Farm Machinery and Equipment I

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Farm Machinery and Equipment I

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Lesson 1. Farm Mechanization: Introduction, objectives and level of mechanization in Punjab and India

SOURCES OF FARM POWER AND MECHANIZATION

Various types of agricultural operations performed on a farm can be broadly classified as:

1. Tractive work such as seed bed preparation, cultivation, harvesting and transportation, and
2. Stationary work like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water.

These operations are performed by different sources of power namely, human, animal, stationary engine, tractor, power tiller, electricity, solar and wind. For doing these operations different types of power available is classified as:

- Human power
- Animal power
- Mechanical power
- Electrical power
- Wind power

HUMAN POWER: The indications are that the decline in number of labourers employed for agriculture is likely to increase in future resulting a greater investment in labour saving devices and mechanical power.

Labour (Human Energy) on Farms: Labour is one of the most important sources of farm power in regions where traditional system of agriculture is practiced. On small farms, high proportion of labour is supplied by the farmer and his family. Only to meet the peak and permanent labour requirements, the hired labourers are employed.

On small farm having very little spare capital to buy appropriate type of hand tools and animal drawn equipment, both labour use **efficiency** and **productivity** are very low. Labour use efficiency can be improved by engaging labour in a group where sequence of operations demands teamwork for effective output. In the absence of the team, single man would waste other energies, which might result into higher cost of operation. For example, a power thresher operation always demands a team effort for efficient utilization of expensive resources i.e., thresher, cleaner, the prime mover, etc.

ANIMAL POWER: Animal power is the most important source of power on the farm all over the world particularly in developing countries. It is estimated that nearly 80 per cent of the total draft power used in agriculture throughout the world is still provided by animals. Different animal sources are:

- Bullocks- can pull of about 15% of its weight
- Buffaloes
- Camels
- Horses
- Donkeys-can pull 80 % of its weight for short period and 10-15% of its weight for sustainable period.
- mules
- and elephants

The average force a bullock can exert is nearly equal to one tenth of its body weight. But for a very short period, it can exert many more times the average force. Generally a medium size bullock can develop between 0.50 to 0.75 hp.

MECHANICAL POWER

The third important source of farm power is mechanical power that is available through tractors and stationary engines. The engine is a highly efficient device for converting fuel into useful work. The efficiency of diesel engine varies between 32 and 38 per cent, whereas that of the petrol engine in the range of 25 and 32 per cent. In recent years, diesel engines and tractors have gained considerable popularity in agricultural operations. Small pumping sets within 3 to 10 hp range are very much in demand. Likewise, engines of low to medium speed developing about 14 to 20 hp are successfully used for flourmills, oil expellers etc. Diesel engines of the larger size are used on tractors. Diesel engines are the main source of power in agriculture. The basic reason for their preference is the **economy** in operation.

ELECTRICAL POWER

Now-a-days electricity has become a very important source of power on farms in various countries. It is steadily becoming more and more available with the increase of various river valley projects and thermal stations. The largest use of electric power in the rural areas is for irrigation and domestic water supply. Besides this, the use of electric power in dairy industry, cold storage, fruit processing and cattle feed grinding has tremendously increased.

WIND POWER

The availability of wind power for farm work is quite limited. Where the wind velocity is more than 32 km/h, wind mills can be used for lifting water. The most important reason of its low use is its uncertainty. Thus the average capacity of a wind mill would be about 0.50 hp. It is one of the cheapest sources of farm power available.

MECHANIZATION

AGRICULTURAL MECHANIZATION involves the design, manufacture, distribution, use and servicing of all types of agricultural tools, equipment and machines. It includes three main power sources: human, animal and mechanical with special emphasis on mechanical (tractive power).

FARM MECHANIZATION: is technically equivalent to agricultural mechanization but refers to only those activities normally occurring inside the boundaries of the farm unit or at the farm unit level (example: village, community, co-operatives etc).

TRACTORIZATION: refers to the application of any size tractor to activities associated with agriculture.

MOTORIZATION: refers to the application of all types of mechanical motors or engines, regardless of energy source, to activities related to agriculture.

AGRICULTURAL IMPLEMENTS: are devices attached to, pulled behind, pushed, or otherwise used with human, animal or mechanical power source to carry out an agricultural operation.

AGRICULTURAL MACHINERY: is a general term used to describe tractors, combines, implements, machines and any other device more sophisticated than hand tools which are animal or mechanically powered.

AGRICULTURAL EQUIPMENT: generally refers to stationary mechanical devices such as irrigation pump-set.

SCOPE OF MECHANIZATION

It is quite true that the farmers of developing countries have the **lowest earnings per capita** because of the **low yield per hectare** they get from their **land holdings**. One of the few important means of **increasing farm production per hectare is to mechanize it**. Mechanization may have to be done at various levels. Broadly, it can be done in three different ways:

I. By **introducing the improved agricultural implements** on small size holdings to be operated by bullocks

II. By **using the small tractors, tractor-drawn machines and power tillers** on medium holdings to supplement existing sources.

III.By **using the large size tractors and machines** on the remaining holdings to supplement animal power source.

As a matter of fact, the progress of the country should be mainly judged on the basis of degree of farm mechanization (production per worker and the horsepower under his command per unit area).

Large amount of labour or draft power, which can be replaced through machines, provides a strong incentive to mechanize.

From the energy application point of view, the Indian agriculture is in the transition from:

Stage 1 (human power) and stage 2 (animal power) to

Stage 3 and 4 (power tiller or four wheel tractor).

FARM MECHANIZATION:

Farm mechanization is the application of engineering and technology in agricultural operations, to do a job in a better way to improve productivity. This includes development application and management of all mechanical aids for field production, water control, material handling, storing and processing. Mechanical aids include hand tools, animal drawn equipment, power tillers, tractors, engines, electric motors, processing and hauling equipment.

SCOPE OF FARM MECHANIZATION:

There is a good scope of farm mechanization in India due to the following factors:

1) Improved irrigation facility in the country.

2) Introduction of high yielding varieties of seeds.

3) Introduction of high dose of fertilizers and pesticides for different crops.

4) Introduction of new crops in different parts of the country.

5) Multiple cropping system and intensive cultivation followed in different parts of the country.

SOME OTHER FACTORS WHICH ARE RESPONSIBLE TO ENCOURAGE FARM MECHANIZATION ARE:

i) Population of the country is increasing at the rate of about 2.2% per year. Steps have to be taken to arrange food and fibre for such large population by adopting intensive farming in the country. Intensive farming requires machines on the farm.

ii) In multiple cropping programme, where high yielding variety of seeds are used, all farm operations are required to be completed in limited time with economy and efficiency. This is possible with the help of mechanization.

iii) Farm mechanization removes drudgery of labour to a great extent. A farmer has to walk about 66 km on foot while ploughing 1 ha land once by bullocks with a country plough having 15 cm furrow width.

iv) A large number of females and children work on farm. So, with mechanization females can work at home and children go to school.

v) The proper utilization of basic inputs like water, seeds and fertilizers will be possible with proper equipment.

vi) There are certain operations which are rather difficult to be performed by animal power or human labour such as:

a) Deep ploughing in case of deep rooted crops.

b) Killing the pernicious weeds by deep tillage operations.

c) Levelling of uneven land.

d) Land reclamation.

e) Application of insecticides during epidemic seasons. These operations need heavy mechanical equipment.

BENEFITS OF FARM MECHANIZATION:

There are various benefits of farm mechanization:

1) Timeliness of operation

2) Precision of operation

3) Improvement of work environment

4) Enhancement of safety

5) Reduction of drudgery of labour

6) Reduction of loss of crops and food products

7) Increased productivity of land

8) Increased economic return to farmers

9) Improved dignity of farmers

10) Progress and prosperity in rural areas

PRESENT STATUS OF FARM MECHANIZATION:

Present status of farm mechanization is quite appreciating. We have:

a) Improved manual tools.

b) Improved animal drawn implements.

c) Tractor operated implements.

d) Custom hiring units on the farm.

e) Other stationary equipments like threshers, irrigation pumps, sprayers, dusters etc.

LIMITING FACTORS IN FARM MECHANIZATION:

There are various limitations in adopting farm mechanization:

1) Small and fragmented land holdings.

2) Less investing capacity of farmers.

3) Agricultural labour is easily available.

4) Adequate draught animals are available in the country.

5) Lack of availability of suitable farm machines for different operations.

6) Lack of repair and servicing facilities for machines.

7) Lack of trained man power.

8) Lack of co-ordination between research organization and manufacturers.

9) High cost of machines.

10) Inadequate quality control of machines.

India has made impressive strides in the field of agriculture by enhancing agricultural production from a mere 51 m-tons in 1950-51 to 258 m-tons by 2011-2012. This has been achieved through the adoption of biological, chemical and mechanical inputs and by creating/promoting required infrastructure and facilities in rural areas. Appropriate Govt. policies such as consolidation of holdings, land levelling, rural roads, and establishment of grain markets, rural electrification, adequate credit and assured minimum support price have helped in this phenomenal increase in agricultural production and productivity. India's well orchestrated Green Revolution has done the nation proud. Beginning the mid sixties, India has witnessed many revolutions which have put our agrarian economy on a sound footing. These include Green Revolution, white revolution, blue revolution & grey revolution. The last named revolution is synonymous with machinery revolution. However, the Indian green revolution is gradually fading. The yields have reached a plateau. The country is now in search of a rainbow or evergreen revolution.

Indian agriculture is plagued with many problems such as low productivity in rainfed areas, decline in soil fertility, receding water tables, change in ecology due to monoculture and indiscriminate use of resources, increasing environmental pollution, staggering losses of perishables (30-40 %), absence of scientific post harvest infrastructures, inadequacy of energy for production and post harvest agriculture, low exports, due to low quality and high cost of production, as well as non-conformance to global quality assurance and management norms. The WTO regime has created an urgency to bring about a paradigm shift in Indian agriculture and mindsets of all concerned. Ecologically sustainable agriculture by adopting conservation farming together with diversification of agriculture in problem areas, greater private investment and setting up chains of agro-processing centres in the rural areas are the new focus of Indian Agriculture. The country has about 60 million tonnes of wheat and paddy in the central food reserve and to avoid further complications and wastage, urgent steps need to be undertaken to promote exports and provide food to nearly 40% of the population which does not have economic access to food, even though the county has plenty of it in the reserve.

In the sixties and early seventies debates were often held by the policy makers, economists, sociologists, engineers and all those concerned with agricultural modernization regarding relevance of agricultural mechanization in a labour abundant economy. Literature is replete with studies commissioned by the Planning Commission through National Council of Applied Economic Research (NCAER), SAU's and other bodies to find out the impact of agricultural mechanization on agricultural productivity, cropping intensity, labour employment and returns to the farmers. These studies conclusively proved that adoption of tractors & farm mechanization led to significant increase in cropping intensity, increase in production & productivity and reduction in the cost of production. For certain operations like harvesting, use of machines did displace the labour but taking into account direct labour on the farm, indirect labour employed for manufacturer, repair, maintenance and subsidiary labour, farm mechanization led to higher employment generation. Timeliness of operations, precision, better quality of operations, accurate placement, uniform distribution, reduction in losses, better quality of produce, reduced cost of production, reduction in drudgery to human beings and animals and enhancing the dignity of labour are the major advantages offered by farm mechanization. It is now agreed that introduction of tractors & machines has also helped to check migration of educated youth, skilled and unskilled man power from the rural to urban areas.

Notwithstanding the wide agro ecological diversity, variation in soil types, climate, precipitation, irrigation intensity, cropping systems, land topography and industrial infrastructure, India has done remarkably well in mechanization of Agriculture. We have evolved a unique model by way of selective mechanization where in we have utilized both the animate and inanimate sources of farm power namely, human labour, draft animals, tractors, diesel engines and electric motors, The country's farmers presently employ over 205 million agricultural labourers, 63 million pairs of draft animals, 3.0 million four wheel tractors, 110000 power tillers and over 18 million irrigation pumps, One of the commonly used indicators to express the level of mechanization of agriculture in a state/country is the availability of farm power per unit area (kW/ha). For India, it stands at 1.12 kW/ha and that for the most mechanized state of Punjab, at 2.96 kW/ha, followed by 2.33 kW/ha for Haryana, 2 kW/ha for Tamil Nadu and 1.48 kW/ha for UP. Table 1, gives the power availability, irrigation intensity, cropping intensity and yield for different states in India, which clearly demonstrates that states with higher power availability per ha also have higher yields per hectare.

FAO publishes a Year Book each year which gives the number of tractors and harvesters per 1000 ha for all countries and continents. For India, the number of tractors available as of now is 14 tractors /1000 ha as against 82 tractors per 1000 ha for the state of Punjab. Indeed, Punjab occupies a place of pride in the development and introduction of farm mechanization technology in India. The beginning was made with the use of stationary power sources (engines and electric motors for pumps, tube wells and threshers) in the late fifties followed by mobile power sources like tractors and combines for a wide range of field operations from land preparation to crop harvesting. India's first power thresher was innovated in Punjab in 1957, so also the animal and tractor operated seed drills, potato planters and diggers, sunflower thresher, seed planters, sugarcane planter, strip till drill, high clearance sprayer, straw combine, various types of weeders, cleaners, graders & vegetable seed extracting machines. Mechanization of a crop or operation always begins from Punjab and spreads first to the adjoining states and later to every nook & corner of India. The role of Agricultural engineers, manufacturers & farmers in mechanizing agriculture is commendable.

Table 1: Power availability, cropping intensity, percent irrigated area, fertilizer consumption and grain yield for different states in India.

State	Annual rainfall (mm)	% Irrigated area	Power (kW/ha)	Fertilizer (kg/ha)	Cropping intensity	Grain equivalent yield (ton/ha)
Jammu & Kashmir	617	40.0	0.71	69.8	1.48	2.01
Himachal Pradesh	494	13.1	1.61	50.9	1.71	2.40
Punjab	555	93.7	2.96	299.5	1.80	5.26
Uttar Pradesh	837	64.7	1.48	150.6	1.49	3.58
Haryana	494	78.6	2.33	202.5	1.68	3.63
Rajasthan	421	29.3	0.53	39.2	1.20	0.93

Assam	1449	27.9	0.56	18.2	1.42	1.61
Bihar	1024	44.3	0.82	93.5	1.38	1.91
West Bengal	1355	24.7	1.21	158.9	1.65	3.11
Madhya Pradesh	1021	25.2	0.71	42.2	1.24	1.38
Gujrat	609	31.1	0.90	81.1	1.13	1.08
Orissa	1123	28.6	0.48	37.7	1.38	1.23
Maharashtra	920	13.4	0.78	76.6	1.24	1.28
Andhra Pradesh	594	40.8	1.18	158.9	1.21	1.83
Karnataka	802	24.9	0.80	90.2	1.15	1.58
Tamil Nadu	950	53.6	2.00	135.4	1.21	2.81
Kerala	1927	19.3	0.86	90.5	1.36	1.45
Total	880	38.3	1.02	97.6	1.32	1.96

Source: Singh, G., 2001, Relationship between mechanization and agricultural production in various parts of India, AMA: 32(2), 68-76.

One can better appreciate the Indian farm mechanization scenario by looking at the extent of mechanization of various crop production operations such as seed bed preparation, sowing & planting, weed & pest control harvesting, threshing & post harvest operations. According to the estimates prepared by Ministry of Agriculture, tillage is mechanized to the extent of 37%, sowing and planting 63%, threshing 20%, irrigation 54%, plant protection 43% and harvesting 2%. Hence there is ample scope for further mechanization of Indian agriculture.

India is today the largest tractor producing nation of the world with an installed capacity of over 4.79 lakh tractors per year. As many as 2.2 to 2.5 lakh tractors are manufactured and sold in the country every year. Apart from 15 tractor manufacturing firms, there are about 3500 farm machinery manufacturers, over two dozen colleges and departments of agricultural engineering, one Central Institute of Agricultural Engineering at Bhopal, One Central Institute of Post Harvest Engineering and Technology at Ludhiana and four Farm Machinery Training and Testing Institutes located in different parts of the country. All these agencies are engaged in R&D, testing and evaluation as well as commercialization of various types of equipment.

BOTTLENECKS IN INDIAN FARM MECHANIZATION SYSTEM

- Low annual use of tractors (only 500-600 hrs/year against recommended 1000 hrs/yr).
- Non availability of matching equipment.
- Cumbersome and energy inefficient designs.
- Poor reliability, frequent breakdowns and high repair and maintenance cost.
- Low quality.
- Use of ungraded materials, absence of inter-changeability of components.
- Inadequate R&D, Testing &Training facilities and inadequate Research funding.
- Inadequate user education.
- Lack of standardization.
- Non-availability of relevant literature like operator's manual, parts catalogues etc.

PRIORITY AREAS FOR INDIAN AGRICULTURAL MECHANIZATION

- Intensification of R & D to introduce energy efficient machines for relatively un-mechanized crops such as cotton, sugarcane, oil seeds, pulses, vegetables & fruits. Use reverse engineering and enforce close collaboration with farm machinery manufacturers. Assist Indian manufacturers in seeking collaboration with well known foreign firms wherever desired engineering technologies are not available.
- Intensify research in the area of tractor design engineering due to their extensive use in Indian farming. India is now the largest tractor manufacturer in the world. TMA needs to be involved in this task.
- Farm machinery management research to find out use patterns, annual usage, breakdown frequencies, repair & maintenance cost and above all reliability.
- Research on safety, comfort, exhaust emissions and health hazards in the use of mechanical power sources and machines needs to be expedited.

- Emphasis be laid on conservation farming and energy saving/energy efficient tools and machines.
- An area of utmost importance from environmental point of view is proper utilization of about 540 million tonnes of crop residues available in India. Punjab alone has 10 million tonnes paddy straw which is mostly burnt. Burning needs to be banned. Appropriate machines for incorporation of residues into the soil, for mulching, for collection, handling & transport for briquetting, gasification, power generation, and/or allied usage is a priority area in the field of mechanization.
- Research on alternate engine /tractor fuels including bio-diesel, ethanol, producer gas need to be intensified.
- Greater emphasis be laid on design and manufacture of high capacity and precision machines for multi farm use, for corporate/contract farming as well as for custom hiring through Agri. Business Centres being promoted by Govt. of India for the benefit of rural youths.
- Equipment for post harvest transport, bulk handling, cleaning grading drying milling packaging and storage are urgently required. These could be imported wherever non-existent. Next revolution in agriculture must be ushered in the area of efficient food processing & agro industries to transform the rural areas & utilize the surpluses. Mechanization packages will be crucial to ensure success of contract/corporate farming.
- Mandi mechanization with a view to introduce bulk handling of grains is an urgent need.
- Mechanization of hill-agriculture (20% total cultivated area), horticulture and floriculture, forage production and handling equipment, forestry mechanization, and efficient transport equipment are some important areas.
- Women-friendly tools and gadgets need to be evolved by modifying the existing ones and designing the new tools to reduce drudgery to women workers.
- Mechanization of experimental plots is an important area requiring urgent attention. A mission mode project under the NATP has recently been sanctioned in this area.
- Nearly two-third of the cultivated area is rainfed. Farm power available in these areas is barely 0.3 kW/ha. Hence, mechanization of these areas should be under taken on priority basis. Large horse power tractors and suitable equipment for conservation of soil moisture, seed bed preparation, seeding/planting, harvesting etc., are required.
- The benefits of farm mechanization have so far remained confined to mainly wheat-based cropping systems. These need to be expanded to all cropping systems including horticulture.

- The present credit policy based on land mortgage is not favourable to small farmers to own mechanical prime movers. It excludes them from the benefits of farm mechanization and supplementing their incomes through hiring out their spare operational capacity. Instead of land mortgage, viability and hypothecation of the machinery may be better criteria.

- There being a positive relationship between power availability and agricultural productivity, power constraint should be removed. An annual growth rate of 4% over 1996 base in power supply to raise it from 1kW/ha to 2kW/ha by 2020 will be adequate to maintain a growth rate of 3% or more in agricultural production. This is based on "power-production relation" studies in India and abroad. The additional power will be supplied by tractors, power tillers, self-propelled machines, engines and electric motors.

- For precision farming, precision equipment for planting and plant protection are required.

- Increasing emphasis on Integrated Pest management and Organic farming would require use of efficient cultivation machinery for weeding and hoeing. Research in this area would be necessary to evolve optimum planting geometry and practices.

- Under the WTO regime with liberalization of markets foreign countries might take advantage of dumping their machinery in India, especially such equipment as sugar-cane harvesters, paddy transplanters, potato combines, cotton pickers, horticultural machinery, sprayers unless required equipment are expeditiously developed indigenously and have cost and quality competitiveness. Joint projects by R&D organizations and Indian firms would be desirable.

SUGGESTIONS FOR FURTHER IMPROVEMENT

1. No Farm Machinery research/development project should be initiated without conducting a market survey to assess the client needs and perceptions.

2. Greater industry-institution collaboration by undertaking joint research projects and use of reverse engineering would be helpful for speedy development and commercialization of new equipment.

3. Computer Aided Design (CAD) must be used for optimum design, cost reduction and reliability. All R&D organizations must have a CAD facility with latest design packages. Train R&D engineers to develop proficiency in computer aided design.

4. R&D engineers must ensure compatibility of their designs with BIS/ISO standards, norms and practices.

5. Standardization of critical components to ensure quality, durability and inter changeability is essential.

6. Up gradation of manufacturing technology to upgrade quality and reduce the cost.

7. It is under stood that a proposal is afoot to establish a Farm Mechanization Institute under the auspices of the Ministry of Agriculture and Co-operation. This institute will intensify research on different aspects of Farm Mechanization including techno-socio-economic aspects with a view to develop a long range Farm Mechanization Policy. A Draft Agricultural Mechanization Policy has already been evolved and it awaits approval of the government. Since bulk of tractor and farm machinery manufacturers are located in the northern states of India, it might be desirable to locate such an apex institution in the Punjab, as this state in spite of being one of the most mechanised states in the country, has just one ICAR institute, whereas her neighbouring states have 2 to 3 ICAR/central institutes.

To sum up, it may be concluded that farm mechanization is a dynamic technology. It evolves with changes in agriculture in a region/state/country. With diversification of agriculture and adoption of frontier technologies with a view to have eco-friendly sustainable agriculture with globally competitive outputs, cutting edge farm mechanization technologies will need to be developed and introduced expeditiously. Reduction in cost and up-gradation of quality are the twin goals to be achieved. Farm mechanization technology being capital intensive, all farm mechanization R&D projects must be demand-driven and reverse engineering approach must be followed. Up-gradation of manufacturing capabilities, use of computer-aided design and close co-operation with industry through joint projects will help improve the quality and reliability of farm equipment. Conformance to global standards and norms will be necessary. In coming years, higher horse power tractors and high capacity machinery will be required to meet the needs of export oriented agriculture, corporate farming, custom hiring and multi-farm use. Human engineering applications to ensure safety, comfort and compatibility in respect of noise levels and exhaust emissions will be necessary. The future of farm mechanization in India is bright. However, we will have to intensify research funding and efforts in frontier areas as outlined in this chapter.

Lesson 2 Materials of construction of farm equipment

I Introduction:

Strength, durability and services of a farm implement largely depend upon the quality of material used. Selection of proper material for a particular application is of critical value. Proper treatment of the selected material affects the initial cost and running cost as well as durability and performance of the machine.

Implement parts / components should be designed to utilize the lowest cost materials which can perform satisfactorily and provide adequate life. Use of high cost materials and expensive treatments sometimes become unavoidable to make for a deficiency in the original design.

II Classification of materials:

Broadly there are two groups of materials namely metallic and non-metallic

Metallic		Non-Metallic
Ferrous	Non-Ferrous	Wood (timber)
Iron: Cast iron Wrought iron	Copper (Cu)	Rubber
Steel: Steel Steel Alloys	Zinc (Zn)	Leather
	Lead (Pb)	Plastics
	Tin (Sn)	Fiberglass
	Aluminum (Al)	Teflon
	Brass (Cu+Zn)	
	Bronze (Cu+tin)	
	White metal or Babbit (Tin+Cu)	
	Solder (Tin+lead)	

III What is an Alloy?

It is a substance that has metallic properties and is composed of two or more chemical elements, of which atleast one is a metal. There is infinite number of alloys. They are made by fusion of metals. Common groups of alloys are:

a) **Alloy steels** using manganese, chrome, nickel, tungsten etc. as alloying elements.

b) Non-ferrous alloys:

Bronze

Brass

Babbit or antimony, solder

Aluminum alloys

IV Classification of Steels:

Steel is an alloy of carbon and iron. Steels are classified according to:

a) Manufacturing Process:

Bessemer Steel

Open Hearth Steel

Electric Steel

b) Carbon Content:

Low Carbon (upto 0.25% c)

(Easy to bend, forge and shear)

Medium Carbon Steel (0.25% to 0.50% c)

High carbon steel (0.50 to 1.2% c)

c) Alloy steel (mixture of two or more chemical substances one of which is a metal)

d) According to Uses:

Structural Steel

Tool steel

e) According to Method of Forming:

Rolled Steel

Forged Steel

Cast Steel

Formed Steel

V Purpose of Alloying Substances:

a) Manganese: Used for cutting tools and high grade ball bearings. It imparts hardness

b) Chromium: Same as manganese

c) Tungsten: Helps in maintaining sharp edge even when the cutting tool is hot.

d) Nickel: Helps in making steel elastic and ductile.

VI Application of Steel:

a) Low carbon steel: Used extensively in the construction of farm machinery. Frames and most of other members are made out of low-carbon steel.

b) Medium carbon steel: Used for greater strength and hardness. Members such as shafts, connecting rods etc. are made of medium carbon steel.

c) High carbon steel: It is very hard and is used for making tools, ball and roller bearings, cutting tools etc.

VII Alloy Steels and Their Composition:

S.No.	**Types of Alloy Steels**	**Composition**
1.	Boron Steel	Contains small amount (2.3%) Boron. Boron increases harden-ability of steel. **Parts made:** Axles, wheel spindles, steering nickel arms, cap screws, studs etc.
2.	Manganese Steel	Contains 11-14% manganese & 0.8-1.5% carbon It has extreme hardness and ductility. Can be cast in desired shapes

		and finished by grinding. **Parts made:** Machine parts subjected to severe wear e.g. feed grinders
3.	Nickel Steel	Contains 2-5% nickel & 0.10-0.5% carbon They are strong, tough and ductile **Parts made:** Used to make parts subjected to repeated shocks and stresses.
4.	Vanadium Steel	Contains 0.20% vanadium It is added for higher tensile strength and elasticity. Comparable to low and medium carbon steels.
5.	Chrome-Vanadium Steel	Contains 0.5-1.5% chrome, 0.15-0.3% vanadium and 0.15-1.10% carbon **Parts made:** Used for hard and malleable machinery casting, forgings, springs, shafts, gears and pins.
6.	Tungsten	Contains 3-18% tungsten and 0.2-1.5% carbon. **Parts made:** used for dies and high speed cutting tools
7.	Molybdenum Steel	Properties similar to tungsten steel
8.	Chrome Steel	Contains 0.5-2% chrome and 0.10-1.5% carbon **Parts made:** used for high grade balls, rollers, races for ball and roller bearings 14-18% chrome used to produce variety of stainless steels
9.	Chrome-Nickel Steel	Contains 0.3-2% chrome, 1.0-4.0% nickel and 0.10-0.60% carbon **Parts made:** used for gears, forgings, crankshafts, connecting rods and machine parts

10.	Stainless Steel	Contains 16-18% chrome, 7-8% nickel and less than 0.15% carbon **Parts made:** ********?
11.	Tool Steel	Tool steel means high carbon steel which is **used for making tools**. It is extremely hard by quenching from a temperature of 800-850°c. Degree of hardness can be altered by heating at lower temperature.

VIII Cast Iron: It is also an alloy of carbon and iron. The percent of carbon varies between 2.4-4.5%. It is very hard and brittle. There are five general types of cast iron:

1. Grey Cast Iron: Carbon occurs in the form of graphite flakes which imparts it grey colour and leads to crystalline structure.

2. White Cast iron: Carbon remains in a chemically combined form and gives it a characteristic white colour when fractured.

3. Chilled Cast Iron: It is made by chilling or rapid cooling of certain portions of the casting. Chilled parts have the characteristics of white cast iron and slowly cooled parts exhibit characteristics of gray cast iron. Example: Mould boards (only one side is hardened)

4. Malleable Cast Iron: It is made by subjecting the white casting to annealing or "softening" process. Cast iron is heated to temperature of about 900°c and is held in the oven for sufficiently long period and is then cooled quite slowly. This changes the chemically combined carbon into free carbon in an "amorlous" form but not in the crystalline form as in the gray cast iron.Casting made out of malleable cast iron are tough, strong and easy to machine.Examples: Mower guards, ledger plates, control pedals (clutch brake), chain links etc.

5. Malleable Cast Iron: It was developed in 1949. It is a high-grade iron produced by adding magnesium alloy to molten iron prepared to produce gray cast iron. Magnesium acts as a desulphurizer when added in controlled amount, it produces spheroidal carbon instead of flake carbon (graphite) as in the case of gray cast-iron. Examples: Sprockets, gears, plow shares, mower guards, parts of hay-bailer knotter mechanism etc.

IX Non-Ferrous Metals: uses of non-ferrous metals and alloys are discussed below:

1. Copper (Cu): tubing, wires, windings etc

2. Brass: It is an alloy of Cu (60-90%) and Zn (10-40%). Used for making radiator pipes, brass welding rods, screen for fuel lines, instrument parts etc.

3. Bronze: It is an alloy of Cu (80-95%) and Tin (5-20%) Zinc is also added sometimes. Used for making bushings, springs, pipe fittings, valves, pump pistons and bearings.

4. Babbit: it is a tin-based alloy with small amount of copper Cu (7-8%), Antimony (8-9%) and Tin (80-84%). Used for making bearings.

Lesson 3. Heat Treatment of farm equipment

Heat Treatment of Steels:

Properties of steel can be modified or altered by processes of heating and cooling. This is called "heat treatment". Various heat treatments include hardening, tempering, annealing, case hardening etc

Glossary of Terms:

S.No.	Term	Definition
1.	Heat Treatment	Combination of heating and cooling operations in a prescribed manner (w.r.t. time, temperature and rate of heating & cooling) to induce desired properties in metals and alloys in the solid state. The conventional heating for hot working does not come within the scope of heat treatment.
2.	Rate of cooling	Temperature decrease per unit time
3.	Quenching	Rapid cooling
4.	Full annealing	Heating to and holding at some temperature above the transformation range, followed by cooling slowly through the transformation range. In the manufacture of forgings and castings, enormous internal stresses are set-up either by the actual forging forces or by unequal contraction on cooling. If not removed, these stresses may lead to cracking of castings on cooling. Annealing consists of heating the parts to about 900°c for half-an-hour and then taking them out of the furnace and allow the oven to cool down very gradually. This process is carried out before hardening if that is also required. It effectively disposes of the internal stresses in materials.
5.	Case hardening	Hardening the surface by changing its composition followed by, if necessary, suitable heat treatment. Wrought iron and carbon steel (c less than 0.5%) are relatively soft

		and can't be appreciably hardened by ordinary heat treatments. They are hardened by case hardening. By this process, it is possible to produce articles that are both resistant to shocks and extremely hard at the surface. The objects to be hardened are packed in iron-boxes with carbonaceous material like animal charcoal or 3:1 wood charcoal + powered bones and are heated to about 900°c for about 5-10 hours according to depth of hard casing required. The carbon combines with iron of the material producing hard cement Fe3c. When the parts are cooled they are unpacked from iron boxes and reheated alone to about 800°c and quenched in cold water to harden the cases. There are many other case hardening methods.
6.	Carburizing (case carburizing)	A process of introducing carbon into the surface of solid pieces of steel by heating and holding above the transformation temperature in contact with a suitable carbonaceous medium.
7.	Flame hardening	Rapid healing of the surface by means of an oxy-gas flame to temperature above the transformation range or cold working.
8.	Hardening	Any process which increases the hardness, for example, quenching from or above the transformation range or cold working. When steel with sufficient carbon (c more than 0.5%) is heated to 850°c (red colour) and quenched in water, brine (salt water) or oil, the steel is hardened. Higher the carbon content (up to 1.2%), the more the hardening effect. But after hardening the material becomes very brittle and it must be tempered to withstand the shock loads. For given steel, more rapid the cooling greater is the hardness and more the brittleness. Oil has slower quenching effect than water, brine cooling is slower than water and air is the slowest,
9.	Induction hardening	Process of hardening by induction heating to the appropriate temperature and quenching in a suitable medium.
10.	Nitriding	A process of surface hardening by introducing nitrogen into the surface in a suitable steel by heating and holding it at appropriate temperature in contact with cracked ammonia or other suitable nitrogenous medium.
11.	Normalizing	A process of heat treatment for improving mechanical properties brought about by grain refinement and uniformity in structure. The

		process involves heating to and often holding for a specified time at a suitable temperature above the transformation range, followed by cooling freely in air.
12.	Stress relieving (stabilizing)	Heating to, and if necessary, holding at a sufficiently high temperature below the transformation range followed by slow cooling to remove internal stresses only. Also, called stabilizing treatment.
13.	Tempering	Heating to elevated temperature but below transformation zone, of hardening steels and holding for specified time at temperature followed by slow cooling to develop desired mechanical properties in these steels. It consists of reheating of the hardened steel parts to about 500°c (blue colour) and quenching them from this temperature. In this way the material losses most of its brittleness and bit of its hardness. Hardening and tempering of the parts of farm machines has become an important process in their manufacture. Steel plough shares, cultivator points teeth of rakes are all heat treated under carefully controlled conditions in order to produce the necessary resistance to abrasion or bending.

Different Case Hardening Methods:

Treatment	**What is done**	**Temp. to which heated**
Case Hardening (2 mm depth)	Surface layer or case is hardened	Material is heated to critical temperature (800°c), exposed to carbon rich atmosphere, cooled and reheated to 200-500°c)
Carburizing	Steel is packed in pitch of charcoal	800°c for long period quenched and tempered
Nitriding	Finished heat treated steel parts are kept in an air-tight box	Heated to 800°c and NH_3 is injected into the chamber
Carbo-	----do----	Heated to 800°c and carbon monoxide and ammonia are

nitriding		injected
Cyaniding	Steel is dipped into molten bath of sodium cyanide for a short-time C&N are absorbed by the steel	
Induction Hardening	High frequency alternating current is passed for a short period. Current is induced on the surface which causes localized heating. After heating surface is flooded with water to quench and harden the part	
Flame Hardening	Oxy-acetylene torch is used to heat the surface quickly. Then quenched with water.	Above initial range 900°c

Lesson 4. Selection of Farm Machines

Selection of Tractor

- **Land holding** - 1 hp for every 2 ha of land

- **Cropping pattern** - more than one crop 1.5 ha/hp

- **Soil** - less wheel base, higher ground clearance and low overall weight in light soil

- **Climatic sand** - Very hot and cool

- **Repair facilities** - Has dealer nearby

- **Running Cost** - Less SFC so mining cost is less.

- **Initial cost and resale value** - keep resale value in mind, initial cost should not be high

- **Test report** - Released from farm machinery testing stations should be consulted for guidance

SELECTION CRITERIA FOR THE MACHINES

1. **Trade mark:** We cannot judge the machine by its appearance. Choose an equipment of well-known and reputed trade mark e.g. HMT 2511, HMT 3511 etc. It is distinguished by the mark of a trader to his goods to distinguish from other traders.

2. **Trade Name:** -do- (Dettol, crocin etc.)

3. **Model:** Buy the latest model with better features like Mahindra B-275, Mahindra DI-540, and Farmtrac-50 etc.

4. **Whether or not the machine is an approved design**: BIS or ISO mark (International standard organization) (Beauro of Indian Standards).

5. **Repair facilities**: To see whether the machine is repairable or not, how far is the service station or existence of repair shop, how easily the repair can be done?

6. **Availability of spare parts**: Whether components of machine are easily available?

7. **Design features:**

i) Points of wear i.e. type of bearing etc. provision for lubrication

ii) Ease of adjustments i.e. disc angle, tilt angle

iii) Safety provisions i.e. shielding of rotary members

iv) Appearance of the machine (eye appeal, aesthetics)

v) Vibrations and noise in the machine should be low

8. Ease of operation: It should not require unnecessary amount of power and labour to operate. Ease of operation may depend upon correct adjustment. Modern machines are equipped with power and hydraulic lifts and once adjusted properly they would require little effort to operate expecting steering and turning.

9. **Ease of adjustment**: Methods and provisions for adjustments of various parts, and adjustment should be easy to make and less time consuming. Discourage the "I am in hurry attitude" to make correct adjustments.

10. **Adaptability of machine to work and working conditions (environment and versatility):** Select the machine or tool which can work under a wide range of conditions. It must be easy to adopt the equipment to different soil, crop and environmental conditions.

11. **Quick change of units**: For machines which are one built in unit packages and design to change them like from plough to cultivator or like multi crop planter, the time required for the change over must be minimum.

12. **Maneuverability**: See if the equipment is a trailed or mounted type. Mounted equipments are easy to lift and easy to turn. Trail equipments which are attached to the draw bar of a tractor cannot make sharp turns. Extended and swinging drawbars are one aid for short turning. (articulated frames are provided in some equipment). Choose a machine with a proper size of wheels. A small wheel sinks into loose soil, drops into shallow ditches and furrows and for the tractor turning is difficult.

13. **Human comfort**: Human comfort is an important factor in the selection and operation of equipment. The seat must be comfortable, stable and adjustable to suit different sized individuals. There should be proper operator safety provisions.

14. **Some other factors are**:

- Power requirement: Power required for operating the equipment. It determines the size of the equipment.
- Cost of operation: Initial cost and operational cost of m/c i.e. economical viability of the machine.
- Initial cost of the m/c
- Availability on custom hiring
- Years of services expected
- Economics of the equipment in relation to size of farm and work to be performed

- If possible purchase multipurpose machines with minimum adjustments for example wheel hand hoe, till planter, ridger seeder
- Capacity of the machine e.g. if you have 10 acre field old tractor can do for that.

Lesson 5. Field capacity, efficiency, economics of machinery use with numerical / problems

Terms related to Field performance of Machines

A) Theoretical Field Capacity: It is the rate of field coverage of an implement that would be obtained if the machine were performing its function 100% of the time at the rated forward speed and always covered 100% of its width.

WxS/10

B) Theoretical Time per ha.: It is the time that would be required at the theoretical field capacity.

C) Effective Field Capacity: It is the actual average rate of coverage by the machine. It is expressed as ha/hr.

C=WxS/10xEr

C= Effective Field Capacity, ha/hr (Acre/hr)

W=Rated width of implement, m (feet)

S=Speed of travel, Km/hr (miles/hr)

Ef=Field Efficiency, %

Thus Effective field capacities on the basis of total minutes per ha., is the sum of the theoretical time per hectare plus the time per hectare required for turns plus the time per hectare required for 'support functions' i.e. time lost as a result of;

i) Adjusting or lubricating the machine

ii) Breakdowns

iii) Clogging

iv) Turning at ends

v) Adding seed or fertilizer

vi) Unloading of harvested products

vii) Waiting for crop transport equipment etc.

Effective or actual capacities will be less than their theoretical or potential capacities.

TFC=ha/ht

EFC=ha/he

EFC<TFC

п= EFC/TFC

ha/he<ha/ht

п=ht/he

Et=Tt + Tu + Ts

ET>Tt

D) **Effective OperatingTime:** It is the time during which the machine is actually performing its intended functions.

E) **Field Efficiency:** It is the ratio of effective field capacity to theoretical field capacity, in %. It includes the effect of time lost in the field and failure to utilize the full width of the machine.

F) **Performance Efficiency:** It is the measure of functional effectiveness of a machine e.g.the % recovery of usable product by a harvesting machine.

G) **Field Machine Index:** It is the percentage ratio of effective operating time plus turning time.

H) **Comparative Index:** It is determined by actual time studies with same machine for different fields.

I) **Time Efficiency:** It is the ratio of time a machine is effectively operating to the time a machine is committed to operation. Following list describes the time elements that should be included when computing the capacities or cost of machine:

1) Machine preparation time at the farmstead.

2) Travel time to and from the field

3) Machine preparation time in the field both before and after operations (includes daily servicing, preparation for towing)

4) Theoretical field time (time the machine is operating in the crop at an optimum forward speed and performing over its full width of action).

5) Turning time and time crossing grass waterways (machine mechanisms are operating).

6) Time to load or unload the machine if not done on-the-go.

7) Machine adjustment time if not done on-the-go (includes unplugging).

8) Maintenance time (refueling, lubrication, chain tightening etc., if not done on-the-go, not include daily services).

9) Repair time (time spent in the field to replace or renew parts that have becoming inoperative.

J) **Material Capacity:** M=SEWEfY / 10

M=Material Capacity, units/hr.

S=Speed of travel, Km/hr

W=Width of implement, m

Ef=Field efficiency, %

Y=Yields, unit/area

K) **Factors affecting field efficiency:**

1) Theoretical field capacity of machine: Field efficiency decreases with increase in TFC (increasing the width of a 4-row implement by 50% will increase the effective field capacities by 35% for com planter and 40% for cultivator) and with increase in operating speed of the implement.

2) Machine Maneuverability: Farm machines need to be easily maneuvered in fields and on the roads to the fields. Field machines need to be designed to make short turns at ends of the fields and while following crop rows planted on the contour and in curves.

Field tillage or seeding machines can make square turns, Raking or windrowing or bailing operations usually follow a rounded corner pattern.

3) Field patterns: Objectives are:

i) Amount of field travel should be minimum.

ii) Number of non-working turns should be minimum.

iii) Number of non-working travel in interior of field should be minimum.

iv) Field patterns should produce level surface to eliminate water ponding.

v) Repeated machine travel over a particular area of field will cause compaction of soil.

4) **Field Shape:** An irregular field has less field efficiency than rectangular fields because of excessive turning time.

5) **Field Size:** Field efficiency of large fields is less.

6) **Yield** (If harvesting operation): If yield is high it changes the width of cut of machine. Throughout capacity of combine approx is 10tan/hr (4m cutter-bar). 50% of St. crop (40% load).

7) **Crop and Soil conditions:** If crop and soil conditions are poor machine forward speed reduced, field efficiency will improve, but this is not the desirable factor.

8) **System Limitations:** Field efficiency may be limited by capacity of other operations in a system, e.g. seedbed preparation and planting is a system in which seeding is required immediately after the soil preparation. Seeding can be done 1 acre/h but seed bed preparation can't (disc narrow one vass acres/h.

A. Mechanisation Terminology:

- Selective mechanization : Use of machines or equipment for selected operations only.

- Low-cost mechanization (cheap & affordable)

Tools, gadgets and equipment which cost less and can be fabricated by village artisans and small scale industries.

1. Tool : It is a simple mechanical or electro-mechanical device to perform a task. An individual working element of a machine such as disc, shovel, cutting blade is also known as a tool.

2. Implement : It is an equipment with no moving or driven parts, such as a plough, cultivator harrow, i.e., it consists of a rigid structure with working tools.

3. Machine : It is a combination of rigid bodies with linkages executing specified motions and performing desired tasks.

4. Equipment :It is a general term used for any tool, implement, machine or gadget.

5. Device :Any mechanical contrivance which offers mechanical advantage.

6. Gadget :A small and relatively simple tool or machine is called a gadget.

B. Types of Implements:

1. Pull-type or trailed implement :

It is pulled and guided from a single hitch point and is not completely supported by the tractor.

2. Mounted Implement :

It is hitched to the tractor through a three-point linkage in such a manner that it is completely supported by the tractor when in the raised position. The linkages p0rovide a rotational stability about the longitudinal axis and permit depth or height control by the vertical support from the tractor

3. Semi-Mounted Implements

It is attached to the tractor through a horizontal or nearly horizontal hinge axis and is partially supported by the tractor at least during transport, but it is never completely supported by the tractor. In heavy and large semi-mounted implements supports wheels at the rear or in the middle together with remote hydraulic cylinder are utilized for raising and lowering the complete implement/machine or its individual units.

4. Self-propelled machine.

One in which propelling power unit is an integral part of the implement/machine.

Advantages of Mounted Equipment:

1. Mounted equipment are less expensive than equivalent pull-type equipment.
2. Support wheels and accompanying structure required on pull type equipment is eliminated.
3. Single depth or height control system forming a part of the tractor.

- Maneuverability is better
- Visibility is better
- Transport is easier
- Draft-sensing advantage
- Vertical load transfer to aid in traction
- Attaching & detaching is easier

Standardisation of Three-point hitch and "Quick-attaching couplers" to permit interchangeable use of different makes of equipment.

Limitations of Mounted Implement:

1. Carrying capacity of tractor chassis
2. Transport stability is a limitation

Advantages of Self-propelled machine:

- Greater flexibility
- Better maneuverability

- Better visibility

- Better control by operator

- Improved mobility

- Reduced losses when cutting unit is in front of the unit.

Disadvantages:

- Greater initial investment. It must have higher annual use to be economically competitive with a pull-type machine.

Economics

Total cost of performing field operation a field operation include charges of implement, tractor power utilized and labour. Implement & tractor costs are divided into two categories;

- **Fixed cost**- Related to machine ownership not related whether machine is used or not. Fixed cost per hour are inversely proportional to the amount of annual use.

- **Variable cost/ operating cost**- These are directly related to the amount of use and include repair and maintenance cost, fuel cost, lubricants cost and servicing. This is inversely proportional to amount of annual use.

Fixed Cost	**Variable cost**
- Depreciation	- R/M cost
- Interest	- Fuel cost
- Taxes	- Oil or lub. cost
- Shelter	- Labour cost
- Insurance	

(i) Depreciation: It means less in the value of machine due to time & use. Machine depreciates for several reasons like age of machine wear & tear of machine, obsolescence (machine becomes obsolete as new model developed). There are various methods to calculate the depreciation as follows:

Methods

1. Estimated value method: It is most realistic method. At the end of each year value is compared with the value of machine possessed at the start of the year. The difference is the amount of depreciation.

Estimated values of depreciation at the end of year:

Machine	%age of purchase price									
	1	2	3	4	5	6	7	8	9	10
Tractor	36	6	5	5	5	4	4	3	3	3
Self propelled combine	41	7	6	6	5	5	4	4	3	3
Tractor operated combine	46	7	6	5	5	4	4	3	3	2

2. Straight line method: It is the most practical and simplest method and gives constant annual charge for depreciation throughout the life of the machine. In this depreciation is:

$$D = \frac{C - S}{L \times H}$$

D	=	Depreciation per hr
C	=	Capital investment
S	=	Salvage or junk 10% of C
L	=	Life of machine in years
H	=	No. of working hrs years

But is not quite accurate method for giving value of machine at same age. In actual practice machine depreciates must faster in first few years than in the later years.

3. Declining balance method: Much more accurate method of estimating true value of machine at any stage as the annual depreciation rate decreases as the machine gets older. Depreciation can be

$$D_{n+1} = \frac{L-n}{Y_d} (P-S), \text{ Rs./year}$$

Where Y_d = Sum of years digits

= L (L+1)

n = age of machine in years

L = Life of machine, years

P = Purchase price, Rs.

S = Salvage value, Rs.

Depreciation can be calculated as;

$$D_{n+1} = V_n - V_{n+1}$$

$$V_n = P\,(1-X/L)^n$$

$$V_{n+1} = P\,(1-X/L)^{n+1}$$

$$D_{n+1} = P\,(1-X/L)^n\,(X/L)$$

Where; D_{n+1} = amount of depreciation charged for year n+1, Rs/year

V = remaining value at any time

P = purchase price, Rs.

N = number of representing age of machine in years

L = Life of machine

X = ratio of depreciation rate

It may be any number between 1 & 2

If X=2 method is called double declining balance method

For used machines X = 1.5

$$SFP = (P-S)\ \frac{i}{(1^{+i})^{2}-1}$$

$$Vn = (P-S)\ \frac{(1^{+i})^{2}-(1+i)^{n}}{(1^{+i})^{2}-1}$$

Vn = remaining value

P = purchase price, Rs.

S = Salvage value, Rs.

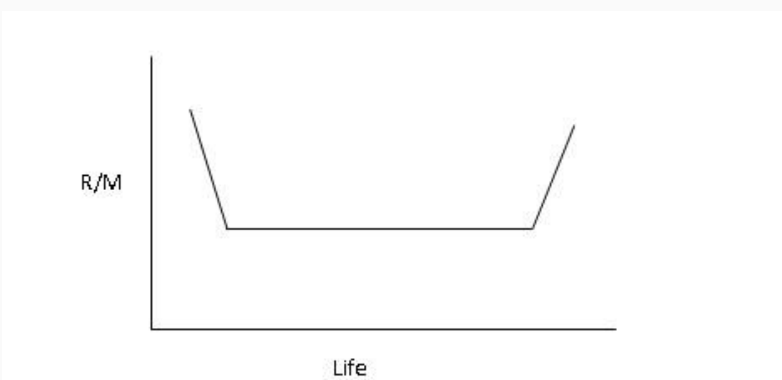
i = interest rate, fraction

L = Life of machine, years

4. Sum of years digit method:

5. Sinking fund method:

<u>Machine life use life of machine</u>



Also called bath-tub curve. Firstly repair and maintenance is less than because constant offer that start increasing i.e. the time to buy a new machine.

Table2.1 shows the obsolescence life and wear out life choose whichever are smaller for calculating depreciation.

Interest on investment: With straight line method average investment is equal to one half the sum of new cost and salvage value.

Interest I = % rate of interest per year

i = 12-16%

Taxes, insurance, shelter- 1% of C i.e capital cost per year

Operating Cost

Repair and maintenance: - It varies between 5 to 10% of initial cost of machine per year.

Fuel cost	-	Fuel cost is calculated on the basis of actual fuel consumption in the tractor.
Lubricants	-	It should be calculated on actual consumption but it varies between 30 to 35% of fuel cost.
Wages	-	Wages are calculated on the basis of actual wages of workers. In the case of skilled or tractor operator = Rs. 135 In the case of non skilled or machine operator= Rs. 100

Lesson 6. Field capacity, efficiency, economics of machinery use numerical / problems

Q.1. Determine TFC for a machine that travels at 5.0 kmph and has an operating width of 20 m.

$$TFC = \frac{S X W}{10}$$

$$= \frac{5 X 20}{10} = 10 \text{ ha/hr}$$

Say loss time is 0.75 hrs in a10 hr day what is the effective Field capacity?

$$\text{Field efficiency Ef} = \frac{\text{Output}}{\text{Input}} X 100$$

$$= \frac{10-0.75}{10 \text{hrs.}} X 100$$

$$= 92.5\%$$

$$\text{Effective field capacity C} = \frac{SXWXEf}{}$$

10 X 100

5X20X0.925

= ----------------

10

= 9.25 ha/hr

Q.2. A farmer purchased a 35 hp wheel type tractor at a total cost of Rs. 1,50,000/- and three bottom plough with 30 cm bottom width at Rs. 6000/-. The fuel consumption of tractor was 6 l/h at plough speed of 5 km/h.

a) Calculate area ploughed per hour

b) Determine cost of ploughing per ha

$$\text{Area covered/hr} = \frac{5 \times 1000 \times 30 \times 3}{100 \times 10{,}000} = 0.45 \text{ ha}$$

For tractor,

Depreciation/h

If L=10 years, H = 1000 h

D = Rs13.50

Interest/h I = $\frac{C+S}{2} \times \frac{i}{H} = \text{Rs } 9.90 \text{ if } i = 12\%$

Repair and maintenance cost @ 10% of initial cost = Rs. 15/hr.

Housing, taxes & maintenance cost = 3% of initial cost = Rs.4.5/hr.

Fuel cost @ Rs. 5.50 per litre = Rs 35/hr.

Lubricants @ 30% of fuel cost = Rs. 9.90/hr

Wages @ Rs.50 per day of 8 hrs= Rs. 6.25/hr

Cost of tractor operation/hr

=13.50 + 9.90 + 15 + 4.5 + 33 + 9.90 + 6.25

= Rs. 92.05/hr.

For plough

$$\text{Depreciation/hr } D = \frac{C-S}{L \times H} = \frac{6000-600}{2400}$$

= Rs. 2.25/hr

H = 300 hrs

L = 8 years

$$\text{Interest} = \frac{6000+600}{2} \times \frac{0.12}{300} = 1.32/\text{hr}$$

Repair and maintenance cost @ 10% of initial cost = Rs. 600/year = Rs. 2.00/hr

Housing @ of 1% of initial cost = Rs.0.20/hr

Cost of ploughing = 2.25 + 1.32 + 2 + 2 +0.20

= Rs. 5.77/hr

Total cost of ploughing with a tractor= 92.05 +5.77 = Rs.97.82/hr

$$\text{Total cost of ploughing/ha} = \frac{97.82}{0.45} = \text{Rs. } 217.34/\text{ha}$$

Q.3: A farmer has 4-bottom, 41 cm M.B. plough of Rs.3000, 5 bottom, 45 cm plough of Rs.4200/-

With either plow operating speed = 6.5 km/h

Field efficiency = 82%

a) If labour cost is Rs. 3.50/h what is minimum number of hectare plowed per year that would justify the purchase of large plow (i.e. break-even pt.)?

b) How many hrs per year would each plow be used at break-even area?

c) How would increased labour cost affect the size of break-even area?

Q.2. 4 m grain drill pulled at 7 km/h with a wheel type tractor having 35 PTO kw. The cost of drill is 3000 & labour cost Rs. 3.50/h. Calculate the following:

a) Total cost/ha for drilling 40 ha/yr.

b) The cost/ha if annual use is 100 ha.

c) The number of hrs required to plant 100 ha.

Lesson 7. Tillage: objectives, methods and terminology, introduction and classification of primary & secondary tillage equipment

Tillage: It is the mechanical manipulation of soil to provide favourable condition for crop production. It breaks the compact surface of earth to certain depth and loosens the soil mass so that roots of the crop penetrate and spread into the soil. These include ploughing, harrowing, mechanical destruction of weeds and breaking of soil crust.

Soil Crust: After sowing, if it rains the top layer of soil becomes so hard that seed is unable to germinate. This strong or hard top soil is called soil crust.

Objectives of Tillage:

1) To obtain deep seed bed, suitable for different type of crops. A granular structure is desirable to allow rapid infiltration and good retention of rainfall, to provide adequate air capacity and exchange within the soil

2) To control weeds or to remove unwanted crop plants (thinning)

3) To manage plant residues, thorough mixing of trash will add humus and fertility of soil, while retention of trash on surface reduces erosion

4) To minimize soil erosion by following such practices as contour tillage, listing and proper placement of trash

5) To establish specific surface configurations for planting, irrigating, drainage, harvesting operation etc.

6) To incorporate and mix fertilizers, pesticides or soil amendments into the soil

7) To accomplish segregation. This may involve moving the soil from one layer to another, removal of rocks and other foreign objects or root harvesting.

Classification of Tillage: Tillage can be classified into (a) primary tillage (b) secondary tillage:

(a) Primary Tillage: The operation performed to open up any cultivable land with a view to prepare a seedbed for growing crops, is termed as primary tillage. It is normally designed to reduce soil strength, cover plant materials and rearrange aggregates. The various equipments used for primary tillage are mould board plough, disc plough, heavy- duty disc harrow, chisel plough, rotavator etc.

(b) Secondary Tillage: Lighter and finer operations performed on the soil after primary tillage, are termed as secondary tillage. These operations are generally performed on surface soil. Very little inversion and shifting of soil takes place and consequently less power requirement per unit area. Implements are disc/other harrows, cultivators, sweeps, tillers etc.

Types of Tillage:

Apart from these major primary and secondary tillage operations we often do tillage in some other ways. These different types of tillage are discussed as follows:

(i) **Minimum Tillage:** Minimum soil manipulation necessary to meet tillage requirements for crop production. The major objectives are:

(a) To reduce mechanical energy and labour requirement

(b) To conserve moisture and reduce soil erosion.

(c) To perform only the operations necessary to optimize the soil conditions

(d) To minimize the number of trips over field

(e) Disadvantages: When surface plants residues are involved insects are increased and effective chemical weed control is essential

(ii) **No- Tillage:** In a single operation, sowing is done without tilling it at all. This is applied where moisture conservation is required. These are suitable in the areas where heavy rainfall is there.

(iii) **Strip Tillage:** Tillage system in which only isolated bands of soil are tilled.

(iv) **Rotary Tillage:** Tillage operations employing rotary action to cut, break and mix the soil, rotary tillers are used. These tillers have low or negative draft requirements, but total power requirements are high and pulverization may be excessive.

(v) **Stubble-Mulch Tillage:** It involves cutting the roots of weeds and other plants and leaving the crop residue on the surface or mixed into the top few centimetres of soil. This is done to reduce wind and water erosion and conserve water by reducing run-off. Mostly used in semi-arid and arid zones. Special blade type sub-surface tillers, v-shaped sweeps having cutting widths 0.6 to 2.4 m, straight blades, vertical disc plough, disc harrows, rotary hoes, chisel ploughs, cultivators.

(vi) **Combined Tillage:** Operations simultaneously utilizing two or more different types of tillage tools or implements to simplify, control or reduce the number of operations over a field are called combined tillage.

FIELD COVERAGE METHODS

Ploughing is the primary tillage operation, which is performed to cut, break and invert the soil partially or completely.

Normal Ploughing: It is the ploughing up to a depth of about 15 cm.

Contour Ploughing: It is the method of ploughing in which the soil is broken and turned along the contours.

Land Ploughing: While ploughing the land separates top layer of soil into furrow slices. The furrows are turned sideways and inverted to a varying degree, depending upon the type of plough being used. It is a primary tillage operation, which is performed to shatter soil uniformly with partial or complete soil inversion. There are a few important terms frequently used in connection with ploughing of land.

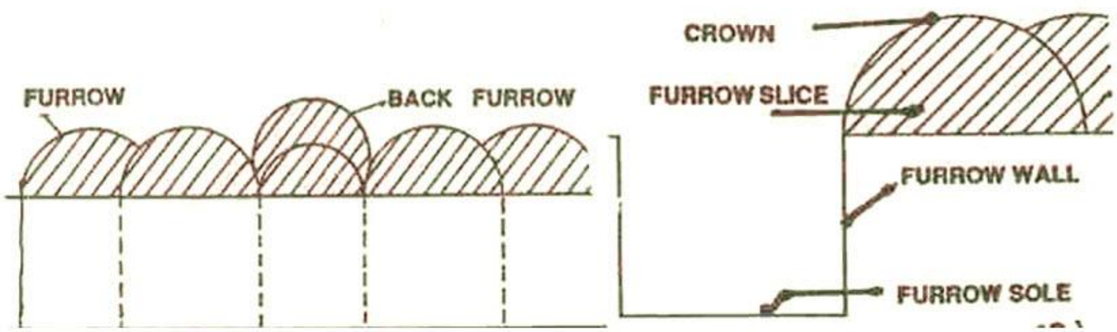
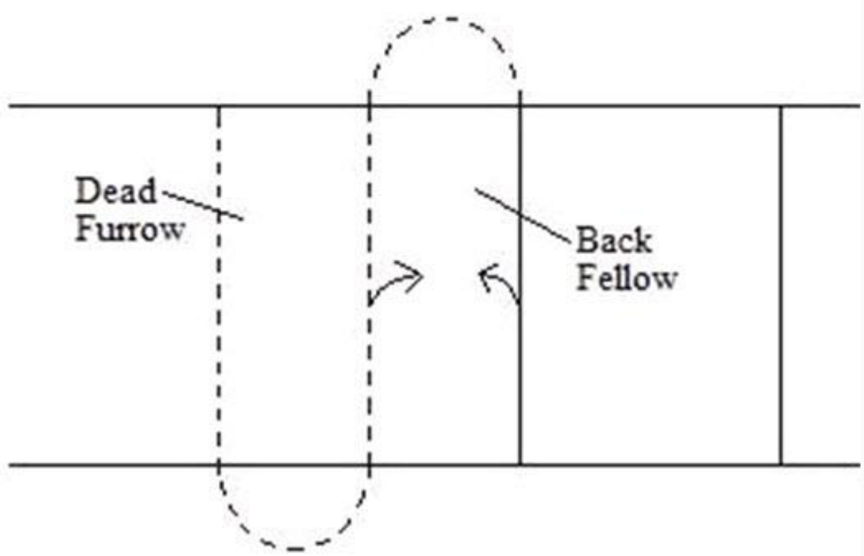


Fig.1. Plough furrow



Furrow: It is an open trench formed by an implement in the soil during field operations.

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

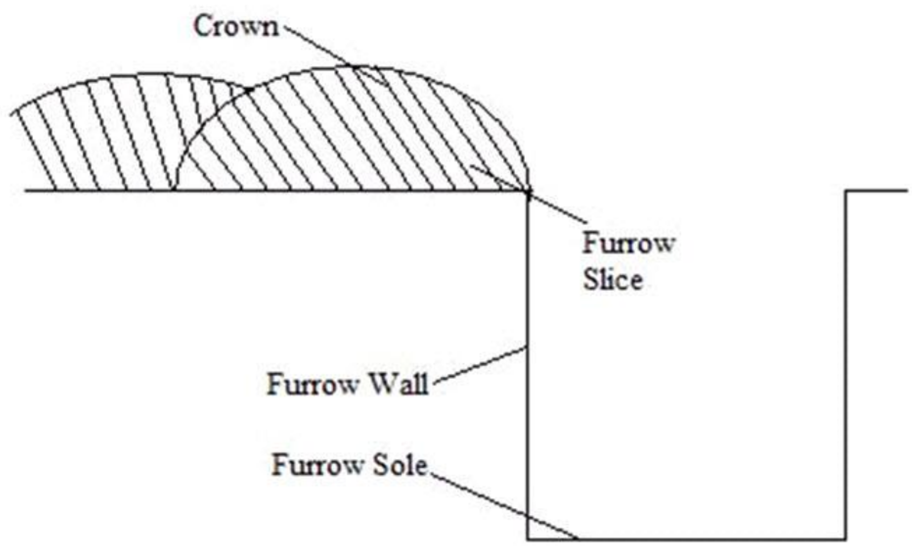
Dead Furrow: An open trench left in between two adjacent strips of land after finishing the plowing is called dead furrow or when two open furrows come together as when you finish working a piece of land that double furrow is called dead furrow.

Furrow Slice: It is the mass of soil cut, lifted and thrown to one side.

Furrow Wall: It is undisturbed soil surface by the side of furrow.

Crown: Top portion of turned furrow slice.

Headland: While plowing with a tractor a strip of unplowed land is left at each end of the field for tractor to turn. It is twice the width of the implement. At the end of each trip, the plough is lifted until the tractor and the plough have turned and are in position to start the return trip. The headland is about 6 meters for two or three bottom tractor plough and 1 metre more for each additional bottom.



Methods of ploughing

Methods of ploughing

In order to provide furrows at all times on the right hand side of the plough two method of working are used a) Gathering b) Casting.

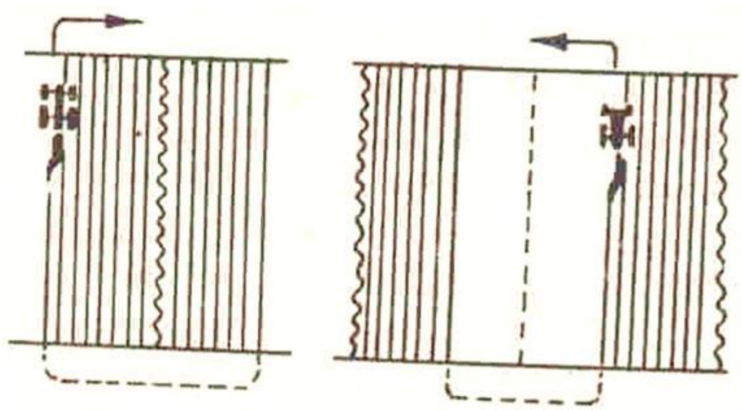


Fig 2 a. Gathering b. Casting

a) Gathering - Whenever a plough works round a strip of ploughed land, it is said to be gathering (Fig.2a).

b) Casting - Whenever a plough works round a strip of un-ploughed land, it is said to be casting (Fig.2b).

Ploughing of a field by casting or gathering alone is normally uneconomical. The following are a few important methods used in tractor ploughing.

i) Continuous ploughing method and

ii) Round and round ploughing

c) Continuous ploughing method

In normal conditions, the continuous ploughing method is considered very convenient and economical. This method is usually used when the tractor and plough never run idle for more than three quarter land width along the headland and never turn in a space narrower than a quarter land width. In this method, first the headland is marked and the first ridge is set up at three quarter of a land width from the side (Fig. 3a). The other ridges are set at full width over the field. The operator starts ploughing between the first ridge and the side land. The operator continues to turn left and cast in the three quarter land until a quarter land width of ploughing is complete on each side (Fig. 3b).

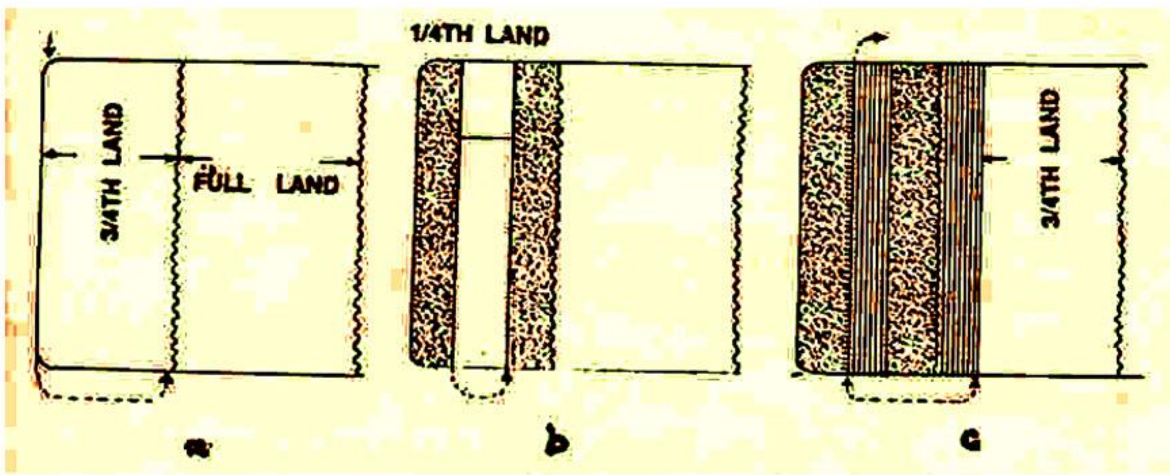


Fig.3 Continuous ploughing method

After this, the driver turns right and gathers round the land already ploughed on the first ridge. Gathering is continued till the un-ploughed strip in first three-quarter land has been ploughed and completed. This gathering reduces the first full land by a quarter (Fig. 3c). The remaining three quarter land can be treated in exactly the same manner as the original three quarter land. This process is repeated for all other lands in the field.

d) Round and round ploughing

In this method, the plough moves round and round a field. This system is adopted under conditions where ridges and furrows interfere with cultivation work. The field can be started various ways as follows:

1) Starting at the center: Small plot is marked in the middle of field and plowed first. After that plow works round this small plot and entire plot is completed. This is not very economical method.

2) Starting at outer ends: Tractor starts ploughing at one side of field and then moves on all sides of plot and comes gradually from sides to the center of field. Wide diagonals are left unplowed to avoid turning with the plough. There are no back furrows in this method. Conventional ploughing is usually done by this method.

3) 270^0 turns from boundaries or centers.

Lesson 8. Study of mould board plough: accessories, adjustments, operation and material of construction Mould Board Ploughs

Equipment used by the farmer to break and loosen the soil for a depth of 6 to 36 inches is called primary tillage equipment.

Why plowing is done?

1) To obtain a deep seed bed for good structure

2) To add more humus and fertility to the soil by covering, vegetation and minerals.

3) To destroy weeds.

4) To leave the soil in a condition to breath or allow the air to circulate freely.

5) To facilitate the introduction of seed in the soil with better contact.

6) To destroy insects and their eggs along with their breeding places.

7) To leave the surface in the condition to prevent erosion by wind

8) To get greater root protection.

When to plow?

1) Early plowing during rainy season reduces weeds. When buried in soil work it becomes manure and is of great importance.

2) In our country there are high winds which bring with them considerable amount of dust with particles of grass, leaves, crop residue like bhusa and all sort of vegetation which settle on ploughed, rough, cloddy surface of field which otherwise get blown off.

3) In a long period of dry and hot weather a good amount of nitrogen is built up in the air and this is caught by first rainfall and brought to the soil. In case the field is ploughed this rain water with nitrogen gets absorbed in loose soil hence works as fertilizer.

In olden days "Desi" wooden plows were popular throughout the world. In 14th century after introduction of steel, steel plows were popular throughout the world.

Mould board plows are:

- One of the oldest of all agricultural implements
- It is considered to be the most important tillage implement

- It consumes more traction energy than any other operation
- It cuts loose the furrow slice, inverts the furrow slice more or less in pulverized form
- It is used for covering grass into soil immediately after rains
- But its design largely depends upon cut and try methods.

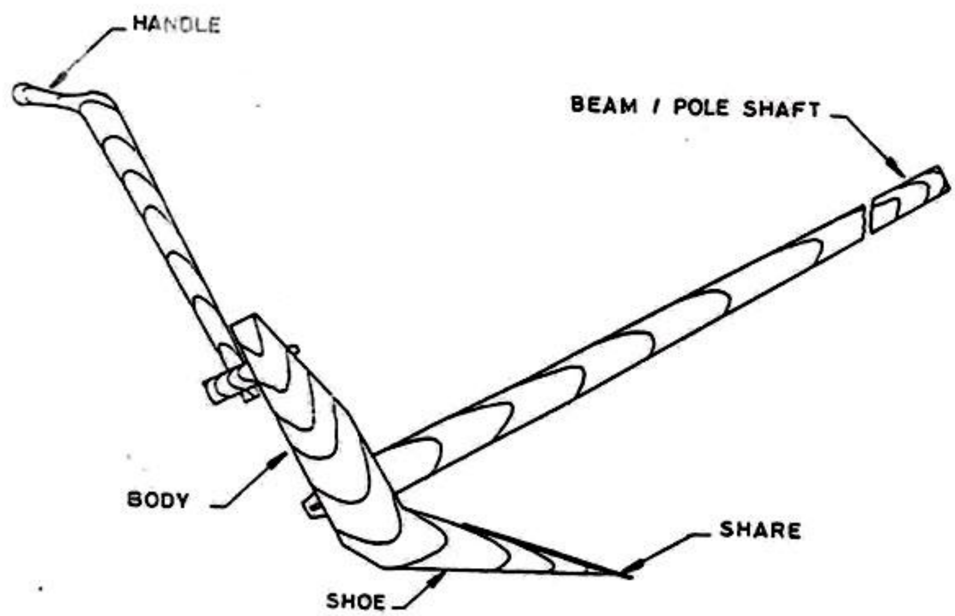


Fig.4 Country Plough

Types of mould board plows:

1) Trailed: It is also known as pull type and it is complete unit in itself supported on two wheels.

The complete unit is hitched by the drawbar of the tractor.

It is available in **1-8 bottoms** depending upon the capacity of the tractor.

Single bottom has one bottom. **Two – Eight bottoms** are called as **gang mould board.**

Sizes available are **36, 41 and 46 cm**.

These are not easily maneuverable.

2) Semi-Mounted: These are more compact and more maneuverable than pull type.

Sizes and number of bottoms are same as that of pull type.

These are less expensive.

These put more vertical load on tractor rear wheels (there by improving tractive ability).

3) Mounted: These are called as direct mounted, tractor mounted or tractor carried plows.

These plows use tractor lift linkages which are controlled hydraulically.

It is available in **2-5 bottoms** depending upon the capacity of tractor.

Sizes available are **30, 36 and 41 cm**.

Increased size of mounted type plows cause tractor instability during transport.

Classification of mould board plows:

1) One way plow: It turns soil to the right hand side.

One way plow require laying out a field in lands, starting with back furrows and ending with dead furrows.

2) Two way plow: It turns soil to both right and left side.

Two sets of bottoms are mounted on a common frame that is rotated about a longitudinal axis to change from one set to other.

Mechanical or hydraulic cylinders are used for rotation

Gage wheels and rear wheels are automatically repositioned as the plow bottom frame rolls over, unless each set of bottoms has its own wheel (which is usually the case of mounted plows).

Two way plows eliminate the back furrow and dead furrow leaving the field more level for irrigation or drainage.

Two way plows are advantageous for terraced fields or contour ploughing and for small irregular shape fields.

Animal drawn two way plow is also called as turn- wrest plow.

Parts of Plow:

1) Plow Bottom

2) Plow Frame

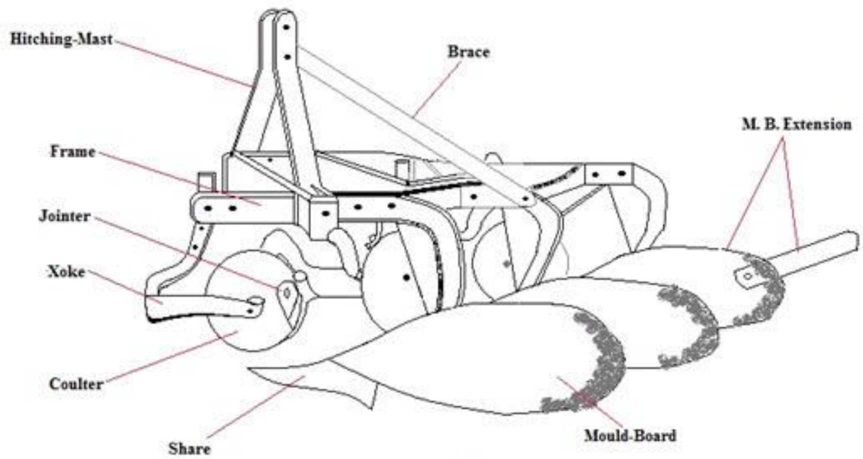
3) Attachments (Coulters & Jointers)

4) Wheels

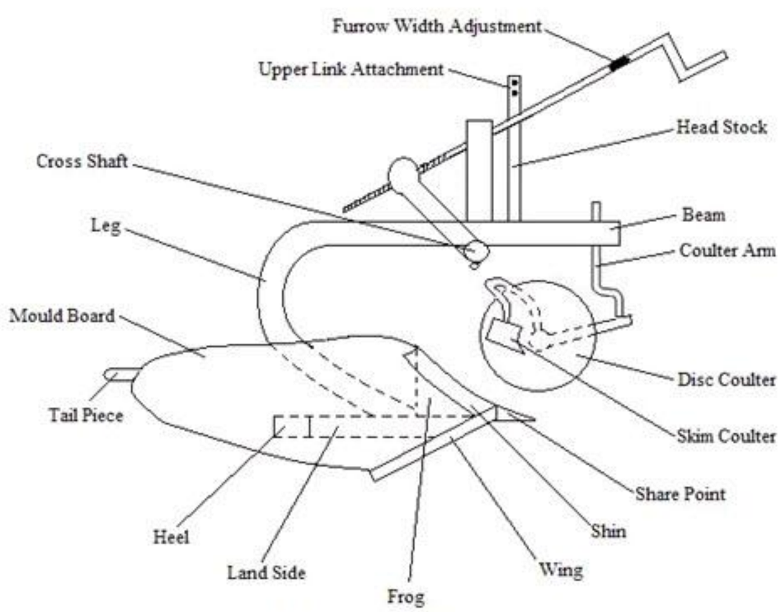
5) Lifting Mechanism

6) Plow Hitch

7) Depth Adjusting Mechanism



MOULD BOARD PLOUGH



Parts of a mounted mouldboard plough

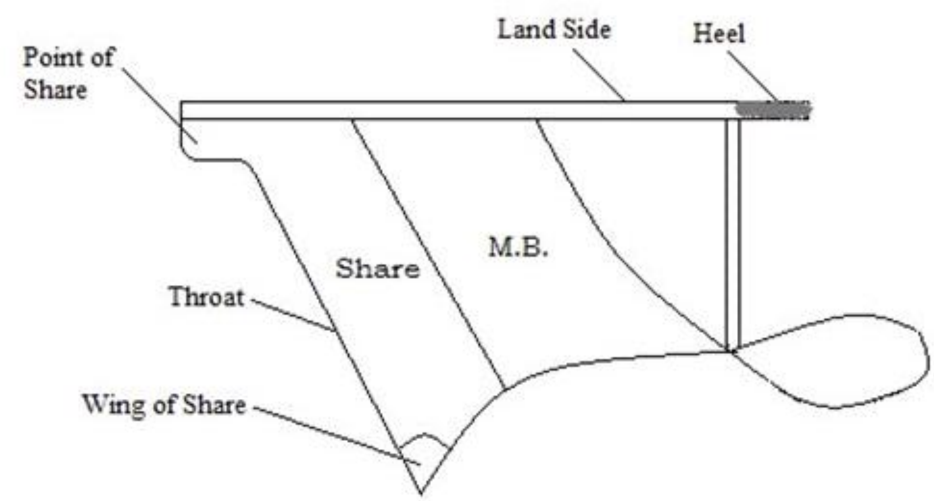
1) Plow Bottom: It is the actual part of the plow.

It is three sided wedge.

There are three main parts i.e. mould board, landslide and share which are rigidly fastened to the frog.

Its main function is to cut the furrow slice, shatter the soil and invert the furrow slice to cover trash.

The size of the plow bottom is the width of furrow it is designed to cut.



Top view of M. B. Plow Bottom

a) Share: It is the part of plow bottom which actually penetrates into the soil and makes a horizontal cut below the surface.

b) Mould Board: It is the curved part which lifts and turns the slice.

c) Landslide: It is the flat plate which bears against and transmits the rear side lateral thrust of plow bottom to the furrow wall.

d) Frog: It is the base of the plow bottom to which other parts are attached.

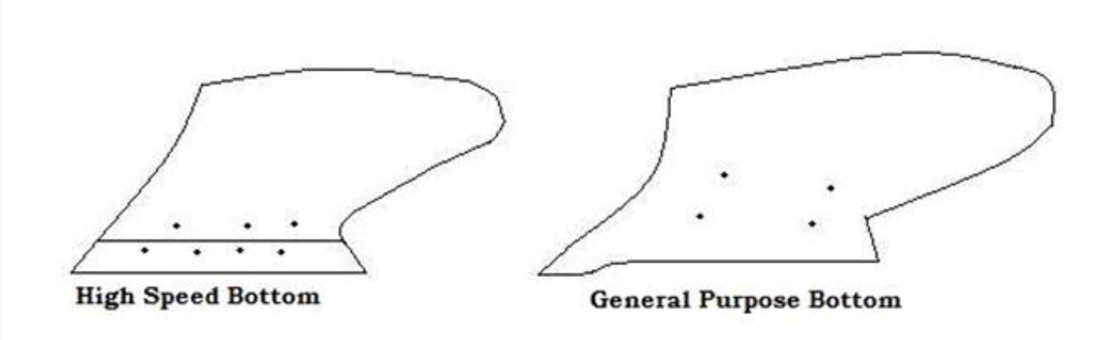
e) Tail Piece: It is the extension of mould board which helps in turning the furrow slice.

Types of Mould Board:

Different soil conditions require plow bottoms of different shapes. The moisture in the soil and texture of soil determines whether it should pulverize thoroughly or merely turned over to be pulverized later on.

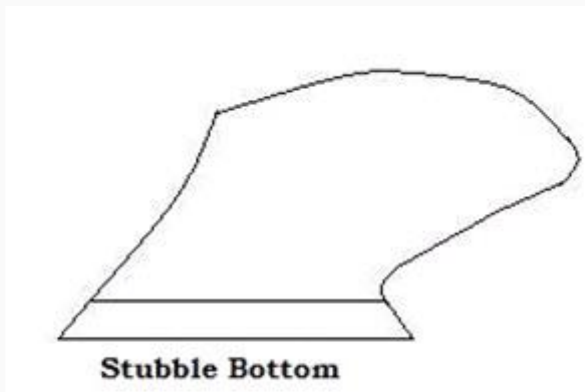
a) General Purpose and High Speed:

These are mostly used and suitable for wide range of conditions. It mostly meets the general demand of seedbed preparation.



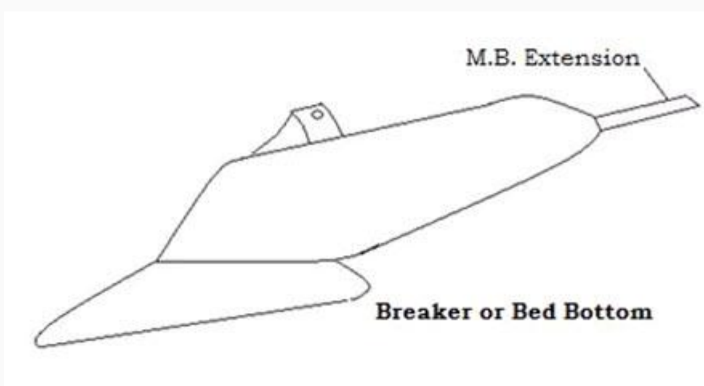
b) Stubble Bottom:

It is generally used for old ground where good pulverization is required. It has relatively short and broad mould board which is curved rather abruptly near the top, resulting in a greater degree of pulverization than with other types.



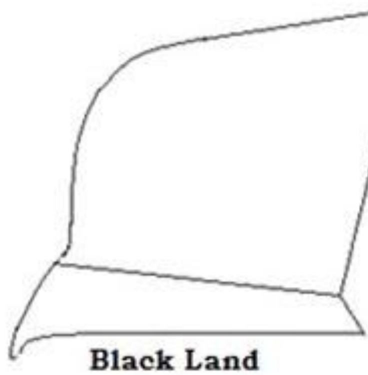
c) Sod or Breaker Bottom:

It is used in tough soil where furrow slices are completely turned over so that grass doesn't grow. It has a long and low mould board with a gradual twist (spiral) that completely inverts the furrow slice with a minimum of breakup, thus covering vegetative matter thoroughly.



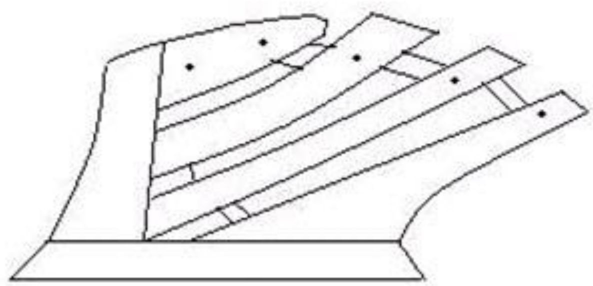
d) Black land Bottom:

It is used for plowing gumbo or buckshot soil where scouring (cleaning) is a problem. It has relatively small mould board area, and its shape tends to promote scouring soils.



e) Slat Bottom:

It is the less common type. It is highly favorable in light and sticky soils where general purpose plow doesn’t scour. The slates fitted give high pressure between soil and mould board scours better.



Material Used for Mould Board:

General Purpose	High Carbon Steel
Stubble Bottom	-----do-----
Sod or Breaker	-----do-----
Slat Bottom	-----do-----
High Speed	-----do-----

Parts of Share:

a) Share Point:

It is the forward end of the cutting edge, which actually penetrates in the soil.

b) Cutting Edge:

Front edge of the share, which makes horizontal cut in the soil.

c) Wing of Share:

Outer end of cutting edge of share. It supports the plow bottom.

d) Gunnels:

It is vertical face of share, which slides along the furrow wall. It takes side thrust of soil and supports the plow bottom against the furrow wall.

e) Cleavage Edge:

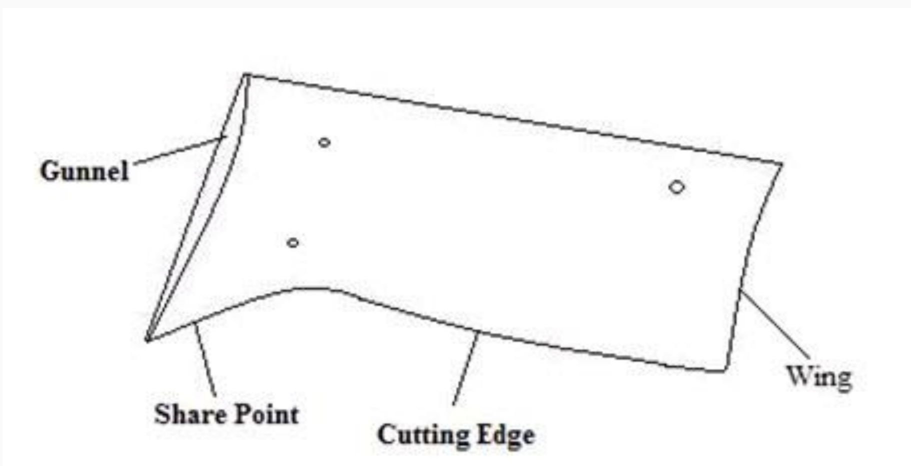
It is the edge of the share which forms joint between mould board and share on frog.

f) Wing Bearing:

Level portion of wing of the share providing a bearing for outer corners of plow bottom.

g) Throat:

Principle parts of the share i.e. share point, wing and cutting edge is also called as throat. Point is the first part to penetrate in the soil, the wing is the outside corner of the cutting edge. The cutting edge extending from the point to the wing is curved and forms the throat of the share.



Types of Shares:

a) Slip Share:

One piece share with curved cutting edge, having no additional part.

Common type of share generally used by the farmers, as it is simple in design.

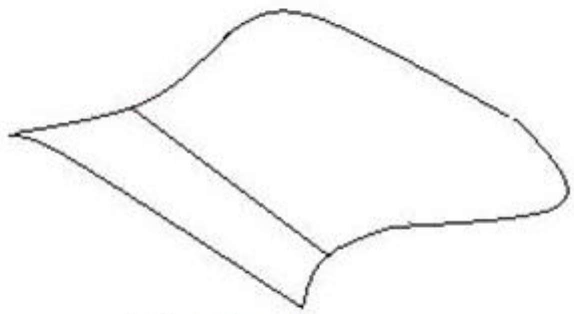
Disadvantage is that entire share has to be replaced if it is worn out due to constant use.

Slip Share

b) Slip-nose Share:

It is a share in which point of share is provided by a small detachable piece.

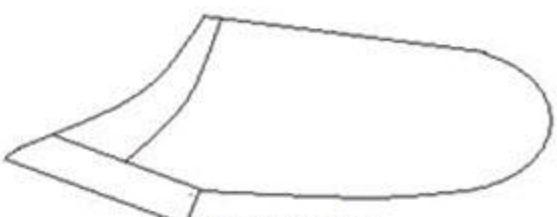
Advantage is that share point can be replaced as and when required. So it is economical.



Slip Nose Share

c) Shin Share:

It has a shin as an additional part.



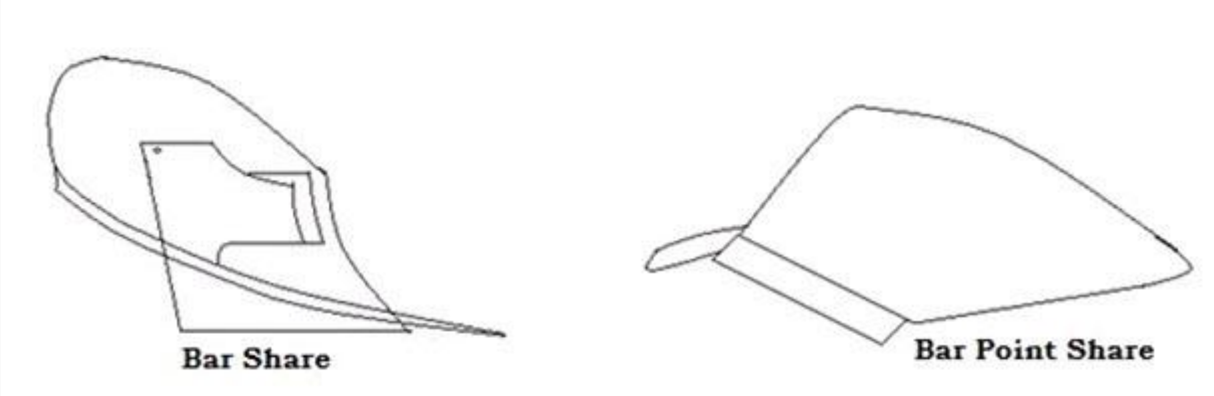
Shin Sahre

It is similar to slip share with a difference that an extension is provided by side of the mould board.

d) Bar Point Share:

It is the share in which point of share is provided by an adjustable and replaceable bar.

This bar serves the purpose of point of share and landslide of the plow.



Materials Used for Share:

Slip Share	HCS, soft center steel, cast iron
Slip-nose Share	Cast iron
Shin Share	HCS
Bar Point Share	HCS

1) Cast Iron Share:

These are made for cheap type of plow.

Require careful handling, as these are brittle and can break easily with sharp blow. If it is broken it has to be replaced. But if it is worn it can be sharpened with the help of grinding stone.

2) Chilled Cast Iron Shares:

These shares have comparatively longer life as these do not rust and do not wear quickly.

These are recommended for sandy and strong soils.

3) Soft Center Steel Shares:

These are used in the soils where soil doesn’t stick to the surface of share or mould board.

These have very hard surface and long life but are costly.

4) Solid Steel Share:

These are used where soil is not abrasive.

These are quite sturdy and can withstand shocks.

These are made out of high carbon steel by forging process.

Types of Landslide:

a) This landslide is about 23 cm long and is used for plows where landslide pressure is not a factor.

b) This landslide is 28 cm long and is used for normal plowing conditions.

c) This landslide is 36 cm long and has landslide heel used for abrasive soils.

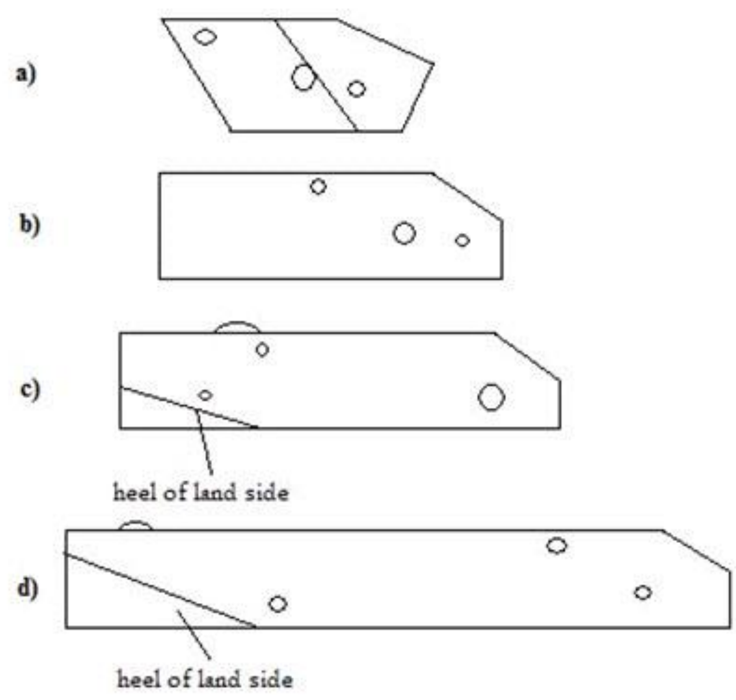
d) This landslide is 50 cm long and has a landslide heel. It is used in plows which don't have rear furrow wheel, it gives support to plow bottom.

Material used for Landslide:

Soft center steel/ MS/ cast iron

Material used for Frog:

MS/ cast iron

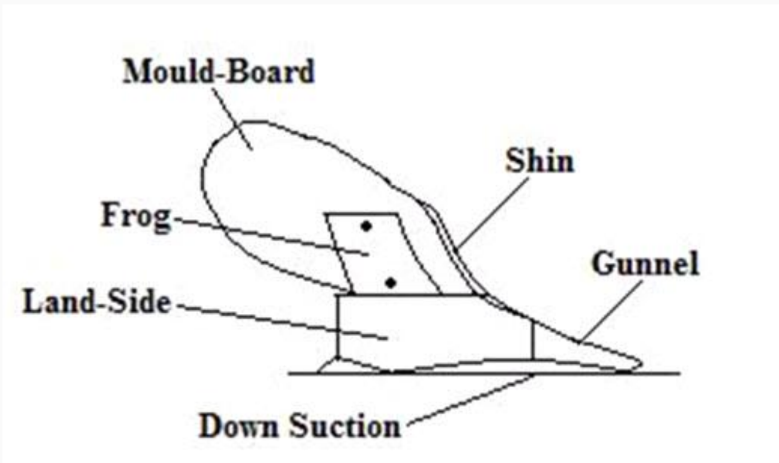


Lesson 9. Study of mould board plough: accessories, adjustments, operation and material of construction

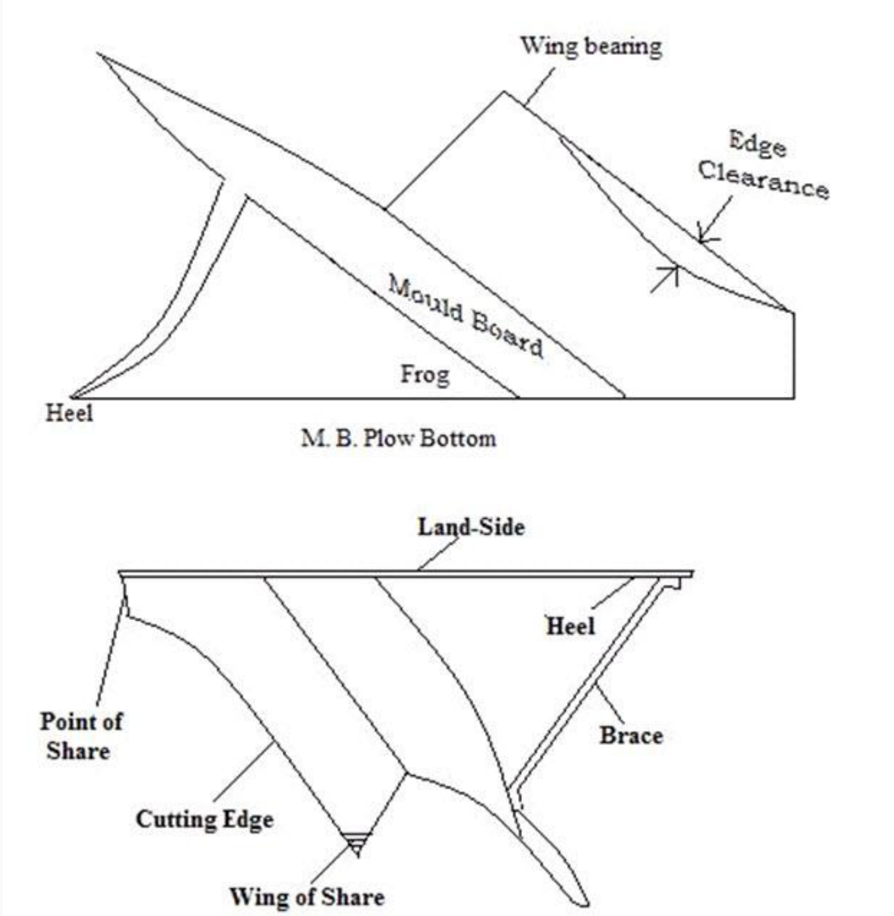
ADJUSTMENTS OF MOULD BOARD PLOUGH

For proper penetration and efficient work by the mould board plow some clearance is provided in the plow. This clearance is called suction. These are of two types:

1) **Vertical Suction:** It is the vertical distance from the ground, measured at the joining point of share and landslide. It helps the plow to penetrate into the soil to a proper dept. It is generally 3 to 5 mm.



2) **Horizontal Suction:** Maximum clearance between the landslide and horizontal plane touching point of share at its gunnels side and heel of landslide. It helps the plow to cut the proper width of furrow slice. It is generally 5-13 mm.



3) **<u>Angle of cutting edge</u>** from direction of travel it is 40-45 degrees.

4) <u>Throat clearance:</u> Perpendicular distance between point of share and lower position of beam of plow.

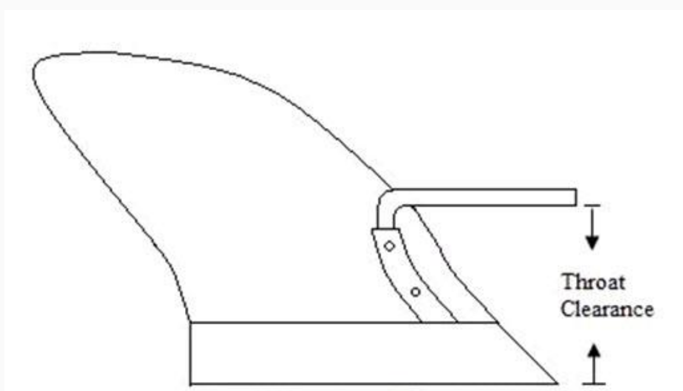


Fig: Throat Clearance

5) <u>Vertical Clevis:</u> It is a vertical plate with a number of holes at the end of the beam to control the depth and adjust the line of pull.

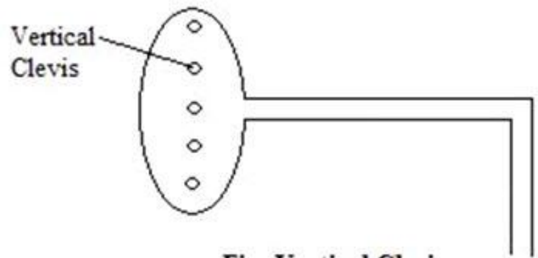


Fig: Vertical Clevis

6) <u>Horizontal Clevis:</u> It is a device to effect lateral adjustment of plow relative to line of draft.

7) <u>Plow Size:</u> Perpendicular distance from wing of share to the line joining the point of share and heel of landslide. The size of mould board is expressed by width of cut of soil. Common size of tractor drawn mould board is 30 cm, 35 cm, and 40 cm. Animal drawn mould boards are of 13 to 20 cm.

8) <u>Mould Board plow cross shaft:</u> It is used to make proper width adjustment of plow.

Fig: M. B. Plow Cross Shaft Adjustment

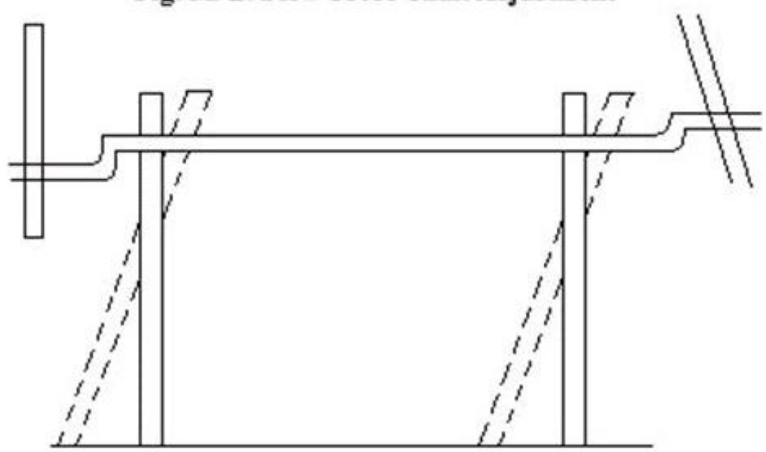


Fig: (A) To increase forrow width

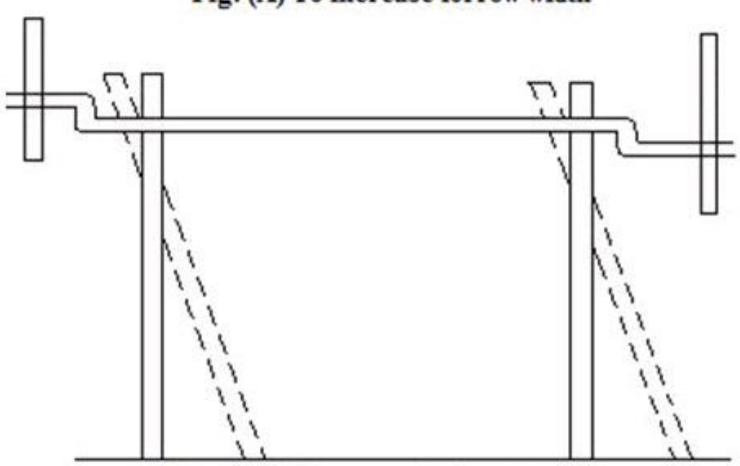


Fig: (B) To decrease the furrow width

9) For tractor drawn plows:

Coulter adjustments:

Vertical adjustments = ½ of depth or 50 mm

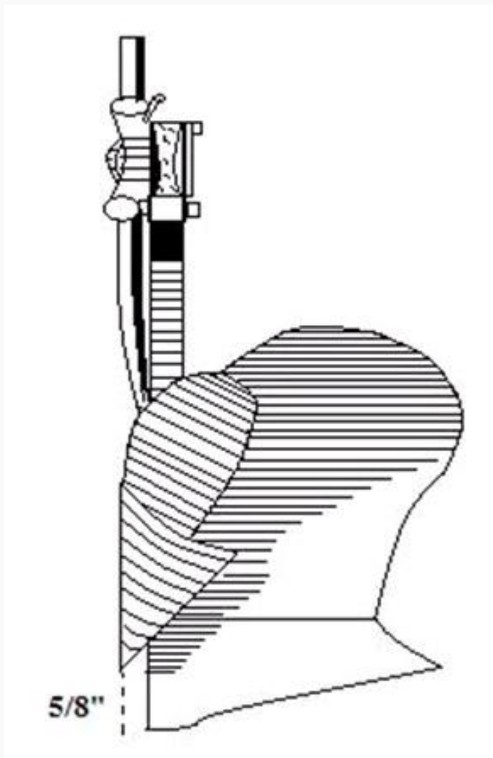
Horizontal adjustments = 20 mm outside the landslide.

Coulter diameter = 30 to 45 cm.

Jointer adjustments:

Depth = 4 to 5 cm

Furrow wheel adjustments: 6 to 12.5 mm clearance between rear of landslide back plow bottom and furrow wall.



REACTION OF SOIL TO MOULD BOARD: Wide range of soil conditions encountered in tillage materially affects the reactions of the soil on mould board surfaces.

1) Hard cemented soil: These soils break into large irregular blocks ahead of the plow, with no definite pattern to soil reactions.

2) Heavy sod: Due to heavy mass of roots normal share planes not observed. Normal reactions occur below the sod.

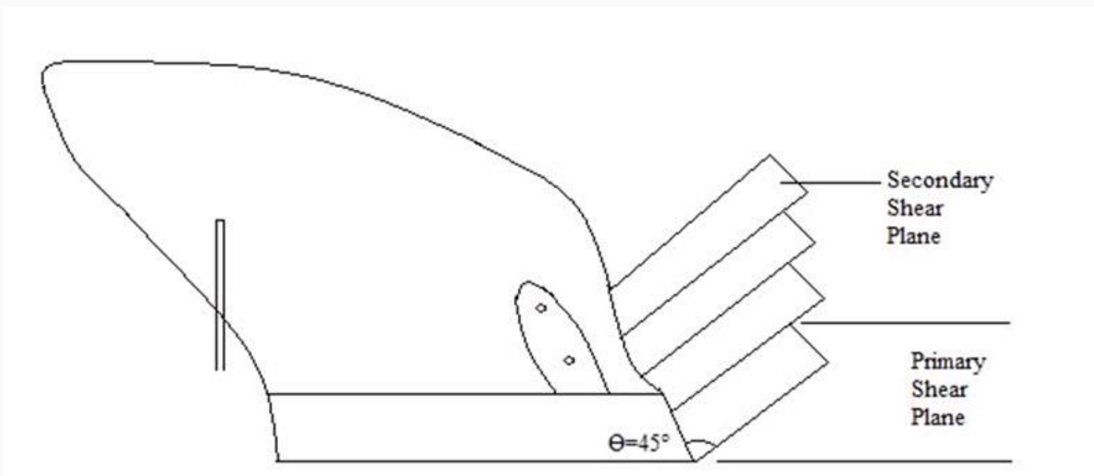
3) Packed or cemented surface: With relatively loose soil below the compacted surface. Blocks of surface layer are broken loose irregularly and lifted like boards.

4) <u>Push Sell:</u> Acts like freshly plowed soil. Adhesion of soil to mould board builds up pressure ahead of plow bottom. Tendencies of soil to push to one side rather than turned or lift.

5) <u>Normal Soil Conditions</u>: These are settled soils with a firm condition and have adequate moisture content for good plowing.

Under normal soil conditions the movement of soil on the mould board is due to the resistance of the soil ahead of the plow bottom and average speed of movement of soil across the mould board is approximately that of plow forward speed.

<u>PULVERIZING ACTION:</u> As a plow moves forward its double wedging action exerts pressure both upward and toward the open furrow. Stresses set up by this action cause soil blocks to be shared loose at regular intervals on parallel inclined share plane. These primary share planes extend forward from plow point at an angle of 45 degree in both horizontal and vertical planes retaining their relative positions as they move across the mould board surface. Soil blocks formed by primary shearing action break down as they move mould board forming secondary share planes at right angles to primary share planes.



<u>TURNING AND INVERSION:</u>

Lifting of furrow slice at the shine side starts earlier than wing side. Turning and inversion starts immediately. Most turning and inversion is affected by the upper part of mould board. Finally pushing and throwing the soil into the adjoining furrow. Amount of throw depends on forward speed and direction of release of soil.

<u>SCOURING:</u> Movement of soil across a tool surface without sticking is called scouring. Best scouring is achieved when soil-metal friction is low than that of soil-soil friction, the angle of approach of tool, soil cohesion and soil adhesion.

Scouring will occur as long as the frictional resistance at the soil-tool interface is less than the resistance at a parallel soil-soil interface. When scouring is adequate, soil flows over the tool along a patch that is determined by the shape of the tool. In non-scouring condition soil flows over a layer of soil attached to the tool surface, usually resulting in increased draft and poor performance.

In practice the soil-metal friction angle is less than the angle of soil shearing resistance. Therefore, an increase in pressure against the mould board will increase soil shearing resistance more than the soil metal frictional resistance and will improve scouring. Non-scouring is likely to occur at low spots or other irregularities, in areas of abrupt change in surface direction and in other low pressure areas.

Adhesion may be reduced by employing material that resists wetting. A slat mould board scours better than a soil mould board because the smaller contact area results in reduced adhesive forces and increased soil pressure.

Teflon is a non-wetting plastic that is being used to make a mould board plow scour in push-type non-abrasive soils. (Test conducted at various countries show that a mould board coated with a Teflon gives 23% less draft at 5.6 km)

Another approach to reduce soil-metal friction and improving scouring is by applying air to the soil-engaging surface to provide an air cushion or boundary layer which separates the two surfaces that are moving relative to each other. Air from a compressor driven by the tractor is delivered to a plenum chamber on the back side of the mould board and passes through a network of small holes to the front of the mould board. Another method is employing a moving surface to transport the soil (belt type mould board). Also mould board is coated with plaster of Paris or enameling.

BEAM-OVERLOAD PROTECTION:

Wide acceptance of mounted and semi-mounted plows need for individual overload protection devices for plow standards (Beam). For increased forward speeds these devices are needed. Spring-trip devices load against share exceeds trip release and permits plow bottom to swing rearward about horizontal, transverse axis. Unless the obstruction will permit share point to move downward entire implement is raised by tripped bottom. In hydraulic reset overload devices, hydraulic cylinders are provided.

EXPRESSING MOULD BOARD SHAPES:

Some means of identifying mould board shape is needed in comparing and analyzing the performance of different plow bottoms and for manufacturing purposes. The shapes can be expressed either mathematically or by identifying empirical methods. Plow bottoms had surfaces that could be fitted by equations representing cylindrical, hyperbolic, spiral paraboloids.

Lesson 10. Disc plough: standard and vertical ; principle of operation, adjustments and accessories

Disc Plough:

As the name implies it is in the form of a disc.

Disc plows are designed to reduce friction by making a rolling plow bottom instead of sliding plow bottom.

It cut, inverts and in some cases breaks furrow slices by means of separately mounted large steel discs to one side.

Advantages over Mould Board Plough:

1. Disc plow can be forced to penetrate into soil, which is too hard and dry for working with a mould board plow.
2. It works well in sticky soil in which a mould board plow doesn't scour.
3. It is more useful for deep plowing.
4. It can be used in stony and stumpy soil without much danger of breakage.
5. A disc plow works well even after a considerable part of disc is worn off in abrasive soil.
6. It works in loose soil without much clogging.
7. When scrapers are fitted it also inverts the soil.
8. If disc plow is used without scraper it has more mixing action rather than inversion.
9. The maintenance cost is low, as there are no shares to replace or sharpen as compared to mould board plows.

Disadvantages of Disc Plow:

1. Disc plow cannot be used at high speed since for cutting action at slow speed is necessary.
2. It is not suitable for covering surface trash and weeds as effectively as mould board plow.
3. It leaves field rough and cloddy than mould board plow.

4. It is heavier than mould board plow for equal capacities as penetration depends on weight rather than suction.

Types of Disc Plow:

Disc plows are divided into two main categories

1) Bullock drawn

a) Sulky type

b) Gang type: attached to universal frame which is mounted on two wheels.

2) Tractor drawn

a) Direct mounted

b) Semi-mounted

c) Trailed

3) According to mounting of Discs

a) Standard disc plow

b) Vertical disc plow or harrow plow or wheat land plow

c) Cylinder plow or disc tiller or tiller disc plow

Standard Disc Plow:

Three bottom mounted type standard disc plow, six bottom trail type standard disc plow, four bottom mounted type reversible standard disc plow.

A series of individually mounted inclined disc blades on a frame supported by wheel.

Usually have 3 to 6 disc blades spaced to cut 18 to 30 cm per disc.

Discs are tilted backward at an angle of 15 to 25 degree from vertical and disc angle of 42 to 45 degree from direction of travel.

Disc diameter ranges from 61 to 71 cm.

Scrapers are used for assisting discs in covering trash and prevent soil build up on disc in sticky soil conditions.

Reversible disc plow (usually mounted or semi-mounted) have an arrangement to reverse the disc angle at each end of field to permit one way plowing.

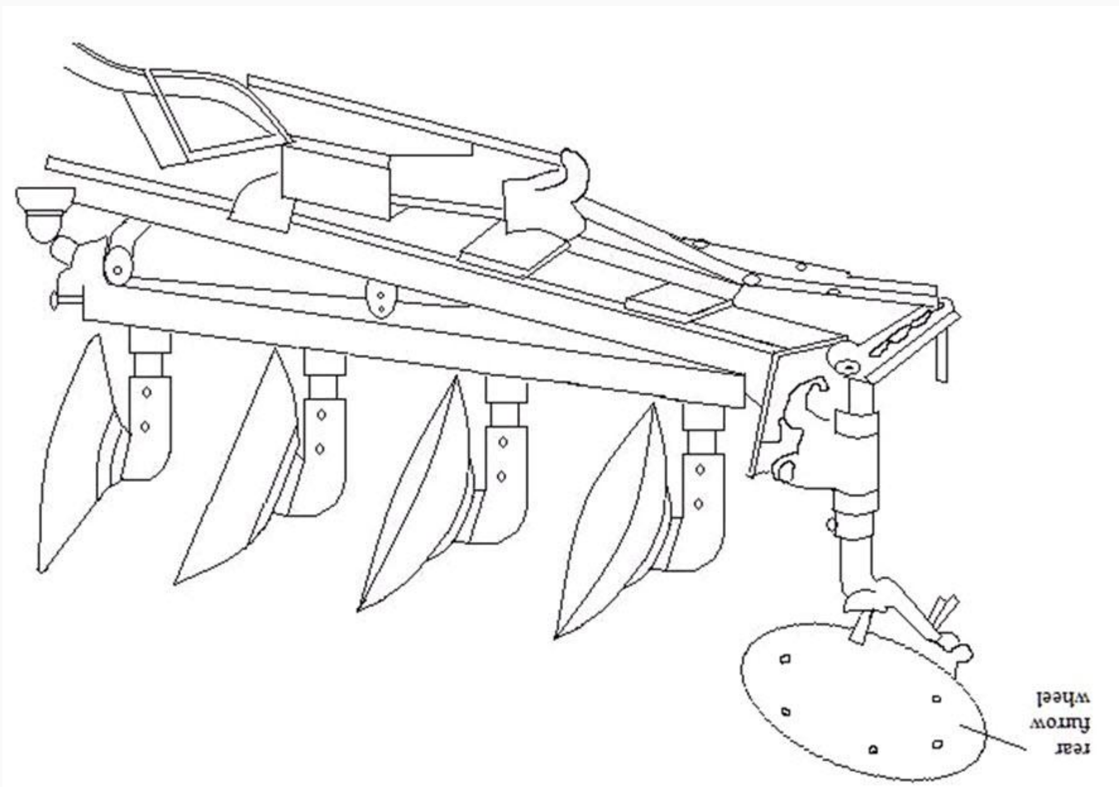
Used in hard and dry soil. Disc tools are forced into ground by effect of gravity upon its mass rather than suction.

Total mass of disc plow varies from 200 to 600 kg.

In mounted type, wheels of tractor take side thrust. Sometimes a rear wheel is fitted to take side thrust of plow to some extent.

In trailed type, furrow wheel bears the side thrust.

Disc is made of heat treated steel of 5 mm to 10 mm thickness.



Vertical Disc Plow:

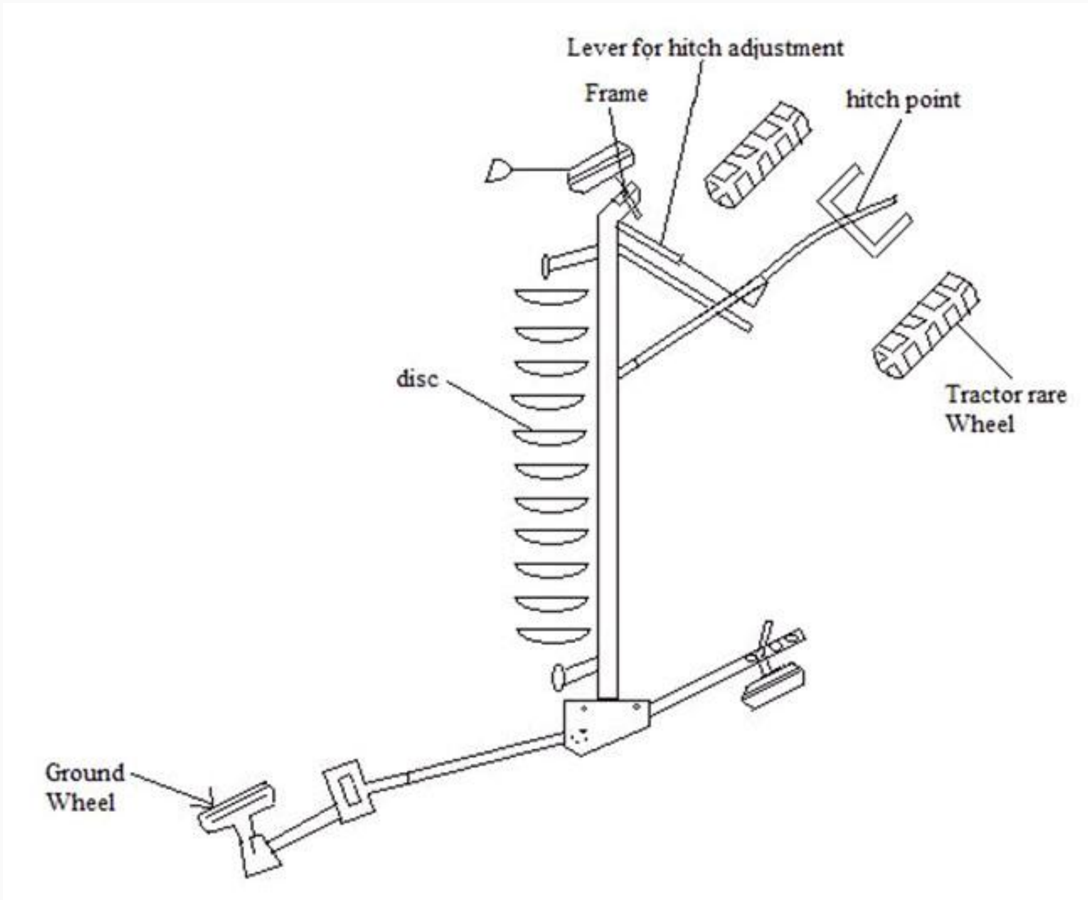
Also called as one-way disc plow, harrow plow and wheat land plow.

Similar to pull type and standard disc plow but discs are uniformly spaced along a common axle or gang bolt and clamped together through spacer spools so the entire gang rotates as a unit (as in disc harrow).

It is about halfway between the standard disc plow and disc harrow in its soil working action.

Generally used in plain areas and where shallow plowing and mixing of stubble with soil is required. Diameter of discs varies from 51 cm to 61 cm and spacing from 20 to 25 cm apart along the gang bolt. Width of cut per disc depends upon the angle between gang axis and direction of travel. Disc angle ranges from 35 to 60 degree and most common angle is 40 to 45 degrees.

Width of cut obtained from various sizes of vertical disc plow ranges from 2 to 6 m. weight of plow ranges from 50 to 100 kg.



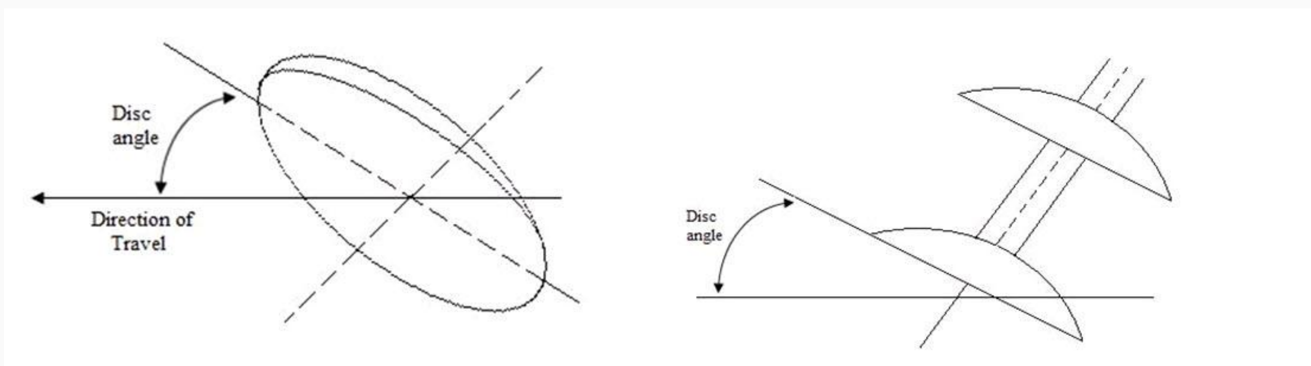
Comparison between Standard Disc Plow and Vertical Disc Plow

S. No.	Comparison	Standard Disc Plough	Vertical Disc Plough
1.	Mounting of disc	Individual axis	Common axis
2.	Number of discs	1-6	5-24
3.	Sizes of discs	60-75 cm	40-60 cm
4.	Spacing	18-30 cm	18-22 cm
5.	Concavity	More	Less

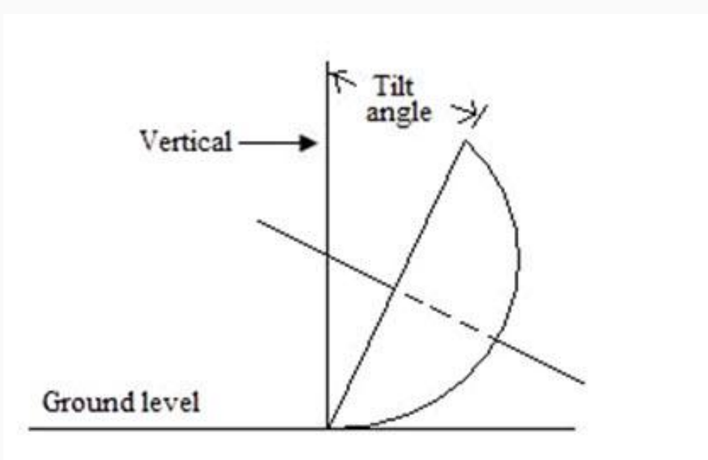
6.	Depth of cut	30-40 cm	8-10 cm
7.	Angle to direction of travel	42-45 degree	35-60 degree
8.	Tilt angle	15-25 degree	0 degree
9.	Weight/disc	200-600 kg	50-100 kg
10.	Draft requirement	High	Low

In standard disc plow provisions are made for adjustments of disc angle and tilt angle.

DISC ANGLE: The angle at which the plane of cutting edge of disc is inclined to direction of travel is called Disc Angle. It varies from 42 to 45 degree.



TILTANGLE: It is the angle at which the plane of cutting edge of disc is inclined to vertical line. Tilt angle varies from 15 to 25 degree.



Adjustment of tilt angle:

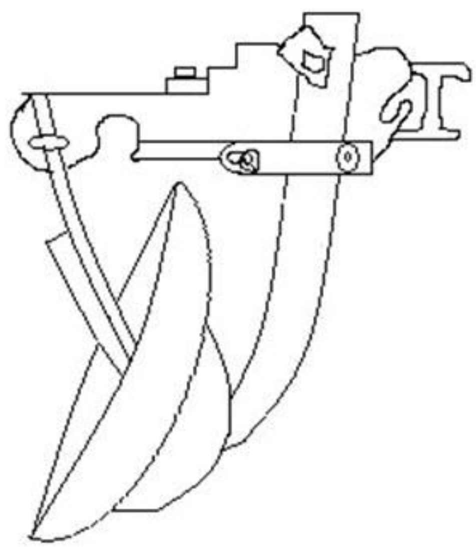
Shifting standard on the frame

By adjusting blocks

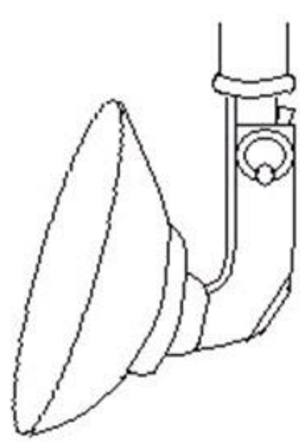
Changing grooves in bearing brackets

Parts of Disc Plough:

(1) Disc blade: Disc type blades are mounted for cutting of soil. Number of blades and diameter determine plough capacity. Concavity affects disc angle and soil turning. Shallow concavity depends on diameter of discs. Depth of cut depends on diameter of discs. About 1/3rd of blade diameter is the limit for depth. Width of cut depends on diameter of blade. Width of cut is normally 0.4 times of diameter of disc blade.

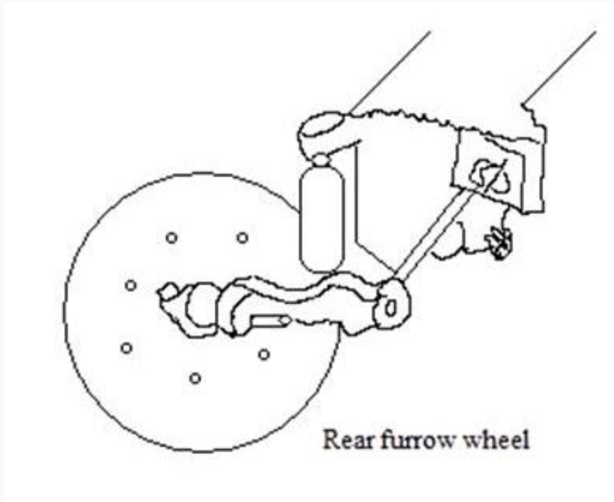


(2) Standard: Connects disc bearing and plough frame. Sometimes beam is bent for disc attachment for reducing the cost.

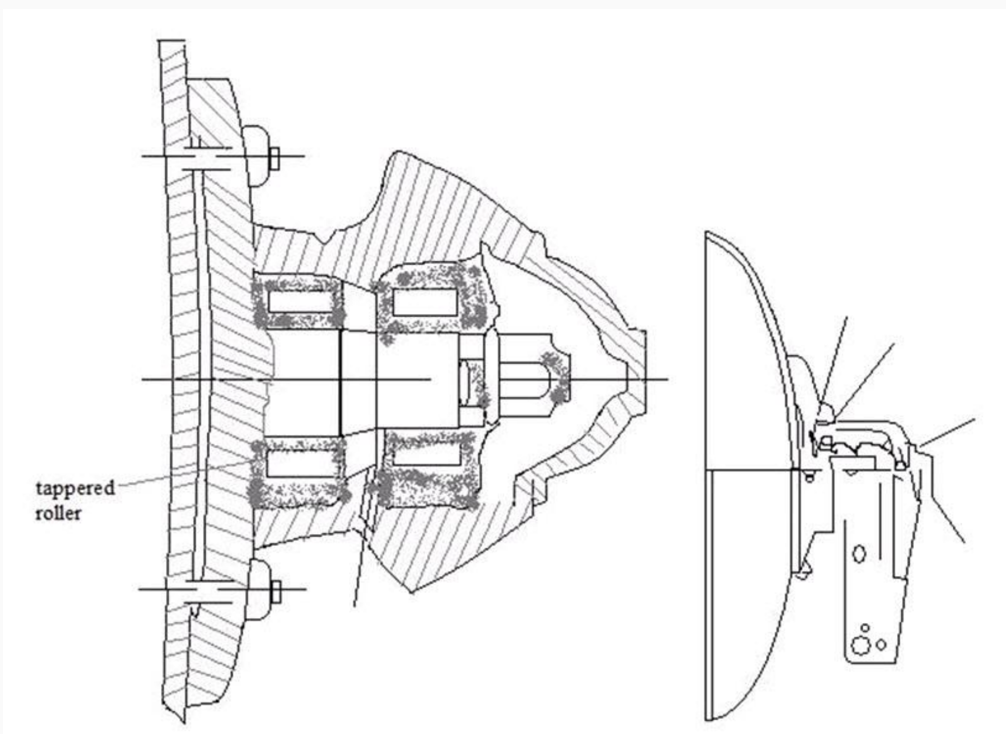


(3) Plough Frame: Standards are attached to the plough frame. It has provision for disc angle adjustment, adding or removing standard and discs.

(4) Rear Furrow Wheel: To stabilize the plough and take side thrust, rear furrow wheel is fixed at end.



(5) Bearings: Disc blades are at an angle to the direction of travel so both radial and thrust forces are present. Radial forces push against an axle at right angle while thrust forces push along the axis. That is why taper roller bearings are used.



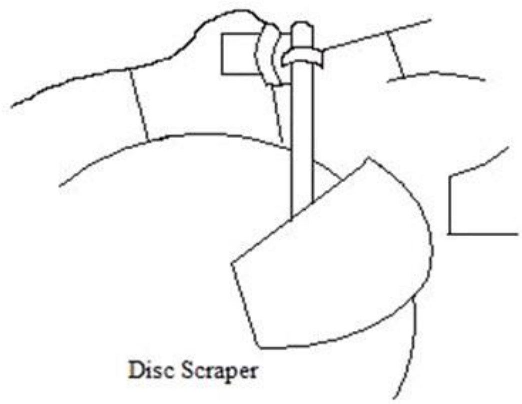
SCRAPER: Device to remove soil that tends to stick to working surface of a disc, for great pulverization to furrow slice, invert the furrow slice and cover the trash better.

Types of scrapers:

1) Disc scraper used in non-scouring soils

2) Mould board scraper used to turn over soil and trash

3) Hoe scraper used in sticky soils.



Disc Scraper

CONCAVITY: It is the depth measured at the center of disc by placing its concave side on flat surface.

DRAFT OF DISC PLOW: The disc plows is lighter in draft than the mould board plow, turning same volume of soil in similar conditions. In very hard soil some extra weight is added to the wheel which increases draft. The bearing and scrapers of disc plow also affect the draft.

- Different adjustments on disc plow affect depth of cut, width of cut and pulverization of soil as;

i) Penetration is improved by increasing disc angle.

ii) Penetration is improved by decreasing tilt angle on standard disc plow.

iii) Penetration is improved by adding additional weight on plow.

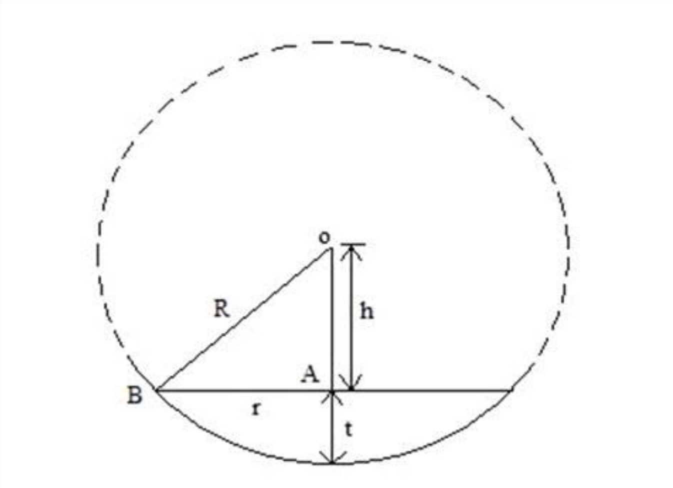
Depth of penetration ranges 3″ - 15″. For better penetration discs should be sharpened.

- **Width of Cut:**

-It is adjusted by adjusting angle between land wheel axle and frame.

-Improved by increasing disc angle and decreasing tilt angle.

To Compute Radius of Curvature of Discs:



R – Radius of Curvature

r – Radius of disc

t - Depth or concavity

OAB

$$R^2 = h^2 + r^2$$

Also, $h = R - t$

$$h^2 = (R-t)^2$$

$$h^2 = R^2 - 2Rt + t^2$$

$$R^2 = R^2 - 2Rt + t^2 + r^2$$

$$2Rt = t^2 + r^2$$

$$R = \frac{t^2}{2t} + \frac{r^2}{2t}$$

$$R = \frac{t}{2} + \frac{(D/2)^2}{2t}$$

$$R = \frac{t}{2} + \frac{D^2}{8t}$$

Trouble Shooting

Defect		Reasons		Remedy	
1.	Low Penetration	1.	Blunt disc	1	Sharpen the edge
		2.	Plow too light	2.	Put additional load
		3.	More tilt angle	3	Set tilt angle
2	Heavy draft	1.	Blunt disc	1.	Sharpen the edge
		2.	Furrow too wide	2.	Reduce tilt angle
3.	Excessive Side Draft	1.	Improper hitching	1.	Hitch properly
4.	Less Scouring	1.	Defective Scraper	1.	Adjust the Scraper
5.	Uneven Furrows	1.	Disc angle not uniform	1.	Set disc angle
		2.	Loose bearings	2.	Set bearings
		3.	Hitching defective	3.	Set hitching

Lesson 11. Sub-soiler and chisel plough: types, working and construction

Chisel Plow & Subsoiler

Soil has three layers as follows:

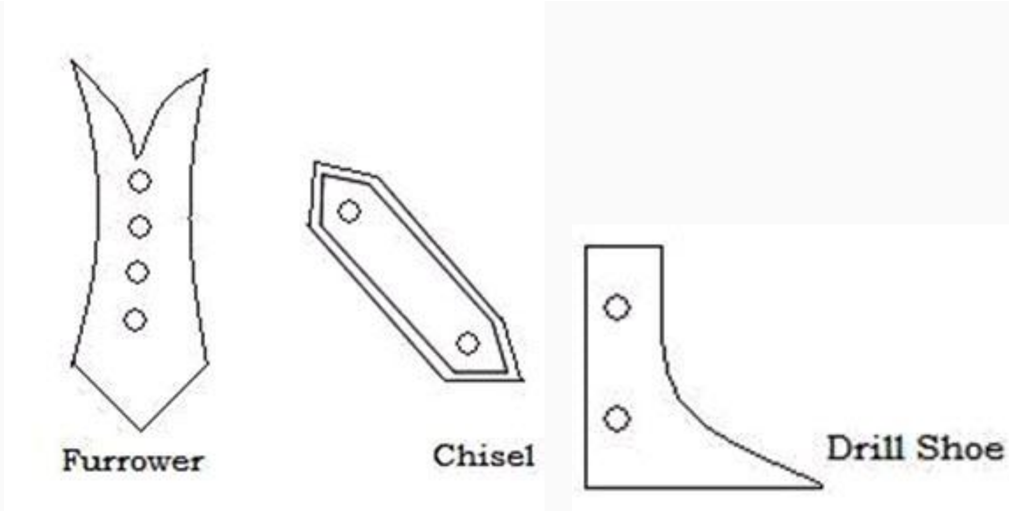
Top Layer

Hard pan 3 to 4" (Chisel plow is used)

Sub Soil (Sub soiler is used)

To break through and shatter compacted or impermeable soil layers and to improve rainfall penetration (infiltration).

- Best results achieved when soil is dry.
- Sub-soilers have one or two heavy standards, but chisel ploughs have a series of standards spaced at 30 cm (12") apart and equipped with replaceable narrow shovels or teeth.
- Maximum depth 45 to 75 cm for chisel plow.
- Chisel plow standards may be rigidly mounted or spring cushioned or may have spring tips.
- Chisel plows are operated at depth below the normal plowing zone. If any imperious layer that may be present is thin up to 18" to 30".
- Chisel plows are also employed in place of M.B. plow where inverting of the soil is not required.
- As chisel plow does not pulverize the soil as much as M.B. plow, several operations are required after chiseling.
- The shanks of chisel plow are made of nickel alloy and heat treated spring steel. This can also be used for doing a number of jobs by mounting different types of tynes.



Drill shoe is used for sowing purposes, furrower and sweep for Intercultural.

Sub-Soiler: It has one or two heavy standards. It breaks the sub-soil, so that the water may penetrate into the open space and can be stored. It is a tool that breaks the ground at depth of 20" to 36".

- It does not pulverize the soil.
- It is heavier than chisel plow. Since depth of penetration is more so 60-85 HP is required to pull one single standard.
- For shallow depth we can have 2 or 3 shanks.
- It can also be used for making tunnel to serve as drainage channel.
- The standard of sub-soiler is usually long and narrow with heavy wedge like point.
- The draft requirement in this case is 70-110 lb per inch.
- Depth of operation for light and medium soil:-

    (i) For heavy soil like clay loam it is 100 – 160 lbs/inch depth.

- The standard is a main part of the implement. The projection in front is called foot. The point is replaceable and made of steel.

Effect of shape upon soil forces

Lift angle and slope of standard have effect on depth and vertical soil force.

Lift Angle: Angle between face of tool and the horizontal plane.

- Shattering requires less effort when tool exerts upward shearing force rather than longitudinal compressive force.

- Draft decreases when lift angle is reduced to 20^0 or less. At 50^0 lift angle compacted soil stucks to the tip of the tool.
- 20^0 slope of standard (bottom and handle are attached, also known as shank) are good from stand point of low draft and large downward vertical force 'V'. But such design requires a large standard and excessive forward projection of the standard.
- Curved standard reduces the draft by about 28%.
- By tilting straight backward standard to 15^0 reduces draft by 12%.

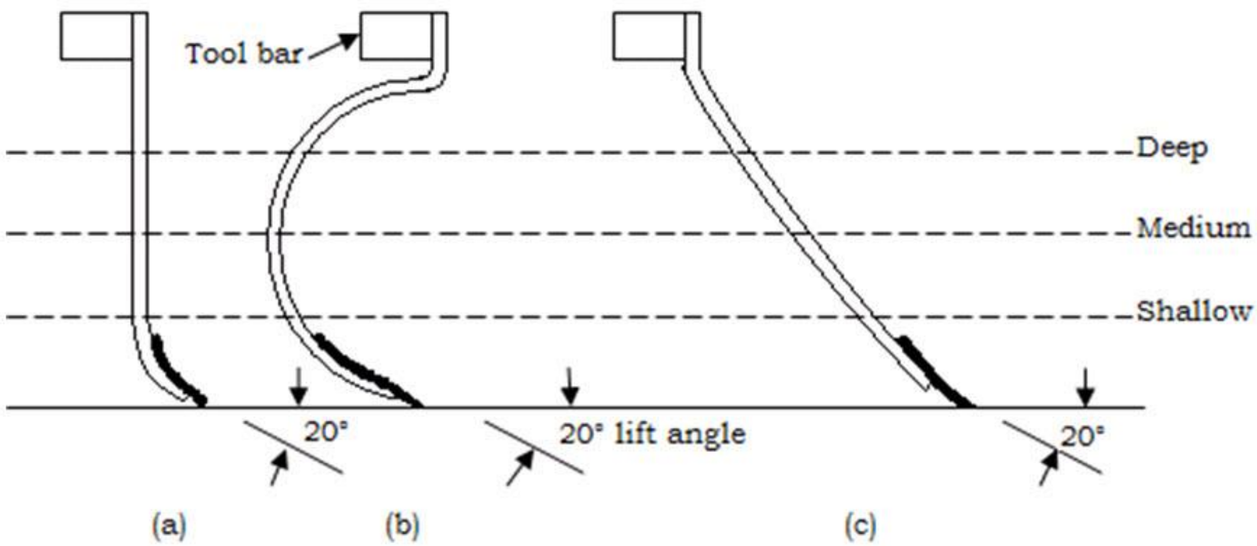


Fig. Rotation of chisel-type tool

Effect of depth and speed upon draft of chisel-type implement

- Effect of depth is influenced by tool shape, orientation, soil type and soil condition.
- Tool surface area, depth and soil condition influence the magnitude of speed for chisel-type implement.
- In some cases a linear relation between draft and speed can be assumed over a limited range of speeds.

Different shapes of sub soilers:

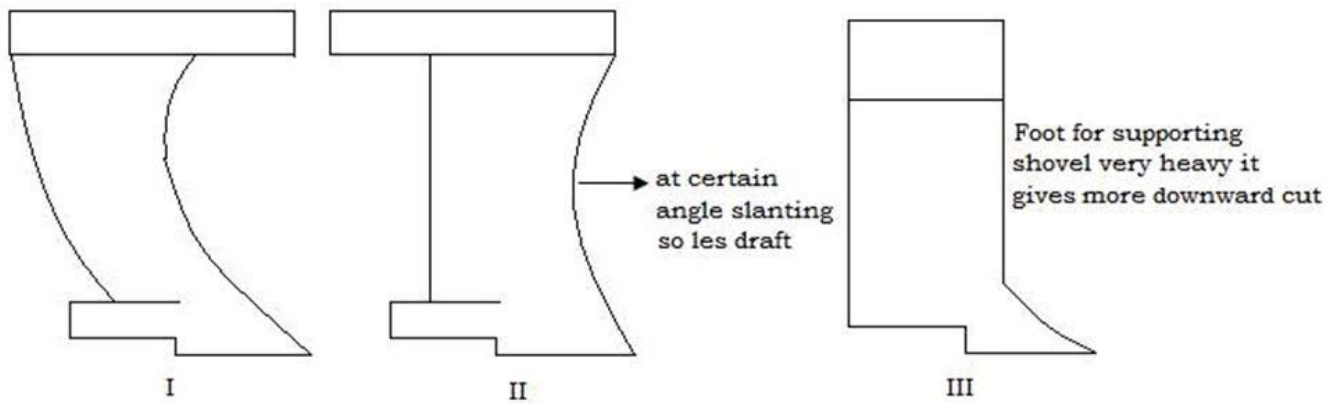


Fig. Different shapes of Sub-Soiless

Spelling of less draft in II and sub-soilers in caption of figure?

- I & II need 25% less pull because of shape of shank.
- I is of curved type which is replaceable if it breaks.
- II is at certain angle slanting, draft requirement is less.
- III foot for supporting shovel.They are very heavy so we operate it at a distance of spacing 4-5 ft. It gives downward cut.

Lesson-12. Secondary tillage: objectives, implements, types, constructional features, working principles & operation

Secondary Tillage:

Tillage operations following primary tillage which are performed to create proper soil tilth for seeding and planting are secondary tillage. These are lighter and finer operations, performed on the soil after primary tillage operations. Secondary tillage consists of conditioning the soil to meet different tillage objectives . The implements used for secondary tillage operations are called secondary tillage implements. Secondary tillage operations do not cause much soil inversion and shifting of soil from one place to other. These operations consume less power per unit area compared to primary tillage operations. Secondary tillage is stirring of soil comparatively at shallow depth.

Main objectives:-

(i) To improve seedbed by better pulverization of soil

(ii) To destroy weeds

(iii) To cut the crop residue and mix vegetative matter in top soil

(iv) To break clods making the soil tilth better for better germination of seeds

(v) To aerate the soil. The soil should not be compacted because it will affect germination.

Machines used:-

Secondary tillage implements may be tractor drawn or bullock drawn implements. They include different types of harrow, cultivator, leveller, clod crusher and similar implements.

Lesson 13. Construction and working of Disc harrows, Spike-tooth and spring-tine harrows

Harrow:

- Implement used for preparing fine seedbed
- Helps in breaking the clods
- Helps in pulverizing the soil or mixing soil thoroughly
- Aerates soil and kills weeds
- Used mostly in lighter soil conditions
- Sometimes used to cover seeds after broadcasting

Harrow is a secondary tillage implement that cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as cut the weeds and mix the material with the soil. Several types of harrow used are:

(1) Disc harrow
(2) Spring tooth harrow
(3) Spike tooth harrow
(4) Blade harrow (Bakhar)
(5) Guntaka
(6) Triangular harrow
(7) Bodela
(8) Zig-Zag harrow
(9) Bindha
(10) Other harrows.

Disc harrow

It is a harrow, which performs the harrowing operation by means of a set, or a number of sets of rotating discs, each set being mounted on a common shaft. Disc harrow is found very suitable for hard ground, full of stalks and grasses. It cuts the lumps of soil, clods and roots. Discs are mounted on one, two or more axles which may be set at a variable angle to the line of motion. As the harrow is pulled ahead, the discs rotate on the ground. Depending upon the disc arrangements, disc harrows are divided into two classes: a) Single action and b) Double action.

Single action disc harrow

It is a harrow with two gangs placed end to end, which throw the soil in opposite directions. The discs are arranged in such a way that right side gang throws the soil towards right and left side gang throws the soil towards left.

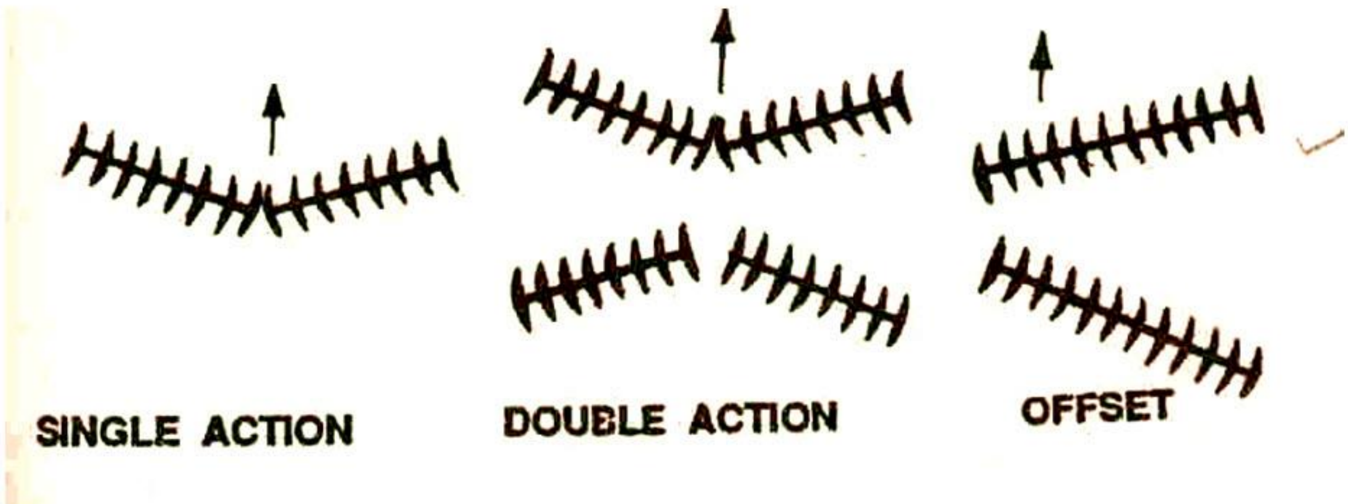


Fig.1. Types of disc harrow

Double action disc harrow

It is a disc harrow consisting of two or more gangs, in which a set of one or two gangs follow behind the set of the other one or two, arranged in such a way that the front and back gangs throw the soil in opposite directions and it generally covers the width ranging from 5 to 15 ft. Thus the entire field is worked twice in each trip. It may be of two types: a) Tandem and b) Off-set.

a) Tandem disc harrow

It is a disc harrow comprising of four gangs in which each gang can be angled in opposite direction (Fig.2).

b) Off-set disc harrow

It is a disc harrow with two gangs in tandem, capable of being off-set to either side of the centre line of pull. Two gangs are fitted one behind the other. The width covered by these types of harrows ranges from 4 to 30 ft. The soil is thrown in both directions because discs of

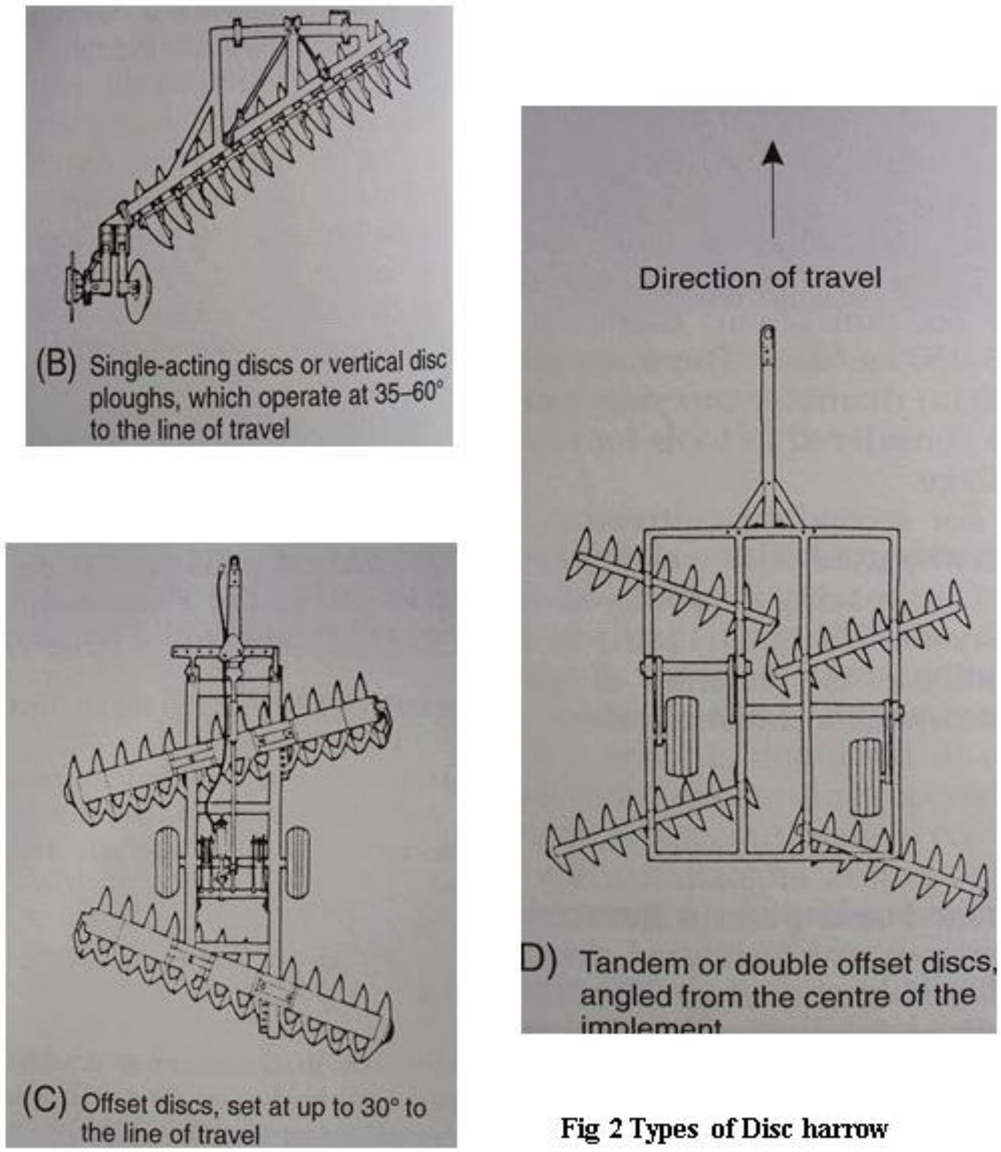


Fig 2 Types of Disc harrow

both gangs face in opposite directions. It is very useful for orchards and gardens. It travels left or right of the tractor. The line of pull is not in the middle, that is why it is called off-set disc harrow (Fig. 2). Off-set disc harrow is based on the basic principle that side thrust against the front gang is opposed by the side thrust of the rear gang. Hence the gangs are arranged at suitable angles so that both thrusts are counter balanced with each other.

Disc harrows are of two types depending upon the source of power: tractor drawn and animal drawn. A disc harrow mainly consists of disc, gang, gang bolt, gang central lever, spool or arbor bolt or spacer, bearings, transport wheels, scraper and weight box (Fig.3).

i. **Disc:** It is a circular concave revolving steel plate used for cutting and inverting the soil. Disc is made of high glass heat-treated hardened steel. Tractor drawn disc harrows have concave discs of size varying from 35-70 cm diameter. Concavity of the disc affects penetration and pulverization of soil. Usually two types of discs are used in disc harrows, plain disc and cut away disc. Plain discs have plain edges and are used for all normal works. Most of the harrows are fitted with plain discs only. Cut away discs have serrated edges and cut stalks, grass and other vegetation

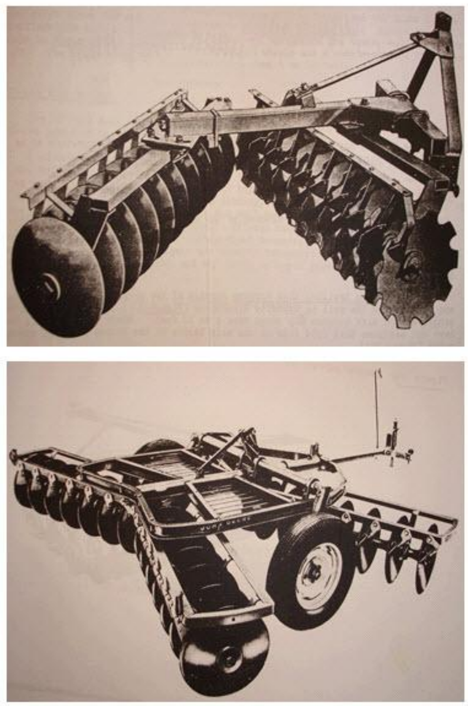


Fig.3. Disc harrow

ii. Gang: Each set of discs that are mounted on a common shaft is called the gang.

iii. Gang bolt or arbor bolt: It is a long heavy square headed bolt from the other end. A set of discs are mounted on the gang bolt. The spacing between the discs on the gang bolt ranges from 15 to 25 cm for light duty and 25 to 30 cm for heavy-duty harrows. The angle between the axis of the gang bolt and the direction of travel is called the gang angle.

iv. Gang control lever: A lever, which operates the gang mechanism of the disc harrow, is called the gang control lever.

v. Spool or spacer: The flanked tube, mounted on the gang bolt between every two discs to prevent the lateral movement of the disc on the shaft is called the \`spool' or \`spacer'. It is just a device for keeping the discs at equal spacing on the gang bolt. The standard disk spacing is 7 inches.

vi. Bearing: Bearing is essential to counter at the end thrust of the gang due to soil thrust. The harrow bearings are subjected to heavy radial and thrust loads. Chilled cast iron bearings are used to heavy radial and thrust loads and are also used due to their durability.

vii. Transport wheel: In trailing type disc harrow, the transport wheels are provided for transporting on roads and for preventing the edges of the discs from damage. Mounted type disc harrows do not require wheels for transportation.

viii. Scraper: It prevents disc from clogging. It removes the soil that may stick to the concave side of the disc.

ix. Weight box: A box like frame is provided on the main frame of the harrow for putting additional weight on the implement. Additional weight helps in increasing the penetration of the disc in the soil.

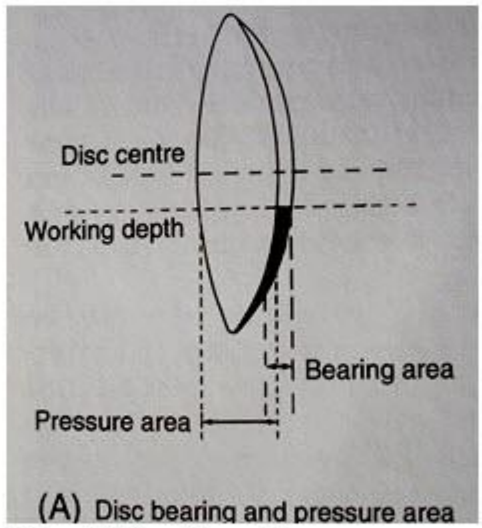


Fig. 4 Disc Bearings

There are several factors which affect the penetration of disc harrow in the field.

The following are a few adjustments for obtaining higher penetration:

i. By increasing the disc angle

ii. By adding additional weight in harrow

iii. By lowering the hitch point

iv. By using the sharp edged discs of small diameter and losses concavity -----? Pl check

v. By regulating the optimum speed.

Lesson 14. Construction and working of Disc harrows, Spike-tooth and spring-tine harrows

Care and Maintenance of Disc Harrow:

1) Bearings must be thoroughly greased at regular intervals

2) All nuts and bolts must be checked daily before taking the implement to the field

3) Blunt edges of the discs should be sharpened regularly

4) During slack season, the worn parts including bearings should be fully replaced

It is better to coat the outer and inner surfaces of the discs when the harrow is lying without use in slack season

Animal Drawn Disc Harrow:

Disc harrow is used for breaking clods while preparing seed-beds. It has **6 to 8 discs fixed in two gangs.** It has strong frame **made of mild steel** on which gangs with discs are mounted**.** An operator's seat is also provided on frame. Transport wheels are fitted for easy movement of harrow from place to place. Its weight varies between 80- 100 kg.

Parts:

- **Disc:** it is the main part of harrow which cuts and pulverizes the soil. Discs are arranged in two gangs. Thickness of material used for disc is at least 3.15 mm. the cutting edge is bevelled for easy penetration. The disc has square opening in the centre to allow the passage of the axle. Discs are made of steel with carbon content 0.80%- 0.90%.

- **Gang Frame:** all the gangs are mounted on the frame, called gang frame. It is usually made of sturdy mild steel structure. The gang frame is bolted to the beam of the implement.

- **Beam:** it is that part of the harrow which connects the implement with yoke. The rear end of the beam has clevis to fix its height of hitching to suit the size of the animals. It is made of wood which is locally available in the area.

- **Gang Angle Mechanism:** it is the angle by which gang angles are adjusted. Arrangement is there for adjusting the width and depth of cut of the implement. It is done by gang angle mechanism. The lever of the gang angle mechanism is made of mild steel flat with a wooden handle. The gang angle can be adjusted between 0° to 27°

- **Scraper:** it is the part of harrow which scrapes the soil from the concave side of the disc and keeps it clean for effective working of the harrow in the field.

- **Spacer (Spool):** spacer is used to separate the two adjacent discs and keep them in position. It is usually made of cast iron. The spacer has a suitable square opening in the middle to allow the passage of the axle.

- **Clevis:** clevis is the part fitted to the beam and the frame which permits vertical hitch of the harrow.

- **Axle:** axle is usually 20x20 mm square section. The length of axle depends upon the size of the harrow.

- **Middle Tyne:** the tyne which breaks the unbroken lstrip of soil left between two gangs of the harrow during operation is called middle tyne. This tyne is suitably fixed to the rear end of the gang frame in such a way that it is replaced easily.

- **Bearing:** There are one or two bearings either of cast iron or wood fixed at each end of the gang.

<u>**Other Harrows:**</u>

Spike Tooth Harrow or Straight tine harrow:

It is a harrow with pegs shaped teeth of diamond cross section to a rectangular frame as working part fitted in a rigid articulated or flexible frame. It is used

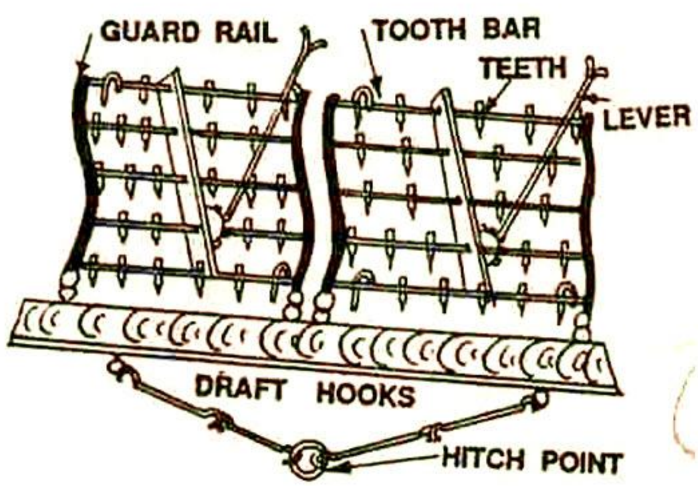


Fig.5. Spike tooth harrow

- to break the clods,
- stir the soil,
- uproot the weeds,
- level the ground,
- break the soil and cover the seeds.

The peg shaped teeth of diamond cross- section is attached in a rectangular frame. Principal used is to smoothen and level the soil directly after ploughing. Spike tooth harrows are of two types:

i) Rigid Tyne: The animal drawn spike tooth harrows are usually of rigid type. There may or may not be provision for changing the angles of spikes in operating condition.

ii) Flexible Type: Tractor drawn harrows are usually flexible type. It has got advantage of being rolled up for transporting purpose.

This harrow consists of:

1) Teeth: may be square, triangular or circular in section.

2) Tooth Bar: The teeth are so placed on tooth bar that one tooth is behind the other. Tooth bars are made of wood or steel. Steel bars may be round flat or channel shaped.

3) Clamps: used to fasten teeth to the tooth bars tightly so as not to be loose while in operation.

4) Guard:

5) Braces:

6) Lever:

7) Hooks:

The harrow is an excellent tool for pre-emergence cultivation to break the rain-firmed crust and small weeds. It generally works about 2 inches of depth. Spike tooth harrows may be of rigid type and flexible type. The animal drawn spike tooth harrow is usually of rigid type. These may or may not have provisions for changing the angle of spikes in operating conditions. Tractor drawn harrows are usually flexible type. It has got the advantage of being turned up for transporting purpose. This harrow mainly consists of teeth, tooth bar frame, clamps, guard, braces, levers and hooks. The teeth are made up of hardened steel with square/triangular/circular in section. The teeth are so placed on tooth bar that no tooth is directly behind the other. Teeth are fastened rigidly to the tooth bar. Clamps are rigidly fixed so as not to be loose while in operation.

Fig. Fully mounted hydraulically controlled 9-m straight-tined harrow

Spring tooth harrow: It is a harrow with tough flexible teeth, suitable to work in hard and stony soils. Spring tooth harrow is fitted with springs having loops of elliptical shape. It gives a spring action in working condition. It is used in the soil when obstruction

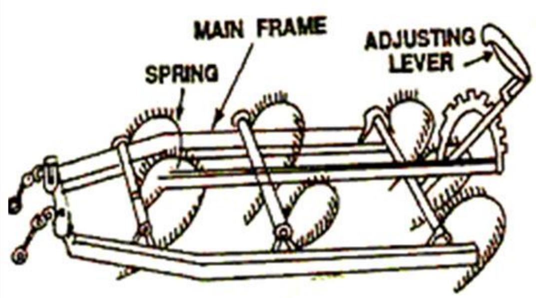


Fig.6. Spring tooth harrow

like stone, roots and weeds are hidden below the ground surface. This pulverizes the soil and helps in killing weeds. This type of harrow mainly consists of teeth, tooth bar, clamps, frame, lever and links. Usually the teeth are made of spring steel. Sometimes reversible points are provided so that one end may be used after the other end is worn out. The teeth are fastened to the tooth bar by means of tooth clamps. They are provided to give rigidity and support to the harrow. The levers are provided for setting the teeth for varying the depth of harrowing (Fig.6). For light harrowing, the adjustment is done in slanting position. Draft hooks are there on each corner of every section for hitching purpose. The depth of ploughing is 7 inches.

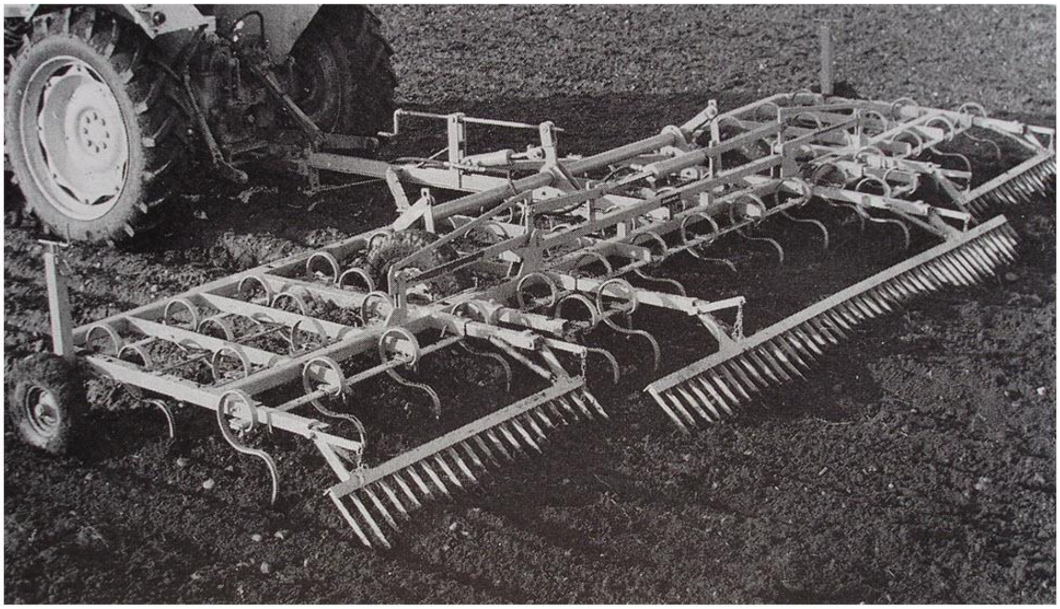


Fig. 6. Spring tined harrow combined with backward sloped crumbler

Acme harrow: It is a special type of harrow having curved knives. It is also called as knife harrow. The front part of the knife breaks the soil and crushes the clods (Fig.7). This harrow obtains a good pulverization. It is good for mulching also.

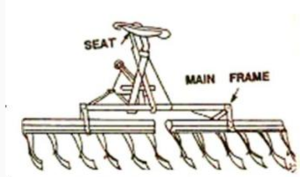


Fig.7. Acme harrow

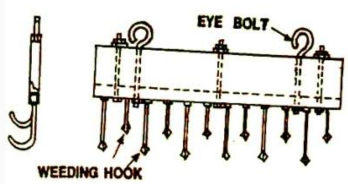


Fig. 8. Patela

Patela It is a wooden plank used for smoothening the soil and crushing the weeds. It is also used for breaking clods, packing and leveling the ploughed soil and to remove the weeds. It is made of a wooden plank with a number of curved steel hooks bolted to a steel angle section, which is fixed or hinged to the rear side of the plank (Fig.8). The cutting edge levels and packs the soil and the curved hooks uproot and collect the weeds.

Triangular harrow It is a spike tooth harrow with triangular frame (Fig.9). The frame is made of wood and pointed spikes are fitted in the frame. The teeth of the spikes are fixed and not adjustable.

Blade harrow It is an implement, which consists of one or more blades attached to the beam or frame, used for shallow working of the soil with minimum soil inversion (Fig.10). It works like a sweep which moves into top surface of the soil without inverting it.

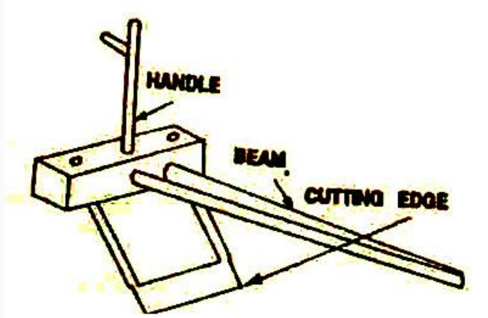


Fig.10. Blade harrow

Reciprocating power harrow It is a harrow fitted with rigid tynes driven by the power take off in a reciprocating, transverse or rotary motion as the machine moves forward. The power harrow is rear mounted reciprocatory comb type. It has two horizontal oscillating arms having staggered pegs in two rows at 200 mm spacing (Fig.11). The two arms move in opposite directions and hence the implement is dynamically balanced. The amplitude of vibration is 200 mm and the frequency of operation is 400 cycles per minute. A transport wheel provided in the rear of the unit ensures depth control. The oscillating pegs break the clods and pulverize the soil to a fine tilth. The width of the harrow is 1500 mm. The field capacity of the unit is 0.5 ha/day.

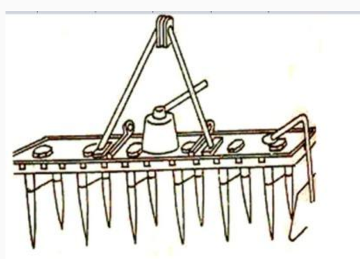


Fig.11. Reciprocating harrow

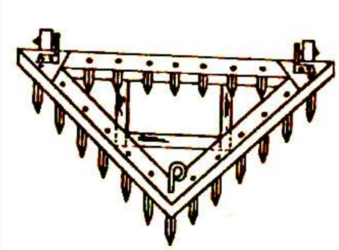


Fig.9. Triangular harrow

Bund former: It is used for making bunds or ridges by collecting the soil. Bunds are required to hold water in the soil, thereby one can conserve moisture and prevent run-off. The size of the bund former is determined by measuring the maximum horizontal distance between the two rear ends of the forming boards. Bund former consists of forming board, beam and handle (Fig.12).

Forming board: It is that part which gathers the soil to form the bund. It is made of mild steel. The thickness of the material is about 1.6 mm for light; 2.0 mm for medium and heavy soil. The forming boards are bolted to the form board supports.

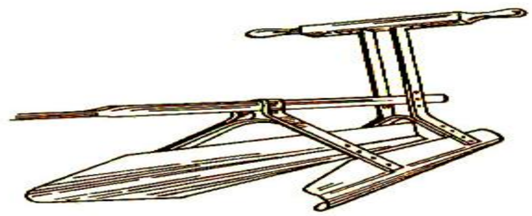


Fig. 12. Bund former

Beam: Beam transmits the pull of the animals to the forming board and form board supports. It is made of hard wood.

Handle: Wooden handle is usually used for controlling the movement of the bund former.

Soil scoop: Soil scoop is used in excavating ditches, clearing drain and moving soil over short distances. It consists of a blade, soil trough, hitching loop and handle (Fig.13).

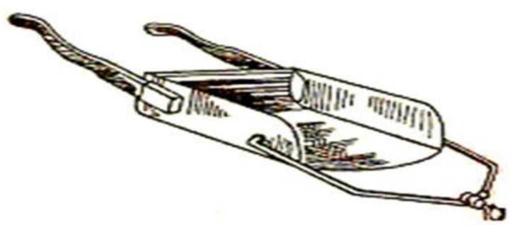


Fig.13. Soil scoop

Ridger: It is an implement importantly used to form ridges required for sowing row crop seeds and plants in well-tilled soil. The ridger is also used for forming field or channels, earthing up and similar other operations. Ridger is also known as ridging plough and double mould board plough. The ridger generally has 'V' shaped or wedge shaped share fitted to the frog. The nose or tip of share penetrates into the soil and breaks the earth. The mould boards lift, invert and also cast aside the soil, forming deep channels and ridges of the required size.

Fig. Ridger

Leveler: Land leveling is expected to bring permanent improvement in the value of land. Leveling work is carried out to modify the existing contours of land so as to achieve certain objectives desired for efficient agricultural production system. These objectives include

(i) Efficient application of irrigation water,

(ii) Improved surface drainage,

(iii) Minimum soil erosion,

(iv) Increased conservation of rain water specially on dry lands and

(v) Provision of an adequate field size and even topography for efficient mechanization.

The animal drawn leveler consists of a wooden leveling board with a handle. Depending upon the soil condition, the shape of the board varies. In the front portion of the board two hooks are provided for connecting it to the yoke. If it happens to be tractor drawn then board hooks are connected to the back of the tractor with suitable link. If the weight requirement is more then either the extra bags of soil or sand or one or two persons can stand over the leveler while in operation.

Factors affecting penetration of disc harrow:

1) If weight of harrow is more penetration will be better

2) By increasing disc angle

3) By making discs sharper

4) Size of discs smaller and lesser concavity

5) By lowering hitch point

6) By regulating optimum speed (low speed).

What HP is necessary for pulling a harrow with 50 tynes each giving a resistance of 1 Kg. when speed of harrow is 5 km/hr.

Soil resistance = 50 X1 = 50 Kg.

$$\text{HP required} = \frac{(\text{Kg})\ \text{Resistance} \times \text{Speed (m/min)}}{4500}$$

$$= \frac{50 \times 5 \times 1000}{4500 \times 60} = 0.926\ \text{HP}$$

Lesson 15. Forces acting upon tillage tool/ implement and symbols used in tillage force analysis

Forces acting on a tillage implement or tool:-

- The engineers are concerned with the forces acting on a tillage implement because of:

i) Total power requirements

ii) Proper hitching or application of pulling force.

iii) Designing for adequate strength and rigidity

iv) To determine best shape and adjustment of tools

- A tillage implement (or tool) moving at a constant velocity is subjected to three main forces or force system which must be in equilibrium. These are:

i) Force of gravity upon the implement

ii) The soil forces acting upon the implement

iii) The forces acting upon the implement and the prime mover

If torque from rotary power transmission is not involved, the resultant of these forces is the pull of the power unit upon implement.

- Clyde sub-divides the total soil reaction into two:

Useful forces: Are those forces which the tool must overcome in cutting, breaking and moving of soil.

Parasitic forces: Are those forces (including friction and rolling resistance) that act on stabilizing surfaces such as land side and sole of plow or upon supporting runners or wheels.

- Under given set of operating conditions with a specific implement the operator has some control over useful soil-resistance forces. However, both designer and operator have some control over parasitic forces.

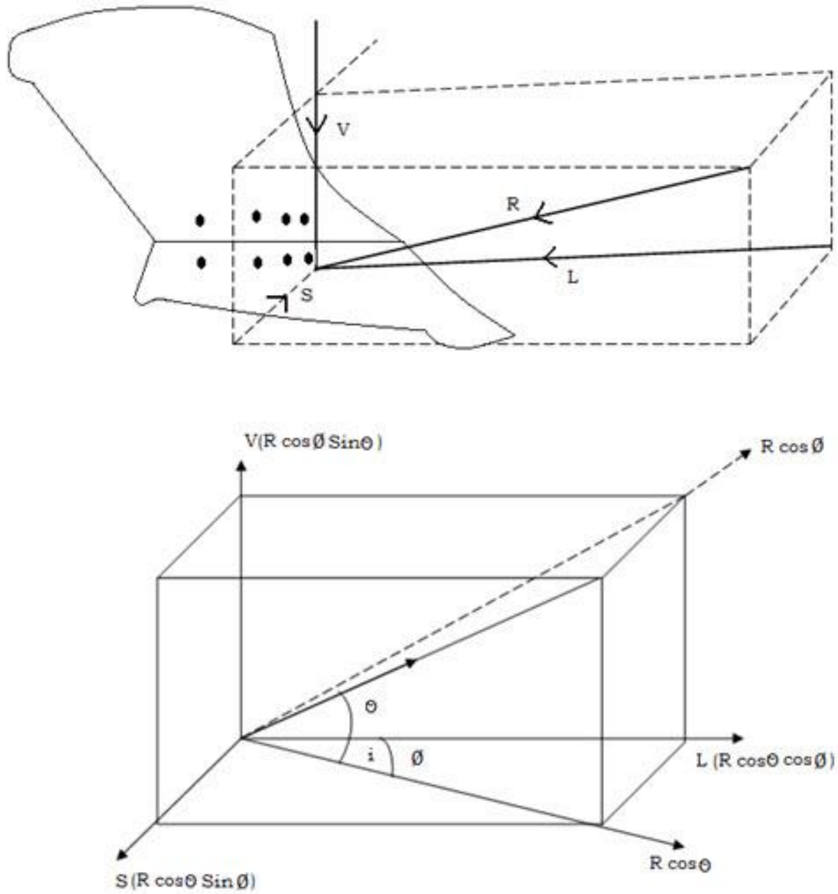


Fig.15 Forces Acting on a Tillage Tool

- If tool is not symmetrical about the vertical, longitudinal plane through its center line, useful soil forces usually introduce rotational effect.

If P = Pull exerted by power unit has components in all the major planes and associated with it is a couple.

R = Resultant of all useful forces acting upon tool or implement.

Let us resolve the forces in three components L, S, V.

L = Horizontal component also called draft.

V = Vertical componentIt removes load from the front wheel of tractor and effects on tractive ability of tractor, stability and steerability. It helps in penetration and maintains working depth.

S = Side draft or force.Maintains directional stability on tractor and implement and affects on draft of implement because of frictional forces.

- From Fig. 15

L = R cosθ cosф

$V = R \sin\theta \quad \cos\phi$

$S = R \cos\theta \quad \sin\phi$

Where; θ = Angle of inclination of 'R' in vertical plane with horizontal.

ϕ = Angle of inclination of 'R' in transverse plane with horizontal.

- For mounted implements supported and pulled by tractor, this force P between implement & tractor in vertical plane is force containing L & V component

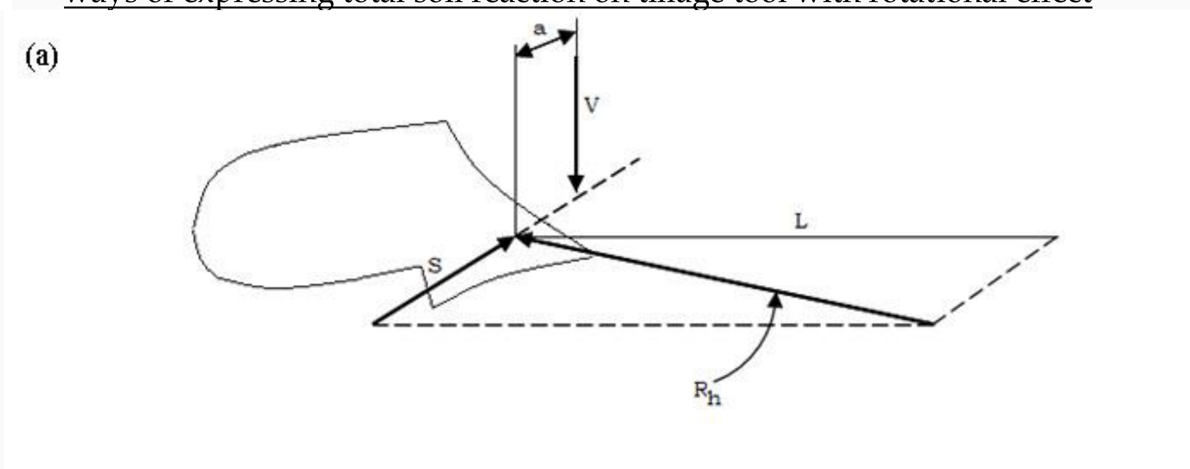
$$P = \sqrt{L^2 + V^2}$$

$$= \sqrt{R^2 \cos^2\theta \ \cos^2\phi + R^2 \sin^2\theta \cos^2\phi}$$

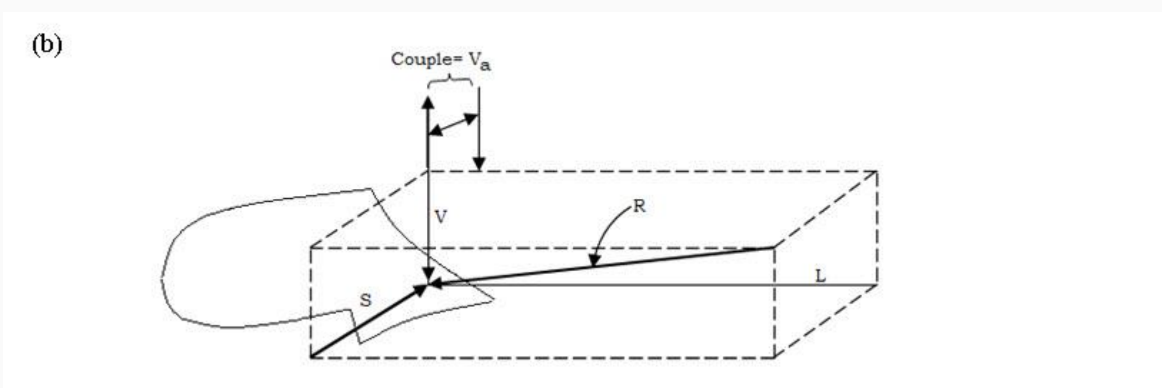
$$= \sqrt{R^2 \cos^2\phi \ (\cos^2\theta + \sin^2\theta)}$$

$$= R \cos\theta$$

- As tools are not symmetrical about vertical and longitudinal plane. There are <u>different ways of expressing total soil reaction on tillage tool with rotational effect</u>



<u>Fig. 16 (a) Two non-intersecting forces R_L & V</u>



<u>Fig. 16 (b) One force R, plus a couple V_a in a plane 1 to the line of motion.</u>

c) A wrench i.e. one force plus a couple in the plane perpendicular to the force.

(d) Three forces on mutually perpendicular axes and three couples in the planes of intersection of axes.

(e) Three forces in three major planes.

- Results of force measurements may be represented by any of these five methods and results expressed in one form can be transposed to another form by method of statics.

Typical Location of R_h and its relation to the Landside Force and Pull

Following discussion force R and its components L, S, V, R_h & R_v refer to resultant of useful soil forces Q indicates parasitic force & P, P_v, P_h and P_x (draft) include effect of both useful and parasitic forces and force of gravity.

of gravity.

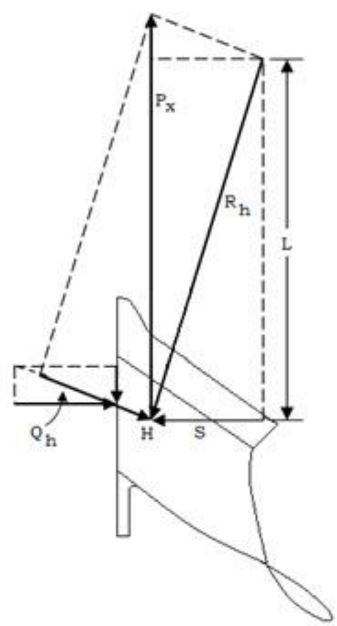


Fig.17 (a) Straight Pull

Horizontal force relations:

- Horizontal component L equal and opposite to R_h

R_h - Resultant of L & S.

- There is no side force on landside and draft = -L
- When horizontal Pulling force is in the direction of travel i.e. P_x (draft) Parasitic side force automatically introduced on landside to counteract S.
- Q_h = Resultant of side force and accompany friction force on landside.
- H = Intersection of R_h & Q_h.

It is the horizontal location of center of resistance of plow bottom.

If Pull is angled to left (fig. (b))

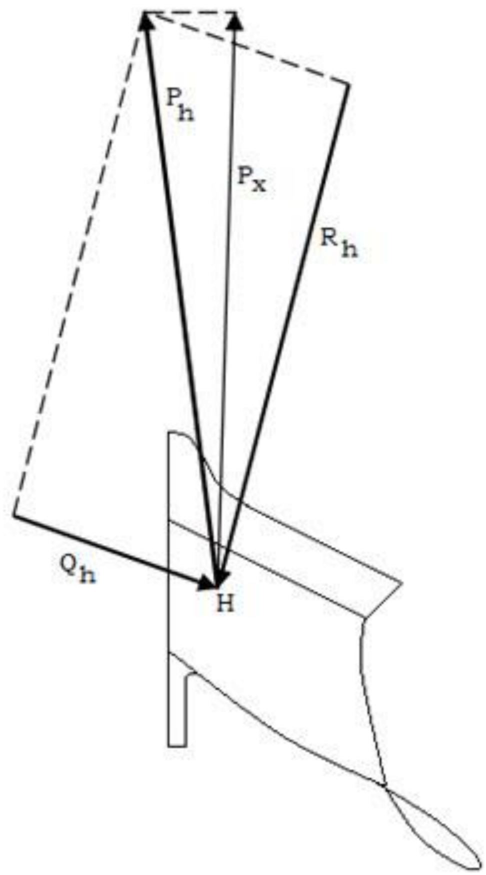


Fig. 17 (b) Angled Pull

P_h = Component of P in horizontal plane.

It increases land side force and increase P_x (draft) more.

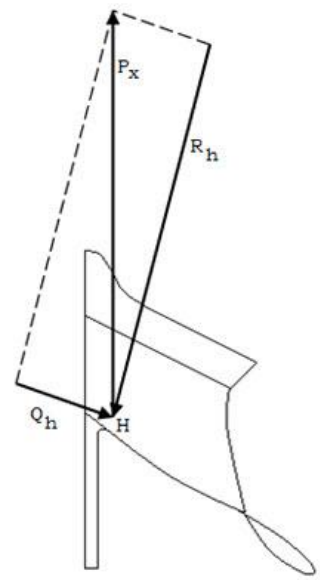


Fig. 17 (c) Long- Landside

Fig. 17 (c), increasing the landside length Q_h (Parasitic force) moves to rear.

Thus, H has to be relocated, farther back.

Now H is closer to landside as line of R_h does not change. Taking most of side force on rear furrow wheel has similar effect.

(b) Vertical force relation:

- Mould board plow has downward acting vertical component.

- Magnitude of V in relation to L varies widely and influenced by

  - Soil type
  - Soil condition
  - Depth of cut
  - Share edge shape
  - Share sharpness.

- Penetrating ability is important characteristic.

- In case of mounted and semi-mounted implements V contributes directly to vertical load on tractor rear wheels and increases load transfer from front wheel to rear wheel.

- Shares with downward Pitch Point (extended forward beyond the line of share edge) have greater suction (downward V) than straight shares, particularly at shallow and moderate depth.

- Share having top beveled - less downward V

- Share having bottom beveled - more downward V

- Leading portion of bottom slightly higher than rear portion reduces V and increases soil compaction.

Lesson-16. Forces acting upon tillage tool/ implement and symbols used in tillage force analysis

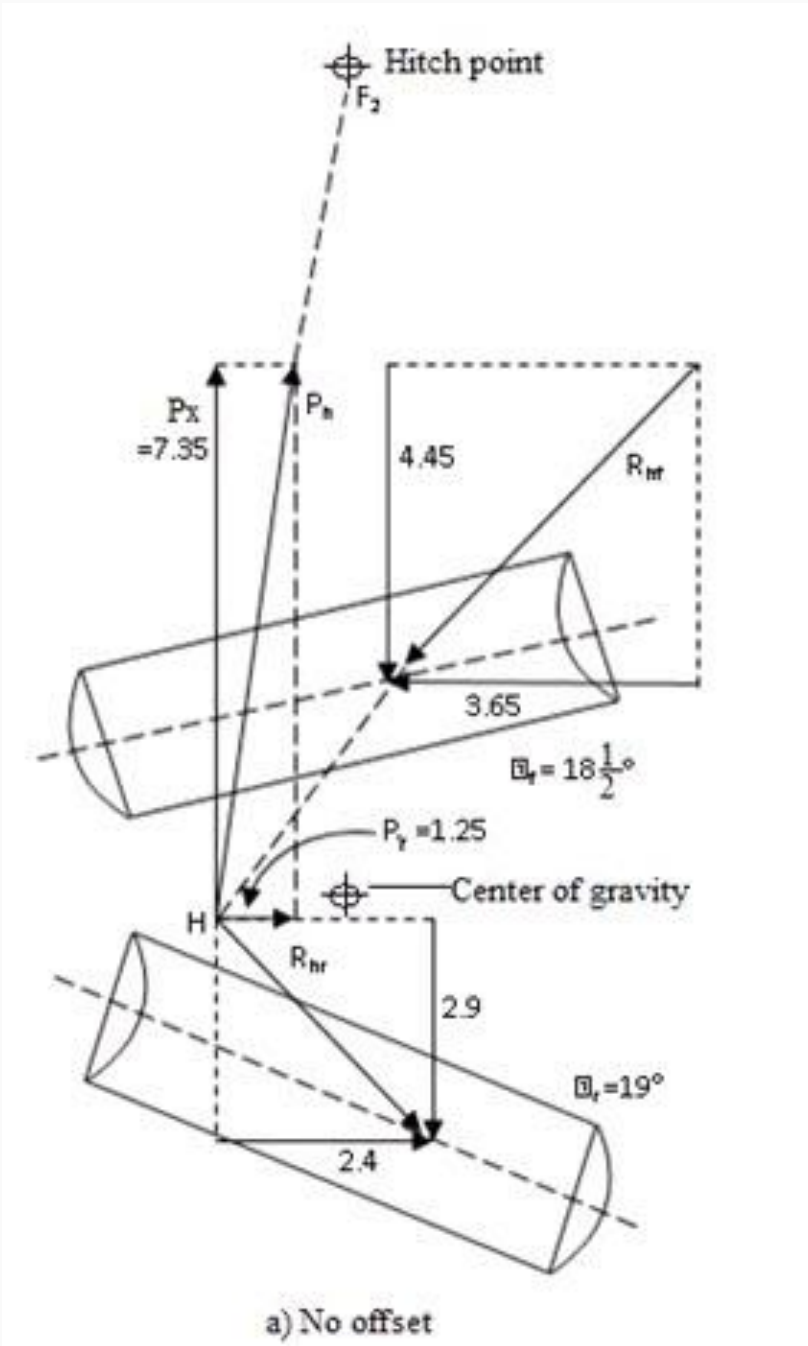


Fig. 16 (a) Thrust Force T, plus a Radial Force U

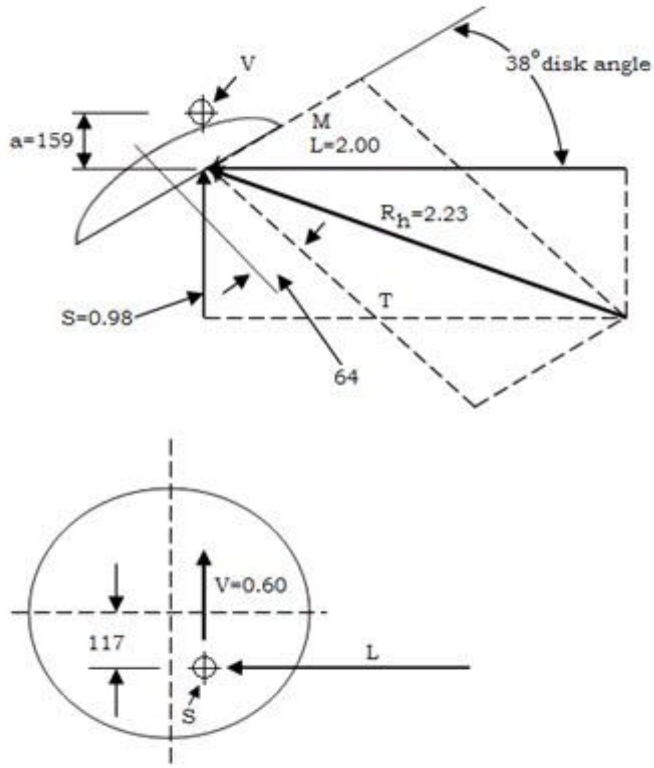


Fig. 16 (b) Horizontal Force R_h, plus Vertical Force V

L & S Components are combined into horizontal resultant R_h so that entire effect is represented by two non-intersecting forces V & R_h

Soil forces acting on a disc blade as a result of operation of cutting, pulverizing, elevating and inverting of furrow slice plus any parasitic forces acting on the disc.

(Useful forces (Tool must overcome in cutting, braking & moving of soil).

Parasitic forces (act upon stabilizing surface of disc, sole of plow, landside. It includes friction or rolling resistance.

- Resultant effect is expressed by two non-intersecting forces,

a) Thrust force T, parallel to disc axis

b) Radial force is

- Thrust force always below disk centerline as soil acts against lower part of disc face.
- Radial force causes rotation of disk and provides torque necessary to overcome bearing friction. It includes vertical support force on disk blade which must pass slightly to rear of disk centerline.

- The resultant effect can be expressed by method which is based on longitudinal, lateral and vertical components.
- As these two forces do not intersect, they introduce a couple V_a that tends to rotate the implement about axis of forward travel.
- This couple is always clockwise for right-hand disc plow if viewed from rear. It is opposite to effect on a mould board plow without a coulter.

Forces Acting on Disc Harrow

The forces acting upon a complete disc harrow are:

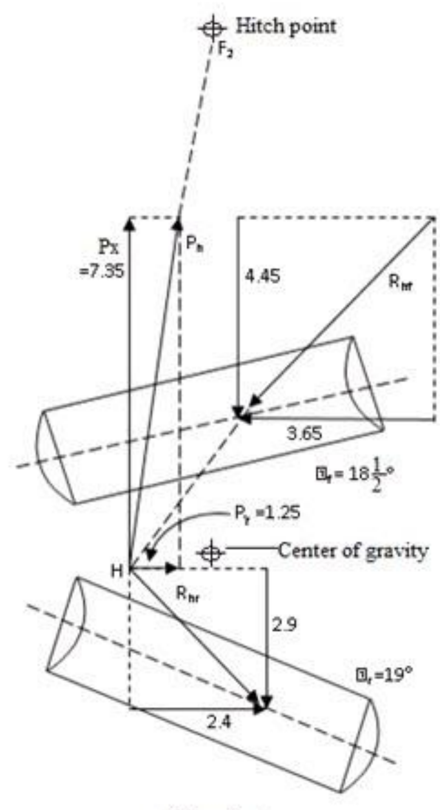
(1) Resultant soil reaction on each gang

(2) Force of gravity upon the implement and any extra mass added.

(3) Any supporting soil forces provided by wheels or as a result of being mounted on a tractor

(4) Pull of the power source.

For uniform motion these forces must be in equilibrium. If there is no side draft, sum of the side component of all soil reactions must be zero. The forces indicated in figs. 18 (a), (b) and (c) can be obtained by proper application of method of statics.



a) No offset

F_o - hitch pt. on tractor

Q_f, Q_r - Disc angle

Horizontal forces:

Fig. 18 (a) shows horizontal forces acting upon offset disc harrow without wheels and operating with no side draft. Location of horizontal centre of resistance H is determined by intersection of R_{hf} and R_{hr}.

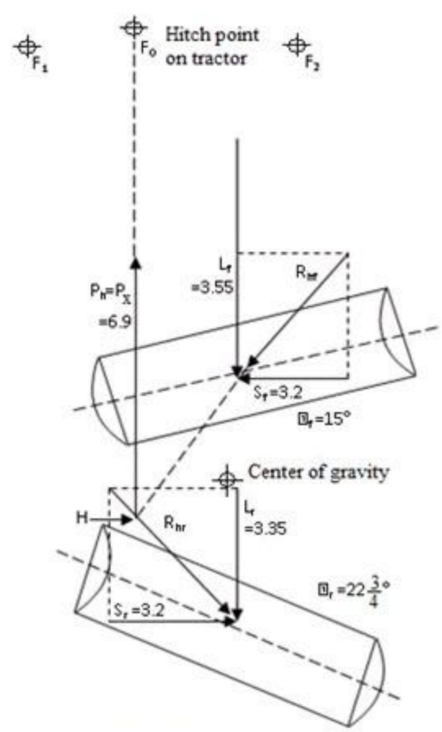
For no side draft condition hitch linkages are adjusted that hitch point F_o is directly in front of H.

- If hitch point is changed to move the implement to either right or left side draft will introduce and operating condition of harrow are changed.

If hitch linkage is changed to move the implement either to right or left side draft will introduced and operating condition of harrow are changed. Like if, hitch point moved from F_0 to F_2, force of equilibrium, momentarily destroyed and side components of new pull acting at H rotate the implement counter-clockwise about F_2. Rotation continues until disk angle of two gangs readjusted themselves. So that difference between their lateral force components Sf and Sr becomes equal to side draft P_y. Magnitude of L_f (i.e. longitudinal or directional component) and L_r and Position H also change during their re-adjustment.

No offset condition:

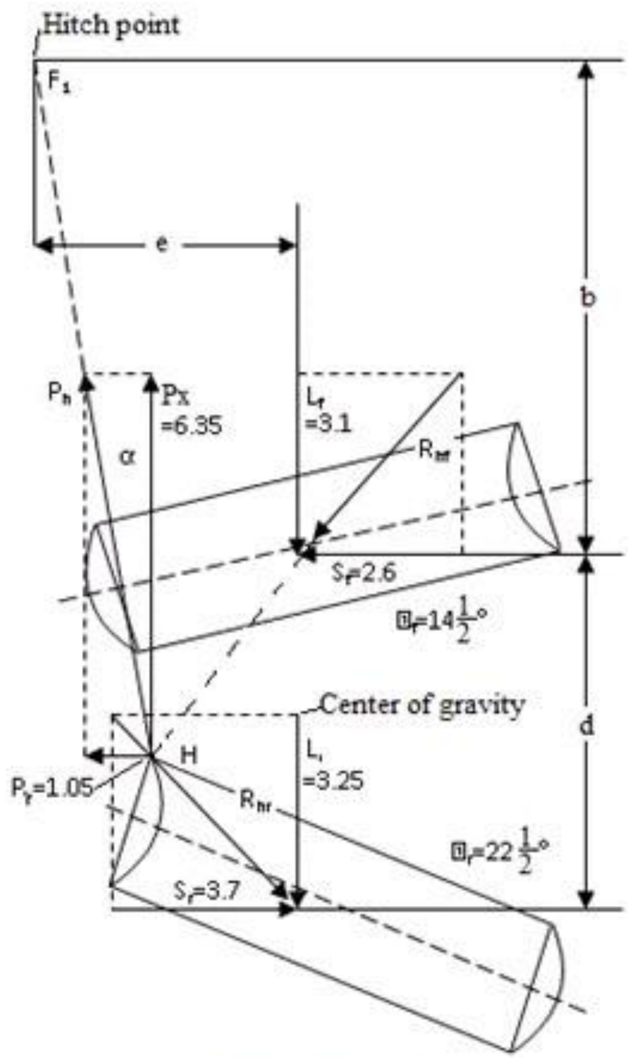
- Changing from condition (b) to (a) fig.18 (b) amount of soil moved by rear gang decreased.



b) No side draft

Extreme right offset positon:

- Fig 18 (c) i.e. In extreme right offset position rear gang does most of the work. Also with no side draft (Fig. 18 (a)) rear gang operates at a greater angle and moves more soil than front gang.

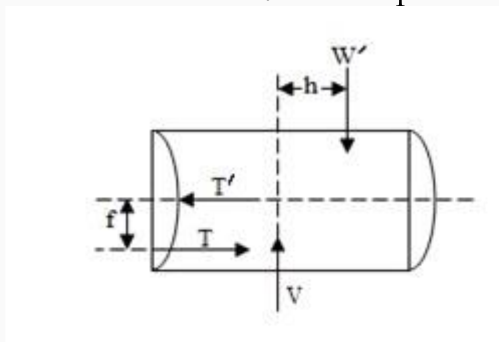


c) Extreme right offset

Amount of offset obtainable

- Let e = amount of offset from hitch point to centre of cut.
- α = horizontal angle of pull
- d = Longitudinal distance between centres of two gangs.
- b = longitudinal distance from centre of front gang to hitch point.

Taking moment about F_1 and assume R_{ht} and R_{hr} pass through centre of gangs.



$eL_f + eL_r + bS_f - (b+d)S_r = 0$

$$\text{or, } e = \frac{b(S_r - S_f) + dS_r}{L_f + L_r} = b\tan\alpha + \frac{dS_r}{L_f + L_r}$$

For condition of no side draft

$S_f = S_r = S$ & $\alpha = 0$

Therefore, offset with no side draft

$$e_0 = \frac{dS}{L_f + L_r}$$

Lesson 17. Hitching System, Forces for Handling Implements and Control of Implements

Hitching System:

- A plow or implement may be well designed and built of high-grade material but unless properly hitched it cannot give the best performance.
- Primary objective of proper hitching of pull-type implements having adjustable pull members is to establish location and/or magnitude of the resultant parasitic support forces (Q or Q_v) and pull (P or P_v).

These are desirable from the stand point of the effects of the pulling force upon tractor and magnitude and distribution of parasitic forces acting upon the implement.

- Force relations for mounted or semi-mounted implements are determined primarily by the design of hitch linkage and implement and by the method of controlling implement depth, rather than by hitch adjustments.

Mould Board trailing Plow Hitches:

- Perfect hitch for a trailing plow to have the center of pulled load directly behind the centre of power unit but this condition can rarely be obtained because of different widths of different size tractors and the different widths and sizes of plows or pulled units.

Hitch Systems and Hitching Tillage Implements:

Force relation is involved in hitching pull type of implements. Useful soil forces components L, S, V and implements gravitational force W are independent force variables and analyze simple drawbar hitch arrangement or integral hitch systems. Parasitic soil forces Q and pull P are dependent variables and can be influenced by hitch arrangement. Analysis of force relation considering horizontal components R, Q, P and W is horizontal hitching and components of these forces in vertical plane is vertical hitching. Primary objective of proper hitching for pull type implements having adjustable pull members is to establish the location and magnitude of the resultant parasitic support force (Q_h or Q_v) and pull (P_h or P_v). Force relation for mounted or semi-mounted implements is determined by design of hitch linkage and implement and by method of controlling implement depth, rather than by hitch adjustments.

Horizontal hitching of pull type Implement:

M.B. plow, disk plow, offset disk harrow are not symmetrical about their longitudinal center lines. Most of other implements are symmetrical about their longitudinal center lines, side components of soil forces are balanced, horizontal centre of resistance is at centre of tilled width and horizontal line of pull is in direction of travel. Plows and offset disk harrows can withstand substantial amounts of side draft (lateral component of pull) so proper hitching is must to minimize adverse effects on tractor and implement. M.B. plows absorb side forces through landsides, disc plows throw furrow wheels, offset disk harrows by automatically changing disk angles to create a difference between soil-force side components for front and rear gangs. Pull type disk plows have free-link pull members. M.B. plow and disk harrows have laterally rigid pull members. It is not always possible to have a horizontal centre of resistance of an implement directly behind the centre of pull of tractor particularly for narrow implements and wide-tread tractors. This implement can withstand side force, alternatives are:

- Central angled pull passing through centre of pull of tractor

- offset straight pull

-offset angled pull

If implement cannot withstand side force only alternative is:

- an offset straight pull.

Centre of pull of tractor is midway between rear wheels and slightly ahead of axle as differential divides torque to wheels equally. Central angled pull does not affect tractor steering but offset pull does. Angled pull introduces a side force on tractor rear wheels and is undesirable with same implement even though implement can resist side force. So a compromise in hitching is best with a part of adverse effect absorbed by tractor and part by implement.

Horizontal Hitching of pull type implement:-

As determined earlier, location of horizontal control of resistance, H for a M.B. plow is determined by the point of intersection of parasitic force Q_h acting upon landside and R_h (Fig. 17.1). Lateral location of H varies depending upon soil conditions, length of landside, amount of side force taken by rear furrow wheel etc.

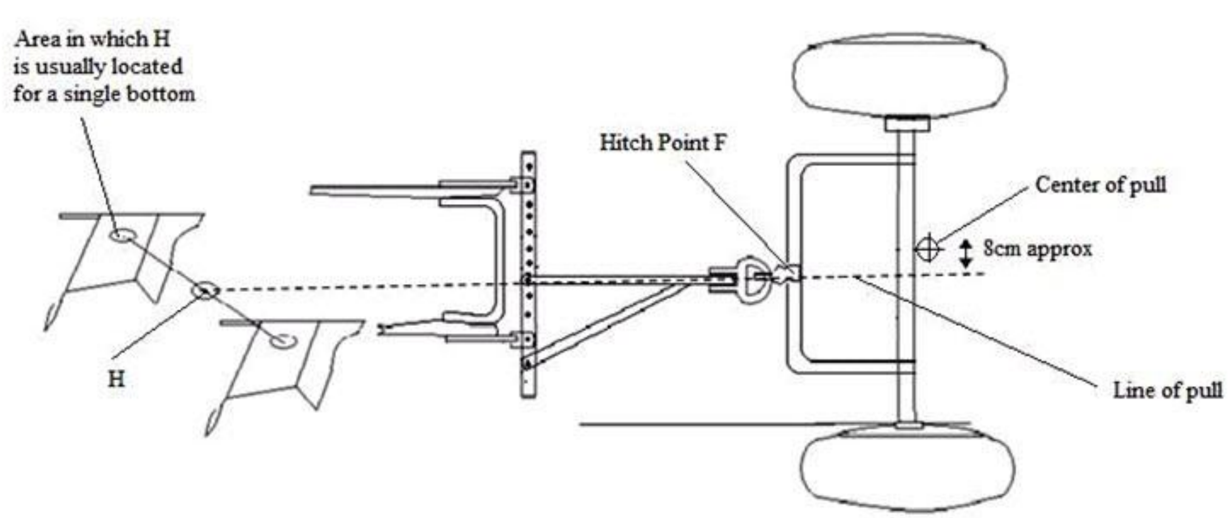


Fig. 17.1 Horizontal hitching for a mold board plow pulled by wider tractor

For hitching, its location can be assumed to be one-fourth of the width of cut over from landside and little behind the rear edge of the share. Line of pull is determined by location of H and location of drawbar hitch point F as pull members are laterally rigid. Ideal hitch is obtained when tractor tread can be adjusted so the control of pull is directly ahead of horizontal centre of resistance. Normal tread of 52 inches can be adjusted to 48 inches. When a central straight pull cannot be obtained, it is better to divide the effect of offset so that line of pull passes a little right of centre of pull but not enough to cause steering troubles.

Horizontal hitching of a pull type disc plow:-

All the side thrust must be taken through the wheels and pull members, which is a free link in regard to horizontal forces. Horizontal line of pull for a disk plow is determined by location of hitch points D & F (Fig. 17.2). The position of horizontal centre of resistance H and location of resultant side force Q_h are established by point of intersection of P_h and R_h. Side forces are divided equally between front and rear furrow wheels. Line of Q_h must pass midway between them. If hitch point D is moved to left of plow frame, H and Q_h move toward the rear of plow, and rear furrow wheel will have more side thrust. Moving D to left or F to left, pull puts more side force on front wheel.

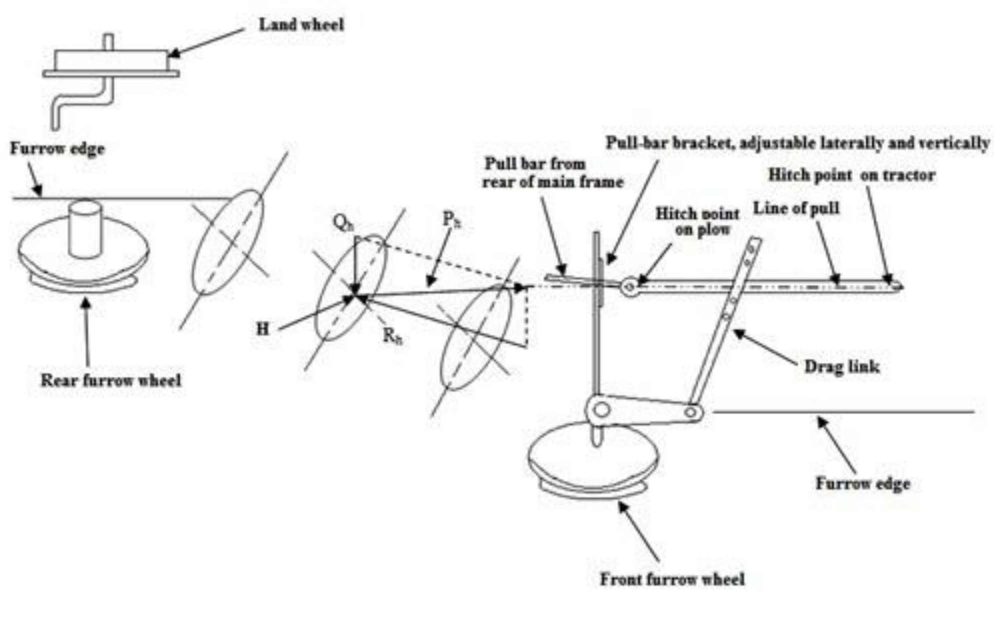


Fig. 17.2 Horizontal force relations and hitching for a pull-type disc plow.

Vertical Hitching of Pull Type Implement

Types of Vertical Hitching Systems:

Pull-type tillage implements fall into one of the following three categories:-

1. Implements with hinged pull members that have support wheels or support runners to gage the depth. The pull members act as a free link in the vertical plane, e.g., M.B plow, disc plow and drag type spring tooth harrow, etc.

2. Implements with hinged pull members that do not have gage wheels or runners. The only support is through soil-working units and parasitic forces cannot be separated from useful soil forces, e.g., disc harrows without wheels, spike tooth harrows and tandem-gang rotary hoes.

3. Single-axle implements with rigid pull members, e.g., field cultivators, chisels, sub-soiler.

Implements having Hinged Pull members and Support Wheels or Runners:-

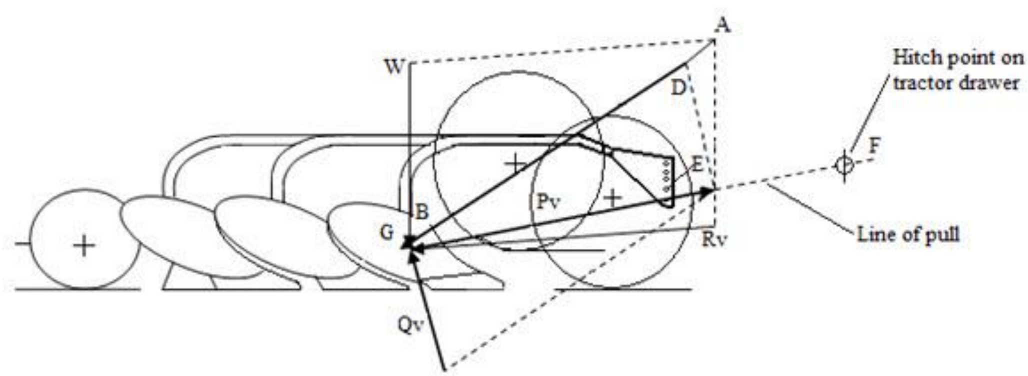


Fig. 17.3 Vertical force relation for a pull type mould board plough having support wheels and hinged pull members

Vertical force relation for a pull-type M.B. plow has been shown in Figs 17.3 and 17.4. For uniform motion W, R_v, P_v, and Q_v must be in equilibrium. Magnitude and location of implement gravitational force W and useful soil force R_v combined graphically into resultant AB. Thus the Line of pull must pass through the hitch point F on the tractor and hitch hinge axis selected at E, since pull member acts as a free link in the vertical plane. The Line of pull and resultant AB intersect at G. Support force Q_v is drawn with some backward slant to include the rolling resistance of wheels furnishing the vertical support. More slants would be needed, if support were on sliding surfaces, to include the friction force.

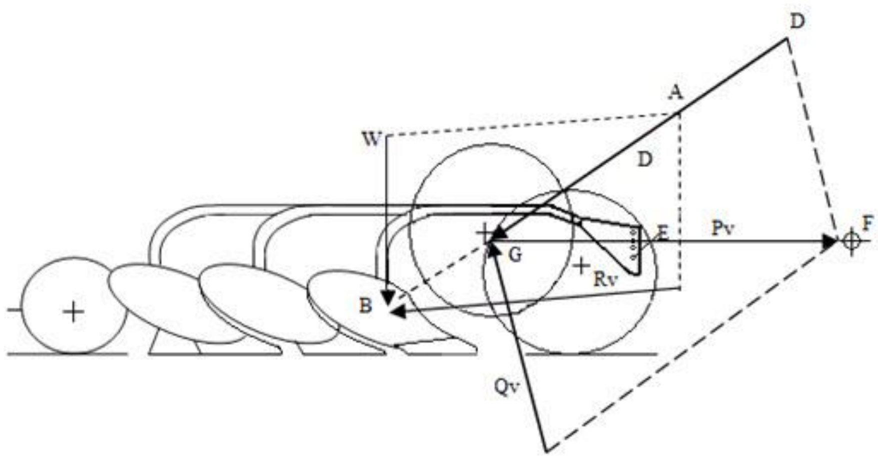


Fig. 17.4 Vertical force relation for a pull type mould board plough having support wheels and hinged pull members

P_v is in equilibrium with AB, and QV, magnitude of Q_v and P_v can be determined by moving AB and DG and completing the parallelogram. Fig 17.3 shows desirable hitch adjustment for a mould board plow with Q_v located well behind the front wheels. So, there is enough load on rear wheel for stable operation. Fig. 17.4 indicates that as hitch point E is too high on plow then Q_v is under the front wheels with no load being carried on the rear wheel. Therefore the rear of plow will be very unstable, especially when momentary variations in the direction and magnitude of R_v are considered.

Hitching at too low point on implement has opposite effect. Resultant force Q_v is moved toward rear and reducing load on front wheels. Thus, by increasing or decreasing the slope of P_v without changing the location of G, decreases or increases Q_v but it does not change its location.

Very high slope for P_v can cause difficulty in maintaining desired depth, particularly with light implements that have little or no suction such as spring tooth harrow. Therefore, for mould board plow, adjustment of hitch height on plow frame should be such that P_v passes through a point slightly below the ground surface and directly above the average location of all share points. Similarly, for disk plow, line of pull is at ground surface midway between the center of front and rear discs. If rear furrow wheel of a disc plow has a lead towards the plowed ground and tends to move out of the furrow then the hitch point on plow frame should be lowered which will put more of Q_v on rear wheel.

b) Implements with hinged pull members but without gage wheels or runners.

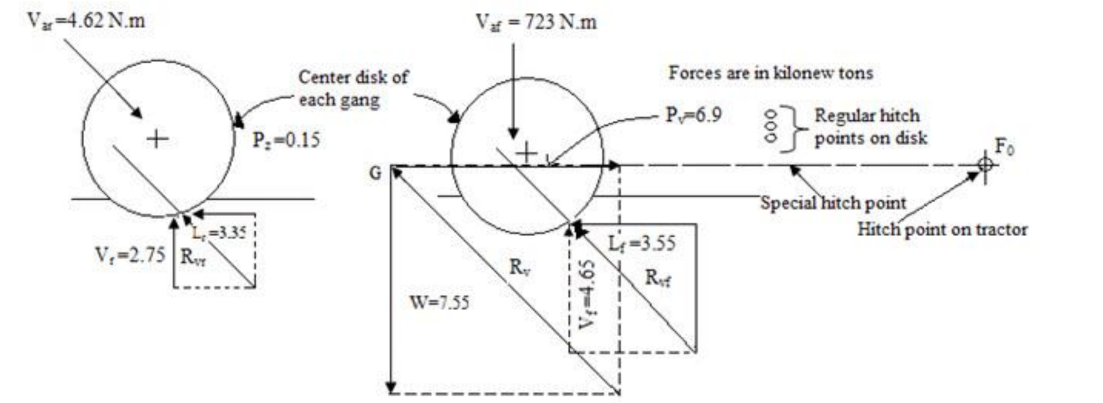


Fig. 17.5 Vertical force relations for a pull-type offset or tandem disk harrow without wheels and with no hinge axis between the front and rear gangs.

Vertical force relation for an offset or tandem disk harrow without wheels is shown in Fig. 17.5. The support from soil is through the disc blades and the position of point G is obtained by the intersection of W and line of pull, P_v. The soil forces R_{vf} and R_{vr} are adjusted by means of depth changes. Therefore resultant R_v passes through point G and is in equilibrium with W & P_v. Raising the hitch on implement frame, raises G and moves R_v closer to front gang, thus R_{vf} increases and R_{vr} decreases. Thus, depth of penetration will increase for front gang and decrease for rear gang. R_{vf} is larger than R_{vr} as front gang is operating in firm soil and rear gang in loose soil.

Single – axle implement with rigid pull members:-

Fig. 17.6 shows the vertical force relation for a single-axle, pull-type implement receiving vertical support only though its wheels. In this condition, the location of Q_v is fixed. The Q_v passes slightly behind the axle center line to supply torque which overcomes wheel bearing friction and causes rotation of wheels. Also point G is fixed by intersection of AB and Q_v. Line of pull is through G and vertical hitch point F at tractor drawbar.

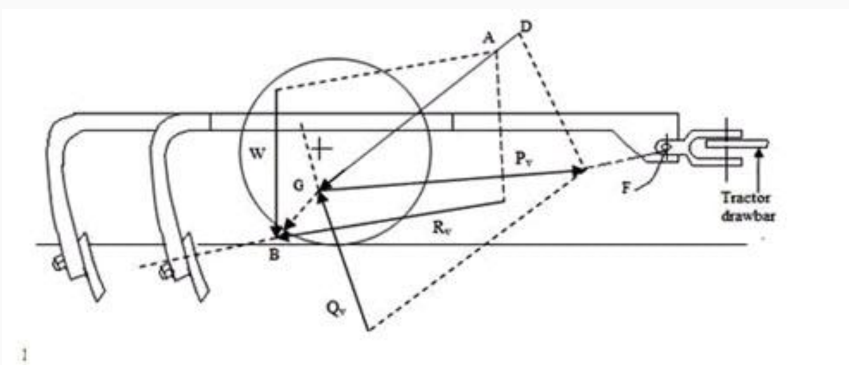


Fig. 17.6 Vertical force relations for a single-axle, pull type implement receiving vertical support only through its wheels.

Possible hitch adjustment is changing the height of drawbar at F, which would change the slope of $P_{v.}$ In fig., R_v has downward slope which moves the wheels rearward with respect to soil-engaging tools and will increase the slope of P_v and reduce the magnitude of $Q_{v.}$

HITCHES OF MOUNTED IMPLEMENTS

Design considerations and types of Linkages:

Generally two types of hitch linkages are used on tractor rear mounted three point converging-link types. The rear mounted three point parallel link type hitches for front mounted cultivators are not common in India. Single axis hitches are replaced by three point hitches. Any of these types can be operated with hitch members acting as free link in vertical plane or restrained links.

Factors considered in designing or evaluating a system for mounting tillage implements on rear of tractors:-

1. Ease of attachment and adjustment, versatility and safety.
2. Standardization to permit inter- changeability.
3. Uniformity of tillage depth as the tractor passes over ground surface irregularities.
4. Ability to obtain penetration of implement under adverse conditions, particularly with implements such as disk harrows and disk plows.
5. Rapidity with which tools such as plows as listers enter the ground.
6. Trailing characteristics of implement around contours and on side hills.
7. Effect of implement upon tractive ability of tractor (vertical load transfer from front wheels to rear wheels).
8. Effect of raised implement upon the transport stability of the tractor.

Three point hitches:

Hydraulic control systems were introduced on tractors in late 1930s. No. of hitching arrangements for rear mounted implements were developed. Most common among these is three-point hitch system. The two lower links cover toward the front and are free to swing laterally within limits. The lower links can also be locked. So, they are laterally rigid, which is desirable in some non-tillage applications. ASAE-SAE standards for 3-point hitches specify all dimensions related to 3 connecting points between implements and tractor and minimum limits for lift height, Lateral leveling adjustments, side sway and minimum lift force to be available at hitch pins. Link lengths and amount of horizontal and vertical convergence are not specified. Maximum drawbar power available for different ranges of categories are:-

Category I - 15 to 35 kW (20 to 45 hp)

Category II - 30 to 75 kV (40 to 100 hp)

Category III - 60 to 168 kW (80 to 225 hp)

Category IV - 135 to 300 kW (180 to 400 hp)

Quick attaching couplers for three point hitches have been developed to facilitate the attachment of implements that are too heavy to be nudged into position by one man. These have been standardized to fit on the standard three-point linkage system. Quick attaching couplers allow the operation to couple or uncouple an implement without leaving the tractor seat thus contributing to both convenience and safety.

Free-link operations of 3-point hitches:

Depth control from mounted mould board plow can be obtained through vertical support from rear furrow wheel and heel of rear land side. When free-link operation is desired, depth is controlled by gage wheels running on unplowed ground. Fig. 17.7 showed vertical force relations for

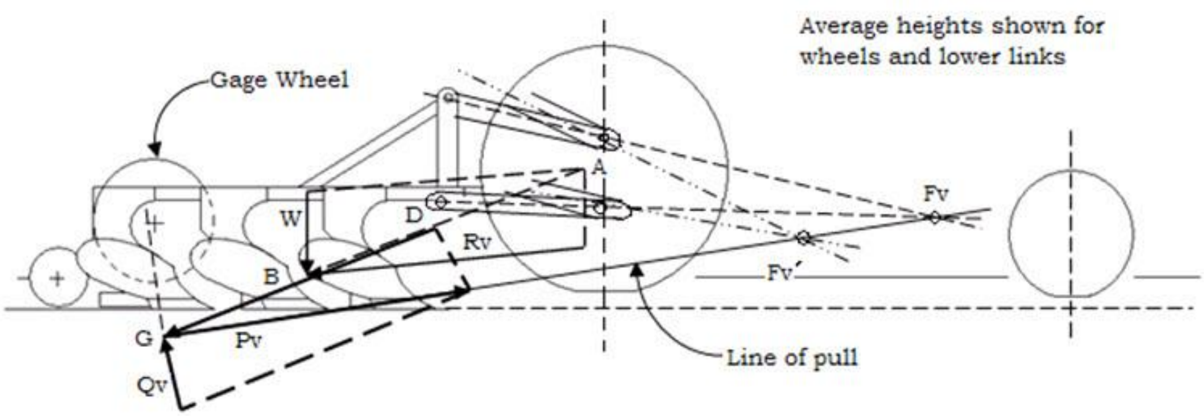


Fig. 17.7 Vertical force relations for a three-point hitch when operated as a free-link system.

free- link operation with M.B. plow having a gage wheel. In free-link operation convergence of links in a vertical plane provides a vertical hitch point or instantaneous centre of rotation as shown at F_v. Location of F_v can readily be changed by modifying arrangement of links and it shifts automatically as implement is raised or lowered. Location of F_v is shown by dotted lines. It is lower than F_v and farther to rear when tool is entering the ground. This shift promotes rapid entry of tools that have appreciable bottom support surfaces (such as a M.B. plow). Force analysis is same as that of single-axle, pull type implement. Line of pull, P_v must pass through virtual hitch point, F_v. All vertical support is assumed to be on the gage wheel and establish the line of action of Q_v. The slope represents the coefficient of rolling resistance. W & P_v are combined into resultant AB. Location of G is established by intersection of AB and Q_v. P_v then passes through G & F_v. Raising F_v by modifying the linkage would reduce Q_v and increase the load on tractor rear wheels. But Q_v must not be reduced to the point where the implement becomes unstable due to momentary variations in P_v. Also increasing the plow length by adding more bottoms would move R, W, Q_v and G farther to rear, P_v in that case would have less slope but higher above the ground at tractor wheels. Gaged free link operation gives more uniform depth than either automatic position control or automatic draft control when field surface is irregular and soil resistance varies particularly with large size mounted M.B. plows. Gage wheels are sometimes used with other systems in light soils where draft is relatively low. Wide field cultivators and chisels have gage wheels to minimize depth variations across the width of implements.

Restrained-Link Operations of Three-point Hitches:

In restrained link operations, implement gets its vertical support from the tractor. Hitch links are free only when tool is entering the ground. Since implement obtains no support from soil, P_v is in equilibrium with W & R_v. Lift links are in tension and implement exerts downward bending moments on the portions of lower links behind lift links. With restrained link operation the effect of implement upon the tractor is that when the implement is at its operating depth it is independent of hitch linkage arrangement. Line of pull P_v

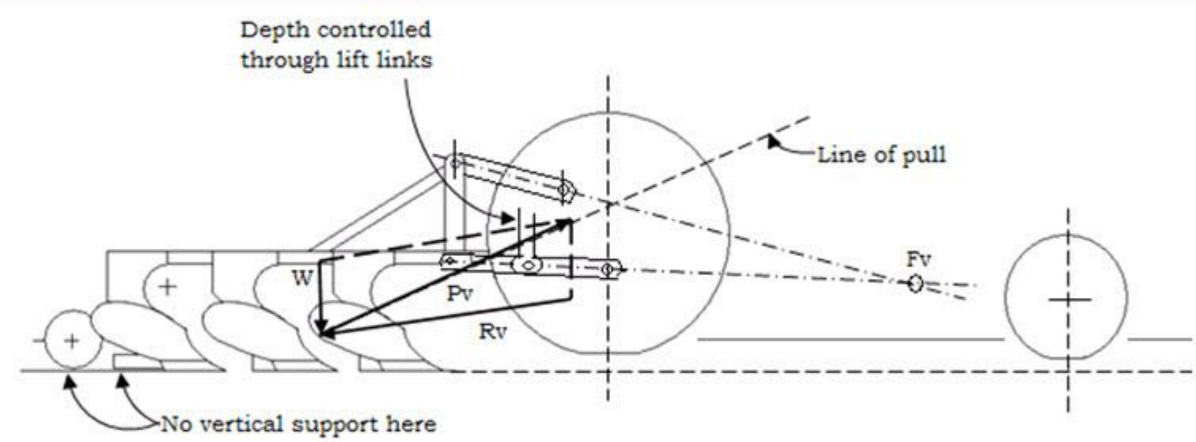


Fig. 17.8 Vertical force relations for a mounted implement when supported by restrained links

will pass through intersection of W and R_v (Fig. 17.8). If implement is operating with restrained links, it will increase the vertical load on tractor rear wheels and provide greater tractive ability. This is because the location of P_v is higher at rear wheel and this will increase the load transfer from front wheels to rear wheels. When the implement is suspended at a fixed height with respect to tractor, as with automatic position control, depth fluctuations caused by ground-surface irregularities are greater than with gaged free-link arrangement. Magnitude will increase in direct proportion to the amount of overhang of implement behind the tractor rear axle.

Automatic Draft Control:

This is a type of restrained link system in which depth of implement is automatically adjusted to maintain a preselected constant draft. If soil resistance is uniform, depth fluctuations caused by irregular ground are less with automatic draft control than with automatic position control. In field, depth will vary as a result of variations in soil resistance, regardless of whether the field is smooth or undulating. In smooth fields, automatic draft control maintains average draft within the available power or tractive ability of tractor. When an overload condition occurs, automatic draft control system attempts to lift the implement against gravity and its inertia and against any downward soil force components. The lifting action behind the tractor results in a counter balancing lifting action of front wheels. Thus, momentarily vertical load from both implement and front wheels transfers to drive wheels and minimizes wheel slippage. If excessive soil resistance persists over any appreciable distance, implement depth is reduced.

Draft Sensing:

Earlier upper link draft sensing was employed on all automatic draft control systems and it is still in use on small and medium size tractors. With mounted implements the upper link is always in compression when implement is in ground.

Vertical hitching relations for a Semi-mounted plow

A semi-mounted plow is usually attached to two lower links. All the vertical support force from soil will act upon rear furrow wheel. Q_v is somewhat forward from rear wheel. W, the gravitational wt. of implement is larger than R_v as semi-mounted plows are 50% heavier per bottom than mounted plows. Line of pull P_v must pass through horizontal hinge axis provided at the three-point hitch (Fig. 17.9). Locating hinge axis higher on frame would raise P_v and thereby increase the vertical load transfer to rear wheels.

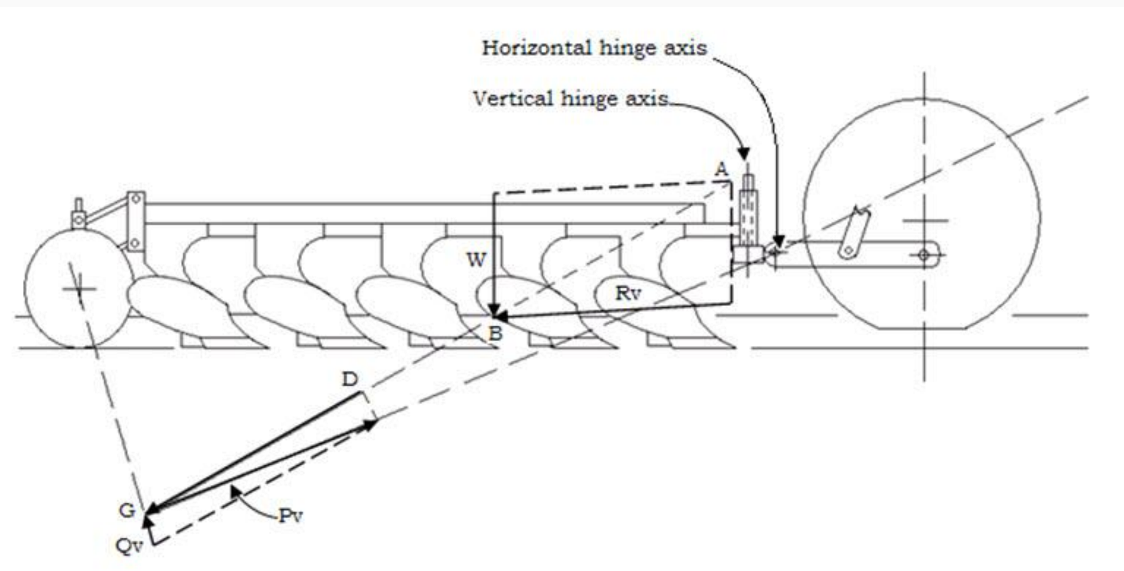


Fig. 17.9 Vertical force relations for a semi -mounted plow.

Vertical effects upon the tractor:-

When magnitude and line of action of P_v are known, the effect of implement upon drive wheel loading of tractor can be determined. R_t & R_f are vertical supporting soil reactions on wheels.

R_t is tractive effort. R_r is slightly in front of rear axle (25 to 50 mm approx.) because of rolling resistance of tractor, bulldozing etc. P_v is the pull of implement on tractor. It is equal and opposite to P_v. P_z and P_x are vertical & horizontal components of P_v. Distance Y is height above the ground at which P_v intersects the vertical line of action of P_r. W_t is the force of gravity on the tractor acting through the centre of gravity (Fig. 17.10).

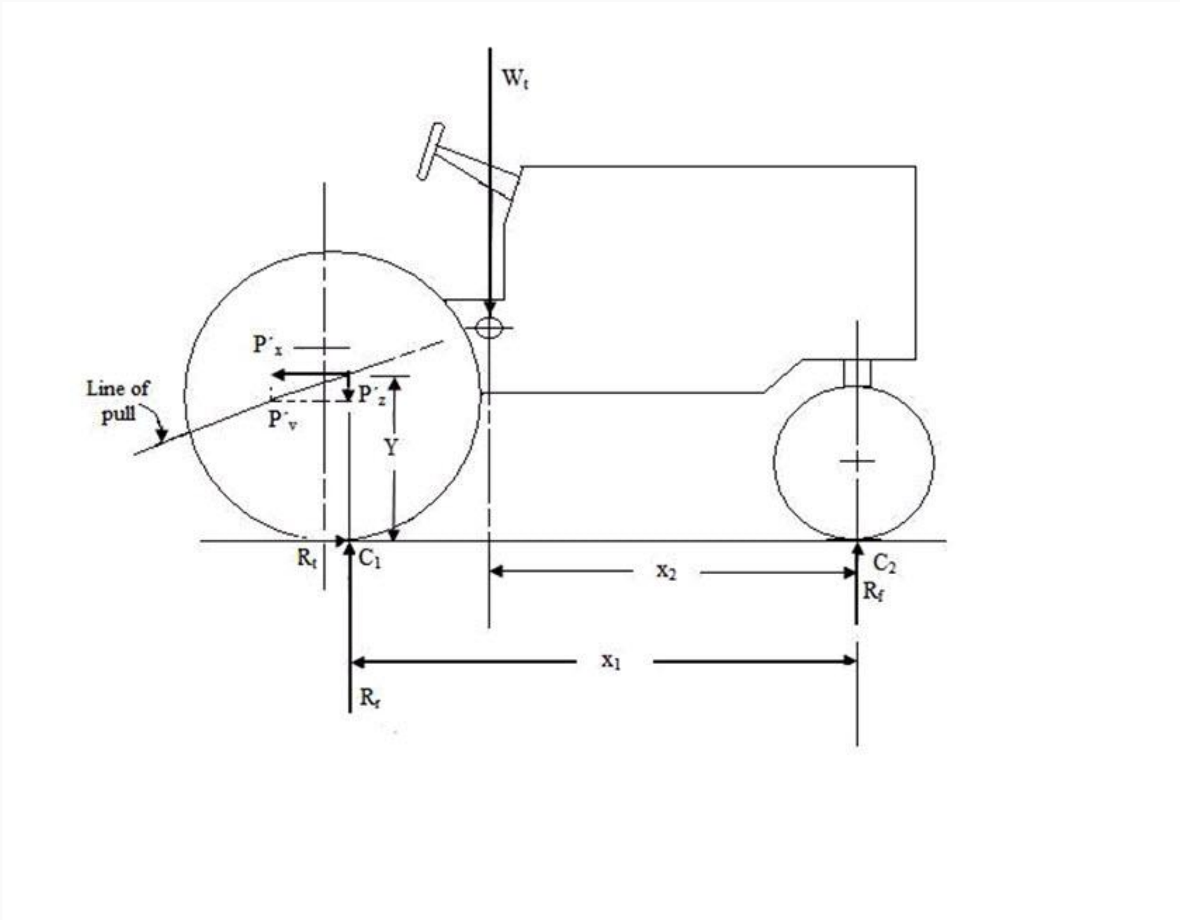


Fig. 17.10 Vertical force relation for a tractor when pulling an implement at a uniform velocity on level surface

Taking moments about C_2

$R_r x_1 - W_t x_2 - P'z x_1 - P'_x y = 0$

$$R_r = W_t \left(\frac{x_2}{x_1}\right) + P'_z + P'_x \left(\frac{y}{x_1}\right)$$

- Taking moments about C_1

$W_t (x_1 - x_2) - P'_x y - R_f x_1 = 0$

$$R_f = W_t \left(\frac{x_1 - x_2}{x_1}\right) - P'_x \left(\frac{y}{x_1}\right)$$

These equations show the effect of implement pull is to add vertical force P'_Z to rear wheels and to transfer vertical force equal to $P'_x\, y/x_1$ from front wheel to rear wheel, thus increasing the tractive ability.

Horizontal Effects of Hitching:

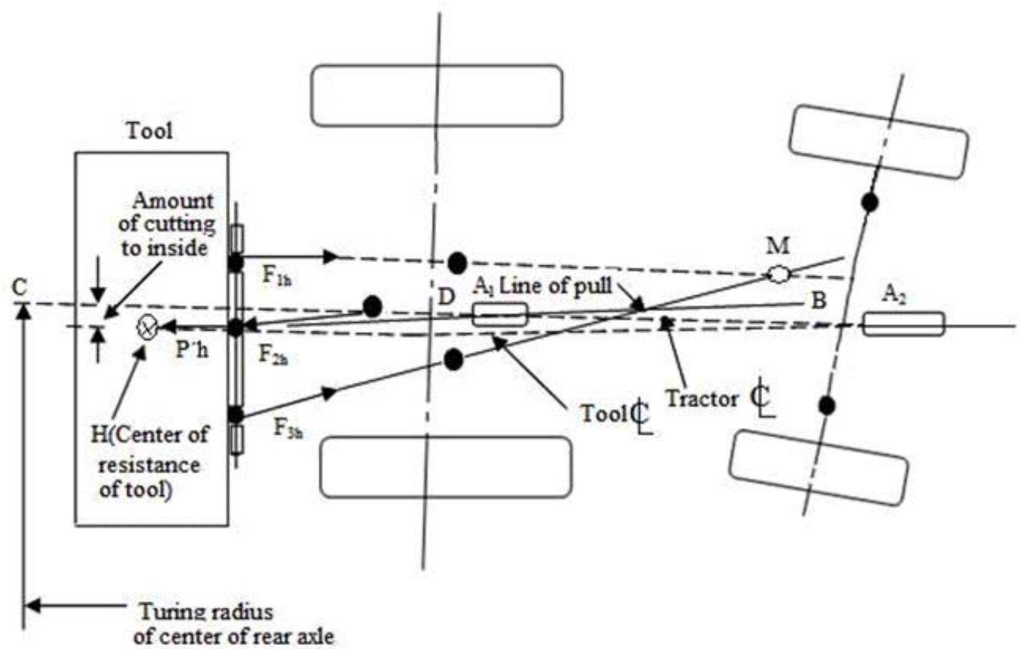


Fig. 17.11 Testing characteristics with horizontally converging pivotal links (three-point hitch) while operating around a curve

The important characteristic of a mounted implement is that a uniform width of cut is obtained when operating around contour without affecting tractor steering. If rear mounted implement is not permitted lateral movement with respect to tractor, implement will cut outside while operating on contour and steering response is also poor because side forces will be developed by implement. The lateral swinging hitch gives easy steering but implements cut soil to the inside on a corner. Fig. 17.11 shows a mounted implement on a three-point hitch. The lower links converge towards the front and are free to swing laterally. The tractor operating on a curve M is centre of rotation of two lower links but it is not virtual hitch point. The line of action of the force in the top link does not pass through M, the sum of the forces in the three links lies along line BH which passes between M and the tractor centerline. It is the horizontal center of resistance of the implement and BH is the line of pull. P_h is the pull of the implement upon the tractor and is in equilibrium with F_{1h}, F_{2h}, and F_{3h}. The direction of P_h can be determined from the linkage geometry in the vertical and horizontal planes. A non directional implement (i.e., one that has little or no resistance to side forces) tends to move along the line of pull when the tractor is on a curve, the linkage adjusting itself so that BH is perpendicular to a radius drawn through H and the turning center for the tractor. The effect is the same as that of a trailed implement pulled from a point within the small area A_1 on the tractor center line. The implement cuts the corner more than it would if M were the virtual hitch point. The total amount of corner cutting is the distance from H to arc CD, as indicated in Fig. 17.11. Some implements, such as a moldboard plow or a cultivator equipped with a guiding coulter or fin, are directional. Within reasonable limits they tend to go in the direction in which they are pointed, rather than in the direction of pull. In this case the implement is pulled toward the virtual hitch zone A_2, representing the intersection of the implement center line and the tractor center line and the implement adjusts itself so A_2H is perpendicular to the radius line through H. Since A_2 is farther forward than A_1, a directional implement cuts the corner even more than an implement that is free to move in the direction of pull. For ideal trailing of any implement around a curve (no corner cutting), the horizontal hitch point (real or virtual) should be on the tractor center line, equidistant from the center of resistance of the implement (H) and the center of pull of the tractor (D). On a side hill, however, where the rear of the tractor tends to slide downhill, the lateral position of the implement will be affected least when the hitch point is well forward on the tractor. A hitch point somewhat forward of the rear axle is also best in regard to ease of steering. Thus a compromise must be made to determine the best overall location for the horizontal hitch point for mounted implements.

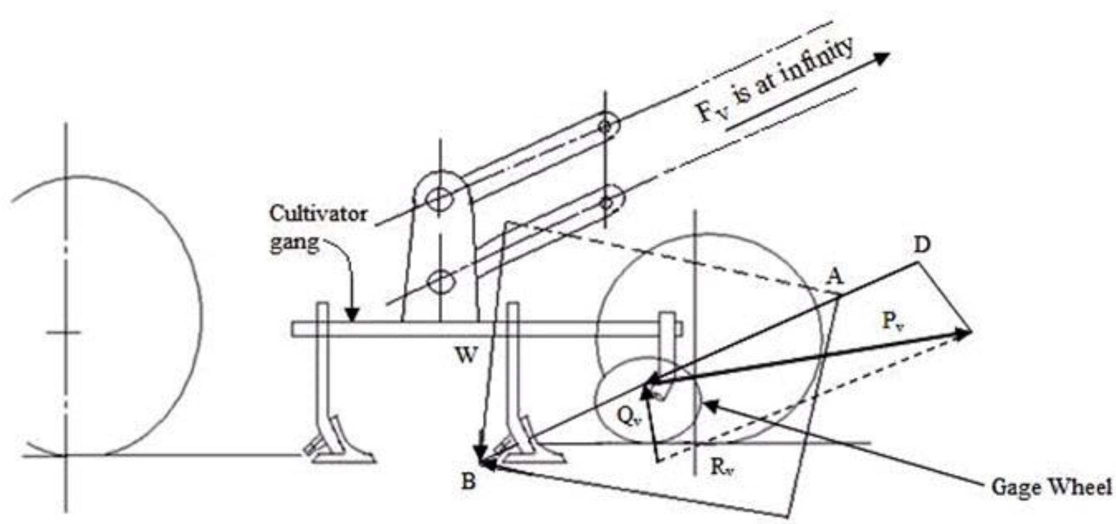


Fig. 17.12 Vertical force relations for a parallel-link hitch operated as a free-link system

Parallel link Hitches:

Generally used on mounted row coop cultivators because raising or lowering the gang or tool bar changes the depth of all shovels by the same amount and does not change the pitch of shovels. Also the lateral rigidity of the hitch is important to permit cultivating close to plants. In case of restrained link operation, depth of cultivation is controlled through the listing mechanism. The free-link operation with gage wheels is common on wide tool bars and on multiple-gang cultivators. The virtual hitch point for free link operation (Fig. 17.12) is at the intersection of parallel links or at infinity. P_v is parallel with the links and magnitude of Q_v can be changed by changing the slope of links. Moving the gage wheel forward or backward has no effect on magnitude of Q_v.

Load transfer Systems for pull –type implements:-

Load transfer with pull-type implements as a means of increasing tractive ability of larger tractors is important. There must be some arrangement for applying moment to the implement pull member which tends to lift the rear end of pull member and front of implement. Pull member is strong enough to withstand these forces. Vertical load from implement and tractor front wheel is transferred to tractor drive wheel. This transfer tends to reduce the depth of same type of implements. Maximum acceptable amount of implement vertical-load reduction is influenced by soil conditions, implement mass and type, method of controlling or gaging depth, tractor front end stability and steering response. Load transfer system requires same modification or addition to implement pull member. Other systems pull from regular tractor drawbar and exert a constant lifting force by means of an adjustable, constant hydraulic pressure applied to rockshaft lift cylinder.

Lesson 19. Study of miscellaneous tillage tools, rotary tillage tools, rotavators, stirring plough, auger plough, rotary hoes, Oscillating tools etc.

VIBRAORY AND OSCILLATORY ILLAGE

This type of cutting tool either vibrates or oscillates. Their primary object is to reduce draft and to improve overall energy utilization efficiency in soil break and provide semi control over the degree of pulverization. These implements reduce draft as much as 50-75% in comparison with non-oscillating tool. Draft reduction is desirable especially with high draft implements like sub-soilers. Operating parameters for a vibratory tillage system include:-

- Travel speed
- Oscillation frequency
- Amplitude
- Direction and pattern of oscillating motion
- Tool shape
- Tool lift angle
- Soil physical characteristics.

The effects of frequency and amplitude tend to diminish rapidly as their values increased beyond optimum values. Several studies resulted that effect of vibration were most pronounced at frequencies that resulted in a forward travel per cycle which was about to or slightly less than the spacing of natural shear planes caused by a non-oscillating tool. This relation makes the optimum frequency a function of soil physical characteristics. Although oscillation of tillage tool has reduced draft but there is little reduction in total energy requirement and sometimes there is substantial increase. That means oscillation conditions that causes large reduction in draft are not best for total energy requirement.

Principle of Vibratory Tillage:-

Vibration causes physical changes to take place in the soil that tend to reduce shear strength. And for maximum draft reduction tillage tool should be oscillated in such a manner that there is definite separation of cutting and soil-lifting operation to minimize soil-metal friction shown in Fig. 19.1 (a), (b), (c)

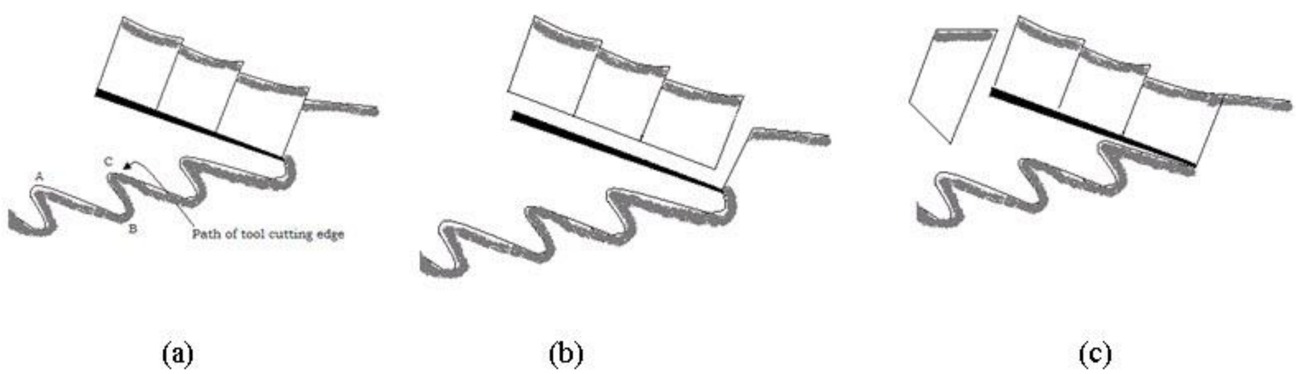


Fig. 19.1 Idealized operation of an oscillating tillage tool. (a) separation and upward acceleration of the soil, (b) soil lifted from tool by inertia at beginning of the cutting stroke and (c) end of cutting stroke

In this Fig 19.1 the tool is pivoted at one point above and it is somewhat ahead of cutting edge. Due to this a forward stroke cutting edge moves downward along point AB. Shearing action takes place on return stroke (Fig a). Since there is little or no forward motion of tool during this operation so energy for shearing, lifting and accelerating the soil upward does not contribute to draft. (Fig b and c) upward motion of soil plus the fact that soil is loose this minimize the friction against upper surface of tool during forward stroke. Tool makes a new cut at a flat angle with little lifting of block being cut (Fig. c). If relation between oscillation angle, tool lift angle and forward travel/cycle is correct there is adequate clearance beneath the tool body. So, in this idealized situation the draft requirement is to overcome cutting resistance and minimal frictional forces of newly cut soil sliding on upper surface of tool.

Multi-powered Rotating Tillage Tools:-

There are various configurations available viz. Vertical axis - unit, Longitudinal axis – unit and Transverse – axis unit.

Vertical axis

These machines have series of two tine vertical rotors across the width of machine.

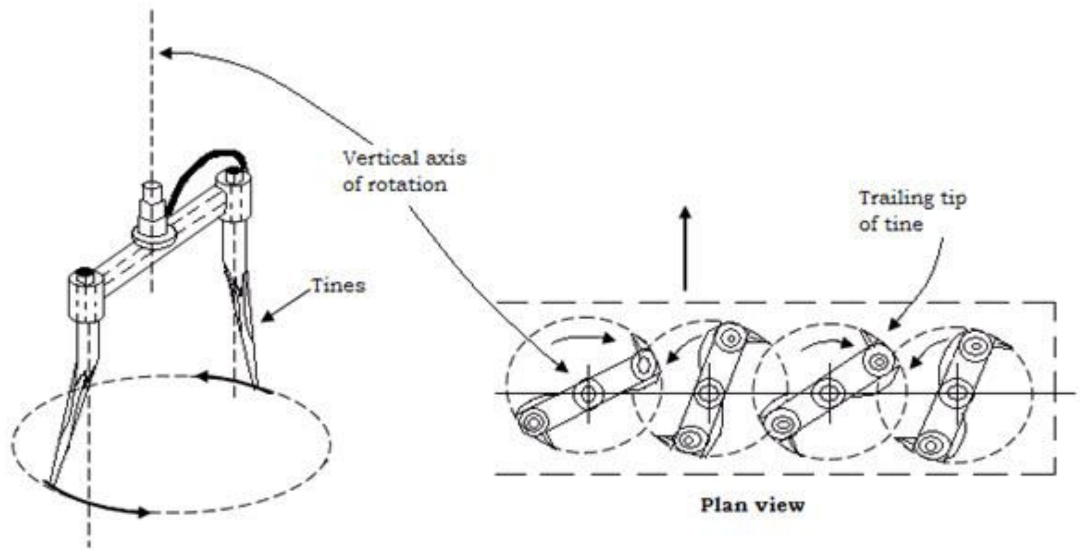


Fig. 19.2 Vertical Axis Rotary Tillers

The path of adjacent rotor overlaps as shown in Fig. 19.2. Gear on upper ends of rotor shaft transmits power from one rotor to other and provide counter rotation of adjacent rotor. Good for pulverization and secondary tillage. Do not work well in loose surface trash.

Transverse axis:

Rotary spading machine is an example of transverse axis type rotating tools. It has transverse, powered rotor with spades attached to arms on it. Mechanical complexity and lack of durability are problems, trash coverage is poor. They are comparable in regard to soil pulverization and energy requirements. Work well in heavy soils.

Rotating Auger Plow:

It is a kind of mould board plow on which rear portion of mould board are replaced with powered rotor. Rotors have teeth (Blades) to assist in soil pulverization. Draft is less than the conventional M.B. but total power requirement is high. Soil pulverization is unsatisfactory in dry, compact soil. Trash coverage poor and driven rotor make this implement more complex and expensive than conventional plow.

Conventional Rotary Tillers:

Blades are attached on flanges along a horizontal shaft that is perpendicular to the direction of motion. Swiss made introduced in 1930 in U.S. Early models were small garden unit. Now heavy-duty tractor mounted or pull type unit width ranging from 1 m to 4 m are used. Tractors using these units for primary tillage should have 0.3 kW PTO power per cm of tilling width (1 PTO HP/inch). Power requirement is high for primary tillage. Degree of pulverization (excessive) is very high. Good for strip tilling, preparing precision seed beds for planting, cutting vegetative matter and mixing it throughout the tilled layer of soil. But coverage is not as complete as with mould board plow. Widely used in rice fields in south east. Asia, China, Japan, Korea. Rice soils are often puddled by means of rotary tillers.

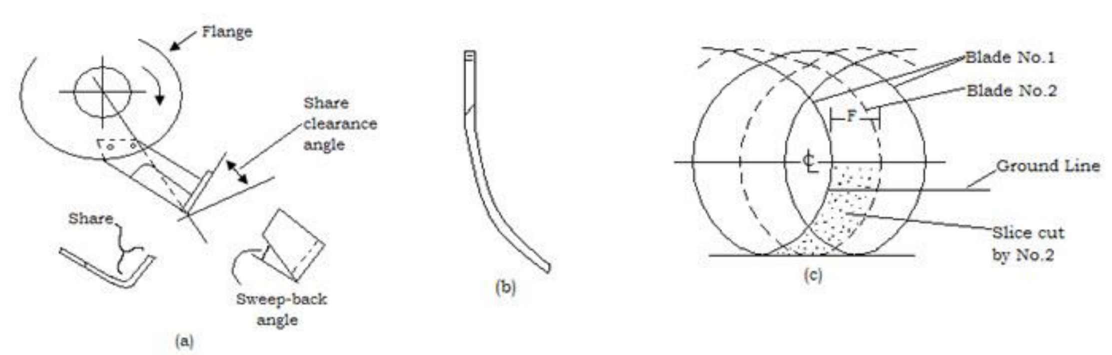


Fig. 19.3 (a) Three views of L-Shaped blade for Conventional Rotary Tiller, (b) Curved blade and (c) Path of cutting edge or tip for 2 blades 180^0 apart in relation to forward travel

Many types and shapes of blades are developed (Fig. 19.3 a)but hoe types are common. L-shaped blades work well in trashy conditions, they kill weeds more effectively and do not pulverize the soil much. Power requirement is high. Curved blades for special situations such as operating on sides of plant beds 'C' type less power requirement than 'L'.

Rotor Speed – 250 – 300 RPM dia of Rotor = 46 cm:

- Rotar rotates in the same direction as the tractor wheels.
- Each blade cut a segment of soil as it moves forward and towards the rear.
- Most rotary tillers make 2 or 3 cuts per revolution along any one longitudinal line.
- Bite length 'F' is defined as amount of forward travel per cut. It can be increased by reducing rotor speed or by increasing forward speed.
- Slice thickness varies during the cut and also the force.
- High peak torques developed during each cut require staggering of blade in different courses, with equal angular displacements between them. So no two blades strike the soil at same time.
- Blades experience an upward component of force 'V' and a forward component 'L'. Relative magnitudes of these forces are influenced by depth, rotor dia, bite length, soil type and condition, type of blade, share (Blade, c clearance angle.
- Upward component reduces the amount of implement gravitational force that must be supported by gage wheels or tractor. Under some conditions it causes rotor to walk out of ground.

- Forward component results in negative draft and –ve specific energy requirement for traction, both increasing inmagnitude and bite length.
- Forward thrust from –ve draft is troublesome to tractor stability and design.
- Researches shows that –ve power requirement represented by forward thrust was less than 7% of rotor power when bite length was 5 cm and 20% of rotor power when bite length was 15 cm.

Lesson 20. Study of miscellaneous tillage tools, rotary tillage tools, rotavators, stirring plow, auger plow, rotary hoes, Oscillating tools etc

Types of RotaryPloughs:

(1) Pull Auxiliary (on the basis of power)

Whose we have a separate unit shaft and pulling of implement by engine.

(2) **Pull power take off drives (on the basis of power:**

- Tractor PTO driven shaft, pulling is also done by tractor.
- Size is approx. 3-4 ft.
- Power requirement varies from 10 to 15 HP/ft.
- RPM at which shaft rotates 300 rpm. Eg rotavator
- Rotavator is used for mixing organic matter and also for better pulverization.
- Different types of blades are available for mounting on rotavator.
- 'L' type and 'C' type
- Power requirement in 'L' type blades is more than 'C' because contact area in 'L' is more than 'C' type.
- Performance of rotavator is better in optimum moisture content.
- In hard soil conditions there can be breakdown of gears.
- Cost of good quality rotavator 60,000/-.
- Depth 4 to 6 inch.
- Power requirement 60 – 90 hp.
- **Advantage:** for cutting vegetative matter and mining it throughout tilled layer.
- **Disadvantage:** Excessive pulverization, high power requirement

Useful soil force in a forward rotating rotary tiller has to components.

- a) Longitudinal (forward component): Results in –ve draft.
- b) Upward component: It reduces the implement gravitational force. It may even cause "Walk out" of the ground.

Power requirement (KWH) $= \frac{TQ}{K} = \frac{2\Pi\ N \times T}{60 \times 1000}$

Or HP $= \frac{2\Pi\ NT}{60 \times 75}$ (Kgfm)

Factors affecting degree of pulverization and special energy requirement:

1) Bite length: increased bite length reduces pulverization.

2) Depth of cut.

3) Rotor speed

4) Blade shape

5) Soil type

6) Soil condition:

Hood & Shield: Are used at rear and they affect the soil break-up significantly.

Combination implements: Chisel or other fixed tool attacked behind a rotary tiller.

(1) Self – Propelled Garden Type e.g. Power Tillers:

- Width of plowing varies from 9 to 3"
- Power 6-15 H.P.
- Mostly 'C' type blades are used.
- 'L' type of blades are also better for trashy lands.
- Most popular rotary tillage tool is rotavotor.

Lister:

- It is a M.B. plow, which throw the soil in both directions. In the centre furrow is formed in which crops are planted. This is also available in disc type of furrow planters. This works well in dry soils, where soil crumbles (breaches).

Puddlers:

- Puddling is a most important operation for paddy growing areas.
- Refers tochurning the soil in presence of excess water by means of puddlers.
- Depth of standing water varies from 5 to 10 cm.

Advantages of puddling:

(1) It reduces leaching (percolation) of water because on settlement of puddling form impervious layer.

(2) To kill weeds by decomposition.

(3) To facilitate transplanting of paddy seedlings by making field soft.

Different types of puddlers:

(1) Hand operating puddlers e.g., paddy weeders.

(2) Animal drawn - 3 to 4 ft width.

(3) Tractor drawn - width is 6 – 7 ft.

(a) Straight flat type

Rotary motion is better for churning and controls better water (percolation less). (With cultivator mixing is not thorough percolation is more)

(b) Rotating blade puddlers. Fig.

(c) Disc harrow puddlers (disc are cut types)

(d) Rotary tillers

(e) Rotavators.

(f) Pulverizing roller with cultivator cultivator opens the soil, pulverizing roller pulverizes the soil. Power requirement is little higher than cultivators.

AUGER PLOUGH

Brief History:

- Plough tested with Ford – 3600 Tractor (4.7 HP)
- 3 bottom Auger plough
- Received by Dept. in June, 1997
- Width of coverage 120 cm.

- Tested for 60 hrs. under different field conditions.
- Covered a total area off 60 acres (including 40 acres paddy land).
- Performance compared with rotavator used for 6 ha only.

Rotating Auger Tests Conditions:

1. Ploughing the land with weeds & trash
2. Puddling the paddy fields.
3. Burying of green manure crop and cotton crop.
4. Ploughing of paddy and maize harvested fields for wheat seed bed.

Results of Rotating Auger Tests:

1. Width of coverage = 120 cm
2. Field speeds of operation = 3 to 6 km/hr
3. AV output capacity = 0.4 to 0.5 ha/hr
4. Fuel consumption = 4.5 to 8.8 lit./hr
5. Depth of ploughing = 15 to 20 cm
6. AV draft = 0.285 to 0.48 kg/cm^2
7. Puddling was done effectively.
8. Green manure crop burying done perfectly
9. Green manure crop height = 1.75 m
10. Cost of operation = 56.18/ha.

Results of Rotavator Tests:

1. Rotavator depth = 5 to 10 cm
2. Rotavator field capacity = 0.2 ha/hr
3. Rotavator fuel consumption = 4.0 lit./ha
4. 4. Puddling was done effectively with rotavator.
5. Green manure crop burying was not upto the mark, coverage was about 50%
6. Cost of operation = Rs. 83.75/ha

General conclusions:

- Basically both implements namely Rotating Auger Plough and rotavator were good.
- Rotating auger plough had an edge over a rotavator with regard to higher work output capacity, higher depth of penetration and effective burying of green manure crop. Also lower cost of operation.
- In heavier clay soils, however both these implements required working in combination with a disc harrow to produce an accepted soil breakup use the disc harrow beforehand.

Lesson 21. Earth moving equipment (Bulldozer, Trencher, Elevator etc.): construction and working principles

Earth Moving Equipment

They are essentially equipment to move the soil from one place to another to modify the contour of field surface.

Earthmoving operations are necessary for:

i) Terrace building

ii) Filling of gullies or depressions

iii) Land smoothening for irrigation or surface drainage

iv) Construction of drainage ditches

v) Building of earth dams

vi) Building of embankments

vii) Construction of ponds

viii) Irrigation channels etc.

Principles & Types of Earthmoving Equipment

Earthmoving involves: (i)Controlled cutting or loading

(ii)moving, and

(iii)Spreading or dumping of soil

Methods for moving the earth after cutting or loading:

a) Lifting and Rolling Action

Ex: M.B. Plow used for terrace marking Disc Plow

b) Throwing Action

Ex: Auger plough (Whirlwind Terracer)

c) **Pushing Action** (is accompanied by some amount of rolling also)

Ex: Scrapers & graders of various kinds such as Bulldozers, Angle-dozers, V-drags, land smoothers (levelers).

d) Carrying Action:

- Scoops
- “Carry-all” scrapers

Machines commonly used for earthmoving jobs:

(1) Crane shovel

(2) Crawler Tractor

(3) Rubbles fixed tractor

(4) Towed Scraper

(5) Self-propelled scraper

(6) Dump trucks and wagons

(7) Motor graders

(8) Belt loader

(9) Elevating grader

(10) Air compressors

Angle-Blade Scrapers and Graders

- Used for moving soil to one side. Also known as “Crowding”. By setting the blade at an acute angle from the direction of travel.
- Blade may also be set in the right-angled position for smoothening or moving moderate amounts of soil by direct pushing.
- Blades have provision for adjustment in all three planes.
- Size ranges from 2-3 m (for rear-mounted utility blades)
- Trailed, two-wheel blade graders (lower cost, better maneuverability and better penetration)

Push-Type Scrapers

Buildozer is the most common tool that moves earth by pushing

Blades are also mounted on the front of a tractor

More heavy and rugged

When blades can be angled these are called as “angle-dozers”

Buldozer is a versatile tool adapted to a wide variety of jobs in the construction work

On the farm it is used for:

a)Land-clearing
b)Back-filling of ditches
c)Moving earth over relatively short-distances (Economical for handling earth to 50-60 meters only)

Trailed Scrapers of Push Type:

- Commonly known as “Land-levelers” have bottomless bowls with skirts added at the ends.
- Carried on wheels to control depth of cutting or spreading through a remote-cylinder.
- Width 2-5 m
- Bowl capacity : 1-4 cu m
- Power requirement: 50-60 hp

Brag-Type “Carry-all” Scrapers

(Roll-over scrapers)

- Load is supported by the bottom of the scraper bowl behind the cutting edge rather than pushing it.
- “Rotary or roll-over” scraper is a common example.
- Filling should take place in distance of 6-7 m at transport speed.
- Bowl is tipped backward for the blade to clear and loaded scraper is dragged on the bottom to the desired location.
- Emptying is done by releasing a latch.
- Roll over scrapers are inexpensive and efficient for small fields.
- Good for moderate hauling distances
- Capacity1/2 to 2 cu m.

Wheel-type Carrying Scrapers

- Self loading
- Wheel type scrapers
- Capacity 1 to 30 cu m
- It can dig its own load, haul it on wheels and then spreading in controlled layers
- Loading is done by means of blade.

Land smoothing

- An essential operation for irrigated fields and also for drainage.

Blades-type long-span smoothers

- Effectiveness of land finishing is dependent on the span or bridging effect.
- "Long wheel-base" smoothers, are also known as "Land Planes"

A land plane consists of:

a) Long frame supported at each end by wheel or skids

b) An adjustable leveling blade at some intermediate point.

- Effective length or span: 10-27 m
- Width of cut : 2-5 m

Lesson 22. Sowing methods and practices, functions and constructional features of a seeding/ planting machine

SEEDING AND PLANTING MECHANISMS

Crop Planting:

Crop planting operations may involve placing of seeds or tubers in the soil at

- Pre-determined depth
- Random scattering or dropping of seeds on field surface (broadcasting)
- Setting plants in the soil.

So, seeding or sowing is an art of placing seeds in the soil to have good germination in the field. A perfect seeding gives:

a) Correct amount of seed per unit area

b) Correct depth at which seed is placed in the soil

c) Correct spacing between row to row and plant to plant.

Methods of Sowing:

a) **Broadcasting**: It is the process of random scattering of seeds on the surface of seed bed. It can be done manually or mechanically. When broadcasting is manual uniformity of seed depends upon skill of man. It requires high seed rate. While in mechanical broadcasting seed rate may be controlled. Machine used is called mechanical broadcaster.

b) **Dibbling:** Process of placing seeds in holes made in seed bed and covering them. In this method seeds are placed in holes made at definite depth at fixed spacing. Equipment used is called dibbler. It is a conical instrument used to make proper holes in the fields. Small hand dibblers are made with several conical projections made in a frame. Time consuming process, specially used for vegetable sowing.

c) **Drilling**: Process of dropping the seeds in furrows in a continuous flow and covering them with soil. Seed metering may be done either manually or mechanically. The number of rows planted may be one or more. This method is very helpful in achieving proper depth, proper spacing and proper amount of seed to be sown in the field.

Drilling can be done by:

- Sowing behind the plow

- Bullock drawn seed drill
- Tractor drawn seed drill

d) **Seed dropping behind the plow:** It is very common method used in villages. It is used for seeds like maize, gram, peas, wheat and barley. A man drops seeds in the furrows behind the plow with a device called malobansa. It consists of a bamboo tube provided with a funnel shaped mouth. A man drops seeds through the funnel and other man handles the plow and bullocks. This is slow and laborious method.

e) **Hill Dropping:** In this method seeds are dropped at fixed spacing and not in continuous stream. Spacing between plant to plant in a row is constant. In case of drills seeds are dropped in a continuous stream and spacing between plant to plant in a row is not constant.

f) **Check Row Planting:** In this row to row and plant to plant distance is uniform. Seeds are placed precisely along straight parallel furrows. The rows are always in two perpendicular directions. Machine used is called check-row planter.

g) **Transplanting:** It consists of preparing seedlings in nursery and then planting these seedlings in the prepared field. Commonly used for paddy, vegetables and flowers. It is time consuming operation and equipment used is called transplanter.

h) **Row-Crop Planting**: If rows/planting beds are far enough apart to permit the operation of machinery between them for inter tilling/other cultural operations, it is called row crop planting. It is done by any method discussed other than broadcasting. In row crop planting system planting may be done on:

Flat surface of seed bed

In furrows or on beds

i) **Furrow Planting: (Or lister planting)** is widely practiced under semi-arid conditions for row crops as corn, cotton and grain sorghum. This system places the seed down into the moist soil and protects young plants from wind and blowing soil.

Furrow planting provides a flat plateau perhaps 7.5 cm high and 25 cm wide in the bottom of furrow.For furrow planting small furrows beside the plateau keep water from standing on the row or washing soil into the row if a heavy rain occurs.

j) **Flat Planting:** It is practiced under natural moisture conditions.

k) **Bed Planting:** It is practiced in high rainfall areas to improve surface drainage.

Bed planting is common for certain types of row crops in irrigated areas with close-spaced row crops such as sugar beet, lettuce and certain other vegetable crops.

Two or more rows are planted close together on a single bed, thereby leaving more width in the spaces between beds for the operation of equipment.

Beds can be on 102 or 107 cm centers with two rows 30 to 40 cm apart on each bed.

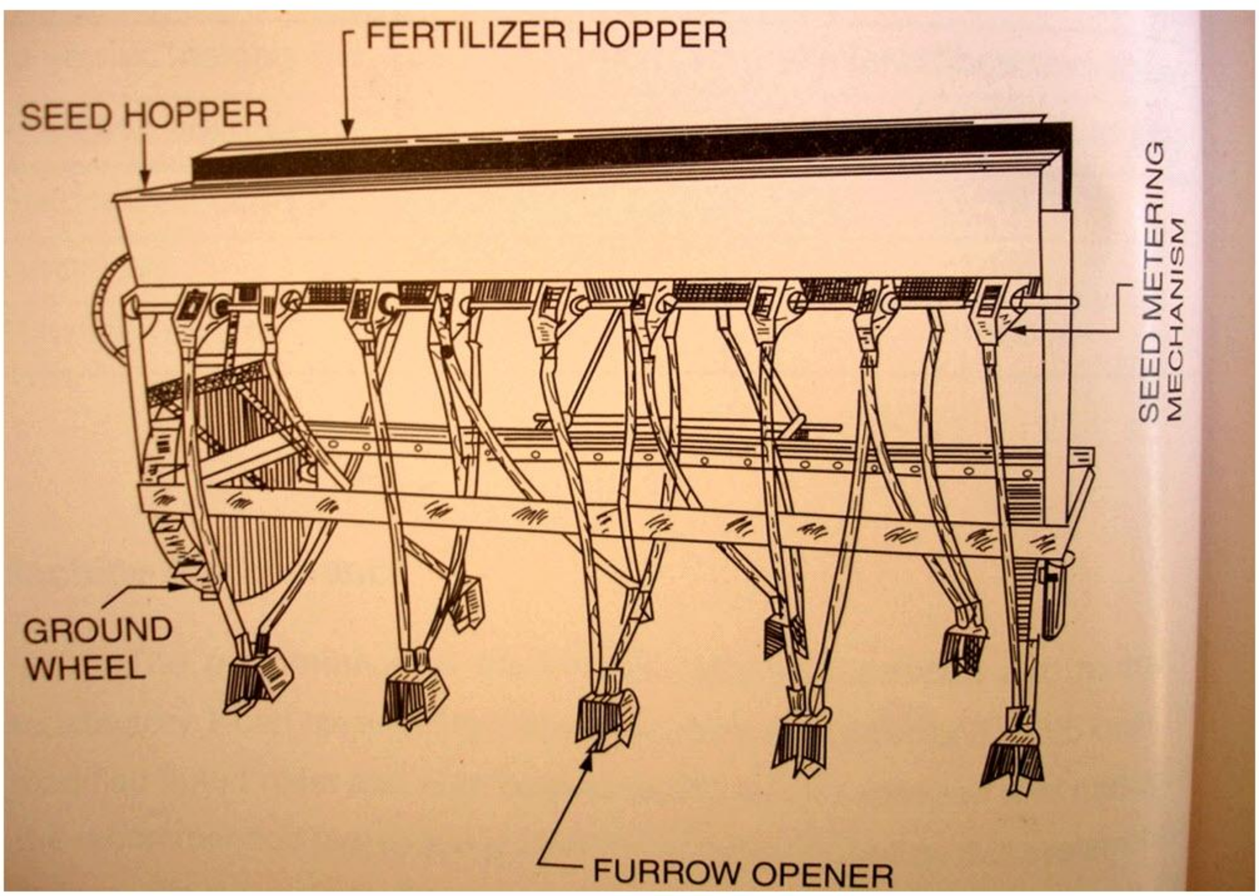
l) **Combination Bed-Shaping and Planting Units:** These are used for vegetables like sugar-beet and other similar crops in irrigated areas.

A unit simultaneously pulverizes the seed bed strip with rotary tiller, incorporates pesticides, form the bed to a firm, flat top shape, applies fertilizers and plants the seeds. Sled runners between beds guide and support the implement while it is in operation, thus minimizing height variations.

- It results in precise operation in which the seeds and chemicals are accurately placed at specific locations with respect to each other and w.r.t. top and sides of each bed.
- If relationships have been properly selected, results should be better and more uniform than from separate operations.

Seed Drill:

Seed drill is a machine for placing seeds in a continuous flow in the furrows at uniform rate and at controlled depth with or without the arrangement of covering them with soil.



Seed Drill

Functions of Seed Drill

1) To carry the seeds

2) To open the furrow to an uniform depth

3) To meter the seeds

4) To place the seed in furrows in an acceptable pattern

5) To cover the seeds and compact the soil around the seed.

Seed-cum-Fertilizer Drill

Seed drills fitted with fertilizer dropping attachment distribute fertilizer uniformly on ground is called seed-cum-fertilizer drill.

Seed drills may be classified as:

Bullock Drawn and Tractor drawn

Components of Seed Drill:

A seed drill with mechanical seed metering device mainly consists of:

1) **Frame:** The frame is usually made of angle iron with suitable braces and brackets. The frame is strong enough to withstand all types of loads in working conditions.

2) **Seed Box:** It is made of mild steel or galvanized iron with suitable cover. A small agitator is sometimes provided to prevent clogging of seeds.

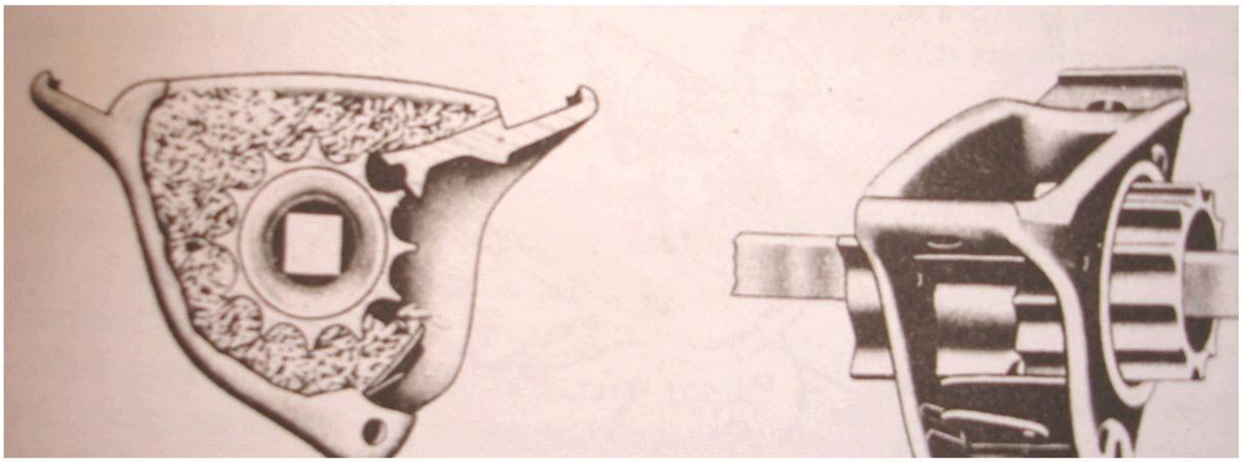
3) **Covering Devices**: It is a device to refill a furrow after seed has been placed in it. Covering of seeds are usually done by patta, chains, and drags, packers, rollers or press wheels designed in various sizes and shapes.

4) **Transport Wheel**: There are two wheels fitted on main axle. Some drills have a pneumatic wheel. The wheels have suitable attachments to transmit power to operate seed dropping mechanisms.

Seed Metering Mechanisms:

The mechanism of seed drill which delivers seeds from hoper at selected rates is called seed metering mechanism. These are of various types:

a) **Fluted Feed Type:** It is a seed metering device with an adjustable fluted roller to collect and deliver the seeds into the seed tube. It consists of a fluted wheel, feed roller, feed cut-off and adjustable gate for different size of grains. The feed roller and feed cut-off devices are mounted on a shaft, running through feed cups. The roller carries groves throughout its periphery. It rotates with the axle over which it is mounted and throws the grains out on the adjustable gate from where it falls into seed tube. Fluted rollers which are mounted at bottom of seed box, receive seeds into longitudinal groves and pass on to the seed tube through the holes provided for this purpose. By shifting the fluted wheel sideways, length of the groves exposed to seed can be increased or decreased and thus the amount of seed is controlled. Thus number of selections is available between closed position and full exposure of fluted wheel. This method is more positive in its metering action than internal double run type.

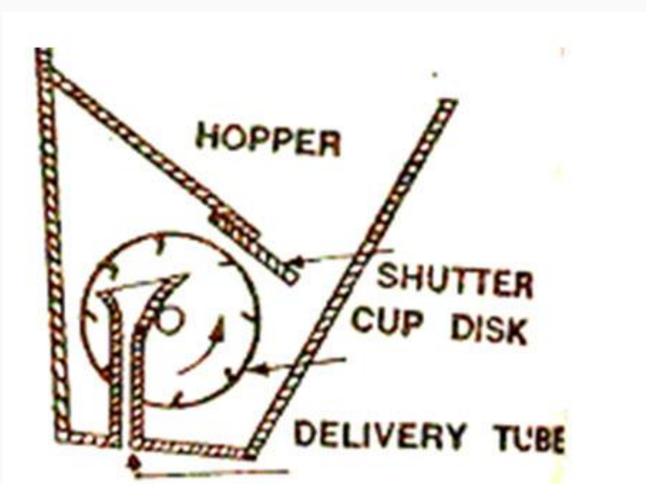


Fluted roller type

b) Internal Double Run Type: It is a seed metering device in which feed wheel is provided with fine and coarse ribbed flanges. It consists of discs, mounted on a

spindle and housed in a casing fitted below the seed box. It has a double faced wheel, one face has a larger opening for longer seeds and other face has smaller opening for smaller seeds. A gate is provided in the bottom of the box to cover the opening not in use. The rate of seeding is varied by adjusting speed of the spindle which carries the discs.

c) Cup Feed Mechanism: It is a mechanism consisting of cups or spoons on the periphery of a vertical rotating disc which picks up the seeds from the hopper and delivers them into seed tube. It consists of seed hoper which has two parts, upper one is called grain box and lower one is called feed box. Shuttles are provided to connect these boxes.

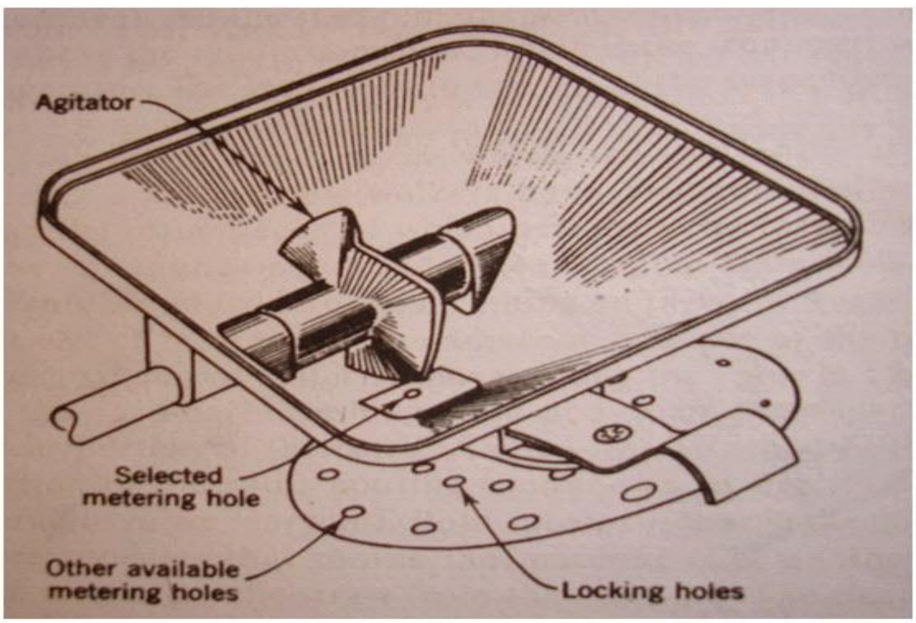


The seed delivery mechanism consists of a spindle, carrying number of discs with a ring of cups attached to the periphery of each disc. The spindle with its frame and attachment is called seed barrel. When spindle rotates, one disc with its set of cups rotates and picks up few seeds and drops them into small hoppers. The cups have two faces, one for larger seeds and other for smaller seeds. The seed rate is controlled by size of cups and rate at which seed barrel revolves. This type of mechanism is common on British seed drill.

d) Cell Feed Mechanism: It is a mechanism in which seeds are collected and delivered by a series of equally spaced cells on periphery of a circular plate or wheel.

e) Brush Feed Mechanism: It is a mechanism in which rotating brush regulates the flow of seed from hopper. A number of bullock drawn planters have this mechanism.

f) Anger Food Mechanism: It is distributing mechanism, consisting of an auger which causes a substance to flow evenly in the field, through an aperture at the base or on the side of the hopper, e.g. fertilizer drills.



g) Picker Wheel Mechanism: It is a mechanism in which a vertical plate is provides with radially projected arms, which drop the large seeds like potato in furrows with the help of suitable jaws.

h) Star Wheel Mechanism: It is feed mechanism which consists of a toothed wheel, rotating in a horizontal plane and conveying the fertilizer through a feed gate below the star wheel.

Furrow Openers:

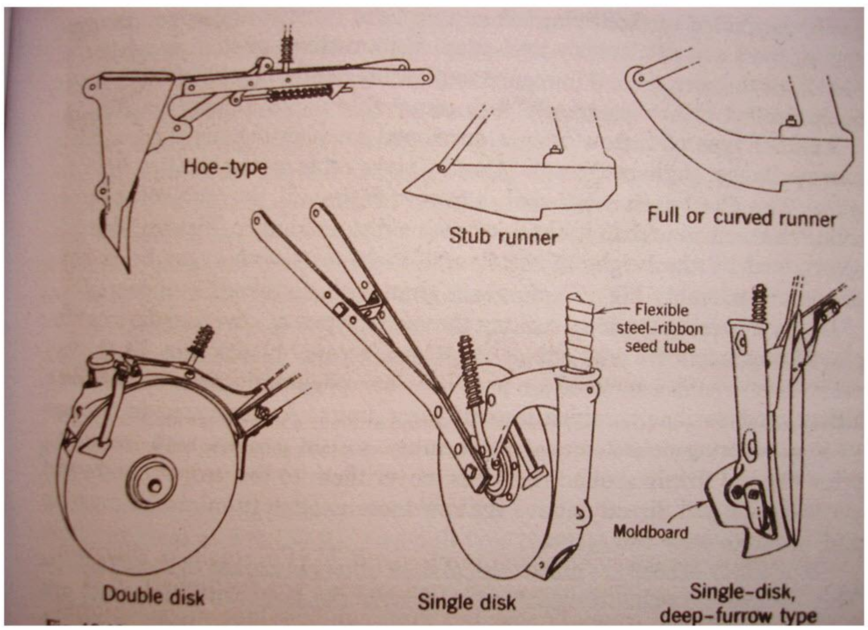
Furrow openers are provided in a seed drill for opening the furrows before dropping the seeds. It may be called a part of seed drill for opening the furrow. The seed tube shifts seeds from feed mechanism into the boot from where they fall into the furrow.

Types of Furrow Openers:

There are various types of furrow openers. These can be chosen and their choice can be influenced by:

The optimum depth of planting which varies widely with different crops.

- Soil type
- Soil moisture content
- Soil temperature and time of year
- Some seeds are sensitive to environmental conditions and require care for planting depth.



a) Hoe Type: They are equipped with spring tips and suitable for stony or root-infested soils. They are similar to shovel type and also used for deep placement of seeds if soil is relatively free of trash.

b) Full or Curved Runner: It is a simple device that works well at medium depths in mellow soil free of trash and weeds. It is suitable for average conditions encountered by corn and cotton planters. Horizontal plate type depth gages may be attached to the runner for soft soil.

c) Stub Runner: It is used in rough and trashy ground on corn planters.

d) Shovel Type: These openers are best suited for stony or root infested fields. These shovels are bolted to the flat iron shanks at point where boots are fitted which carry the end of seed tubes. In order to prevent shock loads due to obstructions, springs are provided. It is easy in construction, cheaper and easily repairable. It is very common with usual seed drill.

e) Disc Type: These openers are suitable for trashy or relatively hard grounds. In wet sticky soils they are more satisfactory than fixed openers because they can be kept reasonably clean with scrapers.

Single disc openers are more effective than double disc in regard to penetration and cutting of trash, used generally on grain drills. Single disc openers with mould board attachments are used for furrow planting of grain.

Double disc openers are well adapted to medium or shallow seeding of row crops that are critical in regard to planting depth because depth can be controlled with removable depth bands.

The furrow openers consist of following parts:

Tine: Like cultivator tine.

Shovel: Made of carbon steel having carbon content of 0.5% and minimum thickness of 4.0 mm.

Seed Tube: It is a tube which carries seeds from the metering device to the boot. Seed tubes are provided at lower end of feed cups. They conduct seeds from feed cups to lower lines through suitable boots and furrow openers.

Boot: It conveys seeds from delivery tube to the furrow. It is bolted or welded to the tine. It is a hallow casing into which lower end of seed tube is inserted and to which furrow openers are attached.

Covering Devices:

Various covering devices are drag chains, drag bars, scraper blades, steel press wheels, rubber covered or zero pressure pneumatic wheels, disc hillers etc.

The function of covering device is to place the moist soil in contact with the seed, press the soil firmly around the seeds, cover them to the proper depth and leave the soil directly above the row loose enough to minimize crusting and promoting easy emergence. Thus for grain drills simple drag chains are used which merely cover the seeds with loose soil where there is ample moisture.

In loose sandy soils or for furrow drilling of grains in heavy residues narrow press-wheels with steel or rubber rims are used behind the openers. These wheels increase the crop stand and yield in areas where moisture is a limiting factor.

Open center, concave, steel press-wheels are common for corn and other larger seed crops.

Zero-pressure pneumatic press-wheels are used for vegetable crops. These are continual flexing which make them self cleaning.

Lesson 23. Seed metering devices for solid drilling and single farming, Furrow openers used in drills and planters

Objectives of Planting:

1) To establish an optimum plant population and plant spacing to obtain the maximum net return per hectare.

2) Population and spacing requirements are influenced by

- Kind of crop
- Type of soil
- Fertility level of soil
- Amount of moisture available
- Effect of plant and row spacing upon cost and convenience of operations such as thinning, weed control, cultivation and harvesting.

3) Principal requirement from yield point is to keep the number of plants per hectare more as with many crops like corn there is fairly narrow range of plant population that will give maximum yield under a particular combination of soil and the fertility conditions. So as the optimum number of plants per hectare is increased the productivity of soil also increases. But for other crops like cotton and small grains there is a wide range of plant population over which yields do not vary appreciably.

Factors affecting Germination and Emergence:

- Factors affecting seed emergence rate are influenced by:
- Viability of seed (% germination under controlled laboratory conditions
- Soil temperature
- Availability of soil moisture to seeds
- Soil aeration
- Mechanical impedance of seedling emergence (resistance of soil to penetration by seedling)

These are influenced by:

- Soil type

- Physical condition of the soil
- Depth of planting
- Intimacy of contact between seeds and soil
- Degree of compacting of soil above the seeds
- Formation of surface crusts after planting
- Final field stand is also due to disease, insects, and adverse environmental conditions.

Field emergence rate of 80% to 90% are typical for corn and other crops that tolerate a fairly wide range of planting conditions.

Field emergence with sugar-beets and many small seed vegetable crops is so low and unpredictable i.e. 35% to 50%.

Functions of Seed Planter:

Seed planter is required to perform following mechanical functions:

1) Open seed furrow to proper depth

2) Meter the seed

3) Deposit the seed in the furrow in an acceptable pattern

4) Cover the seed and compact soil around seed to the proper degree for type of crop involved

5) Planter should not damage the seed enough to appreciably affect the germination

6) Seed should be placed in the soil in such a manner that all the factors affecting germination and emergence will be as favorable as possible.

Effect of Planter or Planting System upon Emergence Factors:

1) Good planter performance is essential for obtaining an adequate stand with crops whose emergence is critical.

2) Precise depth control, placement of seeds into moist soil and non-crusting conditions above the seeds are important for small seed vegetables and some other crops.

3) Packing of soil by planter can affect the availability of moisture, availability of oxygen and mechanical impedance.

Devices for Metering Single Seeds:

a) Devices having cells on a moving member (cells sized to accommodate one seed or group of seeds) e.g. **Horizontal plate planter.**

- **Horizontal plate planter** has a spring loaded cut-off device that rides on top of the plate and wipes off excess seeds as the cell moves beneath it. A spring loaded knock-out device pushes the seeds from the cells when they are over the seed tube.

- **Plates with round or oval holes** are used for drilling or hill dropping of various row crops.

- Edge-cell, edge-drop plates are used for planting relatively large, flat seeds like corn.

- **Inclined plate metering devices** have cups or cells around the periphery that pass through a seed reservoir fed under a baffle from the hopper, lift the seeds to top of plate travel and drop them into delivery tube. A stationary brush is provided for more positive unloading. Seeds are handled more gently than with horizontal plate unit because there is no cut-off device. The metering unit has an edge-cell plate with sizes available to fit various kinds of small vegetable seeds. Plate and surrounding ring are accurately machined to provide uniform cell sizes for precision metering.

- **Vertical-rotor metering devices** are used for precision planting of vegetables and sugar-beets. In some units seed tube is omitted and rotor placed as low as possible and discharge seeds directly into the furrow. These units also have seed cups which move up through a shallow seed reservoir, pick-up single seed, carry them over the top of the circle and discharge them during the downward travel.

- **Cells in a Belt** is also another type of precision metering device in which seeds are fit to size. Seeds from hopper enter the chamber above the belt through opening and are maintained at a controlled level. As belt moves clockwise, counter-rotating seed repeller pushes back excess seeds so there is only one in each cell. Seeds in cells are conveyed over the base and discharged from belt beneath the seed repeller wheel. Lack of positive unloading device causes some variability in seed spacing.

- **Single seed metering devices** that do not have cells are used for all type of corn seeds. In this twelve spring-loaded cam operated fingers on radial arms rotate, gripping one or more seeds as they pass through the seed reservoir. One seed is released as each finger passes over to small indents near top of stationary disk. As finger continues to rotate it throws the remaining kernels into one of 12 cells in the adjacent, rotating seed wheel and seed wheel discharge the individual kernels into furrows.

- **Pneumatic (air-pressure) Metering System** has a centralized hopper and metering unit that serves 4, 6 or 8 rows. The ground driven seed drum has one circumferential row of perforated seed pockets for each planter row. A shallow reservoir of seed is automatically maintained in the drum by gravity flow from the hopper. A PTO driven fan supplies air to the drum, maintaining a pressure of about 4 kPa (0.6 psi) in the drum and in the hopper. Air escapes through holes in the seed pockets until a seed enters the pocket. Differential pressure holds the seeds, the revolving drum carries a stationary brush near the top that knocks off any excess seeds. Air-cutoff wheels on top of drum momentarily block the holes, causing seed to drop into seed-tube manifold. Air flow through the tube carries the seeds to the planting units and deposits them in the furrows. This is generally used for crops such as corn, beans, grain sorghum.

- Pneumatic principle is also used for single row metering devices for unit planters. Small blowers driven by electric motors connected to the tractor's electrical system provide air-pressure in metering chamber. Seeds are held against the holes in the rotor. Seed pockets are carried upward and around in a counter-clockwise direction in the unit. The seeds are released into seed tube when pockets pass a baffle that cutoff the inner air pressure to the front (left hand) portion of the rotor. Different disc rotors are used for different kinds of seeds.

- **Vacuum Pick-Up Devices** are also available for seed metering. In this there is a central vacuum pump with valves to each pick-up orifice, seal between stationary piping and rotating pick-up assembly. A stationary cam extends the piston to produce pressure for unloading the seeds and a spring retracts it to develop the vacuum for seed pick-up. Vacuum pick-up devices can perform effectively with small, irregular shaped seeds like lettuce. These are sensitive to dust and dirt.

    - The average spacing of seed and hill is determined by ratio of linear or peripheral speed of seed pick-up units (cells, fingers etc) to the forward speed of planter and by the distance between seed pick-up units on the metering unit. Changing the speed ratio is the most common method of changing seed spacing.

- **Seed Tape Planting System** is the precision planting system. Seeds are deposited either singly or in groups (hills) on a water soluble table in a laboratory under controlled conditions. Equipment is available for single out and spacing small, irregular shaped seeds on tape with high degree of accuracy. The seeds are placed on the tape at the desired field spacing and a continuous strip of tape is un- released and placed beneath the soil by a simple planting unit. The tape is a polyethylene oxide that is stable under normal atmosphere conditions but dissolves in one or two minutes when placed in most soil. It is used for planting lettuce, tomatoes, cucumbers and some other vegetable crops. The tape is expensive and good soil preparation is imperative. A large amount of tape per hectare is needed especially for close spaced rows i.e.20 km/ha for 51 cm row spacing Precise depth control is difficult to maintain but planting can be done at relatively high forward speed. Seed spacing in the row is pre-determined when seed tape is made and is precise in the field. Increased yields are reported with this for lettuce and cucumbers. A special planter that cuts the tape into single seed sections and deposits these sections in cone-shaped pockets are pressed into the soil. An arrangement is provided to meter a charge of non-crusting soil amendment (vermiculite) into each pocket to cover the tape. Perforations along one side of seed tape synchronized the depositing of seeds on tape and cutting the tape into sections by planter.

Precision Planting:

It means accurate spacing of single seeds in row, precise control of planting depth, especially for shallow planting of vegetable crops, and creates a uniform germination environment for each seed.

The primary objective of precision planting is to obtain single plant spaced far enough apart so that thinning can be done mechanically or with a minimum of hand labour. So, with precision planting:

a) Reduce thinning cost by doing thinning in less time

b) Reduce shock to the remaining plants during thinning

c) Maturing of crop is more uniform and thus increases the feasibility of non-selective

harvesting of crops such as lettuce

Hence, principal requirement for precision planting with a cell type metering devices are:

a) Seeds must be uniform in size and shape, preferably about spherical

b) The planter cells must be of proper size for seeds. Plates and other critical parts of metering device must be accurately made.

c) The seeds must have adequate opportunity to enter the cells. Plate speed and exposure distance of cells in hopper are basic parameters, with low speed.

d) A good cut-off device is needed to prevent multiple cell fill without causing excessive seed breakage.

e) Unloading of seeds from cells must be positive.

f) The seeds must not be damaged enough to appreciably affect germination.

g) The seeds must be conveyed from the metering unit to the bottom of furrow in such a manner that spacing pattern produced by the metering device is maintained.

h) The seeds should be placed at proper depth in a furrow with minimum of bouncing or rolling in the furrow.

Factors Affecting Cell Fill and Seed Damage:

Percent cell fill is defined as the total number of seeds discharged divided by the total number of cells passing the discharge point. According to this definition 100% cell fill does not mean that every cell contains a single seed but implies that any empty cells are offset by extra seeds in multiple fills. The most uniform seed distribution is obtained with combinations of seed size, cell size, and cell speed that give about 100% cell fill. Percent cell fill is influenced by:

1) Maximum seed size in relation to cell size

2) Range of seed sizes

3) Shape of seeds

4) Shape of cells

5) Exposure time of a cell to seed in the hopper

6) Linear speed of cell

- Effect of cell speed appears great for rough surfaced seeds than for large, smooth seeds like corn.
- Double seeds mostly occur at low speed with small seeds than with large seeds.
- In general cell diameter or length should be 10% more than maximum seed dimensions and cell depth should be equal to average seed diameter of thickness.
- Performance is improved by grading seed within close size tolerances.
- Cell size less critical with pneumatic metering devices and not a factor in vacuum pick-up devices.

Controlling Seed between Metering Devices and Furrows:

Precise metering is when seeds are controlled so that each requires same time from meter to furrow. Variation in drop time can be minimized by one of the following:

a) Having short, smooth, small-diameter drop tube with discharge and close to bottom of furrow.

b) Discharging the seed directly from the metering device within a few centimeters of furrow bottom.

c) Mechanically transferring the seed from the metering unit to the furrow as is done with transfer wheels on some hill-drop planters.

d) Slow cell speed or trajectory shaped seed tubes for high plate speeds minimize bouncing.

e) Seed movement in furrow can be minimized by having narrow and imparting rearward velocity component to the discharged seed to partially offset forward velocity of planter.

f) Improved uniformity by angling seed tube 15^0 to 30^0 from vertical.

g) High downward velocity increase seed bouncing and displacement in furrow.

Lesson 24. Calibration of seeding and planting machines

Calibration of seed drill:

The procedure of testing the seed drill for correct seed rate is called calibration of seed drill. It is necessary to calibrate the seed drill before putting it in actual use to find the desired seed rate. It is done to get the pre determined seed rate of the machine. The seed drill could be ground wheel driven and PTO driven. The following steps are followed for calibration of ground wheel driven seed drill.

Procedure:

i. Determine the nominal width (W) of seed drill

W = M x S,

Where,

M = Number of furrow openers, and

S = Spacing between the openers, m

ii Find the length of the strip (L) having nominal width (W).

Suppose we have 1 ha of area

We know 1ha = 10000 m^2

L*W= 10000

L = 10000/W, meter

iii. Determine the number of revolutions (N) of the ground wheel of the seed drill required to cover the length of the strip (L)

L = P x D x N = 10000/W

N = 10000/P x D x W revolutions per minute

iv. Jack the seed drill so that the ground wheels turn freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the ground wheel

v. Fill the selected seed in the seed hopper. Place a container under each boot for collecting the seeds dropped from the hopper

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

vii. Engage the clutch and rotate the ground wheel for N = 10000/P x D x W, revolutions per minute

viii. Weigh the quantity of seed collected in the container and record the observation.

ix. Calculate the seed rate in kg/ha

x. 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.

(a) Measure the ground wheel dia. 'cm'

(b) Measure the number of furrow openers

(c) Measure distance between two openers 'cm'

(d) Perimeter of ground wheel $P = \pi D$

(e) Width of implement $W = 2$ m

Diameter $D = 40$ cm

Give one revolution to the ground wheel

Area covered/revolution of ground wheel

$= \pi DW$

$= 3.14 \times 2 \times 0.40$

$= 2.5 \text{ m}^2$

Recommended seed of wheat = 40 Kg/acre or 100 Kg/ha.

4000 m^2 - 40 Kg

$2.5 \text{ m}^2 - \dfrac{40}{4000} \times 2.5 \times 1000$

$= 25$ gm.

If number of furrows to be sown simultaneously say 10.

Seed to be dropped by each furrow opener per revolution of ground wheel

$= \underline{25} = 2.5$ gm

10

As this is not measurable quantity

Calculate seed dropped in 50 revolutions

2.5 X 50 = 125 gm.

Example: The following results were obtained while calibrating a seed drill. Calculate the seed rate per hectare.

(i) No. of furrows = 10 (ii) Spacing between furrows = 20 cm (iii) Diameter of drive wheel = 1.5 meter (iv) RPM = 500 (v) seed collected = 20 kg.

Sol. Effective width of seed drill = 10 x 20 cm = 2 m

Circumference of drive wheel = π x 1.5 m

Area covered in one revolution = π x 1.5 x 2 m

Area covered in 500 revolution = π x 1.5 x 2 x 500 = 4712.3m

Seed dropped for 4712.3 m = 20 kg

$$\text{Seed dropped/ha} = \frac{20 \times 10000}{4712.3} = 42.22 \text{ kg.}$$

For PTO driven Seed Drill

Let speed of travel while sowing = 2 km/h

Say width of m / c = 1.5 m

$$\text{Field capacity} = \frac{WS}{10} = \frac{2 \text{ X } 1.5}{10} = 0.3 \text{ ha/hr}$$

Seed rate = 40 Kg/acre or 100 Kg/ha in 1 hr

1 hr - 100 Kg

0.3 hr - 100 X 0.3 = 30 Kg

30 Kg seed dropped in 0.3 ha in 1 hr

Say number of furrow openers = 2

Each furrow opener should drop = 15 Kg/h

$$\frac{15 \times 1000}{60} = 250 \text{ gm/min}$$

Calibration of Planter

- Row to row and seed to seed distance has to be set
- Measure diameter of ground wheel
- Calculate perimeter πD =Distance covered on ground.
- Number of revolutions made by planting disc/Roller etc. per revolution of ground

Wheel = N (say)

- Number of cells/spoon groves on disc = C (say)
- Therefore, distance between plant to plant.

$= \pi D/NC$

N can be varied with having a gear train.

C can be of different sizes for different crops and different varieties.

$$N = \frac{\text{No. of rev. of plate}}{\text{No. of rev. of ground wheel}}$$

Lesson 25. Planting mechanisms for potato and sugarcane

Potato Planter:

Potato is an important crop in India. It requires lot of labour for sowing seeds in fields. Potato planters are becoming very popular now a days that open a furrow, drop and space the seed pieces at various distances, place fertilizer to sides and below the level of seeds and cover seed and fertilizer to a desired depth. There are three main types of potato dropping mechanisms:

1) **Automatic Planters:** It consists of a hopper for each row and cups with chain drive mechanism. Graded potatoes are picked up by the cup and carried to furrow opener sprout and released in furrow. A feeder roller connected to compensating tray which contains spare potato checks for each cup. If a cup is empty a potato is released from compensating tray ensuring a uniform seed spacing with no missing. The fertilizer and pesticide can also be placed simultaneously. It can plant 2-4 rows. Its capacity may be 6000-14000 potatoes/hr.

2) **High Speed Automatic Planter:** It has two picker wheels, each having eight picker arms. Two picker wheels revolve only half as fast as a single picker wheel used at a normal speed. High speed planting is done at twice the normal speed but picker arms do not revolve faster than the single wheel.

3)**Semi-**Automatic Planter: It consists of hopper, metering disc and furrow openers. Fertilizer application unit can be attached separately. Potatoes, from hopper, are placed in metering disc which has compartments. The metering disc is rotated through gear drive mechanism. The potatoes drop due to gravity in furrow openers. Ridges are also formed by furrow openers. It may plant 2 – 4 rows @ field capacity of 0.15 – 0.25 ha/hr. It may be operated by a 20 – 25 hp tractor.

Sugarcane Planter:

It is used for planting sugarcane sets. Desired spacing between row to row and plant to plant is maintained for sugarcane planting. The fertilizer and chemical pesticides can be applied simultaneously. The machine consists of a hopper, two rotating distributor discs, two fertilizer hoppers, pesticide tank with a distribution value and two furrow openers. All these components are mounted on a frame and two wheels. Seed distributor box and applicator are powered from ground wheel through a set of roller chains and gears. Two persons are required to put sets in seed rotor manually from hopper. Machine is mounted on a tractor. Output may be 0.6 ha/h and it requires 4-6 men for field operations.

Lesson 26. Transplanting machines for vegetables and paddy: working principles and constructional details

Transplanters:

Machine used to sow seedling of some crops like paddy and other vegetables.

Paddy Transplanters:

Transplanters are divided on the basis of

a) Source of Power

- Manual
- Self-propelled
- Fixed type finger
- Actuating type fingers
- Japanese rice transplanter
- Chinese rice transplanter

b) Type of nursery

- Mat type
- Root-wash type

Transplanters use special type of seedling i.e. mat type seedling. But in some areas like North Korea root wash type of seedlings are popular.

In case when transplanting is done with manual labour it requires Rs. 400/- to 500/- per acre or 5-8 man days.

Manual Rice Transplanter: It consists of skid frame, movable tray and seed picking finger. Mat type seedlings are placed on inclined trays. When fingers are pushed downward they pick-up the seedlings and place them in ground. Seedlings are left on the ground during return stroke. Plant to plant spacing can be controlled by operator. It may be 5-8 rows with comb type finger and working capacity 0.22-0.25 ha/8h.

Japanese or Chinese Rice Transplanter:

It is a self-propelled machine consisting of

1. Air-cooled gasoline clutch

2. Main clutch

3. Running clutch

4. Planting clutch

5. Seedling table

6. Float

7. Star-wheel

8. Accelerator lever

9. Ground wheel

10. Handle

11. Four-bar linkage mechanism

Capacity for Chinese transplanter = 2-3 acres/day

Capacity for Japanese transplanter = 4-5 acres/day

Seedlings:

- Seedling growing is the most tedious job for transplanters as it requires mat type of seedling which are grown with some special procedure and require extra attention and care.

Procedure for Nursery Growing:

1) Level the field

2) Spread the polythene sheet over ground

3) Put frame over it. Width of frame is 15-18 mm

4) Sprinkle soil

5) Sprinkle seed

6) Cover the seed with soil

One frame will use 675 gm seeds. In one acre 10-12 kg seed is required. And in one acre 14-16 frames required in 20 m^2 area. 25-30 days old nursery is used for sowing with self-propelled rice transplanter.

Calibration:

Row to row spacing fixed = 23.5 cm.

Plant to plant spacing = 10-12 cm

For adjusting plant to plant spacing:

- Measure ground wheel diameter and calculate perimeter.
- Give drive to ground wheel and count number of hills planted by actuating fingers.
- Plant-plant spacing = πd/number of times finger go down.

Lesson 27. Fertilizer application and broadcasting machinery and their calibration

Fertilizer application:

- Fertilizers are applied to increase available supply of plant nutrients (N, P, K)
- Improve crop yield and quality
- Important factor is uniform distribution and proper placement

Lesson 28. Weeding equipment: power operated and manual Row crop cultivation equipment

Weeds are robbers and a farmer has to destroy them to save his crops. Control of weeds and grasses are most labour and time intensive operations in the production of crops.

Methods of controlling weeds:

1) **Mechanical cultivation or shallow tillage:**

- Most economical

- Weeds are uprooted, covered or cut-off- Killing weeds and grasses in rows is major problem

2) **Selective burning or flaming** used for controlling weeds in the rows. (Flame weeding)

3) **Chemical herbicides** are used in various stages of crop planting and growth.

- Selective herbicides like 2, 4D used to kill broad leaf plants and do not injure grasses. Similarly Dala Pon kills grasses and does not injure broad leaf plants.

- Pre-plant and pre-emergence applications are incorporated in the soil, in bands of 18-25 cm.

- Post-emergence application of herbicides is also used. Adequate moisture is required to activate the soil-applied herbicides.

- Direct post-emergence general contact weedicides are used in row-crops.

4) **By spreading plastic sheets** between rows treatments are applied to soil surface in conjunction with planting operation (behind press wheel).

5) **Control of weeds by shading crops.**

6) **Hand-hoeing & finger weeding.**

- Weeds in inter-row spacing are controlled by cultivation and those in rows by one or more methods.

- For inter-row cultivation equipment used are cultivators, sickle, wheel hand hoe, triphali.

Functions performed:

1) Inter culture the fields

2) Destroy weeds in the fields

3) Aerate soil for proper growth of crops

4) Conserve moisture by preparing mulch on surface

5) To sow seed when provided with sowing attachment

6) To prevent surface evaporation and encourage rapid infiltration of rain water into soil.

Classification:

I) On the basis of type of tool

a) Disc cultivator – fitted with discs

b) Rotary cultivator – fitted with tines or blades mounted on power driven hori shaft.

c) Tine cultivator – fitted with tines having shovels

II) On the basis of power used

Trailed type

a) Tractor drawn

Mounted type

b) Animal drawn.

Tractor drawn:

a) Trailed type:

- Consists of main frame which carries a number of cross members to which tines are fitted.

- At forward end hitch arrangement is provided for hitching.

- A pair of wheels is provided.

- Tines in each row are spaced widely to allow free passage of soil and trash around them.

- The depth of working is set roughly by adjusting tines in their clamps.

b) Mounted type:

i) **Spring loaded tynes.**

- Tines are hinged to frame and loaded with spring so that it swings back when an obstacle is encountered.

- Each tine is provided with two heavy coil springs, pre-tensioned to ensure minimum movement except when an obstacle is encountered.

- Springs operate when points strike roots or large stones to prevent damage of implements.

- As obstruction passes tines are automatically reset.

- Tines are made of High Carbon Steel.

- This type is particularly recommended for soils which are embedded with stones or stumps.

- Gauge wheel provided for controlling depth.

ii) **Rigid tynes:**

- Tines do not deflect during work in field.

- Tines are bolted to frame.

- Spacing of tynes is changed by slackening the bolts and sliding the braces.

- As rigid tynes are mounted spacing is adjusted easily.

- Gauge wheel provided to adjust depth.

b) **Animal drawn**

- Mostly three tines cultivator with seeding attachment.

- Also used for secondary tillage.

- Also used for intercultural of row crops.

Duck – foot cultivator:

- Rigid type tractor drawn used for shallow plowing, destruction of weeds and retention of moisture.

- Sweeps are attached to rigid tines.

- Sweeps are made up of high carbon steel.

- Size is 225 cm long, 60 cm wide with 7 sweeps.

- For actual cutting of soil different types of shovels and sweeps are used.

a) Single point shovel

b) Double point shovel

c) Spear head shovel

d) Sweep

e) Half-sweep

f) Furrower

Rotary cultivation:

- Rotary hoes are used with or without sweeps in combination.

- Powered rotary cultivators are used for weed control and shallow mulching in crops which are closely spaced in line vegetables.

- Rotary cultivator if provided with suitable shields can be used extremely close to young plants having small root system.

Flame weeding:

- Control of unwanted vegetation by flaming is practiced since 1940.

- Flaming is used for thick – stemmed row crops, also for weeding around trees.

- It is important to control the flame path with respect to ground surface in rows.

- It is done when weeds and grasses are not over 25-50 mm.

- Heat intensity (fuel rate) and exposure time are adjusted to cause expansion of liquid in plant cells and consequent rupture of cell wall but not excessive heat to cause combustion.

- Effect of flaming becomes visible after several hours of flaming.

- Forward speed 4.8 – 6.4 km/hr for flaming.

- Cotton is well-suited. Other crops like corn, grain sorghum & soybeans whose stems are not injured by short exposure to an intense heat.

Components of flame weeder:

- Burner operates on LPG. Two types are used:

    a) Liquid burner or self-vaporizing type

    b) Separate vaporizer connected to tractor engine cooling system

- Fuel rates 7.5 – 15 l/h per burner- Well designed burner should produce broad, thin flame that is steady and well controlled.

- Burners for flame weeding are supported on skids hinged to a rear-mounted tool bar or on 11 – link arrangements having gage wheel.

- In combined flaming and cultivating operations burners are attached to independently gaged cultivator gangs.

Burner Placement and Flaming Practices:

- Optimum burner placement is influenced by type and size of crop and type of burner.

- Burner should set at 45^0 and flame should strike the ground about 50 mm from row centre.

- Parallel flaming can be used for small plants and crops with low resistance to flaming.

- Burners are placed to row on each side 75-125 mm from row centre in 11 flaming. Burner outlets are 100 – 150 mm above ground surface and directed downward at 45^0 towards rear.

Water spray shields for flaming:

- Water spray shields are developed which cause a drastic reduction in air temperature above spray, and increase versatility of planning.

- Conventional fan spray nozzles are used.

Thinning:

Thinning of crops like cotton is required to increase yield.

Methods:

- Manually

- Mechanical devices

- Flame

- Chemicals

- Manual or hand thinning is selective operation but tedious, costly and require high labour.

- Mechanical or chemical thinning may be either random or selective.

- Mechanical thinning done with row thinners and by cross thinning m/cs operated across the rows.

- Cross thinning done by cross cultivation with sweeps, knives etc.

- Chemical or flame thinners have metal boxes at regular intervals on wheels or conveyor. These cover the blocks or spaces to be skipped while flame or chemical spray is applied continuously along rows. These thinners have been employed only to a very limited extent.

Selective Mechanical or Chemical Thinning:

- Electronic sensors which detect first plant occurring beyond the pre-selected minimum distance from preceding plant that was retained.

- These sensors control knives or chemical spray in such a way that intervening plants are killed and selected plant is saved.

Lesson 29. Spraying and dusting equipment: atomising devices & pumps for sprayers, constructional details

PLANT PROTECTION EQUIPMENT

Chemical Control of Weeds:

Due to advancement of agricultural science, most fields remain covered under crops for longer duration of time due to multiple cropping, intensive farming and better irrigation facilities. Due to this there is increase in plant pests and diseases also. So it has now become necessary to use pesticide and fungicide for controlling pests and diseases. Sprayers and dusters are used for this.

TYPES OF EQUIPMENT:

a) Boom-type field sprayers

b) High-pressure orchard and general purpose sprayers

c) Air-blast sprayers which utilize an air stream as a carrier for sprays

d) Air-craft sprayers

e) Granular applicators

f) Ground- rig dusters

g) Air – craft dusters

h) Aerosol generators, which atomize liquids by thermal or mechanical means and are widely used for control of mosquitoes and other diseases – transmitting vectors and have limited application for agricultural pest control.

MANUALLY OPERATED:

1) Hand atomizer: Used in house.

2) Bucket type: Used for small fields.

3) Knapsack

Sprayers are used for various purposes:

1. Application of insecticides to control insects on plants
2. Application of fungicides to control plant diseases

3. Application of herbicides to kill weeds, either indiscriminately or selectively
4. Application of pre-harvest sprayers to defoliate or condition crops for mechanical harvesting
5. Application of hormone (growth regulating) sprays to increase fruit set or prevents early dropping of fruit
6. Application of sprays to thin fruit blossoms
7. Application of plant nutrients (sprays) directly to the plant foliage
8. Application of biological materials such as viruses and bacteria, in spray to control pests

- Because dusts have much greater drift hazard and lower deposition efficiency than sprays, most pesticides application other than granular soil treatments are now in the form of sprays, usually water emulsions, solutions or suspensions of wet table powders.

The main function of sprayers are:

1) To break the liquid into droplets of effective size

2) To distribute them uniformly over the plants

3) To regular the amount of liquid to avoid excessive application

Desirable quality of sprayer:

1) The sprayer should produce a steady stream of spray materials in the desired fineness of particle so that plants to be treated may be covered uniformly.

2) They should deliver the liquid at sufficient pressure so that it reaches all the foliage and spreads entirely over the sprayed surface.

3) It should be light yet sufficiently strong, easily workable and repairable.

BASIC COMPONENTS OF A SPRAYER:

1.	Nozzle body	6.	Pressure regulator	11.	Nozzle disc
2.	Swirl plate	7.	Cut-off value	12.	Nozzle cap
3.	Filter	8.	Spray boom	13.	Nozzle tip

4.	Over-flow pipe	9.	Drop legs	14.	Spray lance
5.	Relief- value	10.	Nozzle boss	15.	Spray gun

Nozzle Body: Main component on which other components of nozzle fit.

Swirl Plate: It is a part of cone nozzle which imparts rotation to liquid passing through it.

Nozzle Disc: Component containing the final orifice of nozzle usually in cone nozzle.

Nozzle Cap: Component which retains the assembled parts in or on a nozzle body. The nozzle disc or tip may be integral with the cap.

Spray Gun: It is a lance from which the spray is readily adjustable during the operation.

Spray Boom: It is spray lance with spray nozzles fitted to a head mounted at right angle to the lance.

Filter: Component to remove suspended matter larger than a pre-determined size from fluid.

Over-flow Pipe: It is a conduit through which excess fluid from a pump is by-passed by the action of relief value or pressure regulator.

Relief-value: It is an automatic device which opens when the pressure of fluid or gas reaches a pre-determined value.

Pressure regulator: It is an automatic device to control the pressure of fluid or gas within a range of settings.

Cut-off value: It is mechanism between pump and nozzle to control the flow of liquid from sprayer. It is operated by hand.

Nozzle boss: It is a lug on spray boom or spray lance to which a nozzle body or cap is screwed.

Nozzle tip: It is the component containing final orifice of nozzle usually a fan nozzle.

Spray lance: A hand-held pipe through which liquid reaches the nozzle mounted at free end.

TYPE OF SPRAY: Sprays can be:

1) **High volume spray:** (More than 400 litres spray/ha).

The dilute liquids are applied by hydraulic machines. It consumes more time and labour. Hand operated - pressure developed 1-7 Kg/cm, mechanically operated or power sprayer - pressure 3-8 Kg/cm^2.

2) **<u>Low Volume Spray</u>:** (5 to 400 li/ha)

It uses air stream from fan as pesticide carried with small quantities of liquid. There is a saving of material and labour.

3) **<u>Ultra-low volume</u> (ULV):** (Less than 5 li spray/ha)

ULV spraying can be defined as plant protection operation in which total volume of liquid applied amounts to a few ml per acre. It is mainly used in air craft spraying. Undiluted, technical-grade liquid pesticides (i.e. no water added). Grasshopper and co-deal leaf petal. Selection of technique depends on type of vegetation, kind of pests and approach to field.

<u>Foam Spraying:</u> In this system a foaming agent (chemical additive) is added to spraying solution. The spray is passed through a special nozzle. This system is economical.

<u>Ultra-low volume sprayer:</u>

The sprayer has a motor powered by 6 to 12 volt battery. Spinning disc is attached to a motor, having grooves or teeth and rotates at a very high revolution per min. (4000-9000). The spinning disc receives the concentrated chemical from a plastic container having a capacity of 1 li. (approx). Average droplet size varies between 35-100 micron. It is used for application of weedicides and for spraying small trees and crops.

<u>Power sprayer:</u>

- Operated usually with internal combustion engines. Prime mover capacity varies from 1 to 5 HP. The pressure pump is operated by a small power unit ensuring a constant steady pressure. They are operated at a pressure of 20 to 55 kg/cm^2 and are usually portable type. Sometimes it is operated by PTO shaft of tractor. The main parts are:

i) <u>Prime mover</u>: needed to supply power to the power sprayer. It is usually internal combustion engine. Power generally varies from 1 to 5 hp.

ii) <u>Tank</u>: Steel tank is used to prevent corrosion. Plastic tanks are also widely used due to prevention from corrosion and ease of molding into smooth shapes. A covered opening fitted with a removable strainer is provided for easy filling, inspection and cleaning. A drain plug is there at bottom of tank for draining the liquid.

iii) <u>Agitator</u>: Agitator is needed to agitate the liquid of tank. Propeller or paddle type mechanical agitators are provided for agitating liquid. Horizontal shaft may be used with flat blades rotating at about 100 to 120 rev./min. Paddle tip speeds in excess of 2.5 m/s may cause foaming.

iv) <u>Air Chamber</u>: Air chamber is provided on the discharge line of the pump to level out the pulsation of pump thereby providing a constant nozzle pressure.

v) <u>Pressure Gauge</u>: Pressure gauge is provided on discharge line to guide the operator regarding spray pressure.

vi) Pressure regulator: It is meant for adjusting the pressure of the sprayer according to the requirement of crops in field.

vii) Strainer: A strainer is included in the suction line between the tank and pump to remove dust, dirt and other foreign materials.

viii) Boom: Field sprayer to be driven by a tractor has a long boom in a horizontal plate

on which nozzles are fixed at specified spacing. Boom can be adjusted vertically to suit the height of plants in different fields.

ix) Nozzle: Used to break the liquid into the desired spray and deliver it to plants. A nozzle consists of (a) body, (b) screw cap, (c) disc, (d) washer (e) vortex plate and(f) strainer.

SPECIFYING PARTICLE SIZES AND SIZE DISTRIBUTION:

- Atomizing type of devices produce a wide band or spectrum of droplet sizes under any given set of conditions.

- The range and distribution of droplet sizes and measure of average size are important in pesticide applications.

- graphical representation of droplet size distribution comparing different atomizing devices and different conditions are:

- Aero droplet size is expressed by one or more of several forms of median or mean diameters.

- Median diameter divides spray into two equal portions on the basis of number, cumulative length (dia.), surface area or volume.

- Volume median diameter (VMD) divides droplet spectrum into two portions such that total volume of all droplets smaller than VMD is equal to total volume of all droplets larger than VMD.

- Mass median diameter (MMD) is also sometimes used in place of VMD.

- VMD or MMD and number median dia. (NMD) are more commonly used parameters for agricultural sprays.

- VMD is larger than NMD as it places relatively more emphasis on larger droplets.

- Various mean diameters are based on arithmetic averages of dia., surface areas, volumes of individual droplets or upon ratios of totals of any 2 of these 3 measures.

- Dusters have no direct influence on particle size, except they affect agglomeration of particles during application, but average size and range of sizes controlled by processor.

- Size distribution is determined by sieving and average is expressed by No. median dia.

Particle size in relation to effectiveness of drift:

- Size of particle is the significant parameter in relation to penetration and carrying ability of hydraulic sprayers, efficiency of 'catch' of sprays or dusts by plant surfaces, uniformity and completeness of coverage on plant surfaces, effectiveness of individual particles after deposition, drift of material is out of the treated area.

- Coarse atomization is good for drift control but more coverage of plant surface with smaller droplets give more effective control with fungicides, herbicides and insecticides.

- Large droplets give satisfactory results with sprays of translocation type.

- For a given Q number of droplets L $1/d^3$

- Particle size also important to particles impinge upon plant surface when carried by air stream.

- Efficiency of dynamic catch is defined as % age of total frontage of approaching air stream that is cleaned of droplets of a particular size.

- Catch e.g. 100% means air sweeping through the foliage would be stripped of that size in a cross sectional area equal to that presented by foliage.

- Increasing size of particle increases %age of catch because of greater momentum of particles.

- Catch varies inversely with size of obstruction.

FACTORS AFFECTING DRIFT:

- Rate of fall of particles

- Initial height and other effects of application equipment

- Wind velocity and direction

- Atmospheric stability

- Other meteorological factors

Size is the most important particle property affecting the rate of fall and associated drift distances

- Small particle settle more slowly than large particles because aerodynamic drag forces are greater in relation to particle mass

- Evaporation of water or other volatile materials from droplets reduces the droplet size and thus, adversely affects both deposition efficiency and drift

- Small droplets evaporate more rapidly than large droplets

- At 30% RH and 25.6^{0}C temperature theoretical time for water droplet to be reduced to 10% of its initial volume is 0.8 s for 40 µm droplets and 4.2 s for 100 µm droplet.

- Drift is minimized by employing devices that produce sprays having large VMD.

- Increasing VMD increases the sizes throughout the distribution spectrum and reduces the number of small droplets.

- Increased size of largest droplets reduces the efficiency in regard to uniform coverage.

- Small droplet size is best for coverage and effectiveness and large droplet size reduces drift thus, ideal situation would to produce a spray having uniform sized droplets or a narrow size spectrum.

- Drift is also influenced by discharge height and direction and air-turbulence and air currents induced by equipment.

- Aircraft and air-blast sprayers create considerable air movement.

- Hydraulic ground-rig sprayers have min. discharge heights and minimum air turbulence which reduce drift.

- Drifts are more with dusts because of smaller particle sizes. Most commercial dusters have NMD 1 to 10 µm.

10 µm dust particles with sp. gravity 2.5 require 100 s to settle 0.g m an1 gm require 3hr.

- Test indicates that 70% of dust particle applied by air plane may drift away from treated area.

ELECTROSTATIC CHARGING OF DUSTS AND SPRAYS:

- For electrostatic precipitation of pesticide dusts commercial electrostatic dusters are developed.

- Primary objective of charging spray as dust particles are to increase %age deposition on plant surfaces.

- Electrostatic spray has no effect on large particles also does not affect the basic trajectory from the application equipment to the target.

- If a charged particle reaches the plant or target area and has insufficient inertia to cause impingement charge increases the probability of depositions.

- Charging dust improved control of insects and diseases on number of different crops. Charging dust or spray has increased deposits on cotton plants by ratio of 2 or 3 to one. Increased deposition efficiency for small particles reduces drift.

- Electrostatic sprayers and dusters are more complicated and more expensive than conventional one. And there are number of practical problems regarding design and effectiveness.

ATOMIZING DEVICES

Generally atomizing devices utilize following principles to atomize liquid:

1. Pressure or hydraulic atomization depends upon liquid pressure to supply the atomizing energy. The liquid stream from an orifice is broken up by its inherent instability and its impact upon atmosphere etc.
2. Gas atomization, in which liquid is broken up by a high-velocity gas stream. The break-up may occur either outside the nozzle or within a chamber ahead of exit orifice.
3. Centrifugal atomization, in which liquid is fed under low pressure to a centre of high-speed rotating devices, like disk, cup, cylindrical screen and is broken up by centrifugal force as it leaves the periphery.
4. Low-velocity jet break-up, in which non-viscous, low-velocity stream after emerging from a small orifice or tube breaks up into droplets as a result of external/internal disturbances and effect of surface tension.

Pneumatic atomizing (two-fluid) nozzles, in which compressed air is employed for atomization and is used to some special low volume sprayers because fine atomization can be obtained at low liquid pressure. Drift hazards from extremely fine particles limit the use of this equipment. High Speed rotating cages covered with fine-mesh screen gauge (40-80 mesh) are used on air-craft and air blast sprays having rotary screen atomizers are developed. Rotary atomizers operating in still air at relatively low liquid flow rate produce uniform droplets of controlled sizes for lab studies but when they are employed on aircraft or air blast sprayers rapidly moving air stream affects the atomization process and produces droplets with considerable range of sizes. VMD is less with hydraulic nozzles used in agricultural spraying.

Hydraulic nozzle:

a) Side-entry hollow cone

b) Disk-type solid cone

c) Core-insert hollow cone

d) Fan spray

e) Flooding

f) Disk-type hollow cone

g) Jet or solid stream nozzle

Hollow-con nozzle: liquid is fed into whirl chamber through a tangential side entry passage or through spiral passages in whirl plate or core insert to give it a rotary velocity component.

Orifice is located on axis of whirl chamber, liquid emerges in form of hollow conical sheet and then breaks up into droplets.

Core-insert is mainly in small size nozzles and used limited in agricultural spraying.

Solid-cone nozzle: there is addition of internal axial orifice which strikes the rotating liquid within the orifice of discharge. The breaking of droplet is due to impact.

Fan-spray nozzle forms narrow elliptical spray pattern. The liquid is forced to come out as a flat fan shaped sheet which is then broken into droplets. It is mostly used for low-pressure spraying.

Flooding nozzle liquid emerging through a circular orifice impinges upon a curved deflector which produces fan-shaped sheet having relatively wide spray angle.

<u>Flow rate of a particular nozzle is proportional to square root of pressure.</u>

<u>Discharge rate is proportional to orifice area.</u>

<u>Nozzles on field sprayers have spray angle 60^0 to 90^0 (Fan, Hollow cone</u>).

<u>Flooding nozzles have spray angle 100^0 to 150^0 and operating pressure below 1.5Kg/cm^2 is undesirable as nozzle does not work satisfactorily.</u>

Low-velocity jet break-up are used to obtain uniform, predictable droplet sizes and reducing drift. Pressure is low that produce non-turbulent flow because of liquid to emerge from a circular orifice or capillary tube as a cylindrical column or filament.

<u>Factors affecting droplet size:</u>

Degree of atomization depends upon:

- Characteristics and operating conditions of the atomizing devices.
- Characteristics of liquid being atomized.

Principal fluid properties affecting droplet sizes are surface tension and viscosity. Increased surface tension and viscosity increases droplet sizes. Emulsifiers or water in oil emulsions are used for increasing viscosity to increase droplet size. For a given flow rate, pressure and spray angle hollow cone nozzles have smaller droplet sizes than fan spray nozzles. Flooding type produces coarser spray.

Droplet sizes and number can be determined by collecting samples of spray on glass slides coated with silicone, magnesium oxide or other similar material or a glossy-surfaced printing material. Correction factor is used to determine original sphere diameter from observed stains.

Droplet sizes can be measured by immersion method. The spray droplets are caught in a shallow dish containing liquid or material in which droplet can sink. There, they remain spherical. Cellulose – thickened water solution containing detergent or soap can be used for oil droplet.

Sizing and counting of collected droplets or stains can be done directly with a microscope, or sample photograph scanned with electronic analyzer. Direct automatic scanning of droplets in flight can also be done.

Field measurement of uniformity of distribution made by collecting sprayed material on mylar sheet or metal plates. Known concentration of trace material is added. The material from each plate is washed into specified volume of water. And concentration of tracer is measured.

Nozzle distribution pattern is determined in lab. By spraying onto a surface that consists of series of adjacent, sloping V-troughs and measuring the liquid collected from each trough. Uniformity of coverage on plant surfaces can be checked by adding fluorescent dyes or insoluble fluorescent materials to spray and viewing surfaces with fluorescent light of the dark.

Pumps for sprayer:

1) Piston or plunger pump: The displacement pump used on sprayers with piston plunger, rotary and diaphragm.

- Self priming.

- Automatic (spring loaded) by-pass valve to control pressure and protect equipment from mechanical damage if flow is shut off.

- Piston plunger well suited for high-pressure orchard sprayers multi-purpose sprayers.

- Designed for both low and high pressure sprayers.

- More expensive, occupy more space, more heavy, durable and handle abrasive material without excessive wear.

- Volumetric efficiency high (90% or more), discharge rate is function of crank speed and volumetric displacement. Crank speed of small spray pump - 400 to 600 r/min., high – pressure of 125-300 r/min.

- Mechanical efficiency 50 to 90% depends on size and condition of pump.

2) **Rotary** – Used for low pressure sprayers.

- Common types gear pump, roller pump.

- Nylon used for rollers, rubber, steel and carbon also

- Rollers held against with centrifugal force.

- Roller rotary pumps are compact, inexpensive and operated at speed suitable for direct connection of PTD.

- Pumping action depends on maintaining close clearance between housing and gear or impellers.

- Classed or positive displacement pump.

- Pressure above 100 psi is recommended.

- Gear pumps cannot be used for wettable powder and abrasive material as rapid wear and short life.

- Roller pumps are better than gear as roller can be replaced.

3) **<u>Centrifugal</u> :** depends on centrifugal force.

- High speed, high volume devices and do not have positive displacement pump.

- Pressure developed is function of discharge rate.

- Discharge rate varies directly with speed.

- Head varies with square of speed.

- Power varies with cube of speed.

- Multistage increases pressure without increase pressure.

- Simple and handles abrasive material easily.

- Well suited to air blast sprayers, air craft sprayers in high flow rate, low pressure needed.

- Speed ranges 1000 to 4000 r/min. depending on pressure required and diameter of 1 impeller.

- They are not displaced, not self brimming and do not require pressure relief valve.

4) **<u>Miscellaneous:</u>** Diaphragm pumps used for flow rates 19 to 23 l/min.

- **<u>Valves and diaphragm only moving part.</u>**

- Handle abrasive material.