount of blast. The shutter(s) at each end of fan should be adjusted properly so that it could provide blast sufficient enough to remove chaff and light materials without grain. Watching the sample and adjusting the blast can help in getting the desired results.

A. Multi-crop Thresher

Since, the Indian farmers raise variety of crops as per the suitability of particular region, climate and soil conditions, there was need to thresh all these crops for the timelines of operation. Developing a multi crop thresher has solved this problem. It can thresh crops like wheat, moong, paddy, grain, soybean etc. For these crop requirements are different, as in the case of wheat bruised straw (bhusa) is the main requirement. For paddy, farmers need long straw. For pulses, seed damage should be minimal; as damaged seeds lower the quality and causes spoilage in storage. The crop factors such as moisture content, grain size, grain-straw ratio, condition of straw etc. influence the design consideration of main components of the threshers. The farmer is primarily interested in the end product, low cost, durable and reliable machine. The suitable multi crop threshers for cereals and pulses are commercially available in the country.

A multi-crop thresher (Fig.3.62) attains the axial movement of the crop while handling paddy and all crop material is made to move through the concave in case of wheat. The axial flow of material can be accomplished by providing seven louvers with spacing of 150 mm in the hexagonal casing. The clearance between louvers and the tip of cylinder spikes is 20 mm. For wheat threshing, the first three louvers are placed with ribbed casing and side plates are fixed with top casing and concave to prevent material flow in the second portion. The direction of rotation of threshing cylinder is opposite for wheat than paddy. That is why, straw outlet of aspirator blower is repositioned. The top sieve has holes of 9-mm diameter for wheat and 5 mm for paddy grains. The lower sieve has

holes of 1.5-mm diameter common for both the crops. The upper sieve can be changed easily depending upon crop to be threshed. The cylinder-concave clearance in the first section of threshing system (i.e., facing the feeding chute) has to be more while handling paddy than wheat. The machine output is 500 kg/h for wheat and 700 kg/h for paddy.

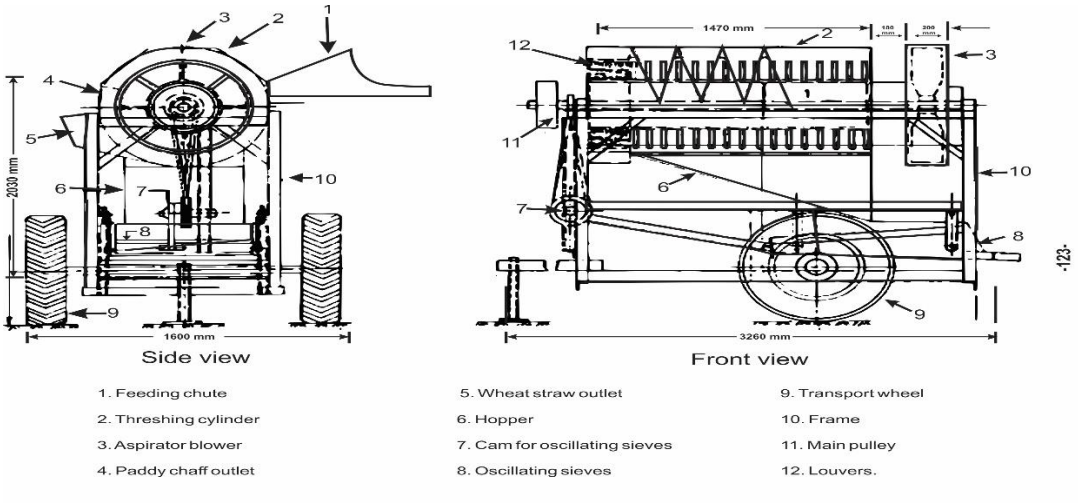


Fig.3.62: Front and side view of multi-crop thresher

4. Winnower

A winnower is device that is used for separating the grains or seed from husk or straw by blowing air. There are following types:

A. Grain Winnower: This machine winnows the paddy already threshed by a paddy thresher or by other means. It has a feeding hopper at the top to receive the threshed paddy with other impurities. It discharges the threshed paddy over a scalper and removes bigger size impurities. A blower is provided at bottom which sends a stream of air against the grain falling through the scalper, that separates the straw, chaff and other impurities. The dust, chaff and straw are collected separately and cleaned paddy is taken out through another outlet near the bottom of the unit. The capacity of unit is 625 kg/h and the unit is operated by one hp motor.

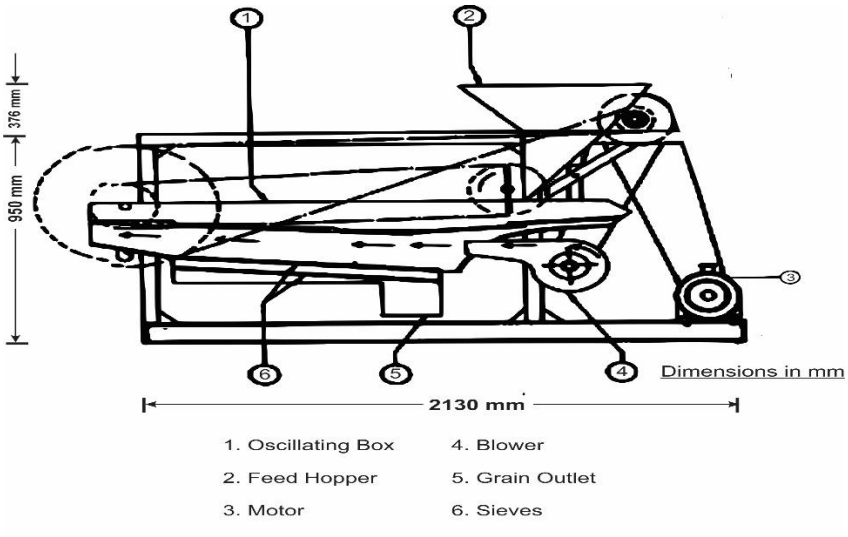


Fig.3.63: Grain Winnower

B. Paddy Winnower: The machine winnows paddy already threshed by the paddy thresher or by other means. It has a feed hopper at the top to receive the threshed paddy, chaff and straw bit. A blower is provided at the bottom that sends a stream of air which separates straw, chaff and other impurities. The dust, chaff and straw come out through an opening and cleaned paddy is taken out through another spout. The unit is continuous type and operated by one hp electric motor.

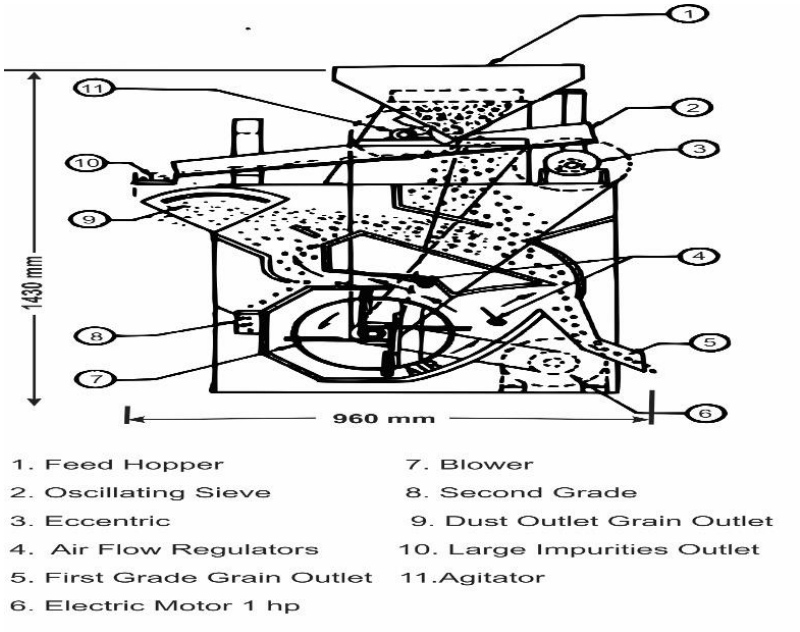


Fig. 3.64: Paddy Winnower

C. Paddy Pre-cleaner: Paddy pre-cleaner is used to remove appendages, glumes and foreign matter. The pre-cleaner is provided with an aspirator, a rotating

scalping sieve and a horizontal reciprocating grading sieve. By suitably changing the sieve, it can also be utilized for other seeds. By using the pre-cleaner, the efficiency of a cleaner cum grader is improved. It also removes both small and large size impurities and the dust from the grain. The capacity of the unit is 150 kg/h and it is operated by one hp electric motor. The efficiency of the unit is 91%.

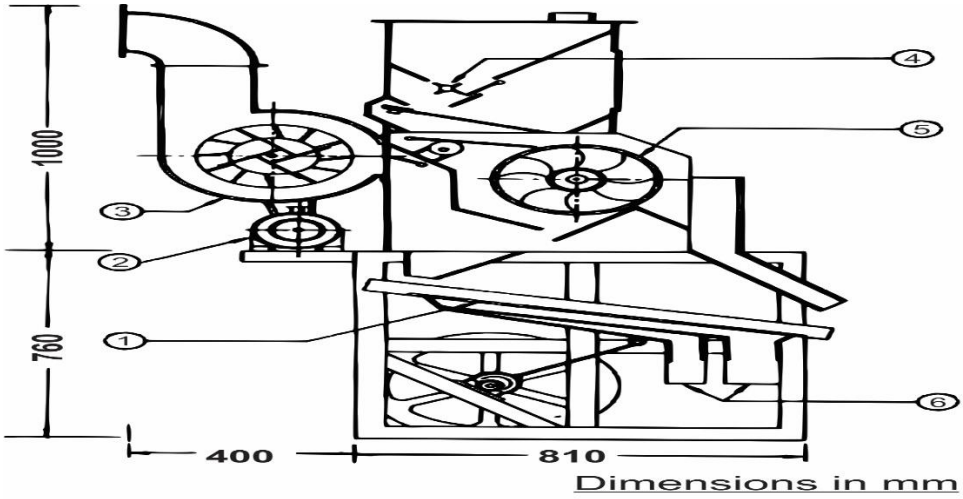


Fig.3.65: Paddy Pre-cleaner

PRACTICAL EXERCISES

Activity 01: Make a sketch of wheat thresher
Material Required:

1. Pen
2. Notebook

Procedure:

1. First, visit to agriculture field/ farm.
2. Then, identify the wheat thresher that are available.
3. Make a sketch and label it.

Activity 02: Make a sketch of Paddy pre-cleaner
Material Required:

1. Pen
2. Notebook

Procedure:

1. First, visit to agriculture field/farm.

2. Then, identify the paddy pre-cleaner that are available.
3. List out the specification.
4. Make a sketch and label it.

CHECK YOUR PROGRESS

A. Answer the following question

1. Write the basic requirement of field crops for mechanical harvesting?
2. Explain the vertical conveyer reaper?
3. Describe the constructional feature of reaper-binder?
4. Write the troubleshoot of reaper-binder?
5. Define thresher and explain functional components of thresher unit.
6. Explain winnower and their types?

B. Fill in the blank

1. A reaper-binder is a ..... implement that improved upon the simple reaper.
2. Harvesting of field crops continues to be one of the most ..... intensive operations in agricultural production system.
3. Lowering and raising of reaper is carried out with the help of ..... system of a tractor.
4. Water control in rice fields is essential to ensure that the fields are drained and relatively dry at ..... time.

C. Match the following

Column A	Column B
1. In this type of feeding device there is a hopper, placed on the top of the threshing cylinder.	A. Wire Loop Type Cylinder
2. In this type of threshing drum, there is a hollow cylinder, made out of mild steel flat.	B. Cleaning Unit
3. This unit is provided to separate the grain from chaff.	C. Feeding Hopper
4. In this type of threshing drum, there is hallow cylinder, over which a number of wooden or mild steel plates are fitted.	D. Spike Tooth Type Cylinder

UNIT 4: OPERATION SAFETY

While driving a tractor and other machinery, the driver must be well known about all rules and regulations required. Operators should also know about all operation safety using machinery and equipment.

SESSION 01: IMPORTANCE OF VALID DOCUMENTS- LICENCE, REGISTRATION, AND INSURANCE

Licence: A tractor is a crucial farm motor vehicle because it is majorly used in farm or agriculture fields. Driver must have a driving licence to drive a tractor on the farm or road. Without a driving licence, one must not drive a tractor. A driving licence is an official document, in the form of a card, which is issued by the respective State Government. It signifies that the licence holder is permitted to drive a tractor on public roads in India without the need for any supervision. The licence is a legal requirement under the Motor Vehicles Act of 1988, which states no one can drive in a public place without a driving licence issued by either the Regional Transport Authority (RTA) or the Regional Transport Office (RTO).

The process of acquiring a licence is simple. You first receive a learner's licence by passing preliminary tests based on your knowledge of road safety and traffic rules. Then you start practicing by driving a vehicle. However, people with a learner's licence shall drive a vehicle only in the presence of another individual with a permanent driving licence.

This learner's licence is like a provisional licence. It allows you to drive on the roads so that you can have sufficient practice and can then qualify for the final test to get a final driving licence.

Learning Licence:
Before you get a permanent driving licence, you will be issued a learning licence. The validity of this document is six months. It implies that you have to learn/enhance your driving within this time and proceed to take a test for a permanent driving licence.

Permanent Licence: Once you appear for a driving test and pass the exam, the RTO office will issue you a permanent driving licence. Any Indian citizen of the age 18 years old or above can apply for a permanent driving licence.

Eligibility to get an Indian Driving Licence

The law dictates the minimum age limits of getting a driving licence. A person must be a minimum of 18 years old with sound knowledge of traffic rules is required to obtain a driving license. As per law, it is necessary to hold a valid driving licence if you wish to drive a tractor on the road.

'Valid' means it should be:

1) Authentic 2) Within the expiry date

You need to get your driving licence renewed on or before the expiry date. Following are the features of a driving licence:

- It carries information about the name of the office, from where it was made and issued.
- It contains the photograph of the licence holder.
- It also carries a unique registration number.
- It contains an authorized rubber stamp and the signature of the officer-in-charge who issued the licence.

Documents needed for making Driving Licence

- For age proof, you will require a birth certificate, class 10-mark sheet, or PAN card (Permanent Account Number).
- For current address proof, you will require an Aadhaar card, electricity bill, Voter ID card, agreement of house ownership, passport, ration card.
- A duly filled application form (either online or in the RTO).
- Passport-size photographs.
- Application fees.
- Medical certificate issued by a certified physician (for people aged 40 years or older).
- Lastly and most importantly, practical knowledge of traffic rules.

Registration of tractor:

In India, it is mandatory to register your new tractor with the "Regional Transport Office" which is commonly known as RTO. It is a government organization that is responsible to keep a track of all the vehicles on Indian roads. For this purpose, every vehicle in India should be registered in the nearby RTO. Every vehicle that is registered will be given a vehicle registration card. Apart from the 'Vehicle Registration' or 'Vahan Registration', RTO is responsible for issuing driving licences, inspecting vehicle insurance, and keeping a tab of pollution created by vehicles.

The RTO assigns a permanent registration number to your vehicle that you will not be allowed to change under any circumstances. As soon as you buy the vehicle, the dealer will assign a temporary registration number which is usually valid for a month. Within one month, you should get a permanent registration number for your vehicle.

Why vehicle registration is needed?

Vehicle registration is needed for many purposes. Firstly, it proves the ownership of the vehicle. The name of the owner of the vehicle for whom the vehicle is registered as per the RTO records.

It is required if and when you decide to sell the vehicle. Without a valid registration certificate, you do not have the legal rights to sell the vehicle or transfer the ownership of the vehicle. Also, in case of an accident, you will be able to track the driver or the owner of the vehicle through the vehicle registration details. This helps people in identifying the people involved in an accident and settle claims peacefully. Transport Ministry of India keeps a track of the number of vehicles in the country and registering every vehicle helps them get the statistics right.

Registering a vehicle is not a choice but a legal requirement in our country. The Motor Vehicles Act, 1988 makes vehicle registration mandatory in our country. Registration of vehicles falls under this Act. According to the Act, a person cannot drive a vehicle that is not registered and the registration number should be displayed on the vehicle at all times.

Tractor Insurance: India is an agriculture-oriented country where more than 70% of its land is agricultural land. Agriculture, therefore, is the primary source of livelihood for most of the population of India. Tractors are an important component of the agriculture process as they help farmers in the cultivation and harvesting process. That is why tractors are very popular and in-demand among farmers and landowners who use their lands for cultivation purposes. If the tractor gets damaged, the farmers face a considerable financial loss. This is why tractor insurance policies become necessary.

Besides the need to cover financial loss, tractors are a type of vehicle that must possess a valid insurance policy on them due to the provisions of the Motor Vehicles Act. Tractor insurance policies are, therefore, compulsory for tractors. Tractor insurance policies are sold by many insurance companies. These policies fall under the commercial motor insurance policies and they offer coverage for farm or commercial tractors.

What is a tractor insurance policy?

A tractor insurance policy is a commercial motor insurance policy that covers tractors against damages suffered. There is also third-party liability coverage wherein damages caused by tractors are also compensated by the policy.
Tractor insurance plans have the following salient features:

1. Usually, a comprehensive tractor insurance policy is offered by insurance companies as a commercial motor insurance policy.
2. Insured Declared Value (IDV) i.e., the sum insured of the policy is calculated as the market value of the tractor after deducting appropriate depreciation based on the tractor's age. The sum insured is called.
3. The policy is issued for one year.

Who can buy a tractor insurance policy?

Tractor insurance policies can be bought by legal owners of a tractor, who want to secure the financial losses faced of their tractor getting damaged and also fulfil the provisions of the Motor Vehicles Act.

What is covered under tractor insurance plans?

Tractor insurance plans, under the commercial motor insurance policy section, cover the following instances of damages –

1. Damages suffered by the tractor due to natural disasters like earthquakes, lightning, road slides or landslides, floods, storms, cyclones, etc.
2. Damages suffered by the tractor due to man-made causes like fire, burglary, theft, strikes, riots, etc.
3. Third-party liability is faced, if the tractor physically hurts another individual or when the tractor damages another individual's property.
4. Personal accident covers for the owner/driver of the tractor which pays a lump sum benefit in case of accidental death and disablement.

Add-ons under tractor insurance plans: Under some tractor insurance plans, you can also find add-ons or optional coverage features. These add-ons are available at an additional premium. The common add-ons that you can choose include the following:

1. Personal accident covers for a paid driver.
2. Cover for electrical accessories of the tractor.
3. Legal liability towards paid drivers and employees.
4. Coverage for bi-fuel kit.

5. Return to the invoice where the invoice value of the tractor is paid in case of theft or total loss.
6. Protection of the no claim bonus in case of a claim.

What is not covered under tractor insurance plans?

The following instances are commonly excluded from the scope of coverage of most commercial motor insurance policies, especially tractor insurance policies:

1. Depreciation and normal wear and tear of the tractor and its parts due to usage.
2. Any type of breakdown such as electrical or mechanical.
3. Violating the limitations of using the tractor and suffering damage due to such violations.
4. Damages are suffered when the tractor is being driven without a valid driving licence.
5. Damages were suffered when the tractor was driven under the influence of alcohol or drugs.
6. Consequential losses suffered after damage.
7. Losses incurred due to war, rebellion, mutiny, and similar perils.

PRACTICAL EXERCISES

Activity 01: Make a list of documents that are required to be submitted for making a Driving Licence

Material Required:

1. Notebook
2. Pen

Procedure:

1. First, the student should visit the RTO office or their website.
2. Collect the information about the required documentation to make a driving licence.
3. List out the name of each document.

CHECK YOUR PROGRESS

A. Answer the following

1. Why do you need a Driving Licence?
2. Prepare a list of documents required to make a licence.
3. Why registration is essential?

4. Where is a tractor registered?
5. What is tractor insurance and why it is required?
6. What is covered under tractor insurance plans?
7. Prepare a list of documents required to make a licence.

B. Fill in the blank

1. A ..... is an official document, in the form of a card that is issued by the respective State Government.
2. The full form of RTA is .....
3. Medical certificate issued by a ..... (for people aged 40 years or older).
4. A tractor insurance policy is a ..... insurance policy that covers tractors against damages suffered.
5. Registering a vehicle is not a choice but a ..... requirement in our country.

C. Match the following

Column A	Column B
1. The Motor Vehicles Act, makes vehicle registration mandatory in our country.	A. Insured Declared Value
2. Full form of IDV is	B. Driving License
3. It carries a unique registration number.	C. Tractor insurance
4. This policy is known as a commercial motor. insurance policy that covers tractors against damages suffered.	D. 1988

SESSION 2: FAMILIARITY AND ACQUAINTANCE WITH THE MACHINE - UNDERSTANDING OPERATORS' MANUAL

A manual is a document that is present usually in the form of a book. It comprises instructions or information about a specific product or service.

Operator manuals help the owner to learn to efficiently run and maintain the machine or tractor by providing valuable information. If you open an operator's manual, you will find on the first few pages the manufacture of the equipment, which asks you to read the manual 'BEFORE' operating the machine. It discusses the following three most important points:

- Safety topics while operating the equipment.
- How to operate the equipment, its safety features, and controls.
- Equipment maintenance.

The manual provides information about the warranty period, date of production, and the serial number of the machine. In addition to this, it informs you whether your machine is under warranty or not. It gives knowledge with all these important details about your machine. The operator's manual serves as a guide and reference for the use of a particular tool or piece of equipment. Every user should read the manual before they start operating the machine or equipment.
The following are the most important five reasons that should always read. The 'User's Manual' of new machine or tractor:

- **Tells you how to set up your tractor:** This is the basic reason why you should read an operator's manual. You may not know everything about your tractor. This is where the operator's manual comes in handy as it will help you resolve any issues you will have with your tractor.
- **Warranty and servicing details:** The manual offers you a good idea of your warranty period, date of production, and the serial number of your machine. In addition to this, it informs you whether your machine is under warranty or not. With all these important details about your tractor, you can easily refer to it whenever you need it.
- **List of complete accessories:** With a user's manual, you will have the complete accessories that come with your tractor.
- **Tells you what not to do with your tractor:** This is very important information which the user's manual provides. It informs you of the things you must not do with your tractor. This information may feature the things that may render your warranty invalid and ways to forestall any risk. You can find this in the safety hazards section.
- **To understand the performance and limitations of the tractor:** Carefully study the Operator's Manual and learn the instructions in the manual before operating or servicing any tractor. Always Keep the Operator's Manual easily accessible. Strictly adhere to all statements and warnings delineated. Review all DANGER, WARNING, and CAUTION safety decals attached to the tractor.

Safety precautions before an operation -Pre-start checkups

1. Safety precautions before operating any tractor: To understand the performance and limitations of the tractor. Carefully study the Operator's Manual and learn the instructions in the manual before operating any tractor.

Before the Drive

- Don't start the engine while standing on the ground alongside the tractor. You must be firmly seated, brakes on, clutch pedal fully depressed, and

controls all in neutral condition, and cleaning should be maintained at the area.

- Remember, the tractor has only one single seat for the operator/ driver, no other seat is available for any other person. There is no safe place for anyone else, especially a child.
- When getting in and out of the tractor – Always use access steps and handholds. Do not jump from the seat.
- Keep mud-free - floors, doors, pedals, and boots
- Don't keep tools, drawbar pins, or top links on the floor.
- Before leaving the seat follow safe stop procedures.
- Get out facing inwards so that you have a good grip.
- Never get on or off a moving tractor.
- Avoid allowing any passenger/ child to be seated in the tractor. Always remain seated in the operator's seat while operating the tractor. Make sure that the brakes and other mechanical components are properly adjusted and do not have excessive wear. At regular intervals, check that all nuts, bolts, and screws are properly tightened or not.
- Keep the tractor clean. Dust, grease, or grass clippings accumulated on the tractor can lead to fire or injury. So, keep the tractor clean from mud and debris.
- Do not modify a tractor on your own. Modification can be harmful to the performance and safety of the tractor and lead to injury or damage.

2. List of Pre-start check-ups

Daily checklists for starting and safety in tractors are:

1. Check fuel in a fuel tank (Is there, enough fuel to complete the task?).
2. Check coolant level in the radiator, or inspect cooling fins on air-cooled models of a tractor.
3. Check tire inflation pressure (refers to owner's manual for proper inflation of front and rear tyres for each job).
4. Check the condition of the tyres. Look for cuts, crack, and buckling.
5. Check the battery, cables and terminals, and electrolyte level.
6. Check the transmission and hydraulic oil levels.
7. Check air filter elements or the oil level in an oil bath-type air cleaner.
8. Check the guards and shields to ensure that they are correctly installed and in good condition.
9. Check operator's station. Be sure that it is clear of spilled fuel, oil, grease, crop residue, or loose objects.

10. Check the lighting system and ensure “Slow Moving Vehicle Emblem” is placed.

3. Safety precautions during operation

A. On field condition – During operations on-field follow these safety precautions:

- First, check all the parts of the tractor are in proper condition.
- All systems are working in the right condition.
- Wear a well-fitted dress or dress which is comfortable.
- Wear a seat belt while driving.
- While driving a tractor without a cabin you should wear hearing protection.
- No extra people on the tractor.
- Keep children away from the tractor.
- Never be in a hurry about anything to do with your tractor.
- Before an operation, check that all the safety features are functioning correctly.
- Reduce speed before turning or applying brakes.
- Watch out for ditches, logs, rocks, depressions, and embankments.
- On steep slopes, without a trailed implement, reverse up for greater safety.
- Engage the clutch gently at all times, especially when going uphill or towing.
- When people are working in the area, keep in good communication with each other.
- Use as wide a wheel track as possible on hillsides and sloping ground.
- Descend slopes cautiously in low gear, using the brake.
- Take short breaks regularly when working long hours.
- When having tea or lunch breaks, stop and get off the tractor for a break, don’t eat, and drive on the run.
- Remain seated in the operator seat when starting a tractor engine operating the levers or controls.
- Never jump off a moving tractor or leave it with its engine running. A runaway tractor can be extremely dangerous.
- Avoid accidental contact with control pedals while the engine is running.

B. Off the field– During operations off-field follow these safety precautions:

- First, follow the operation manual.
- Follow road safety instructions.
- The driver knows the rules and signs.
- Wear a well-fitted dress.

- Wear a seat belt while driving.
- Stay children away from the tractor.
- No extra person should be seated in the tractor.
- While driving a tractor without a cabin you should wear hearing protection.
- Before starting the engine, ensure that all the levers are in the N (neutral) positions, the parking brake is engaged securely, and the Power Take-Off (PTO) switch is in the OFF position.
- For proper control over the tractor while driving you should have to adjust the seat according to your need. That provides effective and comfortable work.

PRACTICAL EXERCISES

Activity 01: Make a list of Pre-start check-ups of a tractor

Material Required:

1. Notebook
2. Pen

Procedure:

1. First, the student should read the operation manual for pre-start check-ups of a tractor.
2. Write the down step by step pre-start check-ups.

CHECK YOUR PROGRESS

A. Answer the following

1. What is the operator's manual and mention its importance in driving?
2. What precautions one should take before operating a tractor?
3. List out the pre-start check-ups.
4. What are the safety precautions of a tractor before operating a tractor?
5. What are the safety precautions during operation on-field and off-field?

B. Match the following

1. It helps the owner, in which valuable information has been given about the machine or tractor.	A. Manual
2. A document, which is present usually in book form, with instructions or information about a specific product or service	B. Power Take-Off
3. Full form of PTO is …….	C. Operation manual

SESSION 3: TRACTOR DRIVING PRECAUTIONS DURING OPERATIONS IN HILLY TERRAIN/EMBANKMENTS/ BUNDS/DITCHES

Driving a tractor through hilly terrain, embankments, bunds, and ditches is extremely difficult for any driver. To avoid a tractor rollover, the driver must be cautious when driving in rough terrain or tough areas. As a result, the tractor driver needs to be well-trained.

Understanding a Tractor Rollover

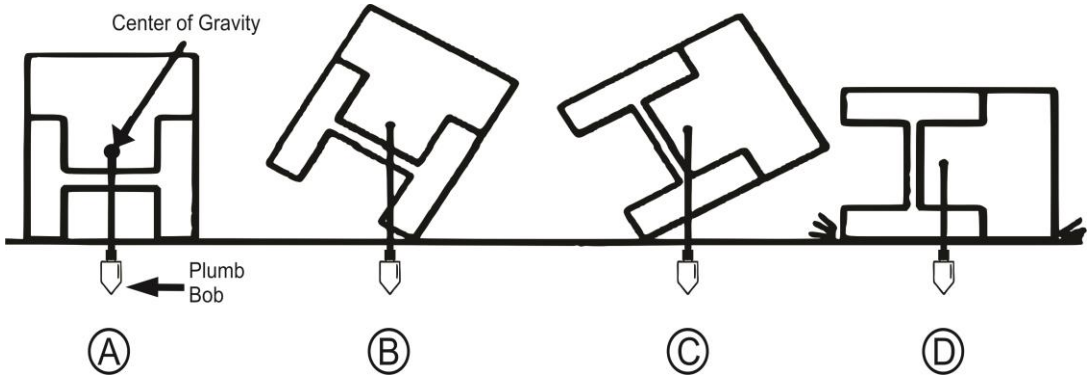


Fig.4.1: Sketch of tractor rollover

- Be familiar with the terrains and drive safely. Use caution on slopes, slow down at all turns.
- Most tractor accidents are caused due to overturning (mostly sideways). They are usually caused by high speed or inattention.
- Remember that rollover because of overturning can happen on flat ground as well as on the slopes.
- In the event of an overturn stay on the seat - do not try to jump out.
- Sideways rollover and backflips account for most of all rollovers.
- Sideways rollovers occur most commonly while traversing a steep slope or cornering too sharply at speed.
- To understand the sideways rollover, we need to understand the relationship between the tipping axis of the tractor and its centre of gravity together with the amount of centrifugal force developed during cornering.
- The tipping axis is the line that a tractor will pivot about during tipping, if driven over a steep enough slope. Once the centre of gravity, usually located in the vicinity of the gearbox in the midline of the tractor, lies outside the tipping axis, a rollover is inevitable.
- Gravity and centrifugal force are the two major forces involved in a sideways rollover.

- Centrifugal force is introduced when a tractor is cornering. This force tends to pivot the tractor on its outside wheels during cornering. This predisposes the tractor to roll over.
- Backflips are produced through rear axle torque and drawbar leverage.
- If axle rotation is prevented like in any case where the tyres are stuck (e.g., if bogged, frozen to the ground, or if the load is very heavy), the rotational force moves the tractor backward around the rear axle, lifting the front wheels off the ground and a backflip can happen.
- Drawbar leverage describes the force which tends to pull the tractor rear-wards when it is towing or pulling an object.
- The magnitude and its effect on tractor stability will vary according to several factors including the weight, draft, hitching point used, resistance to movement, and angle of pull.

Working/ Driving on Hillsides:

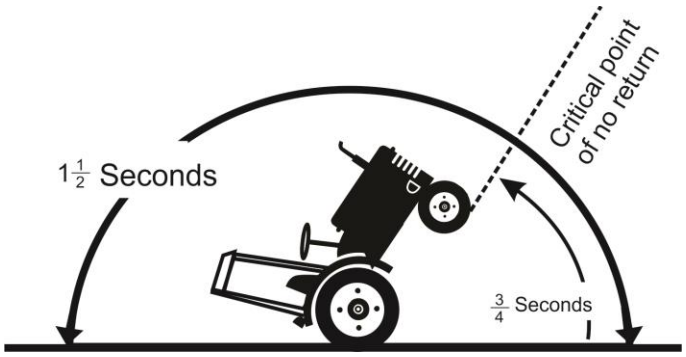


Fig.4.2 (a): Time frame involved with tractor rollover

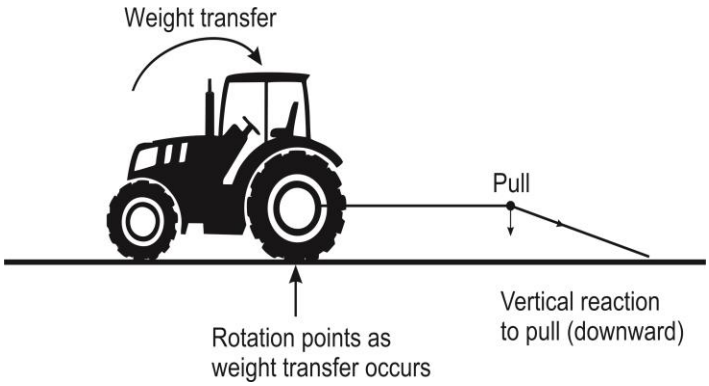


Fig.4.2 (b): Force involved in the angle of pull

Driving on narrow or raised tracks or roads poses a risk of the tractor rolling over embankments and injury to the operator.

- Avoid working across slopes if the tractor has a large diameter, tubeless, low ground-pressure tyres.

- Use caution on slopes and uneven ground. Drive at a speed slow enough to keep complete control of the tractor at all times.
- If there is not enough room for a gradual turn, use a slow three-point turn.
- Don't depress the clutch pedal or attempt to shift gears while going down a slope. And while going up a slope, it is best to back up. Make sure that tractor is properly counterbalanced.
- Although a tractor can be driven up a slope with a hard surface, it cannot necessarily come down the same slope safely.
- Add front-end weights to a tractor pulling a heavy load up a hill when working on mild slopes.
- Always descend straight down the gentlest possible gradient of a slope, rather than driving diagonally across it.
- Avoid turning down a slope - this is especially hazardous.
- Plan work across slopes so that turns are made uphill rather than downhill.
- Use the widest practicable wheel track setting to reduce the likelihood of the tractor overturning.
- Do not park with a heavy load on a steep slope - Try to park on level ground, especially when loading and unloading.
- Agricultural tractors will easily tip to the rear when the rear wheels cannot rotate enough to move the machine forward.

Working/ Driving in bad weather:

- In rainy weather, stay alert and look for holes or ditches hidden underwater.
- Cut the speed to the minimum.
- If it's a thunderstorm, stop. Stay away from large trees and get indoors.
- In icy conditions, use extreme caution.
- Use tire chains and wheel weights.
- If in doubt, walk the ground before driving over it to check for hollows, hidden logs, tree stumps, rock outcrops, rabbit holes, etc.
- Drive slowly where the ground surface is not easily seen, e.g., in long grass, large ferns, etc.
- Keep away from banks and ditches, especially when turning - avoid driving too close to the edge of road side ditches or slopes.

Driving precautions during trolley operations:

Trolleys: Tractors often pull wheeled trolleys using a drawbar with a clevis hitch or a fitted tow ball. Tractors can rear up and roll over backward if they are used with trailers connected to a high hitch point. Accidents happen while steering on slopes or slippery surfaces with poor trailer brakes. Because it pushes the tractor sideways, causing it to slide out of control. Excessive wear can also be placed on the tractor's brakes.

Safety guidelines during tractor-trolley use:

- Don't use intoxicants while operating.
- Don't make adjustments when the tractor is in operation.
- Don't put or take off the belt while the pulley is running.
- Don't sit or stand at unsafe places such as drawbar, mudguard, load, etc. when the tractor is moving.
- No person should mount or dismount from a tractor while it is in motion, except in an emergency.
- Don't wear loose clothes, shoes, etc.
- Put the gear, power take-off to neutral, and lower the attached implements to the ground before leaving the stopped tractor.
- Lock the brake pedals together when traveling on public roads.
- Stop at all unguarded railway crossings and make sure that no train is coming.
- The operator should use a seat belt when operating a tractor fitted with ROPS (rollover protection system) or cabin. It is strongly recommended that no seat belt be used if ROPS or cabin is not provided.
- To avoid sideway overturning of the tractor, special care should be taken during driving at sharp slope, uneven, soft, or slippery ground, alongside ditches or banks, during turning or reversing.
- To avoid tipping backward, special care should be taken while driving heavy loads on a slope, soft ground, ditches, or uneven ground. If necessary, the front of the tractor should be fitted with dead weights.
- When traveling on public roads, keep on the correct side of the road. Use light signals to turn, stop or slow down.
- While transporting farm produce, a trailer should not be overfilled or overloaded.
- Use the rear-view mirror at a properly adjusted angle.

Use Slow-Moving Vehicle

Slow-moving vehicle: A slow-moving vehicle (SMV) is a vehicle operated on a street or highway at speeds slower than that of other motorized traffic. The term "slow-moving vehicle" is generally applied to equipment and vehicles such as farm equipment including tractors, construction equipment, and trucks, and towing trailers, or any such vehicles which cannot operate above a specified speed.

Slow-Moving Vehicle Emblem: The slow-moving vehicle (SMV) emblem shows a fluorescent orange triangle with "retroreflective" borders. It warns the approaching motorists to slow down. Additionally, SMV emblems are required on other specific vehicles, including horse-drawn vehicles. Some vehicles have trouble keeping up with the speed of traffic. Look for these vehicles and adjust the speed before reaching them. Slow-moving vehicles may have an orange triangle on the back as shown in Fig.4.3.

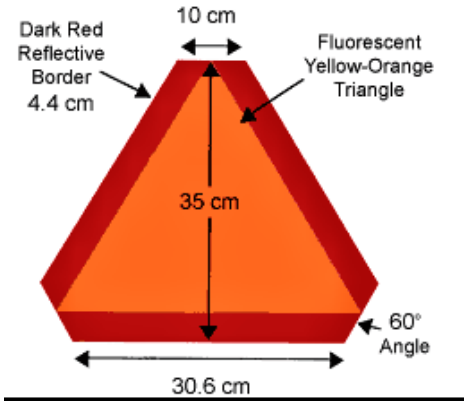


Fig.4.3: Slow Moving Vehicle Emblem

This sign is a warning to slow down. Do not get impatient if you are behind one of these vehicles. The driver will usually try to pull over to the side of the road whenever possible to prevent traffic back-ups. Farm tractors, animal-drawn carts, and road-maintenance vehicles are not designed for high-speed travel and move slowly. Watch for large trucks and small, underpowered cars, and be patient, especially on long or steep hills where they lose speed. Also, when entering traffic, these vehicles take longer.

Farm tractors, animal-drawn carts, and road-maintenance vehicles are not designed for high-speed travel and move slowly. Watch for these vehicles and be prepared to adjust the speed according to them.

a. General rule: All implements of husbandry and special mobile equipment designed to operate at 25 miles per hour or less – (i) When traveling on

highway (ii) All animal-drawn vehicles (iii) Display on the rear of the vehicle a reflective slow-moving vehicle emblem as specified in regulations of the department.

The use of the slow-moving vehicle emblem shall be in addition to any other lighting devices or equipment required by this title.

b. Limitations on use or display: No person shall use or display the slow-moving vehicle emblem except as provided in this section nor shall any person display the emblem on a vehicle traveling at a speed more than 25 miles per hour.

c. Towed vehicles: The emblem shall be required to be displayed on a slow-moving vehicle that is being towed on a highway unless the towing vehicle displays the emblem in such a manner as to be visible from the rear.

All motorists should decrease their speed around slow-moving vehicles bearing an orange warning sign. You should also keep in mind that these vehicles take longer to accelerate when entering a stream of traffic and will lose speed on long or steep.

PRACTICAL EXERCISES

Activity 01: Draw a tractor rollover figure step by step.

Material Required:

1. Notebook
2. Pencil
3. Eraser
4. Sharpener

Procedure:

1. First, the student should know about tractor rollover.
2. Then, identify the rollover figure.
3. Draw the figure step by step about tractor rollover.

Activity 02: Draw a slow-moving vehicle emblem.

Material Required:

1. Notebook
2. Pencil
3. Eraser
4. Sharpener

Procedure:

1. First, the student should know about the slow-moving vehicle emblem.
2. Then, identify the slow-moving vehicle emblem.

3. Draw the figure slow-moving vehicle emblem.
4. Label the measurement specification of the emblem.

CHECK YOUR PROGRESS

A. Answer the following

1. What is the roll-over of a tractor on the hillside?
2. What are the safety precautions during tractor operation on hilly terrain?
3. What is a slow-moving vehicle emblem?
4. What does a slow-moving vehicle emblem look like?

B. Fill in the blank

1. ..... and ..... force are the two major forces involved in a sideways rollover.
2. Backflips are produced through ..... torque and drawbar leverage.
3. The .....emblem shows a fluorescent orange triangle with "retroreflective" borders.

C. Match the following

1. Slow-moving vehicle emblem sign	A. 4.4 cm
2. In the slow-moving vehicle emblem, the dark red reflective side is.....	B. 25 miles per hour
3. All implements of husbandry and special mobile equipment designed to operate at	C. 

SESSION 4: AWARENESS ABOUT TRAFFIC RULES AND SIGNS

Knowing the meaning of the traffic sign is the basic knowledge that every driver should have. If you are new to the traffic sign system, read this to know all the traffic signs and their meanings in India.

The sign is a language using visual images to communicate specific meanings across without words or sounds. People can interpret the meanings of signs within seconds without paying too much attention. For this reason, signs are universally used in traffic as a way to communicate traffic rules, guides to the road-users. Being able to tell the meanings of the traffic signs is one of the key skills for all road users, be it the driver or the pedestrian. Therefore, knowing the meaning of traffic signs is one of the criteria for drivers to gain a licence.

Fig.4.4: Traffic Signs

What are the types of traffic signs in India?

In India, the traffic signs are categorized into three major groups, which are - regulatory signs, warning signs, and informative signs.

a. **Regulatory sign**: Most signs under this category come with a round shape. Some of them feature a red border inside with a black symbol on white background, while some others can be depicted in blue circles with white symbols within. These regulatory or mandatory signs indicate rules that should be followed strictly. Otherwise, the driver will be punished and receive a challan for their violation. Not following these signs might affect the traffic flow and cause a serious accident. Refer to table 2.5 to understand in detail.
b. **Cautionary sign:** The signs of this category are usually depicted with the red triangular border with smaller black graphics inside. These signs give warning to the road users about the potential dangers ahead. For example, turn and curve warnings, lane transition warnings, and pedestrian crossing warnings. Even though, there is hardly any regulation or penalty levied on not following them. These signs have a crucial meaning to people's safety. When seeing

these warning signs, a driver should pay more close attention and get prepared for the situation. Refer to table 2.6 to learn all the cautionary signs.

c. **Informatory sign:** While the other two types of signs have a particularly important meaning for the safety of the road users, the third category includes signs that provide information regarding the destinations, distance, fuel stations, and other locations. Observing these signs will help you navigate through the complicated traffic system.

What are the meanings of shapes and colours in traffic signs in India?

Images are represented in shapes and colours. These are also two major factors that play a vital role in communicating the meaning of signs. Knowing the meanings of the colour and shape used will also help you to remember the meaning of the sign in a systematic and organized way. In some cases, the drivers might not see the images clearly due to the heavy fog or snow and drivers can only capture the shapes and the colour of the sign. So, knowing the meaning of the colours can shapes will be very helpful.

Fig.4.5: Stop signboard

Sign Shapes

- **Round shape:** As mentioned above the round shapes are mostly used for the regulatory signs. Whenever any sign of this shape is seen, one shall pay attention without fail. Follow these signs accordingly or else a fine will be levied for any violation.
- **Triangle shape:** Triangular shape is mostly used for cautionary signs. Whenever you see a sign in a triangle shape, drive more carefully and pay close attention to the road ahead. However, there is one triangle sign that belongs to the regulatory sign groups. It is the “Give Way” sign with an upside-down triangle shape.
- **Octagon shape:** This sign is used exclusively for the stop sign. Due to this exclusivity, you will hardly notice any other signs using this shape for other meanings.

- **Rectangular sign:** Rectangular is used for informational signs. While navigating toward a specific destination, pay attention to the rectangular signs.

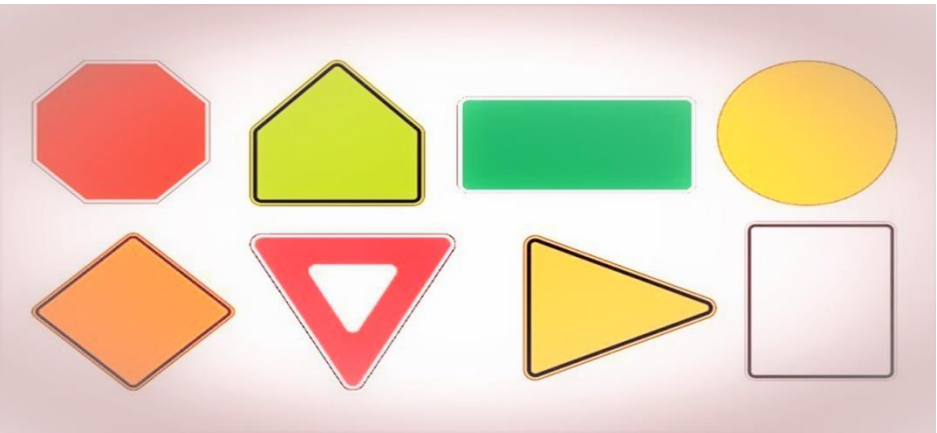


Fig.4.6: Shapes of Traffic Sign

Sign Colours

- **Red:** Red is usually associated with danger. The use of red in traffic signs usually indicates compulsory rules and possible dangers. When it comes to traffic lights, it means that you have to stop. For traffic signs, the red colour can be used to indicate other meanings rather than stop. It is usually used for Regulatory and cautionary signs. Never skip a red traffic sign.
- **Yellow:** Yellow is also one of the three colours used for traffic lights. However, in the traffic sign, you will see less yellow than red or green. In most cases, it suggests the vehicles slow down or be more cautious.
- **Green:** Green is usually used for informative signs which give you directions or a guide to a particular destination. Mostly, green signs will give you information regarding the distance toward a destination.
- **Blue:** Blue colour with a rectangular shape is mostly used to indicate a destination nearby. The combination of blue colour and round shape are usually used for regulatory signs. In most cases, these signs require you to take a turn.

Table.4.1: Traffic Sign Colours

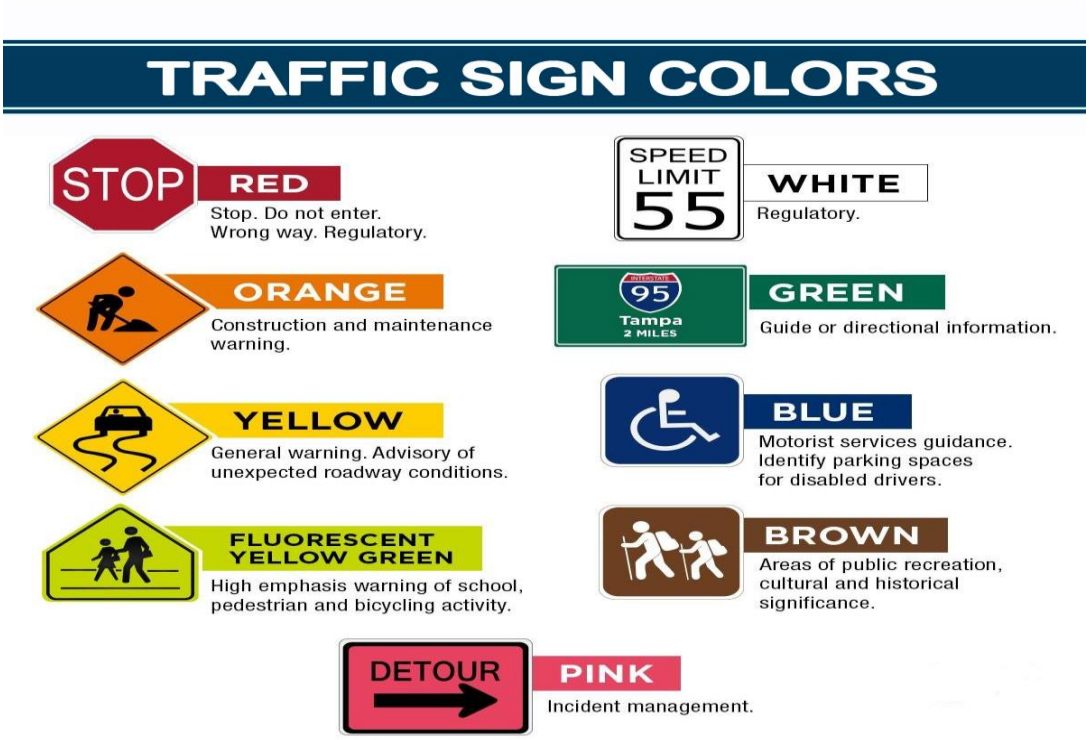
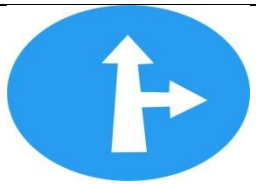
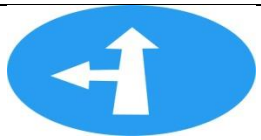


Fig.4.7: Traffic sign colours

List of Indian traffic signs with their meanings

Table. 4.2: Regulatory Signs

Traffic Signs	Name	Meaning
	"Stop"	This sign means the driver must stop.
	"Give Way"	This sign reminds drivers to give way to right-side drivers.
	"Vehicles Prohibited in Both Directions"	This sign suggests the area ahead is blocked from both sides.
	"Right Turn Prohibited"	This sign directs the driver to not take the right turn.

	"Left Turn Prohibited"	This sign directs the driver to not take the left turn.
	"U-Turn Prohibited"	This sign directs the driver to not take the right turn.
	"Overtaking Prohibited"	This sign indicates that overtaking is not allowed.
	"Horn Prohibited"	This sign shows that drivers should not honk and keep silent when driving through a particular area.
	"No Parking"	Parking in a designated area is not allowed.
	"Speed Limit"	The driver should not surpass the speed mentioned on the Speed Limit sign.
	"Compulsory Turn Left"	The sign indicates that one should turn left.
	"Compulsory Ahead"	The sign indicates that one should go in a straight direction.
	"Compulsory Right Turn"	The sign indicates that one should turn right.
	"Compulsory Ahead or Turn Right"	This sign indicates to either go straight or turn right.
	"Compulsory Ahead or Turn Left"	This sign indicates to either go straight or turn left.

	"Compulsory Sound Horn"	This sign indicates that you must use the horn to alert the oncoming traffic.

Table.4.3: Cautionary Signs

Traffic Signs	Name	Meaning
	"Right-Hand Curve"	It notifies about a right-hand curve on the way ahead.
	"Left-Hand Curve"	It notifies about a left-hand curve on the way ahead.
	"Right Hair Pin Band"	This sign is usually seen on hilly roads with sharp turns. It indicates there's a sharp right turn ahead.
	"Left Hair Pin Band"	This sign will warn you about a sharp left turn ahead.
	"Right Reverse Band"	This sign indicates the same Z-shaped formation of the road ahead towards the right. When seeing this sign, the driver should reduce speed.
	"Left Reverse Band"	This Z-shaped sign gives road users a warning about the same Z-shaped formation of the road ahead towards the left.
	"Steep Ascent"	This sign gives you a warning about the steep upward slope.
	"Steep Descent"	This sign is usually found on hilly roads with a steep downward slope.

	“Narrow Road Ahead”	This sign indicates a narrow road ahead.
	“Road Widens Ahead”	This sign indicates the widening of the road ahead.
	“Narrow Bridge”	This sign indicates that there’s a narrow bridge ahead.
	“Slippery Road”	This sign gives road users a warning about the slippery road ahead.
	“Loose Gravel”	This sign is usually seen on the hilly area where there’s a possibility of loose earth or gravel keeps on falling.
	“Cycle Crossing”	This sign will warn the driver that a cycle path is crossing a major road
	“Pedestrian Crossing”	This sign indicates that there's a crossing for pedestrians. After seeing this sign, the driver should either slow down or stop the vehicle and let the pedestrian cross the road first.
	“School Ahead”	This sign indicates that there is school ahead.
	“Men at Work”	This indicates that people are working or doing repairs ahead on the road.
	“Cattle”	This sign indicates that there might be cattle straying on the road.

	“Falling Rocks”	This sign gives a warning about the falling of rocks ahead.
	“Cross Road”	This sign suggests that there is a crossing of two roads ahead.
	“Gap in Median”	This sign suggests there is a provision of a U-turn ahead.
	“Side Road Right”	This sign indicates, that there is a right side turn along with a straight way ahead.
	“Side Road Left”	This sign indicates, that there is a left side turn along with a straight way ahead.
	“Y-intersection”	This sign suggests that there is a Y-shaped formation ahead.
	“Staggered Intersection”	This sign is placed where both left and right turns are closely located on the straight road.
	“T-Intersection”	This sign suggests that there’s a T intersection on the road. It means that you cannot drive straight ahead.
	“Major Road Ahead”	This sign notifies of a major crossroad ahead.
	“Round About”	This sign can be used as a substitute for a road crossing.

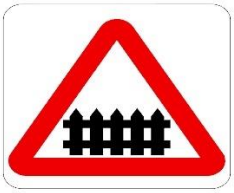
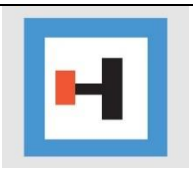
	"Dangerous Dip"	This sign suggests there is a dip ahead on the road.
	"Hump or Rough Road"	This sign suggests that there is a hump or rough road ahead
	"Unguarded Level Crossing"	This sign indicates that there is a railway crossing ahead
	"Guarded Level Crossing"	This sign indicates that a railway crossing ahead is guarded by a person.

Table. 4.4: Informatory Signs

Traffic Signs	Name	Meaning
	"Public Telephone"	This sign indicates that there is a telephone service ahead.
	"Petrol Pump"	This sign suggests there is a petrol pump on the way ahead.
	"Hospital"	This sign suggests there is a hospital ahead.
	"First Aid Post"	This sign indicates the first aid facility ahead.
	"Eating Place"	This sign indicates a food facility ahead.

	"Light Refreshment"	This sign suggests there is a light refreshment ahead.
	"No Thorough Road"	This sign suggests there is no exit ahead.
	"No Thorough Side Road"	This sign is placed when there is a no-thorough side road on the main road.
	"Park This Side"	This sign suggests there is a place where you can park the vehicle.
	"Parking Scooters and Motorcycles"	This sign suggests there is parking space for scooters or motorcycles.
	"Parking Lot Cycles"	This sign suggests there is parking space for bicycles only.
	"Parking Lot Cars"	This sign indicates that the parking space is for cars only.
	"Resting Place"	This sign suggests there's a motel or a lodge nearby.

PRACTICAL EXERCISES

Activity 01: List out the regulatory sign with a neat sketch
Material Required:

1. Notebook
2. Pen
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, the student should visit the RTO office.
2. Identify the regulatory sign at the office.
3. Note down their name and detail.
4. Draw the figure of the regulatory sign.

Activity 02: List out the cautionary sign with a neat sketch.

Material Required:

1. Notebook
2. Pen
3. Pencil
4. Eraser
5. Sharpener

Procedure:

1. First, the student should visit the RTO office.
2. Identify the cautionary sign at the office.
3. Note down their name and detail.
4. Draw the figure of the cautionary sign.

CHECK YOUR PROGRESS

A. Answer the following

1. Define the traffic sign?
2. What are the types of traffic signs in India?
3. What are the meanings of shapes in traffic signs in India?
4. What are the meanings of colours in traffic signs in India?
5. List out the informatory signs.

B. Fill in the blank

1. The ..... is a language using visual images to communicate specific meanings across without words or sounds.
2. ..... shape is mostly used for cautionary signs.
3. Green colour is used for .....which give you directions or a guide to a particular destination.
4. ..... sign shows that driver should not horn and keep silent when driving through a particular area.

C. Match the following

Column A	Column B
1. "One Way" suggests that the vehicles must go in a single direction.	A. 
2. Right turn prohibited sign indicate that the driver does not take the right turn.	B. 
3. This sign indicates the first aid facility ahead.	C. 
4. This sign suggests there is a dip ahead on the road.	D. 
5. This sign suggests there is no exit ahead.	E. 
6. This sign is placed where there are left and right turns are closely located on the straight road.	F. 

SESSION 5: GENERAL SAFETY RULES WHILE OPERATING A TRACTOR

Operating a Tractor: Tractors are the main cause of accidental deaths on farms. Over the years, many farmers, farm-workers, and others living on or visiting farms, have been killed or seriously injured after falling from moving tractors, being run over by tractors, or being crushed when a tractor rolls sideways or backward.

While operating a tractor:

- Drive at a speed slow enough to retain control over unexpected events.
- Reduce speed before turning or applying brakes.
- Watch out for ditches, logs, rocks, depressions, and embankments.
- On steep slopes, without a trailed implement, reverse up for greater safety.
- Engage the clutch gently at all times, especially while going uphill or towing.
- Use as wide a wheel track as possible on hillsides and sloping ground.

- Descend slopes cautiously in low gear, using the motor as a brake.
- Never mount or dismount from a moving tractor.
- Ensure the parking brake is on and operating effectively before dismounting.
- Take short breaks regularly when working for long hours.

While towing implements:

- Fit attachments according to the manufacturer's instructions.
- Always attach implements to the drawbar or the mounting points provided by the manufacturer.
- Never alter, modify or raise the height of the drawbar unless provided for by the manufacturer.
- Regularly check safety pins on towed left-wing implements, to ensure they are not worn.
- Ensure all guards on towed implements are in place before operating.
- Never hitch above the centreline of the rear axle, around the axle housing, or to the top link pin.
- Never adjust or work on implements while they are in motion.
- Never attach implements unless the PTO shaft is guarded.
- When parking, always lower the three-point linkage and towed implement.

To avoid strain injury:

- Adjust the tractor seat for back support and comfort.
- When buying a tractor, ensure seating is safe and comfortable.
- Check seat height, seat depth, backrest height, and angle, fore and aft movement, seat tilt, firm padding, partial pivoting (if you have to spend long periods looking behind you), and vibration-absorbing suspension.
- Dismount every hour or so, and spend 5 or 10 minutes doing something active.
- Plan for your next tractor to include suitably low steps, handgrips, adequate doorway and cab space, and a safe mounting platform.
- Dismount by climbing down - not jumping down - and use each provided foot and handhold.

Safety tips to avoid tractor tragedies: Tractor-related accidents are still the top causes of farm injuries and deaths. While tractors are your farm's workhorse of choice, they're still the leading source of work-related injuries and farm work fatalities. Minimize those risks with these top 10 tips for tractor safety:

- **Match the operator to equipment:** Consider a person's size, experience, and decision-making ability relative to the size and sophistication of the tractor and attached machinery.

- **One tractor seat equals one person:** There's no safe childcare location on a tractor. Extra riders compromise operator attention to detail and decision-making.
- **Have a rollover protection system:** The safest tractor has a ROPS with an enclosed cab. The second safest tractor has a four-post ROPS. The third safest has a two-post ROPS. There is no fourth safest.
- **Stay in the protective zone:** That means on the seat and using the seat belt.
- **Keep up good maintenance:** Your checklist should include brakes, guards, hazard decals, signals, lights, and all other safety devices.
- **Take preventive measures to avoid slips, trips and falls:** Don't be in a hurry. Use handholds, steps, and three-point mounting/dismounting procedures.
- **Avoid side rollovers:** That means clearly understanding the principles of center of gravity and centrifugal force on slopes and hillsides.
- **Avoid rear overturns:** Understand the principles of rear-axle torque and how quickly it can happen. Hitch only to the drawbar.
- **Keep PTO guards in place:** Make a rule to never use an implement missing a guard.
- **Limit mixing tractors and vehicular roadway traffic:** When possible, travel at off-peak times. If you must be on the road, use clean, highly reflective slow-moving vehicle emblems, turn signals, flashing lights, and escort vehicles. When possible, pull off and let traffic pass. By motioning another driver to pass around your tractor and equipment, you assume responsibility for their actions.

Safety precaution while operating thresher, chaff cutter

1. Safe use of Threshers: The crop is fed manually into these machines through a feeding chute. It has been observed that human factors such as inattentiveness, un-skillfulness, overwork, and physical incapability, wearing of loose clothes, hand-wears, and use of intoxicants are mainly responsible for about 73% of accidents. The machine factors such as the improper design of feeding systems, sub-standard material, and defective design contribute to about 13% of accidents. Crop factors such as the feeding of ear-heads, short crop stalks, and wet crops contributed about 9% of accidents whereas inadequate light, crowded surroundings, and slipping on the threshing yard contributed to about 5% of accidents. The threshing accidents can be minimized provided the farmers adopt the following measures:

- The farmer should buy only those threshers, which are fitted with safe feeding chutes as per B.I.S standards. For safety, the minimum length of the

feeding chute should be kept 90 cm, covered upto a minimum of 45 cm, and inclined to the horizontal at an angle of 5-10 degrees. The angle of the covered portion with the base length of the feeding chute should be kept equal to 5 degrees.

- Employ only skilled and trained workers for feeding the crop to the thresher.
- Avoid feeding ear-heads without stalks as it may lead to serious hand injuries. Similarly, the feeding wet crop should also be avoided which otherwise might lead to fire accidents.
- Avoid talking while working on the thresher. Do not work on thresher under the influence of alcohol or any other intoxicants. Do not work on thresher for more than 8 hours or when feeling tired. Do not wear loose clothes, a wristwatch, and bangles while working on the thresher.
- Ensure proper lighting in case the machine is to be operated at night; other poor visibility may lead to accidents.
- Keep the workplace and surrounding of thresher free of all kinds of obstructions.
- Do not smoke or light a fire near the threshing yard.
- Do not cross over the flat belt or move near it.
- Keep a first aid box handy for use in the event of need.

2. Safety Precautions in Power Chaff Cutters

- Do not wear a loose dress, bangles, watch, etc., while working.
- Do not smoke and light a fire near dry fodder being cut.
- Do not work under the influence of intoxicants.
- Children and aged persons should be discouraged from working.
- Use pushing device for feeding.
- Put the cover on the blade and lock the flywheel after completing the work.
- Never bring hand near feed rolls and open blade.
- Do not touch the belt while the pulley is running.

A plate having a 'Danger Signal' shall be rigidly fixed near the blades of the chaff cutter. Each chaff cutter shall be provided with an operator's manual in which all safety aspects are also to be highlighted along with the precautions to be taken for the safe operation of the chaff cutter.

Safety precaution while operating plant protection equipment

Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. 'NEVER' eat, smoke, drink, or chew while using pesticides. Provide emergency medical care 'IN ADVANCE' as required by regulation. Plant Protection

Equipment (PPE): These types of equipment are used to apply insecticides, pesticides, herbicides to the crops to protect from insect pests, and plant diseases. The most common types of equipment are sprayers and dusters,

Safe use of pesticides and equipment:

1. While purchasing
2. During storage
3. While Handling
4. While preparing spray solution
5. Selection of equipment's
6. While applying spray solution
7. After spray operation

Table No.4.4: Instruction for safe use of Pesticide and equipment

Do's	Don'ts
While Purchasing • Purchase pesticides/biopesticides only from Registered pesticide dealers having valid Licence. • Purchase only just the required quantity of pesticides for a single operation in a specified area. • See approved labels on the containers/packets of pesticides. • See Batch No., Registration Number, Date of Manufacture/ Expiry on the labels. • Purchase pesticides well packed in containers.	**While Purchasing** • Do not purchase pesticides from footpath dealers or un-licenced people. • Do not purchase pesticides in bulk for the whole season. • Do not purchase pesticides without an approved label on the containers. • Never purchase expired pesticides. • Do not purchase pesticides whose containers are leaking/loose/ unsealed.
During Storage • Store the pesticides away from house premises. • Keep pesticides in original containers. • Pesticides/weedicides must be stored separately. • Where pesticides have been stored, the area should be marked with warning signs.	**During Storage** • Never store pesticide in house premises. • Never transfer pesticides from the original to another container. • Do not store insecticides with weedicides. • Do not allow children to enter the storage place.

• Pesticides are stored away from the reach of the children and live stocks. • The storage place should be well protected from direct sunlight and rain	• Do not allow children to enter the storage place. • Pesticides should not be exposed to sunlight or rainwater.
While Handling • Keep pesticides separate during transportation. • Bulk pesticides should be carried tactfully to the site of application.	**While Handling** • Never carry/transport pesticides along with food/fodder/other eatable articles. • Never carry bulk pesticides on the head, shoulder, or back.
While Preparing spray solution • Always use clean water. • Use protective clothing viz., hand gloves, face masks, cap, apron, full trouser, etc. to cover the whole body. • Always protect your nose, eyes, ears, hands, etc. from a spill of spray solution • Read instructions on pesticide container labels carefully before use. • Prepare the solution as per requirement. • Granular pesticides should be used as such. • Avoid spilling pesticides solutions while filling the spray tank. • Always use the recommended dosage of pesticide. • No activities should be carried out which may affect your health.	**While Preparing spray solution** • Do not use muddy or stagnant water. • Never prepare spray solution without wearing protective clothing. • Do not allow the pesticide/its solution to fall on any body parts. • Never avoid reading instructions on the container's label for use. • Never use left-out spray solution after 24 hours of its preparation. • Do not mix granules with water. • Do not smell the spray tank. • Do not use overdose which may affect plant health and the environment. • Do not eat, drink, smoke, or chew during the whole operation of pesticides.
Selection of Equipment's • Select the right kind of equipment. • Select right-sized nozzles. • Use a separate sprayer for insecticides and weedicides.	**Selection of Equipment's** • Do not use leaky or defective equipment. • Do not use defective/non-recommended nozzles. Do not blow/clean clogged nozzles with a

	mouth. Instead, use a toothbrush tied with a sprayer. • Never use the same sprayer for both weedicides and insecticides.
While applying spray solutions • Apply only recommended dose and dilution. • Spray operation should be conducted on a cool and calm day. • Spray operation should be conducted on a sunny day in general. • Use recommended sprayer for each spray. • Spray operation should be conducted in the wind direction. • After spray operation, the sprayer and buckets should be washed with clean water using detergent/soap. • Avoid the entry of animals/workers in the field immediately after spray.	**While applying spray solutions** • Never apply over-dose and high concentrations than recommended. • Do not spray on a hot sunny day or strong windy conditions. • Do not spray just before rains and immediately after the rains. • Emulsifiable concentrate formulations should not be used for spraying with a battery-operated ULV sprayer. • Do not spray against the wind direction. • Containers and buckets used for mixing pesticides should never be used for domestic purposes even after thorough washing. • Never enter the treated field immediately after spray without wearing protective clothing.
After Spray Operation • Leftover spray solutions should be disposed-off at a safer place viz. barren isolated area. • The used/empty containers should be crushed with stone/stick and buried deep in the soil away from water sources. • Wash hands and face with clean water and soap before eating/smoking. • On observing poisoning symptoms give the first aid and show the patient to the doctor. Also, show the empty container to the doctor.	**After Spray Operation** • Leftover spray solution should not be drained in or near ponds or water lines etc • Empty containers of pesticides should not be re-used for storing other articles. • Never eat/smoke before washing clothes and taking bath. • Do not take the risk by not showing the poisoning symptoms to the doctor as it may endanger the life of the patient.

First Aid Kit: It is very important to contain the first aid kit in the vehicle for any driver.

Fig. 4.8: (A) Safety kit (B) A person wears a safety kit during spraying

In the first aid kit, the following materials are listed below-

- Gloves.
- Eye protection.
- CPR (Cardio-pulmonary resuscitation) pocket mask.
- Tourniquet.
- Roller gauze (bandage).
- 4×4 gauze pads.
- Medical Tape.
- Two triangular bandages.
- Sam splint.

Safe disposal of hazardous material: Hazardous waste material is produced by a typical farm which includes the material produced by tractors and machinery. Hazardous waste encompasses an expansive range of materials used to aid to maintain and repair tractors and machinery, protect crops and ensure general upkeep of the farm. These include:

- Chemicals– used, unused, expired, or de-regulated pesticides and biocides such as herbicides, fungicides, and insecticides.
- Medicines – expired, used, or partially used doses, dips, wormers, dry cow and mastitis tubes, needles, and syringes.
- Waste paints – both solvent and chromate-based paints.
- Coolants and antifreeze.
- Oil and air filters.
- Brake fluid and brake pads.
- Waste engine and hydraulic oil.
- Aerosols.

- Contaminated gloves, rags, clothes, and overalls – used when administering medicines, spraying pesticides, handling oils, or any other hazardous materials.
- Grease guns and containers.
- Used silicone guns.
- All batteries – including AA batteries, tractor, and car lead batteries, remote control batteries, etc.
- All used light bulbs.
- Any waste electrical equipment – including broken power tools, monitors, etc. – anything that is operated by a plug or battery.
- Asbestos and asbestos sheeting.
- Creosote – the remains of burnt wood, tar, coal, or other fossil fuels.

The above materials should never be included in the general waste disposal and must be collected by hazardous waste disposal or waste oil disposal contractor.

Best Practices for Managing Hazardous Farm Waste

Ensuring effective hazardous waste management involves the incorporation of four key best practices into your daily farm routine:

1. Never mix hazardous waste materials: Certain hazardous waste materials can have flammable, carcinogenic, and combustible properties which can ignite when stored with or exposed to other materials. For this reason, each type of hazardous material must be stored individually, even if the level of waste is quite minimal. In particular, waste oil should never be mixed with any other substances. Such mixed wastes are the safety risk posed.

2. Label and contain all hazardous waste: To reduce the risk of incident or injury from chemicals or hazardous substances, it is important to clearly label all hazardous waste. Farmworkers can only follow safety guidelines for handling and managing hazardous waste if they are aware that it is the hazardous waste they are encountering. Each type of hazardous waste must be identified if it is to be permitted to be collected by a hazardous waste collection service too.

3. Keep stock of chemicals and medicines to a minimum: Another key hazardous waste management best practice is to actively minimise the level of chemical waste disposal on site where possible. This can be achieved by minimising the stock of chemicals and medicines stored on site. Only buy what you need – a significant portion of hazardous farm waste results from expired, de-regulated, or partially used chemicals and medicines. Keeping a small stock of chemicals and medicines also reduces the risk of incident or injury due to leaks, spills, or exposure.

PRACTICAL EXERCISES

Activity 01: List out the First Aid Kit

Material Required:

1. Notebook
2. Pencil
3. Eraser
4. Sharpener

Procedure:

1. First, the student should visit the medical shop.
2. Identify the first aid material in the shop.
3. List out the first aid material and write their use.

CHECK YOUR PROGRESS

A. Answer the following

1. What safety precautions should be taken during using a tractor?
2. What are the safety precautions in using a thresher?
3. What are the safety precautions in using a chaff Cutter?
4. Make a list of essential items of a First Aid Box or Kit.
5. What precautions should be taken while using pesticides?
6. What are the precautions you must take to use the plant protection equipment.
7. List out the equipment that may be used in spraying.
8. Why safe disposal of hazardous material is essential on the farm?
9. Make a list of hazardous materials related to tractors and machinery.

B. Fill in the blank

1. A plate having a …… shall be rigidly fixed near the blades of the chaff cutter.
2. The full form of PPE is ……
3. ……. waste material is produced by a typical farm which includes the material produced by tractors and machinery.

Answer Key

Unit/Session	Fill in the blank	Match the following
Unit 01- Session 01	1. Power 2. 0.1 3. Animal drawn disc harrow	1. B 2. E 3. D 4. A 5. C
Unit 01- Session 02	1. 1914 2. Ship of mouth 3.1908 4. Escorts	1. C 2. D 3. A 4. B
Unit 02- Session 01	1. Large, lesser 2. Powerful 3. Economic 4. Trailer 5. farming	
Unit 02- Session 02	1. weather 2. time 3. Varies, high 4. Less, spare 5. ground clearance	1.C 2. A 3. D 4. B
Unit 02- Session 03	1. Diameter 2. Differential lock 3. Electrochemical 4. sun gear 5. toe in	1. C 2.E 3. F 4.B 5. D 6. A
Unit 02- Session 04	1. 18 year 2. Operators seat 3. Log book 4. 4-8 km/hr 5. gear	
Unit 02- Session 05	1. Manufacturer 2. Drain 3. Alternator 4. Horizontally, minimum	1. D 2. A 3. B 4. C
Unit 03- Session 01	1. Depth 2. gauge wheel 3. small aggregates 4. frog bearing 5. Dead furrow	1. E 2. D 3. A 4. C 5. F 6. B

Unit 03- Session 02	1. wet puddle 2. Rotary 3. inter-cultivation 4. convex side 5. rigid	1. C 2. E 3. D 4. B 5. A
Unit 03- Session 03	1. Degree 2. wet or sticky 3. Seedlings 4. scattering	1. D 2. A 3. C 4. B
Unit 03- Session 04	1. Droplets 2. Foot 3. 15 m 4. powder	1. C 2. A 3. D 4. B
Unit 03- Session 05	1. lower to higher 2. Mechanical 3. high-velocity 4. impeller	1. C 2. D 3. A 4. B
Unit 03- Session 06	1. farm 2. labour 3. hydraulic 4. harvesting	1. C 2.D 3. B 4. A
Unit 04- Session 01	1. Driving license 2. Regional Transport Authority 3. Certified physician 4. Commercial motor 5. Legal	1.D 2. A 3. B 4. C
Unit 04- Session 02		1.C 2. A 3. B
Unit 04- Session 03	1. Gravity and centrifugal 2. rear axle 3. slow-moving vehicle	1. C 2. A 3. B
Unit 04- Session 04	1. sign 2. Triangle 3. informative signs 4. Horn Prohibited	1. C 2. E 3. B 4. A 5. F 6. D
Unit 04- Session 05	1. Danger Signal 2. Plant Protection Equipment 3. Hazardous	

GLOSSARY

Agitation: It is act of mixing things up like the washing machine that moves the water, detergent and clothes around and gets the dirt out.

Backflip: A backflip is a tricking and free running movement.

Cultivator: A mechanical implement that is used for breaking up the ground surface and uprooting weeds.

Digging: It is the process to move the earth and make a hole in the ground surface.

Ditches: A narrow channel dug alongside a road or in a field to store or move water.

Embankment: An elevated structure (usually made of soil or gravel) that is used to hold back water or carry a roadway.

Emblem: A thing that serves as a symbol for a specific quality or idea.

Farming: To manage a farm/agriculture land or working on it.

Fertility: It is a capacity of a soil to provide crops with all essential plant nutrients which required during their plant growth stage.

Harrow: A piece of farming equipment that is pulled over land that has been turned over, to break up the earth before planting.

Harvesting: It is the process of gathering the plant's useful parts at the time when all of the nutrients have formed and the edible sections have reached the right level of maturity.

Horsepower: Horsepower (hp) is a unit of measurement for power, or the rate at which work is completed, usually in relation to the engine or motor output.

Haulage operation: It is the one that operates between the working faces to the main loading points.

Intercultural operation: Intercultural operations are all the lighter and finer actions performed on the land between sowing and harvesting.

Leaching: It is a process of removal of chemicals from soil surface by passing through it.

Lubrication: The process of applying a material to an engine or component, such as oil or grease, in order to reduce friction and allow for smooth movement.

Lugged: To drag (something heavy) with a lot of effort.

Penetration: It refers to entering or making your way through something.

Ploughing: It is the process of loosening and turning the soil (tilling).

Priming: It is the process of preparing or making something ready for operations.

Puddling: It is a type of land (wet) cultivation that involves mixing soil and water to create an impermeable layer.

Pulverize: It is the process to reduce (by the method of crushing, beating, or grinding) into very small particles.

Quarries: It is a place, typically a large deep pit from which stone or other materials are extracted.

Reap: To cut and collect the crop from the field.

Retro-reflective material: This material is made with tens of thousands of tiny glass beads that reflect light and send a focused image directly back to the original light source.

Seedbed: It is a bed of fine soil in which seedlings are germinated.

Serrated: It means, having a sharp edge or notched edge like hacksaw

Sieving: It is a process to separates the finer particles of a mixture from coarser particles.

Sow: It is the process of plant the seeds in the ground surface.

Sowing: It is the process by which seeds are buried inside the soil.

Spraying: It is the process of a liquid (chemicals or pesticides) application in the form of small particles ejected from a sprayer.

Subsidized rate: The price for a product is reduced because the government has paid part of the cost of producing it.

Surplus: The quantity left over after a use or necessity has been met.

Tampering: The act of touching or changing something you shouldn't, usually when you're attempting to harm it or do something illegal.

Terrain: It is an area of land or a type of land when you are considering its physical features. It also involves the vertical and horizontal dimensions of the land surface. It is also known as ‘relief’.

Tillage: It is the process of soil preparation that involves several types of mechanical agitation, such as digging, stirring, and overturning.

Tiller: A tiller is a shoot that grows from a grass plant's base.

Tilting: It is a process to move, or make something move into a position with one end or side higher than the other.

Tool: A piece of equipment such as a hammer or file, that you hold in your hands and use to do a particular job or work.

Weed: A unwanted plant that grow with the crop in a field because it prevents other plants from growing properly.

Weeding: It is the procedure of getting the removal of weeds from the field.

Yield: The amount or quantity of a crop, that is produce.