Mechanization in Sugar Beet Cultivation

24

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Abstract

Mechanization in agricultural production has an important effect on both product quality and yield. It is an important input to agriculture in terms of the timely execution of farm operations. Mechanization has an important role in processes such as timely and low-cost realization of agricultural practices, increasing the productivity of high-cost inputs and soil fertility, improving product quality, and completing time-consuming agricultural works appropriately. It is normal for regional conditions and technological developments to lead to differentiation of mechanization practices. Criteria such as regionally applied mode of production, power source, land size, marketing conditions, purchasing capacity of the farmer are important factors in the selection of mechanization tools for an efficient and economical agriculture. Sugar beet mechanization includes agricultural operations such as leveling, tillage, sowing, fertilizing, hoeing, irrigation, weeding, spraying, harvesting, cleaning, and loading. Timely and appropriate mechanization applications are important for high efficiency, low loss, and high product quality. In order to be useful to all who are interested in sugar beet, the main mechanization steps used in sugar beet farming and some important properties are summarized in this chapter.

Keywords

Agriculture · Sugar beet · Mechanization · Automation · Precision agriculture

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24.1 Introduction

Labor costs and low space efficiency increase the need for mechanization and automation in agricultural areas. Due to advanced production techniques, mechanization has become a necessity rather than a requirement for efficient and quality production. Today, engines, hydraulic-pneumatic systems, tractors, tillage, sowing-planting, spraying, fertilizing, irrigation and harvesting machines are the most common types of machines in agricultural areas. Along with technological developments, computer and auto control systems, drone disease monitoring, and product prediction systems are becoming widespread in agricultural production. Machine is a tool that does the defined work by changing the direction and magnitude of the force it receives from the power source. Agricultural machinery refers to all machines and tools that are used in plantation, cultivation, care, and harvesting of agricultural products. Agricultural mechanization is processed based on increasing labor productivity with tools and machines in agricultural operations from field preparation to harvest. There are two main power sources in this process, human and mechanical. In addition, the manufacture, maintenance-repair, management and operation of agricultural tools and machines are important issues for the efficient and effective use of machines. In this section, the mechanization stages used in sugar beet agriculture and the agricultural characteristics of the machines classified below are explained.

1. Soil cultivation machines
2. Sowing, planting machines
3. Hoeing machines
4. Fertilizing machines
5. Harvesting machines
6. Cleaning and loading machines

24.2 Soil Cultivation Machines

Tillage is the process of arranging the land according to the conditions of the product to be grown by using agricultural machinery. Tillage covers the mechanization processes carried out for purposes such as soil tillage, seed bed preparation, weed control, creating a suitable environment for plant growth, reducing erosion, diseases, and pests. Soil tillage practices are generally grouped under four headings:

- To turn upside down of soil (plough),
- To loosen the soil without upside down (harrows and cultivators),
- To till the soil by mixing (rotary cultivators),
- To press on the surface for leveling and compression (land rollers).

Untimely, incorrect and excessive tillage can cause deterioration in soil properties, loss of time and energy. In sugar beet cultivation, the effect of pre-sowing processes on production can reach as high as 70% (Bee et al. 2004).

Some of the most suitable tools and machines for tillage applications are as follows:

- Heavy disc implements
- Wide-board ploughs
- Rotovators, interrow cultivators
- Chisel plough
- Roller

24.2.1 Some Application Guidelines for Tillage Practices

The optimum benefit can be obtained if certain rules are followed in tillage practices. Some of those are as follows:

– Minimize tillage. The more crop residues such as grain and stalks can be reduced, the faster and easier the ideal soil structure can be created. If soil conditions and machines are suitable, it would be better to consider direct planting. In this case, a little more manpower may be needed for weed control.
– Instead of plows and rotavator that overturn and disintegrate the soil, tools such as cultivators or chisels should be preferred.
– The main factor that determines the timing of tillage is soil weathering.
– Unless necessary, tillage deeper than 8–10 cm should be avoided.
– If deep tillage is required, subsoiling, which increases water infiltration and encourages early root growth, should be preferred.

24.3 Soil Tillage Systems

Conventional and conservation tillage methods constitute two main groups.

24.3.1 Conventional Tillage

The plow is the main tool of the conventional (traditional) tillage system and is tilled upside down at a depth of 25–30 cm. By causing intensive and excessive tillage, conventional methods increase soil compaction and erosion. Then seed bed preparation is made with secondary tillage machines. The following practices are mostly used in the traditional tillage system:

– Tillage with moldboard plow
– Crushing with disc plow (1 or 2 times)

- Harrow or cultivator processing (1 or 2 times)
- Planting and fertilization
- Hoeing with a cultivator or interrow cultivator (1 or 2 times)
- Irrigation
- Pulverizing and plant protection applications
- Harvest

Compared to conservation tillage, the traditional method requires higher inputs in machinery investment, maintenance, repair, and labor. In this system, the excessive number of cultivation causes erosion, deterioration of soil structure, and compaction. Studies on the water and energy savings required for sustainable agriculture are not common in traditional tillage. Stubble and plant residues are burned, removed from the soil, or mixed with the soil. In other words, the land remains bare until the next planting period (Fig. 24.1).

24.3.2 Conservational Soil Tillage

Conservation tillage is a system of weed control and seedbed preparation with minimal field traffic. In this system, chisel that makes subsoiling at a certain depth is preferred instead of plow. Chisel breaks down the hard layer that prevents plant growth, and product residues remain on the field surface. The positive effects of conservational system on erosion control have been revealed. As in conventional tillage, basic tillage, seedbed preparation and planting can be applied separately or together (Fig. 24.2).

Conservation tillage provides significant savings in labor, energy consumption, and timeliness. This method has many advantages over traditional tillage. The total power requirement, fuel consumption, operating time, and energy consumption required in the system are significantly reduced. In the soils where this system is applied, the physical structure becomes more stable over time, the carbon-nitrogen balance is provided, and the conversion of plant residues into organic matter occurs faster.

24.3.3 Reduced Tillage

In reduced tillage, which is a subgroup of conservation tillage, the energy requirement is even lower. Chisel or disc tools are used in primary tillage, and disc tools, cultivators, or combined tools are used in secondary tillage and seed bed preparation (Fig. 24.3).

Fig. 24.1 Processing steps of the conventional tillage method

24.3.4 Mulch Tillage

In the mulch method, where the stubble and residues of the previous crop are left on the soil surface, the difference from the direct sowing method is the subsoiling. Soil preparation is done with chisel, disc tools, cultivators, or combinations of tools, and

Fig. 24.2 Processing steps of the conservational soil cultivation method

Fig. 24.3 Processing steps of the reduced tillage method

weed control is done with weeders, herbicides, and/or harrows. The number of applications is limited to ensuring that sufficient residue is left on the surface to provide erosion control (Fig. 24.4).

24.3.5 Strip Tillage

It is an alternative method to no-till agriculture, which is tilled only the area to be planted and leaving the stubble in the remaining area as it is. The strip width is 5–30 cm (Godwin 1990). The strips can be prepared before planting, or it is more suitable to apply fertilizer in one pass with the planting. In areas susceptible to erosion, significant energy savings are achieved compared to full-area tillage in the appropriate method for sustainable agriculture (Fig. 24.5).

As with all no-till methods, the high amount of weeds and pests creates a problem in the strip cultivation method. Nonetheless, it is easier for growers to remove crop residue by strip tillage than full-width tillage. In the method, the correct placement of the seeds on the tilled area depends on the correct matching of the harmony between the planter coulter and the strips.

Fig. 24.4 Mulching in sugar beet

Fig. 24.5 Strip tillage-applied sugar beet field

24.3.6 Direct Sowing (No Tillage, Zero Tillage)

In direct sowing or no-till farming methods, sowing is done without any tillage. In direct sowing, the seeds are sown directly into the line opened by especially designed sowing machines, covered and pressed in accordance with the precision sowing technique. The contact of the seed with the soil is of absolute importance for ideal planting.

There is no traditional plow or disc plowing, and even hoeing is not done during the development and maturation period of the plant (Fig. 24.6). The direct sowing

Fig. 24.6 Direct sowed sugar beet

Fig. 24.7 Some types of direct sowing machines used in sugar beet cultivation

method provides significant time and fuel savings (Köller 2003; Šarauskis et al. 2010); however, the final emergence rate is lower and seedling growth is slower after emergence (Richard et al. 1995; Tuğrul and Dursun 2003; Koch et al. 2009) (Fig. 24.7).

24.4 Sowing, Planting Machines

Sugar beet, like other plants that need large living space, is planted with precise sowing technique. Precision sowing to leave the seeds one by one between the rows, on the row, and at equal depth, and the machines that apply this are called precision sowing machines. It is generally divided into mechanical and pneumatic precision sowing machines according to the way the seed is taken from the seed box and left to the seed bed (Fig. 24.8). The features that the precision sowing machine should have can be listed as follows:

– The double filling and discharging amount of the seeding systems will be low,
– To ensure uniformity in sowing, seed drop height will be maximum 7 cm,
– The adjusted seed distance in a row should not change,

Fig. 24.8 Mechanical sugar beet precision sowing machine

– Sowing units will be able to follow the field surface independently,
– Seed distances should not change during sowing.

The main difference between mechanical and pneumatic precision sowing machines is the way that the seeds are held on the sowing system. In mechanical systems, the sowing wheel located just below the seed box carries the seeds to the seed bed through the holes on its outer surface. In mechanical sowing systems, the hole or slot dimensions and the seed dimensions must match. Sowing wheel, horizontal disc, inclined disc, and banded systems are sowing systems in mechanical precision seed drills (Fig. 24.9).

Pneumatic sowing systems have a sowing disc. The seeds are transported to the seed bed by being held on the holes with a vacuum of 40–50 mbar created by a fan driven by the PTO. While the holes on the sowing wheel differ depending on the seed calibration, the holes on the sowing disc vary depending on the crop type (Fig. 24.10).

There are various scrapers of mechanical and pneumatic (suction and pressure) type to carry out single seed delivery to the seed bed in sowing machines (Fig. 24.11).

Another important part to be considered in sugar beet precision sowing machines is press wheels. Based on the machine type, press wheels can be front-middle-back, front-back, or just back. The front press wheel creates a sowing line of appropriate density to ensure seed-soil contact by pressing the seed furrow. The middle-pressure wheel presses the seed in the furrow providing maximum contact with the soil. The back pressure wheel creates a suitable structure for germination by pressing on the seed covered with soil and creates a structure that will prevent the crusting of the soil. The pressure wheels, for which soil properties are an important factor in the selection, are manufactured from adjustable metal material with a double-sided

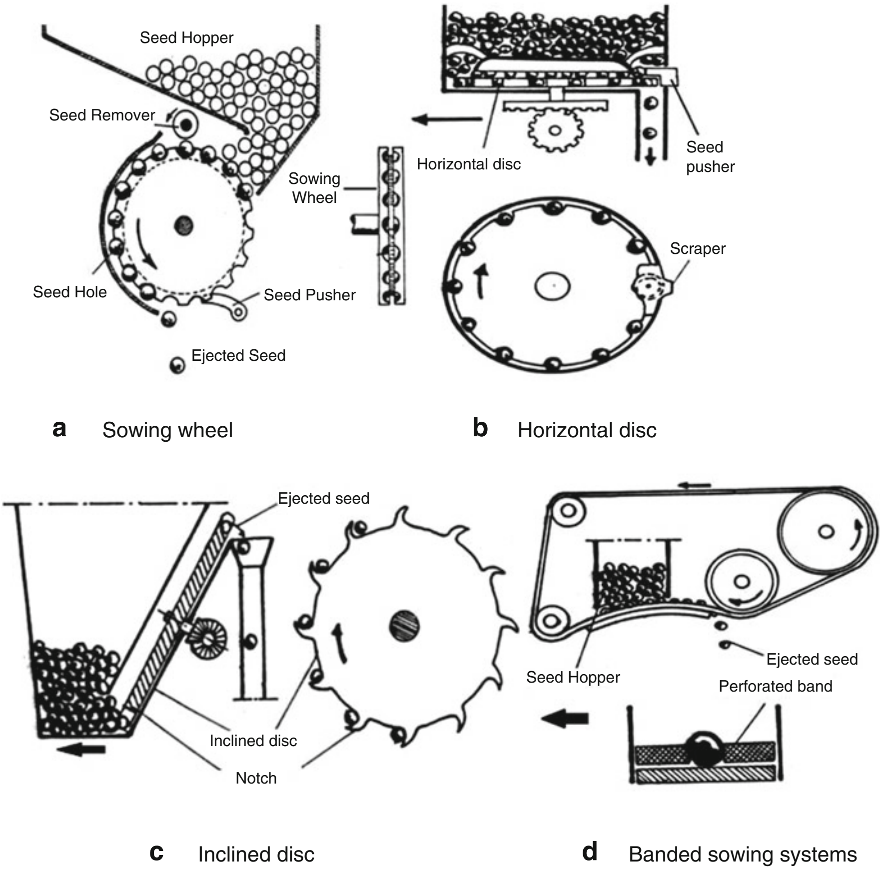

Fig. 24.9 Sowing systems used in mechanical precision sowing machines. (**a**) Sowing wheel, (**b**) Horizontal disc, (**c**) Inclined disc, (**d**) Banded sowing systems

conical structure, rubber filled and zero pressure rubber material, depending on the machine type (Fig. 24.12).

Precision sowing provides much better seed distributions and is commonly used for a wide range of crops such as beets. In precision sowing, the plant distribution on the row is disrupted in cases of poor seedbed (missing or double seeds) and non-germinating seed. The frequency distribution of intervals can usually be multiples of the average range. In such cases, the field emergence rates should be calculated correctly and the seed distance should be adjusted to ensure the ideal number of plants. For this, the sowing range, sowing depth, sowing speed settings of the machine should be checked and correct adjustments should be made. In addition, clod pushers, press wheels, and soil coverers settings and whether there are enough seeds in the drill hoppers should be checked.

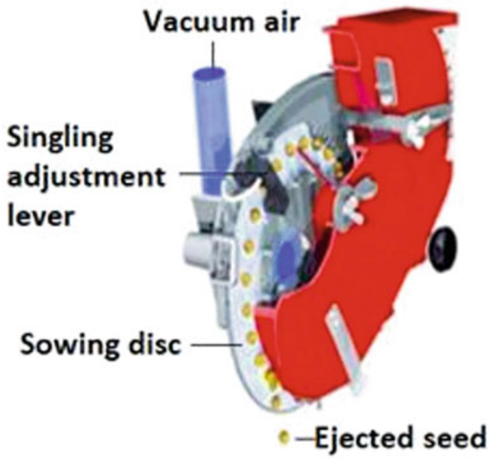

Fig. 24.10 Sowing systems used in pneumatic precision sowing machines

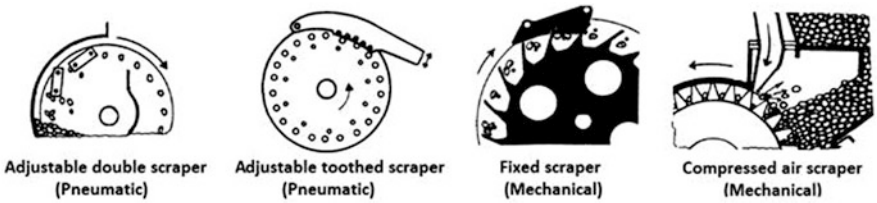

Fig. 24.11 Various types of scrapers using on the sugar beet precision sowing machines

24.5 Hoeing Machines

Hoeing is the process done at 2–6 cm depths for loosening the soil, weeding and mixing the fertilizer. A suitable environment is created for the growth of the plant by performing the throat filling process together with hoeing. Hoeing in the cultivation of the plants sowed with wide row spacing has found a common application area in agricultural operations as it allows to do weed control together with tilling.

Hoes are examined in two categories:

1. Hand hoes
2. Tractor hoes

Tractor hoes are called hoeing machines and are in mounted type. Hoeing machines are also classified according to their attachment to the tractor;

– those attached to the front of the tractor,
– those connected between the axles of the tractor, and
– those mounted on the back of the tractor by towed attachments.

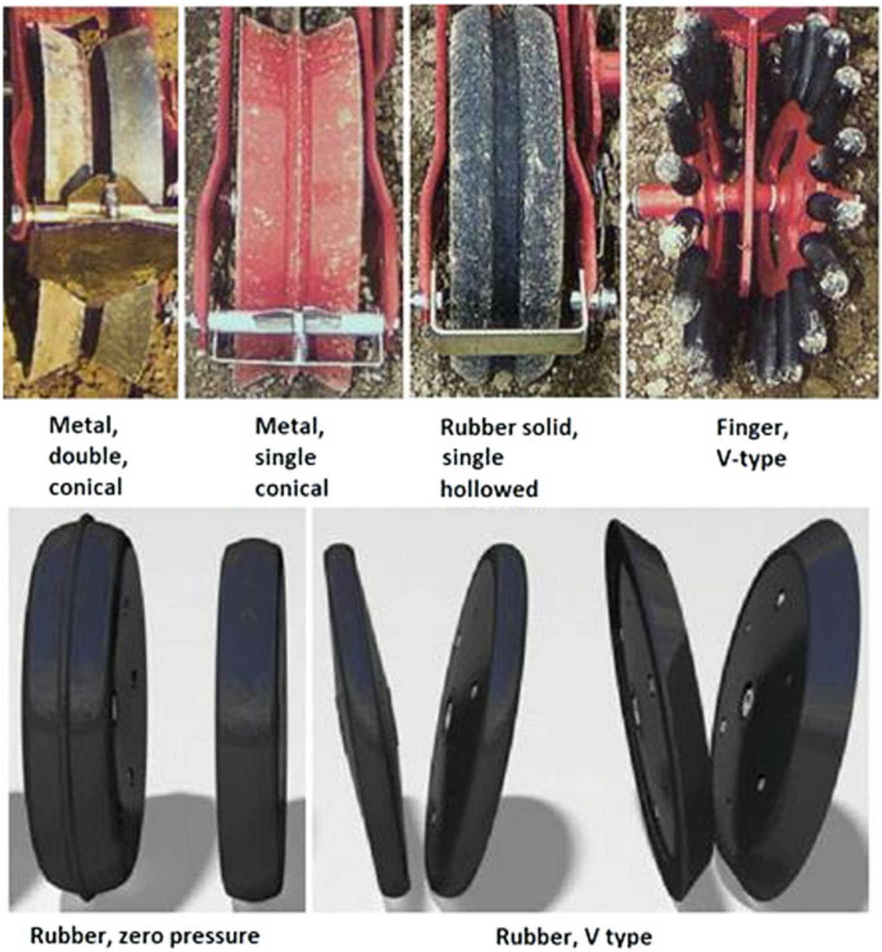

Fig. 24.12 Types of back press wheels used on the sugar beet precision sowing machines

Hoes mounted at the front of the tractor provide easy steering, but the tractor wheels trample the tilled area. Hoes connected between tractors axles are mostly used with tool carrier type tractors. Precise steering is not required. Rear-mounted hoes are the most used machine type. These are generally grouped in two ways depending on foot types:

1. Rigid tine hoes
2. Rotary hoes

The working part in rigid leg hoes is usually a different shaped cultivator attached to a universal chassis. The angle between the cutting edges of duck foot shares is 30–35° and the width is between 7 and 20 cm. Hoe legs can be rigid, semi-spring, or

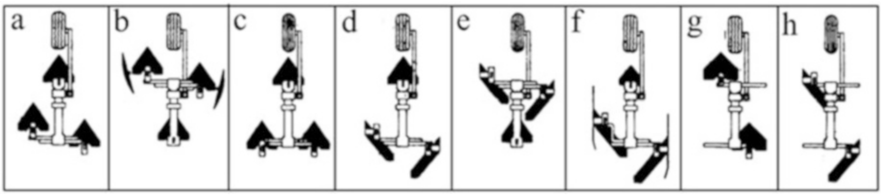

Fig. 24.13 The position of the cultivating legs according to different cultivation features

full spring. The legs are mounted parallel to a universal chassis, allowing independent movement of each unit and achieving a homogeneous hoeing depth.

24.5.1 Rigid Tine Hoes

The compatibility of the width between the rows and the track width of the tractor in hoeing machines is an important issue in preventing plant losses. For this, the units can be mounted symmetrically or asymmetrically. Weed density, plant height, spacing between rows, working speed, and crust condition in the soil are important factors in the selection of different foot combinations and the related hoeing efficiency.

The arrangement of the hoe legs in the form of cultivator primarily affects the entry of feet into the soil and weed. In angled blades, they cause only a very little soil around the plant to move (d, e, h). Plants can be hoed depending on the arrangement of the legs (a, c, g) even at different soil conditions and working speeds. Cultivator leg can be adjusted based on the high weed rates (b and e) and narrow rows (g and h). Areas with high grass density can be controlled by deep hoeing (Fig. 24.13).

24.5.2 Rotary Interrow Cultivator

It is an efficient machine with high success in full area and interrow cultivating. While interrow cultivator removes weeds by cultivating between rows, it also saves labor with fertilizer application. It can work in different widths between 45 and 80 cm row distances. The hoe width on each unit can be increased or decreased by turning the hoe blades inside or outside (Fig. 24.14).

In rotovators and interrow cultivators, the blades on the flange connected perpendicular to the rotor are arranged at different angles relative to the neighboring flanges, creating a helical appearance. This arrangement prevents impact operation when blades entering the soil. Blade types can be in horizontal position such as L, wedge, hoe type, or vertical structure (Fig. 24.15).

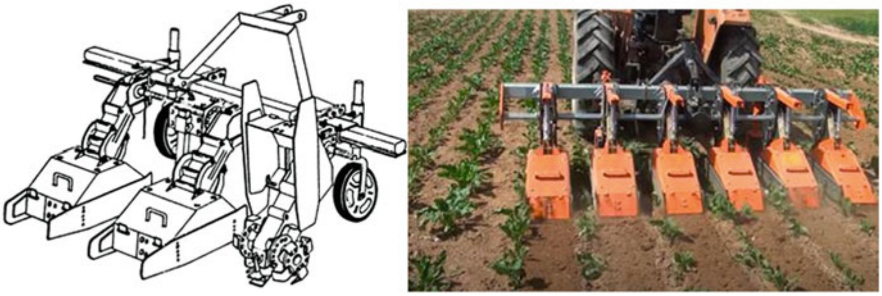

Fig. 24.14 Schematic and general views of a rotary inter row cultivator and its units

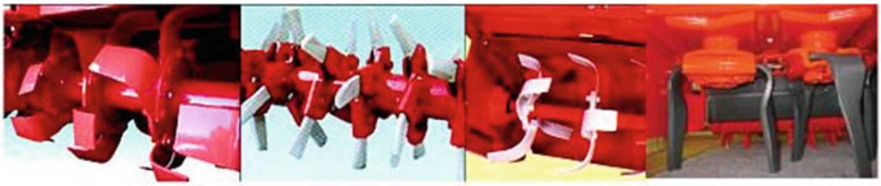

Fig. 24.15 Blade types used in rotovators and rotary interrow cultivators

24.6 Fertilizing Machines

Fertilizer is organic or inorganic substances that can be taken by the leaves or roots of the plant, containing the nutrients that the plant needs for its development. Fertilizers provide the nutrients needed by the plant or the soil, as well as improve the structure of the soil and increase development. Fertilizers are an important tool in increasing agricultural production. Fertilizers generally contain three basic nutrients, nitrogen, phosphorus, and potassium. In a profitable agricultural production, first of all, the nutrient deficiencies in the soil should be determined by soil analysis, and then the type and amount of fertilizer should be determined and applied in a timely manner with the most effective method. Farm manure is an important source for the protection and improvement of the soil with its plant nutrients, humus, and organic substances. Farm manure also has important benefits such as increasing the water holding capacity and aeration in the soil and supporting the formation of humus by improving its physical properties. Fertilizer applications can be divided into four parts as broadcasting, banding, fertigation, and foliar application.

Fig. 24.16 Fertilizer spreader

24.6.1 Broadcasting

A recommended rate of fertilizer is spread over the cultivation area and incorporated into the soil with a cultivator. Broadcasting is a method that is generally applied in large fields, when time or labor is limited (Fig. 24.16).

24.6.2 Banding

Fertilizers are applied to the furrows, which are at about 5–8 cm around the seeds or plants and are 3–5 cm deep from the seed furrows. It provides significant fertilizer savings compared to broadcasting (Fig. 24.17).

24.6.3 Fertigation

Nitrogen and potassium fertilizers are applied to plant production systems with irrigation water at regular intervals. Since phosphorus fertilizers contain insoluble compounds in their structures, they create a risk of clogging, so they are not suitable for application in this way (Fig. 24.18).

24.6.4 Foliar Application

The rapid absorption of nutrients from the leaves by the plant, especially the application of micronutrients together with the main elements such as N, P, and K, has become widespread. Applications can be made with various tools such as sprinkler and mobile irrigation systems and sprayers.

Fig. 24.17 Band fertilizing

24.7 Types of Fertilizing Machines

24.7.1 Organic Fertilizing Machines

24.7.1.1 Liquid Farm Fertilizer Distribution Machine

Liquid manure of farm animals is stored in especially prepared liquid manure wells. Liquid fertilizers taken from the wells are transported and applied in cylindrical shaped tanks (Fig. 24.19).

24.7.1.2 Solid Farm Fertilizer Distribution Machine

They are wheeled vehicles consisting of a conveyor and a distributor. Distribution systems can be located in horizontal or vertical structures, rear or side (Fig. 24.20).

Fig. 24.18 Fertigation

Fig. 24.19 Fertigation

24.7.2 Inorganic Fertilizing Machines: Solid (Mineral) Fertilizer Distribution Machine

24.7.2.1 Tank Type Fertilizer Spreader

In this group, there are systems with a single fertilizer hopper used in grain planting and a united fertilizer hopper in precision planting technique. The amount of fertilizer can be adjusted precisely (Fig. 24.21).

Fig. 24.20 Manure distributer

Fig. 24.21 Tank type fertilizer spreader

24.7.2.2 Centrifugal Fertilizer Spreader

It is used in two types as single and double disc in spread fertilizer application. Fertilizer distributors are divided into two as trailed and mounted according to their capacities (Fig. 24.22).

24.7.2.3 Liquid and Gas Fertilizer Spreader

In these systems, liquid fertilizer is pressurized with a pump and delivered to the desired area. It is possible to apply in combination with sowing machines or field sprayers (Fig. 24.23).

Fig. 24.22 Centrifugal fertilizer spreader

Fig. 24.23 Liquid fertilizing machine

Fig. 24.24 Beet harvesting machine

24.8 Harvesting Machines

Harvesting is the process of taking the mature plant from its growing environment and evaluating it. Conditions for effective harvesting often deteriorate during autumn and the risk of severe frost increases. Therefore, in most soils, beet harvesting should start in mid-September and end in early December. Sugar beet harvest consists of topping, lifting, cleaning, and loading stages, and sugar beet harvesters show structural differences depending on their features at these stages (Fig. 24.24).

24.9 Topping System

Making the beet top straight from the lowest green leaf level is considered a suitable topping. Topping directly determines harvest quality and losses. Insufficient topping causes the green part remaining on the head to continue to grow after harvest. Continuing the growth means consuming the sugar in the root. Conversely, deep heaping causes an economic loss as it causes weight and sugar losses (Fig. 24.25).

Fig. 24.25 Topping system

Fig. 24.26 Lifting system

24.10 Lifting System

It is the unit that removes the roots of the beet from the soil as a single piece without damaging it. Beets damaged during harvesting are exposed to infection and sugar loss increases (Fig. 24.26).

24.11 Cleaning System

It is the unit that cleans the soil that is stuck on the beet and carried together after lifting and leaves it to the field. Otherwise;

Fig. 24.27 Cleaning system

Fig. 24.28 Loading systems of beet harvesting machine

– Taking adherent soil together with beet increases soil loss.
– The soil and straw pieces attached to the beet create a good growth environment for microorganisms in the silo, and decay and sugar loss increase.
– The soil transported with the beet will increase the transportation costs per unit of beet (Fig. 24.27).

24.12 Loading System

It is the system of loading the topped, lifted, and cleaned beets into a vehicle to be sent to reception centers or the factory. Loading is done with the units of harvesting machines or beet cleaning machines (Fig. 24.28).

24.13 Suggestions for an Ideal Harvest

1. Not overtopping and no leaves: All leaves should be cut from the lowest petiole level. In a good harvest, 5% of the harvested beets are allowed to be cut above 2 cm and 5% to be cut deep. Beets with more leaves cause extra sugar loss during storage (Tijink 2010).

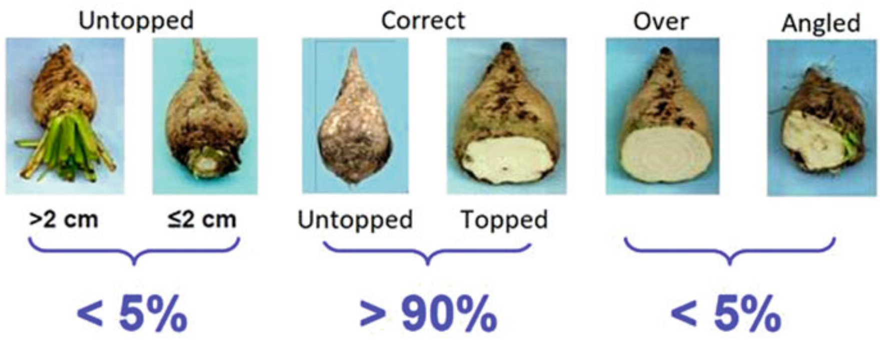

Fig. 24.29 Recommended cutting quality of sugar beet head

2. Good separation of beets and soil: The soil on the beet should be cleaned and there should be no breakage and/or damage to the roots. To achieve this, the lifting shares and the working depth should be adjusted carefully.
3. Beet-friendly cleaning: Direct root breakage losses and storage losses from cleaning should not be allowed, and very high rotation speeds of turbines should be avoided.
4. Cooperation of grower and harvester operator: For high harvesting performance, good cooperation between the producer, contractor, and driver should be ensured. The grower must provide a flat seedbed, homogeneous plant row, and excellent harvesting conditions, while the contractor must provide good machinery and a skilled driver (Fig. 24.29) (Tijink 2010).

If the soil wetness is above the field capacity during harvest, it reduces the bearing capacity of the soil and increases soil compaction. The moisture condition should be controlled during harvest to avoid compactness. Deeper lifting should be done to reduce root tip breakages in dry and hard soil. Excellent harvest is obtained under normal humidity conditions around the field capacity, and subsoil compaction is prevented when the tire pressure is 1.5 bar and below. In very wet soils, it is necessary to wait for the soil to dry sufficiently for harvesting. This waiting period can take several hours in sandy soil and 3–5 days in clay soils (Tijink 2010).

24.14 Machinery Harvesting Systems

Features such as the size of the beet cultivation land, the economic situation, the organization of sugar factories, the habit of using machinery, and the tractor power have led to the emergence of the combined and gradual harvesting system. In the combined harvesting system, topping, lifting, cleaning, and loading operations are performed in one go, and in the gradual harvesting system, each operation is done with a separate machine.

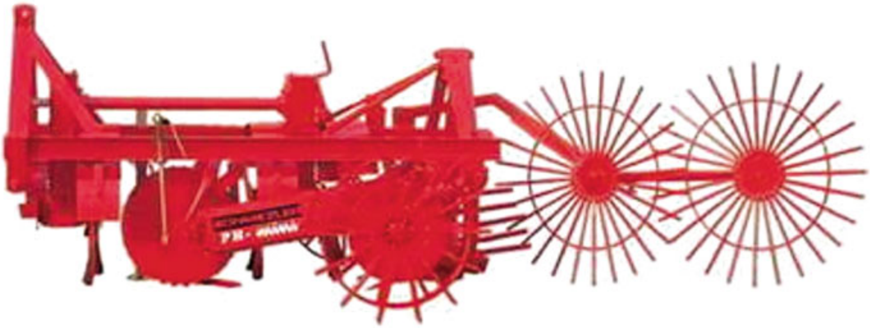

Fig. 24.30 One-row trailed harvester (without bunker)

Fig. 24.31 One-row trailed harvester

The systems in which topping, lifting, cleaning, and loading are done in one step are defined as the combined harvesting system, and the systems in which each operation is done with a separate machine are defined as the multi-stage harvesting system.

24.14.1 Types of Harvesting Machine

24.14.1.1 One-Row Trailed Harvester (without Bunker)

These are the machines that make topping and lifting and leave tha^{-1}beets on the field surface (Fig. 24.30).

24.14.1.2 One-Row Trailed Harvester

These are the harvesting machines that have a hydraulic control system and carry out cleaning, storage, and loading operations in addition to the single row trailed type harvester. Daily capacity (10 h) of this type of machine is 1.8–2.0 t ha^{-1} (Fig. 24.31).

Fig. 24.32 Double-row trailed harvester

Fig. 24.33 One-row self-propelled harvester

Double-row trailed beet harvester: It is a two-row trailed combined harvester. Daily capacity (10 h) of this type of machine is 6–7 t ha^{-1} (Fig. 24.32).

One-row self-propelled beet harvester: They are single row self-propelled combine harvesters. Daily capacity (10 h) of this type of machine is 2.2–2.5 t ha^{-1} (Fig. 24.33).

24.14.1.3 Six-Row Self-Propelled Beet Harvester

It is a six-row self-propelled combine harvester with a capacity of 1.5 ha h^{-1} (Fig. 24.34).

The quality parameters in the beet harvester are as follows:

– Total beet loss
– Topping quality
– Soil and leaf tare
– Beet injury rate

When purchasing or renting a machine, learning the test values from the manufacturer or machine users, if any, provides information in the evaluation of the harvest quality of the machine.

24.15 Cleaning and Loading Machines

They are high-capacity machines that load the beet into a vehicle after it is cleaned from substances such as leaves and soil (Figs. 24.34, 24.35 and 24.36).

The advantages of beet cleaning loading machines can be summarized as follows:

– Facilitating the loading of beets from field silos to vehicles after harvest,
– Reducing low-tare beet delivery and transportation costs with effective cleaning,
– Providing opportunity to producers to start field preparation in a short time for other crops in rotation,

Fig. 24.34 Six-row self-propelled harvester

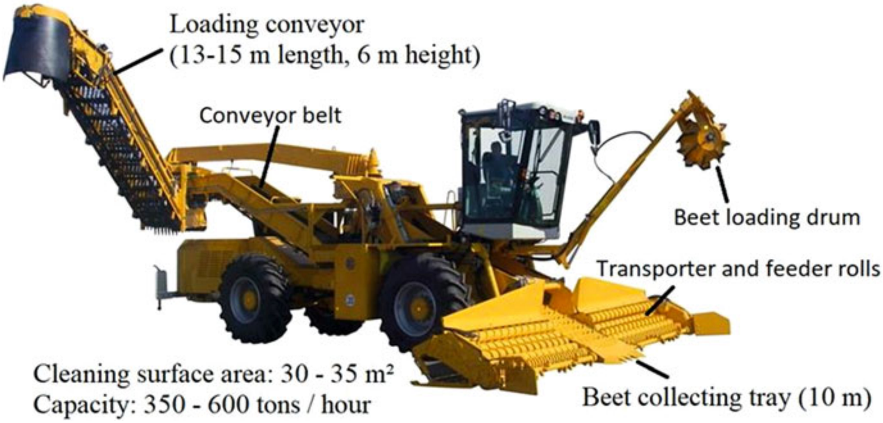

Fig. 24.35 Cleaning and loading machines (mouse)

Fig. 24.36 Cleaning and loading machines (mouse)

Fig. 24.37 Drone application in agriculture

– Preventing soil erosion,
– Effective cleaning of weeds and soil from beets,
– Purchasing low-tare clean beets,
– Reducing business losses.

24.16 Drone Use in Sugar Beet Farming

With the use of drones in agriculture, aerial imaging devices have become widespread. Drones are tools that allow rapid and accurate evaluation in the detection of diseases and pests in plants, water stress, yield/maturity levels detection, weed and flora tracking, irrigation and monitoring of agricultural workers (Figs. 24.36 and 24.37).

The usage purposes of drones in sugar beet agriculture can be summarized as follows:

1. *Monitoring:* Images from drones' built-in cameras allow tracking crop development and identifying areas of poor performance for better crop management.
2. *Easy mapping:* Making field maps facilitates the planning of irrigation, fertilization, and spraying according to the data obtained from the maps.
3. Precision spraying: Drones use advanced sensor combinations to distinguish healthy plants from unhealthy ones. These sensors precisely detect color differences, giving the chance to intervene before diseases spread further. Drones can perform precise spraying at low altitudes, except for equipment scanning the soil.

Crop development in sugar beet is monitored through normalized difference vegetation index (NDVI) data, and even yield estimation can be made with NDVI images taken in autumn (Hoffmann and Blomberg 2004; Bu et al. 2016).

24.17 Future Prospects

The excessive increase in input costs has made economic agriculture impossible in small-scale enterprises. In larger scales, automatic control and smart systems and applications with fast and variable rate instant data are gaining importance. Artificial intelligence methods are taking place in agriculture in the detection of pests and diseases with robotic devices that instantly monitor soil quality and plant growth. Systems that offer or implement fast and effective protection have completed the research phase and have been put into practice. Instead of spraying an entire field, using an agricultural drone that can deliver the required amount of pesticides to the right spot will reduce harmful chemicals and decrease costs. Accurate and fast selection of product types depending on water potential, changing soil properties with soil mapping will contribute to increase agricultural potential. Today, it is thought that the most efficient agriculture can be done with giant agricultural machines on large-scale lands. The heavy machinery used, besides being expensive, causes soil compaction that can last for years. In addition, although the control of the machines has been facilitated, the need for labor in agricultural operations, which are still heavy and tiring, continues. In conclusion, it can be predicted that in the future, small and autonomous robots will be widely used in practice and efficient and economical agriculture will be possible without soil compaction with big data-based applications (King 2017).

24.18 Conclusions

The function and correct use of agricultural machinery have an increasing importance in the sustainability of agricultural production. Therefore, it is necessary to know that the role and characteristics of machinery in agriculture must be well explained in order to be able to plan in the next projections. In addition to having sufficient tractors and equipment in agricultural activities, ensuring the rapid transition from the traditional system to the conversational system is considered important in terms of productivity and sustainability. Individual machines such as moldboard plow, cultivator, disc harrow, and mechanical sowing machines that are still used in agricultural production should be replaced with combined tools/machines that operate in one pass without wasting time.

Because of its deep root structure, sugar beet should be planted in a deep structured field and with a field preparation without compaction. For this, reducing field traffic or planning operations on the track line in large areas is the right solution. Attention should be paid to the timing of agricultural practices and applications should be completed quickly. Early sowing provides a great advantage in sugar beet cultivation. However, the possibility of agricultural frost should be considered in early planting, meteorological data should be followed, and long-term annual statistics should be evaluated at the location of the land. In summary, it can be said that choosing the tools/machines that will perform the agricultural operations in the shortest possible time and performing the operations correctly and quickly with trained operators will guarantee high yield and quality in sugar beet cultivation.

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