Chapter 9

Tillage Equipment and Field Preparation

Preparing a field for planting a vegetable crop entails moving soil by using tillage operations. Primary tillage operations first loosen the soil and incorporate organic residues. Under some conditions, a field will also need secondary tillage to prepare an adequate seedbed for planting. In secondary tillage operations, the top several inches of soil are further worked to smooth it out, break up crusts and clods, or kill weeds. In other situations, no-till production is an option. How much tillage is necessary depends on soil conditions—including the amount of residue on the field—and on the needs of the particular crop and planting equipment.

Soil and Crop Considerations

The extent of tillage should be matched to the crop and cultural practice requirements. Fine seedbeds are required for sowing small-seeded crops or for laying plastic mulches. Rougher seedbeds may be tolerated with large-seeded crops or transplants, saving on labor and soil structure. Thorough incorporation of cover crops, weeds, or soil amendments such as lime and manure may call for several tillage passes over a field.

Unnecessary tillage of any sort is to be avoided, as tillage is generally harmful to soil structure because it breaks up soil aggregates and earthworm channels and promotes compaction. The minimum soil disturbance to get the job done should be the goal.

Since annual vegetable production generally requires a significant amount of tillage, compensating stewardship practices are necessary to maintain soil health. These include regular additions of organic residues via animal manures, cover crops, and compost, and rotation by sod crops. For more information, see the chapters on soil fertility management (beginning on page 46), on-farm composting (beginning on page 63), crop rotation (beginning on page 69), and cover crops and green manures (beginning on page 78).

Tractors

On most vegetable farms, tractors provide the power to push and pull a wide variety of tillage implements as well as operate pumps, mowers, spreaders, and other equipment with a PTO (power-take-off). A few vegetable farmers use horses exclusively, or in addition to tractor power. It can be argued that this is more sustainable, reducing dependence on fossil fuels and energy-intensive industrial manufacturing, as well as enhancing soil stewardship by providing manure, reducing compaction, and encouraging rotation between forages and vegetable crops. However, the skills, equipment, and motivation for horse-powered agriculture are not widespread.

Tractor Options

Many small-scale vegetable growers use two-wheel *walk-behind tractors*, either fixed-unit rototillers with the sole role of soil disturbance, or units like that have interchangeable attachments for tilling, plowing, mowing, spraying, and other operations. Wheeled *sulkies* allow the operator to ride behind the power unit, which is generally 8–12 horsepower.

Cultivating tractors used primarily for weed control are described in "Tractors for Post-Emergence Cultivation," page 166–167. These are generally 25 horsepower or less. Some types can be used for other activities on the farm that do not involve heavy lifting or towing, such as pulling small wagons or mowing. Most vegetable farms of about 5–10 acres and up will be using bucket loaders, multi-bottom plows, heavy disks, chisels, or large wagons, requiring *utility tractors* with about 40–60 horsepower. On farms with large acreage, heavy soils or hardpans (compacted layers of soil) that require deep tillage, large volumes of crops to move around, big PTO-powered irrigation pumps to run, or specialized activities like large-scale composting, a tractor with 80 horsepower or more is justified. Vegetable farms with a couple dozen acres or more usually have three tractor sizes: cultivating, small utility with bucket, and large utility. Having at least one four-wheel-drive tractor can come in handy, too.

Used Tractors

New tractors are expensive, so used tractors are in demand. A well-cared-for tractor can last many decades. When shopping for a used tractor, consider the following: A three-point hitch is essential for attaching most modern implements. Tractors built in the 1950s and earlier may not have this feature, although conversion kits are usually available for several hundred dollars. *Wide front-end tractors* are preferable to *tricycle-type tractors* because they have greater stability and are more suited to vegetable farms, where it is necessary to straddle beds or crop rows.

When buying a used tractor, also keep in mind that about 50% of fatal farm labor accidents involve tractor overturns. To help protect yourself and those who work with you, look for a wide front-end tractor with a certified Roll-Over Protective Structure (ROPS). ROPSs have been available for many tractor models since the 1960s.

Examine the underside of used tractors for evidence of leaks or welds that indicate previous repair. Beware of new paint that may be covering up rust or repair. Check filters and fluids, wires, and plugs for condition as an indication of maintenance. Look at the extent of wear on treads and of sidewall cracking or cuts on tires. Take a drive, and preferably put the tractor under a heavy load to test performance. Ask owners if they have maintenance records and an owner's manual (the latter can often be obtained from the manufacturer).

Talk to nearby farmers, agricultural parts dealers, and repairmen to find out what makes of tractor will be easiest to find parts for and service locally but otherwise keep an open mind with regard to brand, and look for a good deal on a well-maintained, safe tractor. Also see "Cautions on Buying Used Equipment," page 18.

Equipment for Primary Tillage

Primary tillage incorporates residues and loosens the soil to make it more suitable for crop production. This can be done with moldboard plows, heavy disks, heavy field cultivators, chisels, subsoilers, rototillers, rotavators, or spading machines. The choice depends on the desired seedbed characteristics, the amount of surface residue to incorporate, soil texture, the extent of soil crusting and compaction, and available tractor horsepower. Tillage implements vary in ability to bury or mix in crop residues, manures, and amendments; break up crusts; pulverize clods; cope with compacted or rocky soils; aerate; and level-off the soil. Heavier soil textures, thick sods, and extensive surface residue usually increase the tractor horsepower required and the aggressiveness of the tillage tools used.

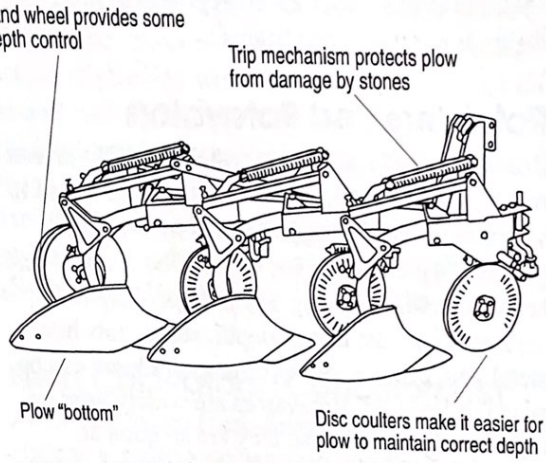
Moldboard Plows

The *moldboard plow* is a large and heavy curved piece of metal that, when set down into and pulled through the soil, cuts and flips over a slice of the plow layer 12–18 inches wide and 8–12 inches deep, depending on plow size and orientation (figure 9.1). Moldboard plowing inverts the soil surface, completely burying residues in most cases. Depending on soil conditions and equipment adjustment, surface residues can be partially buried by plowing. Multiple plows are usually mounted on a metal frame, and the individual plow is called a *bottom.* Plows come in various

shapes that affect how deep they go and how they move the soil. Approximately 10–15 tractor horsepower is required per bottom, depending on conditions, so two- to four-bottom plows are common on vegetable farms in the Northeast. *Coulters* are metal disks mounted ahead of the plow to cut the soil and assure that it breaks cleanly and flows smoothly over the plow. Extension bars are often mounted behind the plows to insure that the soil is flipped over completely. This is especially helpful to fully bury crop residues, weeds, or cover crops and to leave a more level surface. However, rough plowing without smoothing the surface helps reduce winter erosion if the soil is to be left bare after fall tillage. (A winter cover crop is the best option for protecting soil from erosion. However, leaving soil bare can make it easier to get onto fields in early spring, since less residue may promote soil drying and save on tillage time. This allows for earlier planting. Growers have to balance the need for early planting with the desire to protect against erosion.)

Plowing, because it flips over the soil without pulverizing it, is a good way to bury residues, but it does not thoroughly mix them into the soil or fluff up a seedbed as a rototiller does. However, rototilling can be more deleterious in terms of the soil's physical condition.

a. The moldboard plow turns the soil, burying crop residue.



b. Moldboard plow

Figure 9.1 Moldboard plow with three bottoms
Source (a.): Adapted from Brillion Iron Works, Inc.

Chisel Plows

Chisel plows are heavy metal curved shanks that are pulled through the soil to break up the plow layer without incorporating much surface residue (figure 9.2). Chisel plowing loosens the soil but leaves a lot of residue on the surface. On sloping soils, chisel plowing may be preferable to moldboard plowing prior to sowing large-seeded crops like sweet corn because more residue remains on the surface to protect against erosion. Chisel plowing should be across slopes, not up and down. Many growers like to chisel plow or subsoil the middle of beds before planting deep-rooted crops like carrots, parsnips or daikon; if soils are heavy or have a pan, all beds may be treated this way.

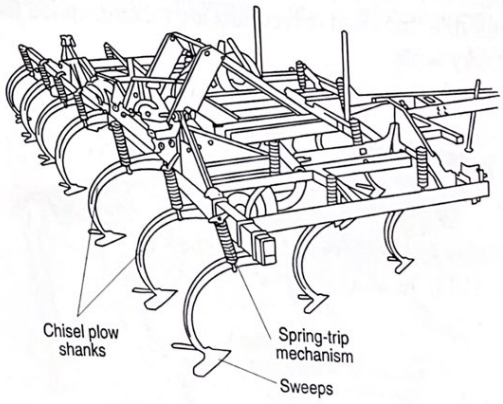


Figure 9.2 Chisel plows
Source: Adapted from an illustration by John Gist in *Steel in the Field: A Farmer's Guide to Weed Management Tools*

Subsoilers (V-Rippers)

Subsoilers, or "*V-rippers,*" are longer and stronger than chisels, with straighter shanks that are pulled deeper, usually 18 inches or so (figure 9.3). Subsoilers are used to open deep drainage channels in compacted soils. There may be an attachment at the bottom to help fracture a plow pan or natural pan, both of which are compacted layers of soil that impede water movement and root penetration. Subsoiling is useful to improve deep drainage, aeration, and root penetration. Each shank requires about 25 horsepower to pull, depending on soil conditions.

Rototillers and Rotavators

Rototillers and rotavators, which are PTO-driven rototillers, have numerous metal tines attached to a rotating shaft that aggressively mix the soil (figure 9.4). The tines are covered by a shield that keeps rocks from flying out and may help level the soil. To adjust tillage depth, some units have metal gauge shoes, or the three-point hitch can be raised or lowered. Rotavators are widely used on vegetable farms because they are so good at preparing a fluffy, fine seedbed. Rotavators come in widths from 30 inches to 8 feet, which require approximately 20–100-horsepower tractors, respectively. It is important to select a tiller that is rated to match the horsepower of your tractor. The tines of rototillers and rotavators are usually independently attached to allow replacement if they break off or wear down, which is not uncommon in rocky soils. Heavier-duty brands with durable tines and drivetrains are recommended for rocky soils.

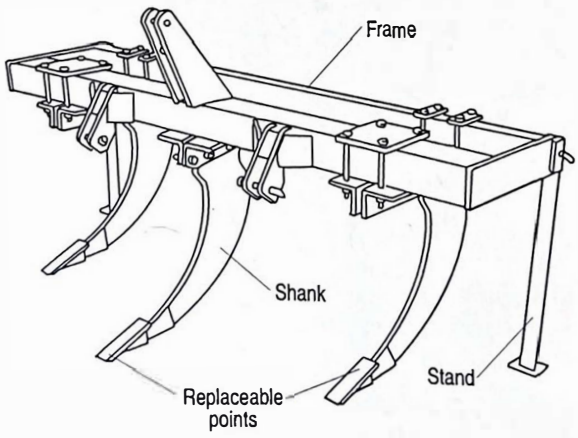
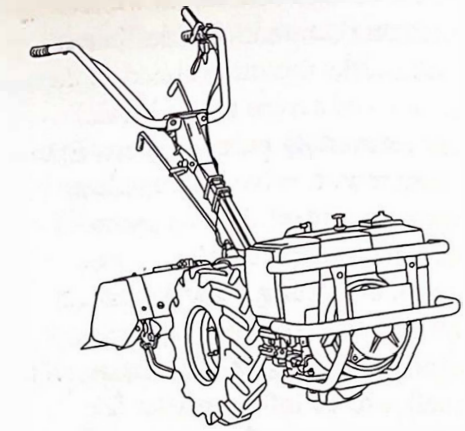
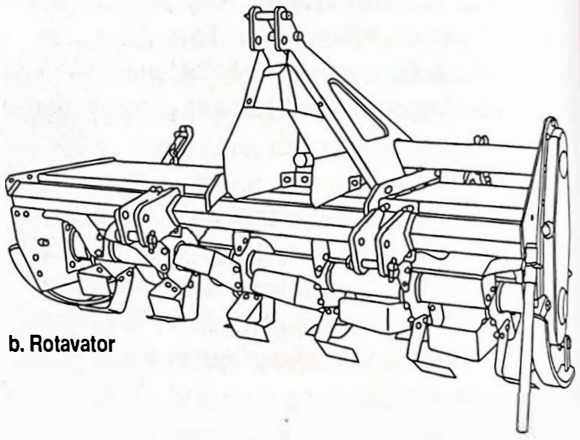


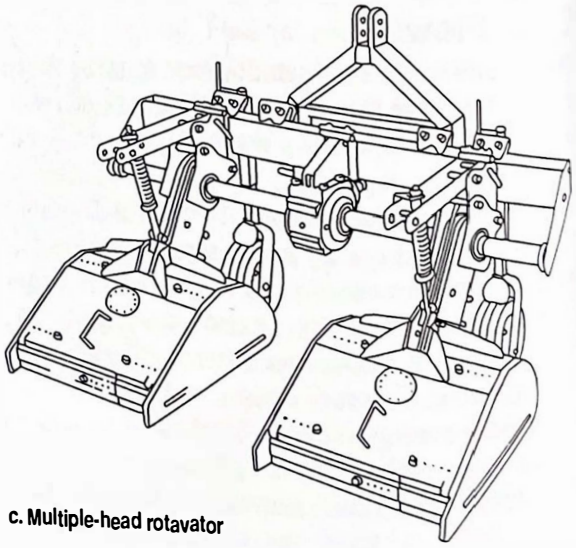
Figure 9.3 Subsoiler



a. Rototiller



b. Rotavator



c. Multiple-head rotavator

Figure 9.4 Rototiller, rotavator, and multiple-head multivator
Source: (b.): adapted from Howard

Spading Machines

Spading machines are similar to rototillers, but the tines are wider and rotate more slowly, providing less soil disturbance while incorporating surface materials (figure 9.5). Spading machines are used for primary tillage to loosen soil without compacting or inverting the soil profile. Spading machines also incorporate residues and mix the soil, eliminating the need for secondary tillage in some cases. However, they do not create as fine a seedbed as rototilling. These units are European made, and not widely used in the northeastern U.S. at this writing. Increased availability and interest in protecting soil structure may enhance their popularity.

Disks

Disks come in many sizes, shapes, and configurations that offer different degrees of soil disturbance. They consist of groups of metal disks that rotate freely as they are pulled over the soil, chopping, cutting, and mixing as they go (figure 9.6). Individual disks may be smooth, serrated, or notched; light or heavy; set straight or at an angle; mounted singly or in multiples ("gangs"). Groups of disks may be arranged in one row or multiple rows that may be tandem or offset. Heavy disks, rather than plows, may be used for primary tillage on soils without much residue to incorporate. Lighter disks are used for secondary tillage, as harrows to smooth ("finish") fields after moldboard or chisel plowing. Disks are also used to incorporate broadcast soil amendments such as fertilizer, lime, and modest quantities of manure or compost.

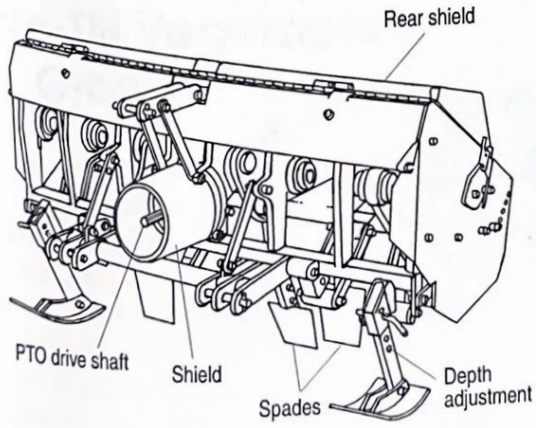


Figure 9.5 Spading machine
Source: Adapted from Celli, S.p.A, Italy

Equipment for Secondary Tillage

Secondary tillage works the top several inches of soil to smooth it out for planting, break up crusts and clods, and kill weeds. Equipment used for secondary tillage includes various types of harrows and various types of field cultivators and bed formers.

Harrows

Harrows (figure 9.7, page 92), are used to smooth and pulverize plowed soil, or they may be used instead of plowing when there are few residues on the soil surface. Harrows are used for shallow tillage to prepare a seedbed, break up soil clods, and remove small weeds. They include disk harrows, chain link harrows, spring-tooth harrows, spike-tooth harrows, and combinations of shanks and roller cages or soil crumblers.

Field Cultivators (Conditioners)

Field Cultivators ("conditioners") are used when the soil is rougher or has more residues on it (figure 9.8, page 92). A field cultivator combines different implements on a tool bar frame. In general, field cultivators are heavier than harrows and have either C-shanks or S-shanks (sometimes called Danish S-tines) mounted on a toolbar frame. Figure 9.9 (page 93) shows types of shanks. There may not be much difference between a heavy-duty harrow and a light field cultivator. Field cultivators come in a wide array

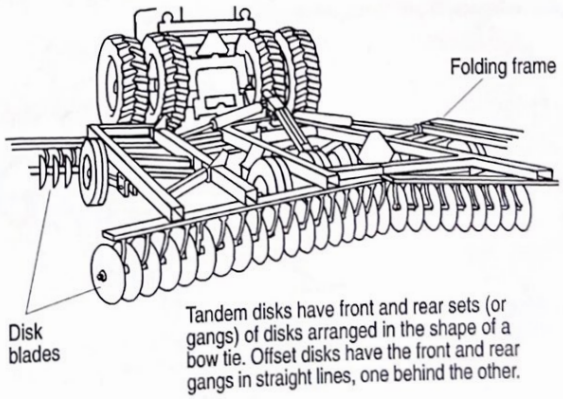
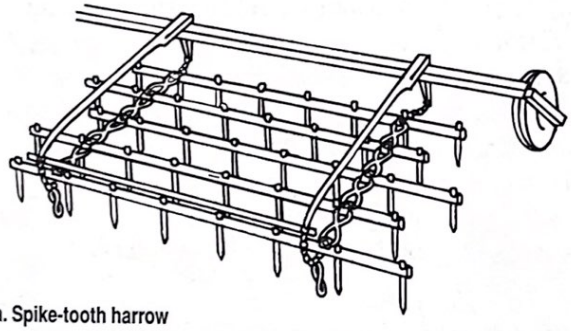


Figure 9.6 Disks
Source: Adapted from an illustration by John Gist in *Steel in the Field: A Farmer's Guide to Weed Management Tools*

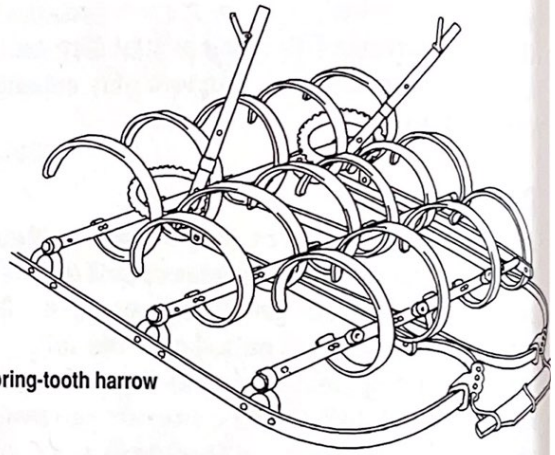
of configurations suited for different soil types, field conditions, and residue levels. They may include sweeps, stiff or flexible tines, chains, and rollers.

Bed-Formers (Shapers)

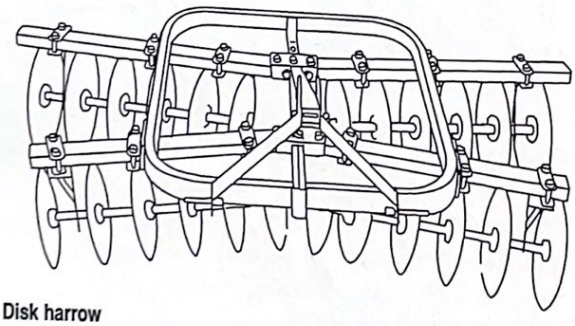
Bed-formers, or *"shapers"* gather, press, and flatten soil to create a raised surface, usually 4–12 inches above field level and 2–5 feet wide (figure 9.10). Raised beds encourage soil warming and drainage, allow for concentration of water and nutrient inputs near the crop, and help guide precision planting and cultivation equipment. After rotavation or disking have loosened the soil, hilling disks, rolling cultivators, or V-plows can be used to push soil into ridges that are then shaped into beds by a metal or wooden pan that presses the top and sides of the ridge. This can be accomplished using either a combination of on-farm equipment and a homemade pan, or a com-



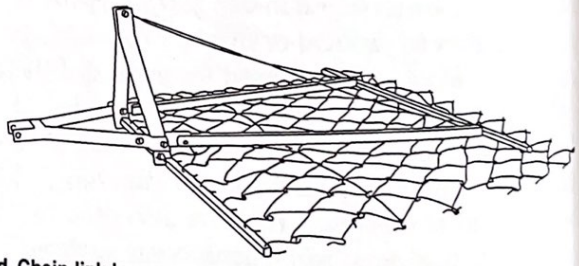
a. Spike-tooth harrow



b. Spring-tooth harrow



c. Disk harrow



d. Chain-link harrow

Figure 9.7 Harrows
Source (a.): Adapted from an illustration by John Gist in *Steel in the Field: A Farmer's Guide to Weed Management Tools;* (d.): adapted from Rem Manufacturing Ltd.

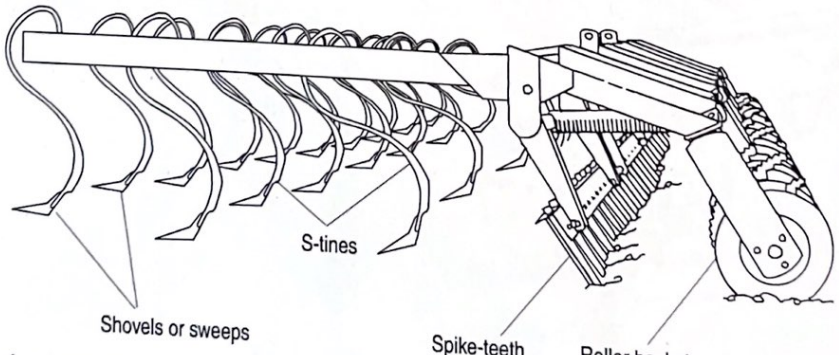


Figure 9.8 Field cultivator (conditioner)
Source (a.): Adapted from Unverferth Manufacturing Co., Inc.

mercial bed-former. Press pan units gather soil and form it into a firm bed. Some bed-forming units can also apply fertilizer and lay plastic mulch, and/or drip tape.

Conservation Tillage (No-Till or Minimum Tillage)

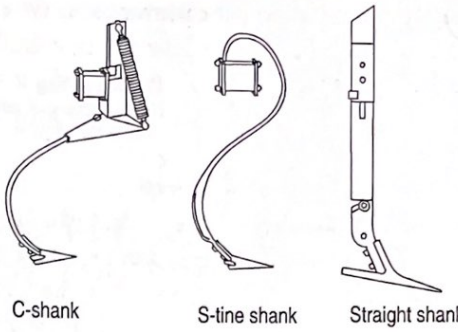
Conservation tillage (no-till or minimum tillage) leaves a significant amount of residue on the soil surface when crops are planted, unlike conventional tillage. Conservation tillage is an option with vigorous crops that do not require a fine seedbed. It should be considered on highly erodible soils. Strip-tillage, which alternates residue-free seedbed strips with high-residue strips, has been used with laterally-spreading crops like pumpkins and winter squash. This allows conventional planting equipment to be used in the tilled strips. No-till corn planters have been adapted to plant pumpkins into a killed-rye sod (see the grower profile of Jim Barber, page 216), and a no-till vegetable transplanter has also been developed in recent years (figure 9.11, page 94) Also see the grower profile of Steve and Cheri Groff (below).

For several reasons, not all vegetable crops and farms are suited to no-till: it requires specialized equipment and herbicides; it does not result in the fine seedbed required for direct seeding of some crops; and it leaves surface residues that may slow soil warming. No-till seems especially suited for transplanted vegetables on sloping land that would otherwise be prone to erosion.

No-Till Vegetables—A Grower Profile

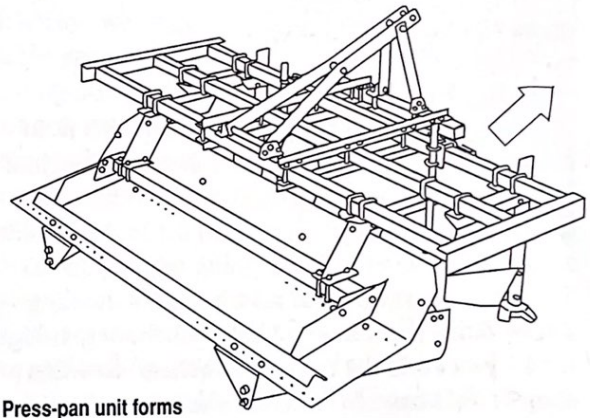
Steve and Cheri Groff
Cedar Meadow Farm
Holtwood, Pennsylvania

Steve Groff, his wife Cheri, and his parents farm 175 acres of rolling land in Lancaster County. They grow 40–50 acres of vegetables on loamy soils, in addition to hay and field crops like corn, soybeans, and small grains. Their markets are mostly wholesale.

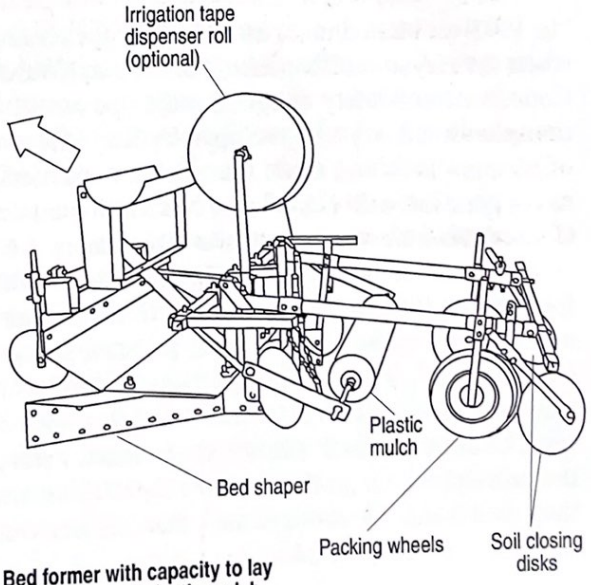


Shanks have a tool (such as a shovel or sweep) attached at the bottom. In general, C-shanks vibrate slightly; S-tine shanks vibrate vigorously; and straight shanks are rigid.

Figure 9.9 Types of shanks

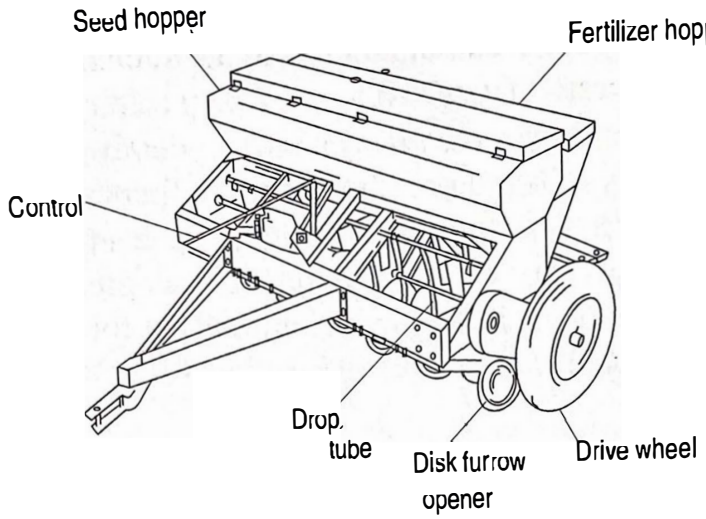


a. Press-pan unit forms bare soil raised beds.

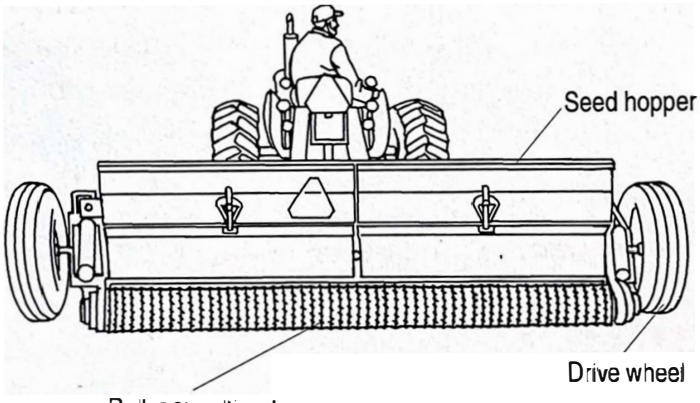


b. Bed former with capacity to lay drip irrigation and plastic mulch

Figure 9.10 Bed-formers ("shapers")
Source (a.): adapted from Buckeye Tractor Co.; (b.): adapted from Holland Transplanter Co.



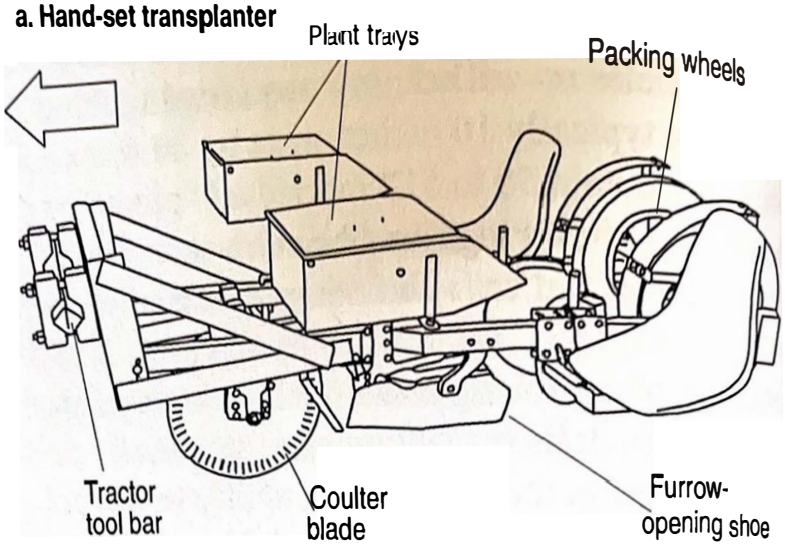
a. Grain drill for small grains that are sown in close rows

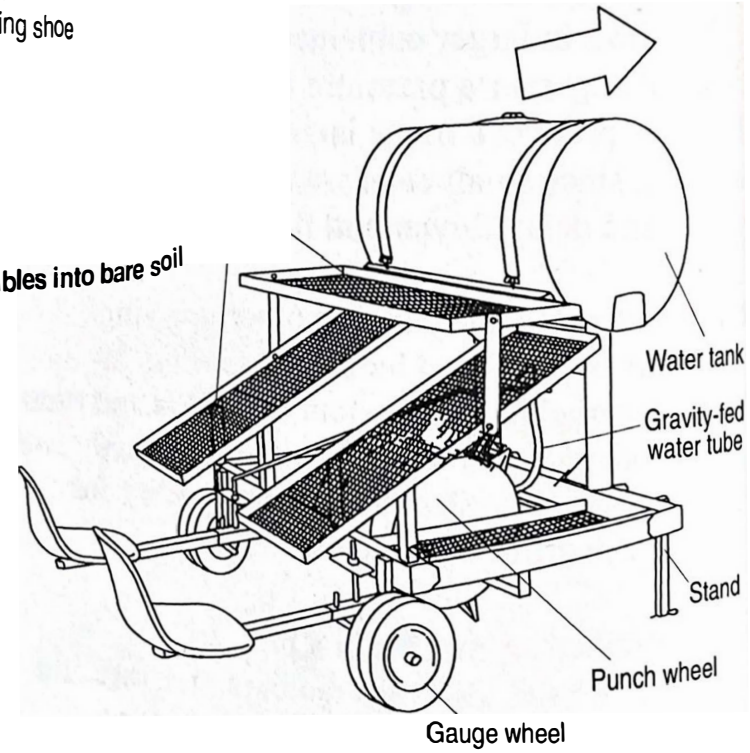


b. Roller seeder for small grains and small legume seeds

Figure 10.5 Grain drills for sowing small grains
Source (a.): *Fertilizer and Manure Application Equipment*.

a. Hand-set transplanter





Water-wheel transplanter for planting vegetables into bare soil or plastic mulch