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Soil Tillage in the Tropics and Subtropics

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5.0 SPECIAL IMPLEMENTS FOR IRRIGATED AGRICULTURE

With the traditional method of irrigated agriculture the special surface configuration of the field regulates the manner in which the water is distributed so that the soil becomes an integral part of the irrigation system. The shape, gradient and topography of the fields are determined by that system. Careful and intensive tillage is necessary to obtain the proportionally higher yields required to justify the high financiel investment in an irrigation system. The transport and distribution of water and its infiltration, storage and release to the plant demand a high standard of soil (field) preparation and tillage.
In the case of surface irrigation the soil surface should be level so that the water is uniformly distributed over the entire area, thus avoiding waterlogging on lower sites or water deficits on higher sites. Some (slight) gradient should also be maintained if the field is to be evenly wetted. To achieve efficient water distribution the size of the fields must be reduced as the standard of field preparation drops. A level field surface should be the objective even during the primary tillage activities (e.g. by using a reversible rather than a one-way plough).
The range of implements discussed in the previous chapters does not include the various items for tillage operations in irrigated agriculture. Specific implements are needed for special jobs, such as the levelling and creation of ridges and furrows. Most of the well-known implements have been developed for the large irrigation schemes in California, Australia or South Africa while traditional irrigated crop production in the tropical and subtropical developing countries still uses mainly manual and animal labour. The introduction of tractors on these traditional small holdings (usually about 1 ha) will not only cause serious difficulties but will also mean that suitable machine systems will have to be adapted or developed. The field accessibility, trafficability and workability are particular problems in irrigated agriculture.

Some special operations performed as part of the tillage in irrigated agriculture are:
- levelling the surface,
- building (border) dams along the slope (following the direction of the water movement) to direct the water flow to borders and strips,
- the construction of (cross-check) dams to improve the uniform distribution of the water,
- shaping the cross-section and surface of the ridges,
- the construction of small ridges for corrugation irrigation (again following the direction of the water movement).

Many soils in the climatic zones where irrigated agriculture is carried on tend to form crusts which must be destroyed after each water gift.

5.0.1 Literature

See literature for chapters 1 and 6.

Buxton, D.R. and J.C. Zalewski, 1983. Tillage and cultural management of irrigated potatoes. Agronomy Journal, 75(2): 219-225.

FAO, 1977. Mechanization of irrigated crop production. FAO Agricultural Services Bulletin No. 28, FAO Rome, pp. 404.

NN (Various authors), 1982. Mechanization of irrigation farming in semi-arid areas. Proceedings of an International Symposium at the 56th DLG Exhibition. Band 173, DLG Verlag, Frankfurt, pp. 238.

5.1 The Landplane, Leveller

5.1.1 Use And Assessment

The landplane and leveller are used for:
- moving the soil, levelling the surface,
- water management and distribution,
- reducing evaporation,
- protecting against soil erosion,
- terracing,
- road building.

The landplane (Fig. 106) and leveller are essential implements for preparing fields for surface irrigation.

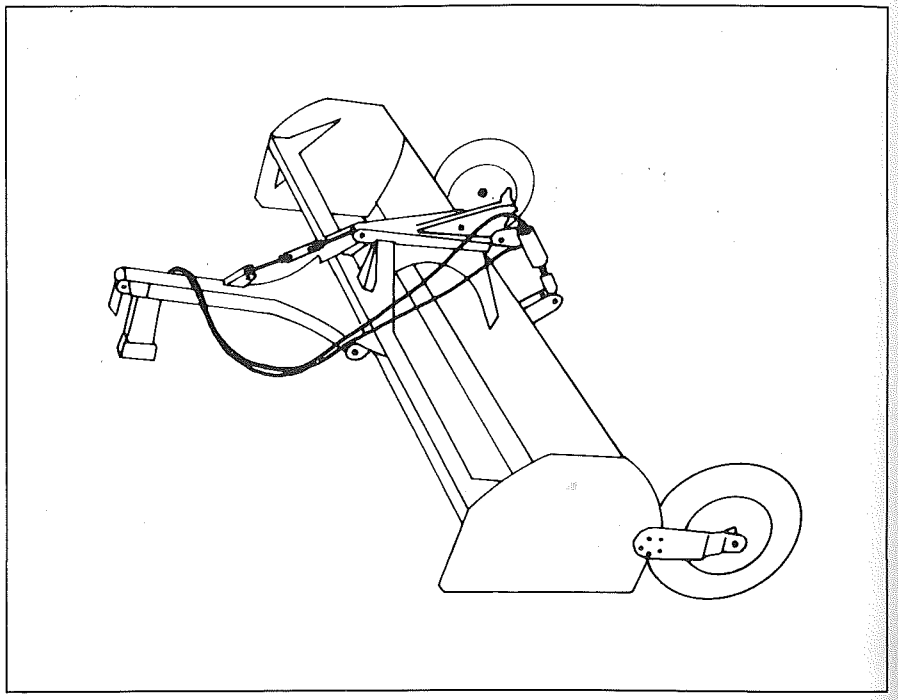


Fig. 106. Landplane or leveller.

5.1.2 Functioning

The blade of the landplane presses on field irregularities in a horizontal direction so that any soil above the blade's cutting edge is moved along the direction of travel. Depending upon the depth setting, between 5 and 40 cm of the soil is taken up and deposited in depressions. The soil should be dry enough to avoid smearing. To achieve the best levelling action the tractor hitchpoint, the blade and the plane's support wheels should be as far apart as possible. On the other hand, landplanes should be easy to manoeuvre in small irrigated fields. A float is dragged behind the plane as an auxiliary implement to smooth any remaining irregularities.

5.1.3 Linkage And Drive System

Smaller implements may be (semi-)mounted either in front or to the 3-point hitch system behind the tractor. Larger implements are usually trailed models. The depth is set on the implement itself. Support wheels are absolutely essential. The power required is determined by type and condition of the soil, the speed, working width, fixed working depth and the configuration of the surface. It ranges from 15 to 50 kW per metre of working width.

5.1.4 Description Of The Implement And Tools

A large number of different models of land planes are available. Very simple models are made of wood in the form of a float. The large implements which are used mainly on very large farms or cooperatives will not be examined here and this description will be limited to the simple smaller versions used by the farmer himself. The basic frame - constructed from steel - carries a rigid planing blade or bucket with a replaceable edge mounted perpendicularly to the direction of travel. The plane is designed as either a mounted or a trailed implement and is supported by one or more wheels. The depth can be adjusted manually or hydraulically. Landplanes are usually equipped with a smoother attached to the rear of the plane and used for the final smoothing of the surface.

5.1.5 Adjustment, Operation

The working depth is adjusted manually or hydraulically by one or more guide wheels. If the tractor and guide wheels are far apart, not all the tractor's vertical movements are transmitted to the blade. The depth depends upon the volume of soil to be moved and the power available from the tractor. The landplane can easily be mounted by one man; quick-coupling devices may be used. The larger implements are steered from the tractor. Accurate working is necessary. Little maintenance is required and, on the larger implements, is limited to lubrication of the wheels.

5.1.6 Technical Data

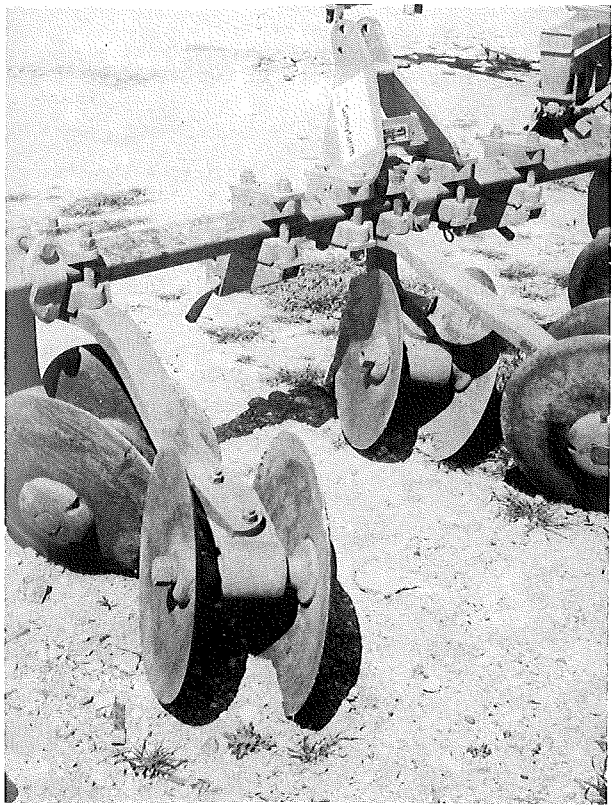
Working width	1.5-3.0 m
Volume of soil moved	1-2.5 cubic metres
Speed	3-6 km/h
Power required	15-50 kW/m
Total length	up to 12 m

5.1.7 Literature

See literature for chapters 5 and 6.

Buras, N. and G. Manor, 1970. Field comparison of land smoothers. Trans. of the ASAE, 13(5): 639-640,643.

5.2 The Ridger (Furrower)



Three types of ridgers can be distinguished:
- rigid type (mainly made of wood),
- mouldboard type (lister), as described in Chapter 4.7,
- disc type (disc bedder).

5.2.1 Use And Assessment

The ridger (Fig. 107) is one of the most important implements for irrigated farming. It is used principally to build ridges for furrow, strip and border irrigation systems (Fig. 108) but can also carry out the following tillage activities:
- building ridges for bordering plots or for planting on their crests (ridges or beds),
- controlling weeds emerging from the ridges,
- covering manure (fertilizer), herbicides in furrows, rows and on ridges,
- producing a coarse surface in ridge systems to improve aeration and water infiltration,
- building contour(dams) for erosion control,
- digging trenches for irrigation and drainage.

Successful use of ridgers depends first and foremost upon the choice of the correct implement and its accurate adjustment. The lister is often preferred for crop maintenance operations (Figs. 103 and 105). The implement can be adapted to the required ridge shape and the prevailing conditions by using suitable configurations of the bodies (see Fig. 109). The disc ridger is used principally when harvest residue, stones or roots are likely to be encountered. The disc ridger is also preferred for cotton production.

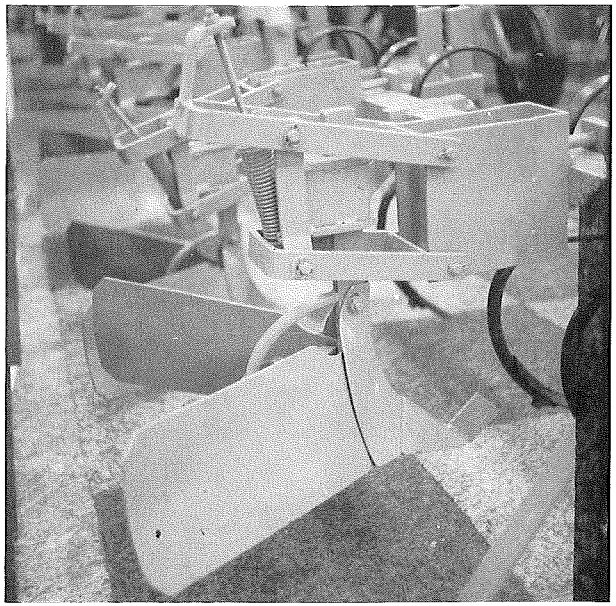


Fig. 107. Ridging body (mouldboard type) with coulter welded on share. Parallelogram mounting.

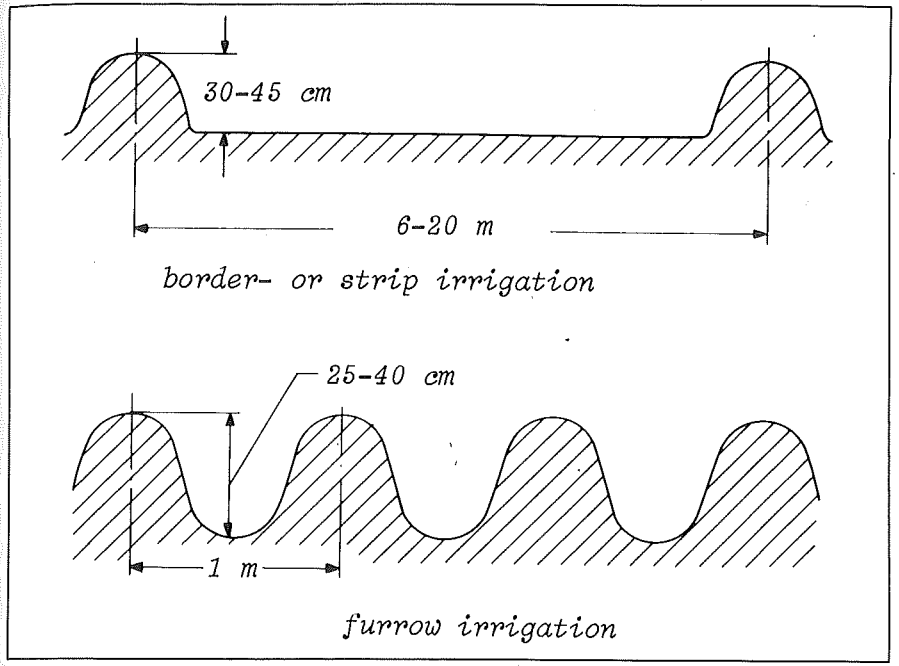


Fig. 108. Ridges (bunds) for strip- or border irrigation (top) and furrow irrigation (bottom).

The disc ridger has advantages when short furrows have to be formed on a steep slope for furrow irrigation. It creates a loose crumbly furrow which reduces the flow velocity and increases the water infiltration rate. On the other hand, listers are recommended for long, slightly sloping fields since they create a clean furrow (faster surface flow, lower infiltration rate). The disc is more effective on the edges and thus causes less damage to small plots.

The disc ridger leaves a narrow depression along the top of the ridges and this may impede harvesting operations (e.g. cotton leaves collect in it). A cut-out disc performs more satisfactorily than a mouldboard (lister) on firm moist soils while ridgers with two or more discs per gang may clog up on moist adhesive soils.

5.2.2 Functioning

As on all disced implements, the working parts of a disc ridger are driven by their contact with the soil (Fig. 110). They crumble the soil and so do not produce smooth shoulders on the ridges. Multiple-disc units give a finer topsoil than single disc models which leave a rough furrow. The ridge is relatively level and loose with a high infiltration capacity. Some crops and soils require subsequent compaction - particularly for moisture control - and this is usually performed in a separate pass.

If correctly adjusted, the disc units should be able to tear a heavy weed cover (such as grass) away from the ridge and deposit the sod in the centre of the furrow for subsequent chemical weed control treatment. In the case of contour farming on slopes it is advisable to fit discs with larger diameters on the downslope side of the unit so that more soil can be transported upwards. As regards listers, simple wooden designs with oblique mounted boards or planks give results comparable to the mouldboard types.

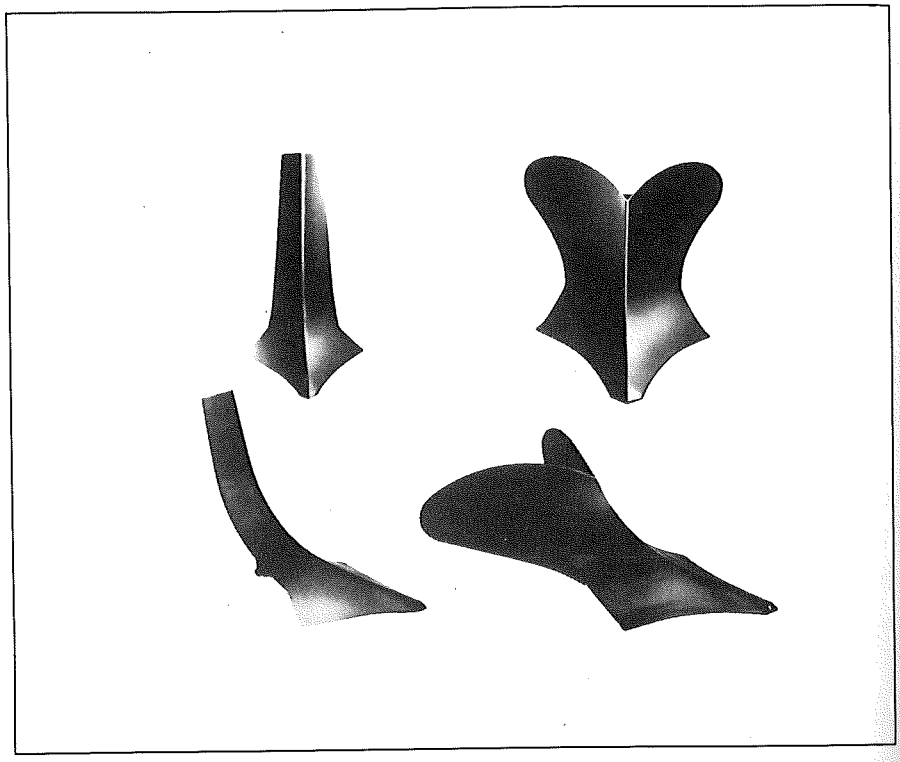


Fig. 109. Ridging bodies: Left: body for hard, dry soils (in combination with discs), right: universal body.

5.2.3 Linkage And Drive System

Listers and disc ridgers are usually mounted on a toolbar which allows them freedom of movement in a lateral direction. The toolbar is suitable for 3-point hitching. Wooden ridgers are trailed. Disc ridgers are driven by contact with the soil while listers are passive tools drawn through the soil.

The draught required for disc ridgers depends upon the number of discs, design, size, weight, tilt and disc angle, working speed and the type and condition of the soil. The draught required for listers depends upon the geometry and adjustment of the share and wings and on the soil parameters. The traction power required for each body is 5 - 15 kW.

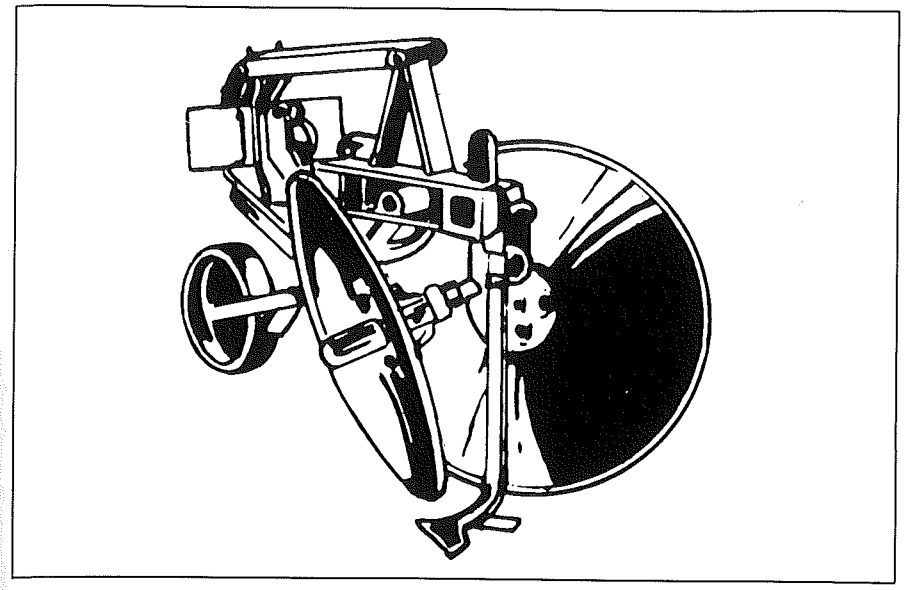


Fig. 110. Disc ridger with two discs.

5.2.4 Description Of The Implement And Tools

Ridger bodies and discs are usually mounted to a multi-purpose toolbar. Two opposite discs or disc gangs form a disc ridger unit. A unit may consist of between two and ten discs; a 6-disc unit (Fig. 111), for example, has a left and a right-handed gang of three discs each which are mounted to the toolbar by a support, allowing both horizontal and vertical adjustment. The shaft of each gang is mounted to the rigid unit frame with tapered or roller bearings. The discs attached to the shaft may be fitted with scrapers.

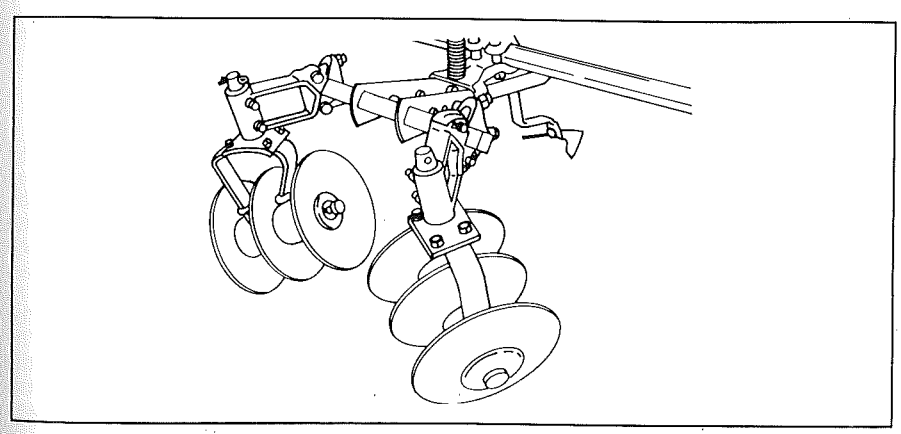


Fig. 111. Disc ridger with two gangs of three discs each.

Notched discs are preferred when plant material or hard soils make cutting difficult. When large ridges are to be formed, different sized discs are required with the largest disc running along the bottom of the furrow at the rear of the unit. Ridgers are often combined with other tools or implements, especially chisel tines (Fig. 112) and press wheels and also with manure spreaders and herbicide sprayers.

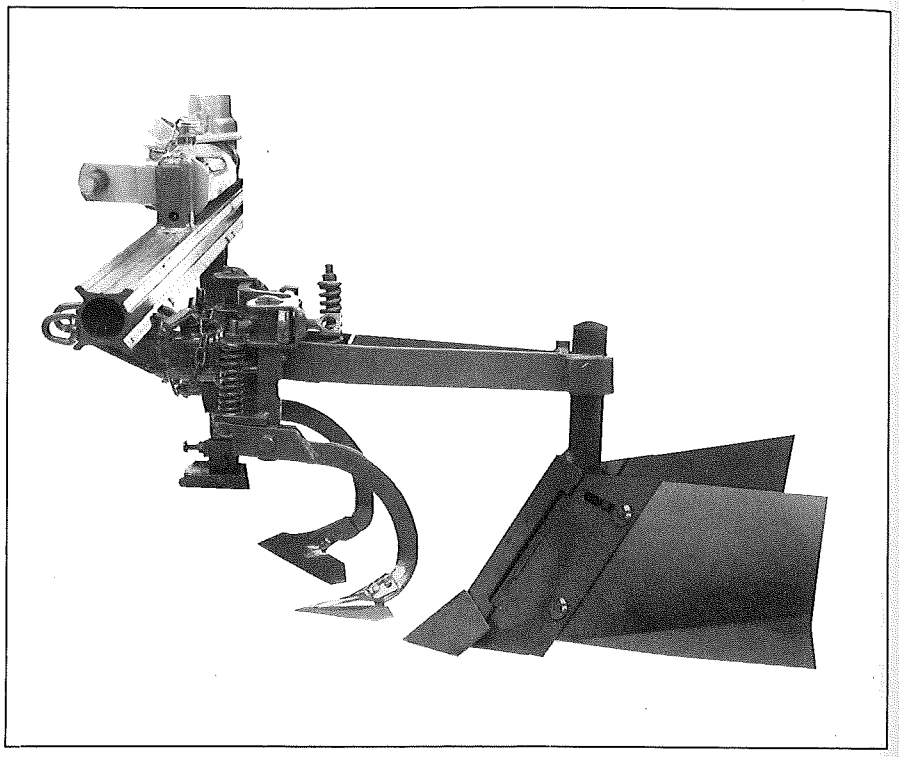


Fig. 112. Ridging body with duckfoot chisels running ahead.

5.2.5 Adjustment, Operation

The width of the ridges and the distance between them can be controlled by shifting the tools on the toolbar in a lateral direction. In the case of listers, the height and gradient of the shoulders are determined by the shape of the share and wings and only rarely by setting the angle. The depth can be changed in various ways (e.g. altering the spring load, the height of the toolbar or the support wheels). On disc ridgers the angles can be adjusted in the same way as for disc ploughs. When the disc angle is increased, the disc "grip" is improved so that more soil is moved. The setting of the tilt angle determines the slope of the ridge shoulders. The best working speed is 5 km/h. The height of the ridge increases with the speed (sharper crests). Increased crumbling can be produced by mounting two or three discs in each gang. When the condition of the soil makes penetration difficult, extra weights can be added.

Both types of ridgers are simple to operate. The bearings of the disc ridger shafts should be lubricated. The wear is spread over the entire circumference of the discs and is relatively light.

5.2.6 Technical Data

For listers see chapter 4.7.

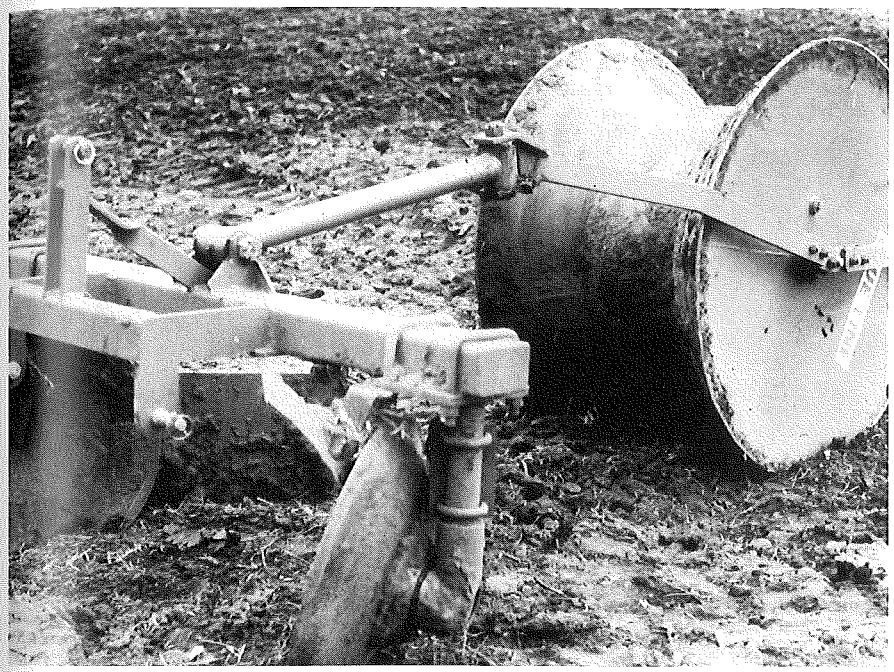
Disc ridges:

Discs' external diameter	400-650 mm (900 mm)
Concavity ("depth")	100-200 mm (300 mm)
Thickness	4-6.5 mm (9 mm)
Discs per unit	2-10
Distance between discs	200-300 mm
Disc angle	0-50 deg
Tilt angle	0-45 deg
Weight without extra weights	25-50 kg per disc

5.2.7 Literature

See literature for chapters 4.7 and 5.0.

5.3 The Bed Shaper



The bed shaper is used for:
- geometric shaping of ridges and beds,
- compacting the soil (surface),
- configuring the soil surface.

The bed shaper is useful for soil and water management, for distributing and conducting water and for stabilizing ridges to protect them against heavy rainfall.

The bed shaper is often used in combination with the ridger or other implements. Since it closes the macropores and the surface, it increases the velocity of the water flow and allows better distribution of the water over the length of the field, particularly after a disc or strip rotary tiller has been used on loose surface soils, when only a short consolidation time is available and on long fields with a slight gradient. Plant-beds for 1, 2, 3 or 4 rows of plants may be formed after stubble tillage or immediately before planting. Salts may accumulate at the crest of a ridge in regions with high evaporation rates. To protect them against salt damage the plants should not be planted in the zones where the highest concentrations of salt can be expected, usually on the sides of the bed (Fig. 113, centre). Another solution is to build a narrow ridge where the salt can accumulate on top of the bed and between two plant rows (Fig. 113 bottom).

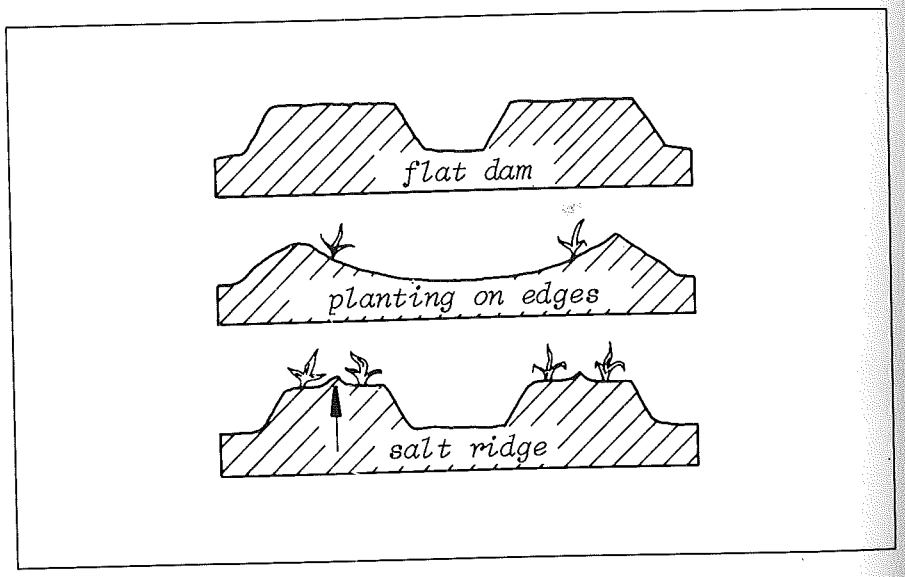


Fig. 113. Bed shapes to protect plants against salt damage.

Various designs and models of ridge and bed shapers are available, ranging from simple and press wheels running between the ridging bodies over the crest of the ridge, to profiled cone-shaped rollers (Fig. 114) and trailed profiled bodies (runners, Fig. 115).

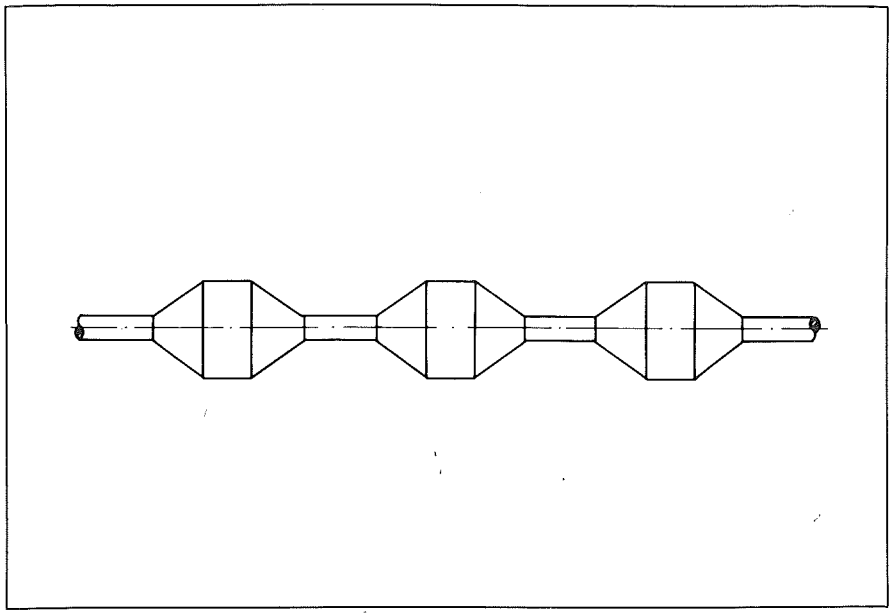


Fig. 114. Bed shaper (profiled roller).

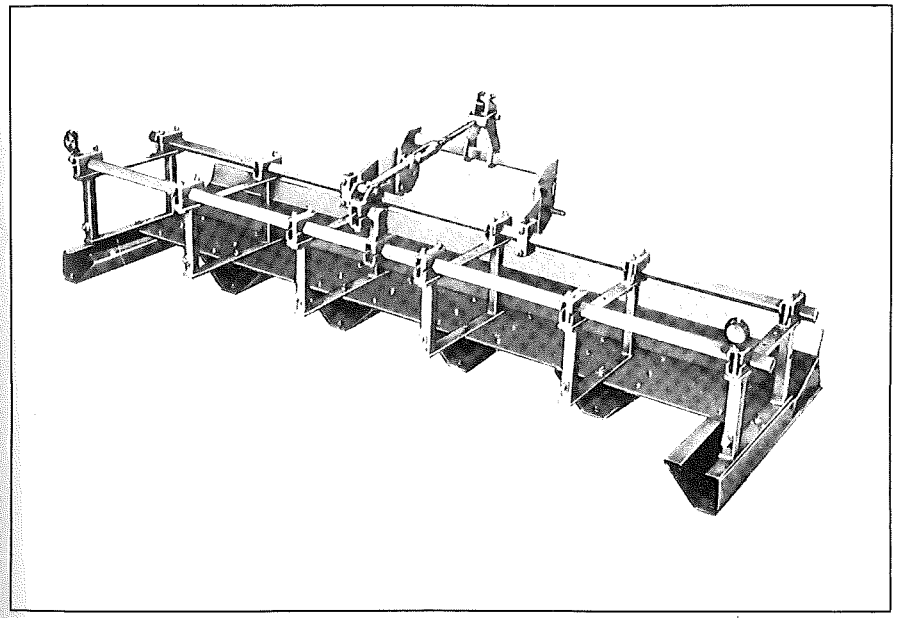


Fig. 115. Bed shaper.