TILLAGE AND SEEDING MACHINES

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Summary

Tillage and seeding machines are fundamental for crop establishment, growth and amount of yield. Seeding machines can also influence the effectiveness of mechanical harvesting. For these reasons manufacturers have designed numerous types of tillage and seeding machines, sometimes especially designed according to farmers' requirements for a particular crop or a particular cultivated land. Therefore this article

only describes the most common tillage and seeding machines, giving the main information on their utilization for the various crops and types or conditions of soil. In addition some general principles on crop and soil requirements are given. Tillage machines are classified according to their use for primary or secondary tillage operations and possible hitching configuration. Various classifications of seeding machines are also given, according to their hitching configuration, planting method, main use and type of seed distribution mechanism.

1. Tillage Machines

Tillage operations are mechanical manipulations of soil carried out with the aim of modifying the state of the soil for providing the most favorable conditions to crop growth. Therefore tillage machines have the following main tasks:

- to create a soil structure suitable for a seedbed or a rootbed, which can allow good air and water retention and circulation, which can easily be penetrated by plant roots, and at the same time can assure good contact of the soil particles with the seeds, in order to favor moisture and nutrient absorption;
- to control weeds;
- to incorporate previous crop residues into the soil;
- to incorporate soil amendments, fertilizers, manure and agrochemicals for weed or pest control into the soil;
- to favor succeeding agricultural operations (e.g. planting, irrigation, harvest);
- to control and minimize soil erosion.

Three hitching configurations are available for tillage machines: mounted, semi-mounted and trailed. Mounted and semi-mounted machines are attached to the three-point hitch of the tractor, trailed machines are attached to the drawbar of the tractor.

Tillage machines can be classified as machines for primary or secondary tillage operations, where primary tillage is intended as a major soil working operation on an uncultivated soil or after harvest of the previous crop, while secondary tillage is intended for all the operations following primary tillage. Table 1 lists all the most common types of machines used in a conventional tillage system for primary and secondary tillage operations. The related possible hitching configurations are also listed.

Machines for primary tillage	**Possible hitching configurations (M, S, T)**	**Machines for secondary tillage**	**Possible hitching configuration (M, S, T)**
Moldboard plows	M, S, T	—	—
Disk plows	M, S, T	Disk harrows	M, S, T
Chisel plows (heavy duty cultivators)	M, T	Rigid or spring tine cultivators (harrows)	M, S, T
Subsoilers	M, T	—	—
Rotary plows	M, S	—	—
Rotary cultivators (rotary tillers)	M	Rotary cultivators (rotary tillers)	M, S, T
Reciprocating spading machines	M	—	—
Listers, ridgers, bedders, grubbers	M, S, T [a]	—	—

		Power harrows	M
		Rotary hoes/harrows	M, S, T
		Rollers, land levellers	M, S, T [a]

[a] often combined with other implements

Table 1. Machines for primary and secondary tillage operations in a conventional tillage system. Related possible configurations: M = mounted, S = semi-mounted, T = trailed.

Several of the implements described below can be combined on the same machine main frame, in order to obtain both primary and secondary tillage in one pass or to create clods of a different size at different depths. A classic example of such a machine has: long heavy tines at the front, that cut the soil vertically causing a shatter in the deep layers; a PTO-powered rotary tiller, that creates the tilth, at shallower depth, mixing previous crop residues and soil; a crumbler or packer roller at the end, to provide a level surface and a fine compact tilth ready for drilling. Other examples are disk plows combined with subsoiler, chisel plows combined with disk harrows and rollers of various shapes combined with any type of secondary tillage machine.

In some cases tillage implements can be combined with drilling and/or fertilizing implements to carry out several operations in one pass (e.g. direct drilling).
During the last 10 to 20 years conservation tillage systems were developed in order to conserve soil (prevent or minimize soil erosion) and water, and to reduce time and energy required for tillage. Minimum tillage, strip tillage and zero tillage are the most common names for these systems. Minimum tillage eliminates any primary tillage operation, while zero tillage eliminates both primary and secondary tillage operations. Strip tillage consists of only secondary tillage operations carried out in small bands or strips of soil where the seeds (or plants) will be planted in a row crop system.

2. Primary Tillage Implements

Primary tillage implements are generally used on uncultivated land or after the harvest of the previous crop to break down the soil and incorporate plant residues. Implements used for primary tillage are plows, subsoilers, bedders, grubbers, listers, ridgers, rotary tillers and spading machines.

2.1 Plows

Plowing is still the most common primary tillage operation carried out after harvesting a crop. Implements used for plowing are moldboard plows, disk plows, chisel plows and rotary plows.

2.1.1 Moldboard Plows

Moldboard plows are widely used because of their effectiveness in cutting a furrow slice and inverting it in order to bury any vegetation or manure present on the soil surface. At the same time the bottom of the furrow slice is exposed to the action of weathering agents and of other implements.

Figure 1 shows the main parts of the body of a traditional moldboard plow.

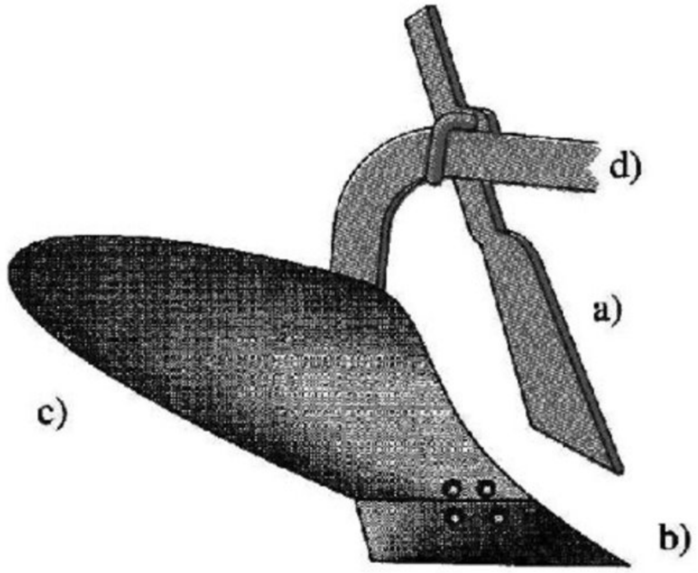

Figure 1. Body of a traditional moldboard plow: a) coulter, b) share, c) moldboard, d) beam (Peruzzi A. and Sartori L. 1997).

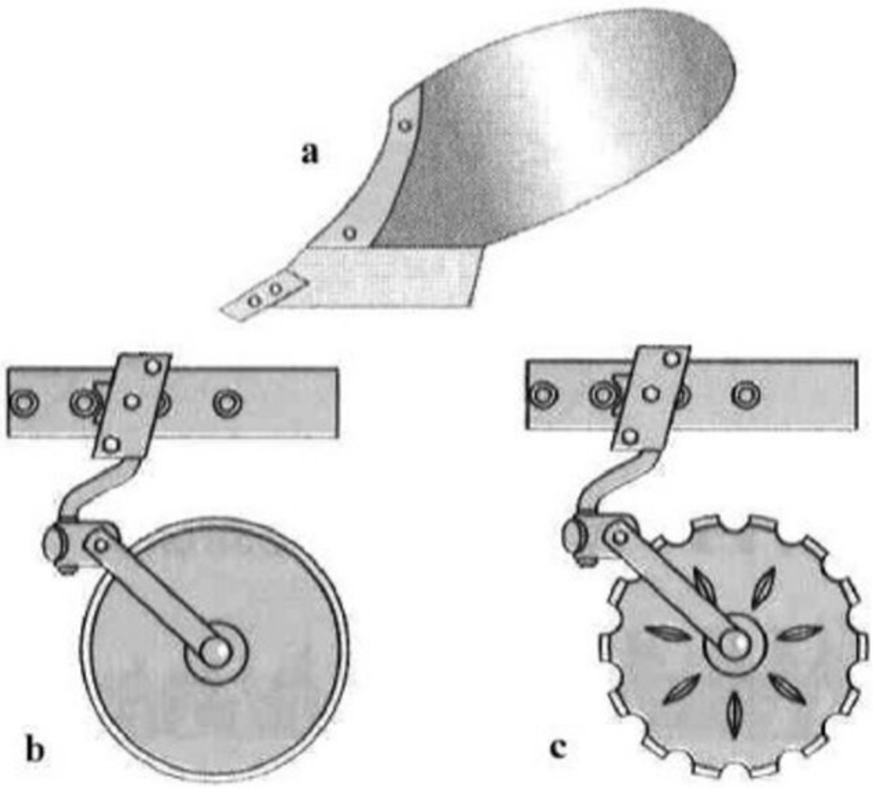

Figure 2. Type of coulters: a) shin coulter (incorporated in the front part of the moldboard); b) plain-edge disk coulter; c), ripple-edge disk coulter (Peruzzi A. and Sartori L. 1997).

The coulter (Figure 1a) makes the vertical cut, separating the furrow slice from the unplowed land. It can be shaped in several ways as shown in Figure 2. The knife coulter, fastened to the beam by a clamp (Figure 1a, d), is now less used. More common are the disk coulters that, acting as a wheel, can reduce the draft. Ripple-edge disks (Figure 2c) may reduce the clogging effect of straw and other plant residues pushed along in front of plain disks (Figure 2b). Renewable shin coulters can be attached to the moldboard breast (Figure 2a). Sometimes a skim coulter is fixed rigidly to the beam, right in front of the knife coulter or just behind the disk. It consists of a miniature plow and improves the burial of crop residues and manure.

The share (Figure 1b) makes the horizontal cut that separates the furrow slice from the soil below. Manufacturers have designed shares of various shapes (trapezium, diamond, etc.) with bolted point and wings, often separately renewable (Figure 3). Sometimes the share cutting edge is placed well in advance of the moldboard to reduce the pulverizing action of the soil.

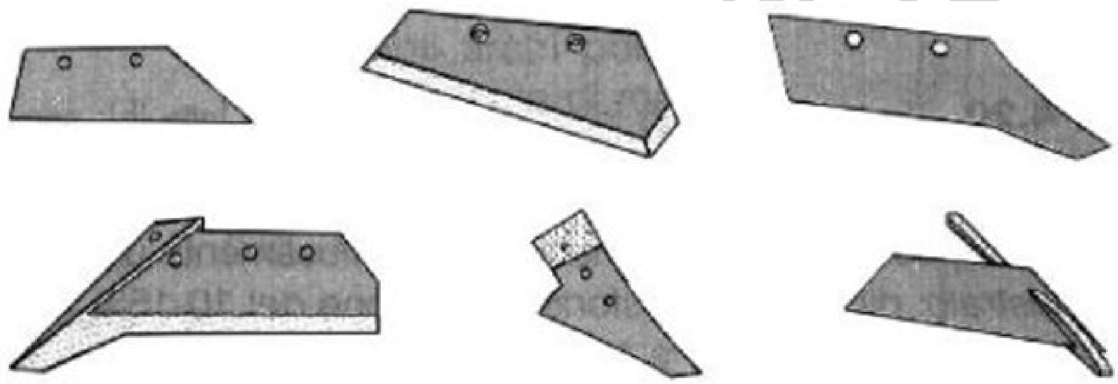

Figure 3. Various shapes of shares (Peruzzi A. and Sartori L. 1997).

The moldboard (Figure 1c) is responsible for inverting the furrow slice and sometimes for shattering it, depending on the type of moldboard, plowing depth and soil conditions. Moldboards exist in several shapes, some of which are shown in Figure 4.

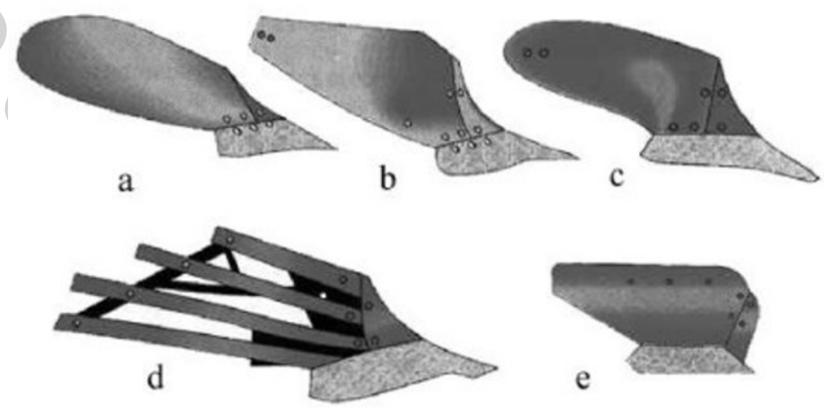

Figure 4.Various shapes of moldboard: a) general-purpose; b) digger; c) semi-digger; d) slatted; e) diamond (Peruzzi A. and Sartori L. 1997).

The general-purpose moldboard (Figure 4a) is long, with a gentle curvature and a cross-sectional convex curve from top to bottom. It turns the furrow slice slowly almost without breaking it, and is normally used for shallow plowing (maximum 200 mm depth).

The digger moldboard (Figure 4b) is short, with a concave cross-section both from top to bottom and from shin to tail. It turns the furrow slice rapidly, giving maximum shatter. It is normally used for very deep plowing (300 mm deep or more).

The semi-digger moldboard (Figure 4c) is a bit shorter than the general-purpose moldboard, but with a concave cross-section and a greater curvature. Being intermediate between the two moldboards above described, it has a performance that comes in between (approximately 250 mm deep) and with less shattering than the digger moldboard.

Several other types of moldboards have been designed by manufacturers for more specific purposes and/or soil conditions. Two examples are shown in Figure 4d and 4e. The slatted moldboard (d), diminishing the friction surface between the furrow slice and the moldboard, offers a specific plowing resistance of 10 to 20% lower than that of the conventional moldboards. The diamond moldboard (e) also reduces plowing resistance (15 to 20%) and soil compaction in the furrow bottom.

Other parts of a moldboard plow body are: the landside, which presses against the furrow wall and absorbs the sideways thrust due to the turning of the furrow slice; the heel (or slade), placed at the bottom of the landside, and absorbing the downward pressure due to the weight of the furrow slice and of the plow itself; the frog, to which the share, moldboard and landside are attached; the beam, to which the frog is bolted and to which the plowing pull is applied.

Cast iron and forged steel are the materials more commonly used for the various parts of the plow body. Often they are hardened at the surface and/or at the edges in order to reduce wear; sometimes other very hard materials (e.g. ceramics, cast alloy) are used for the same reason.

The plow body is attached to a main frame (normally made of tubular steel with rectangular, square or round cross-section) which has the main task of linking the plow to the tractor.

Mounted, semi-mounted or trailed hitching configurations, depend on the type, size and weight of the plow, number of bodies, etc. The main frame may carry one or more bodies (normally up to six), plus the plow controls and adjustments (furrow width and depth, pitch and sideways level) and the safety devices for shock and overload protection. Figure 5 shows a trailed single-furrow deep digger plow with hydraulic controls used for very deep plowing.

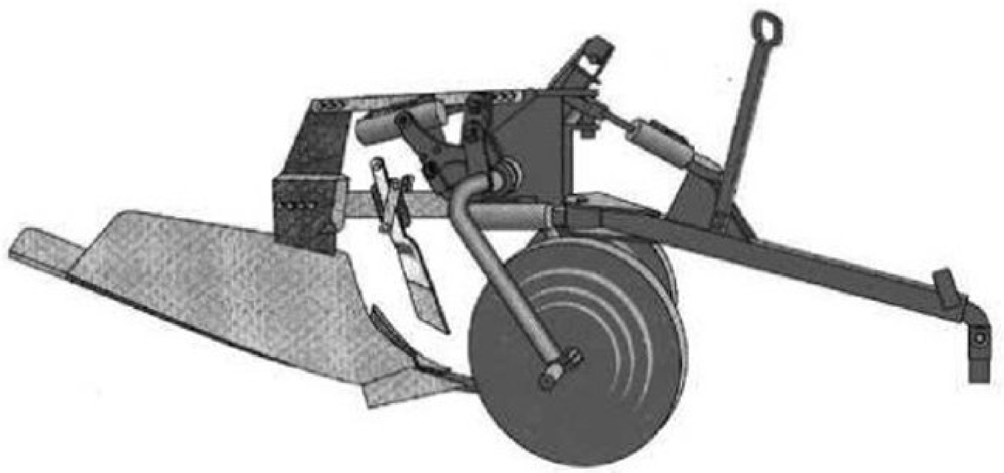

Figure 5. Trailed single-furrow deep-digger plow with hydraulic controls (Peruzzi A. and Sartori L. 1997).

In Figure 6, two types of tail wheel for the mechanical control of plowing depth are shown.

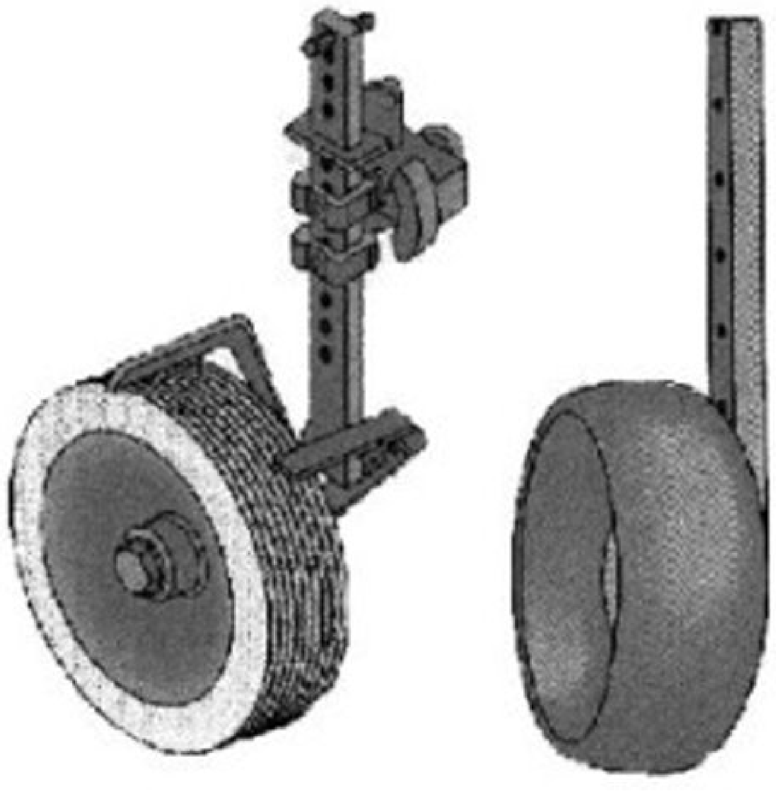

Figure 6. Example of tail wheels for the mechanical control of plowing depth (Peruzzi A. and Sartori L. 1997).

The attachment of the plow body to the main frame is often equipped with overload protection devices which allow the body to move rearward and upward to pass over an obstacle (e.g. rocks hidden below soil surface) without damage. The most simple mechanism is a breaking bolt that needs replacement (Figure 7a). Sometimes a spring mechanism or a hydraulic cylinder (Figure 7b) allows the automatic resetting to the original plowing position after passing over the obstacle.

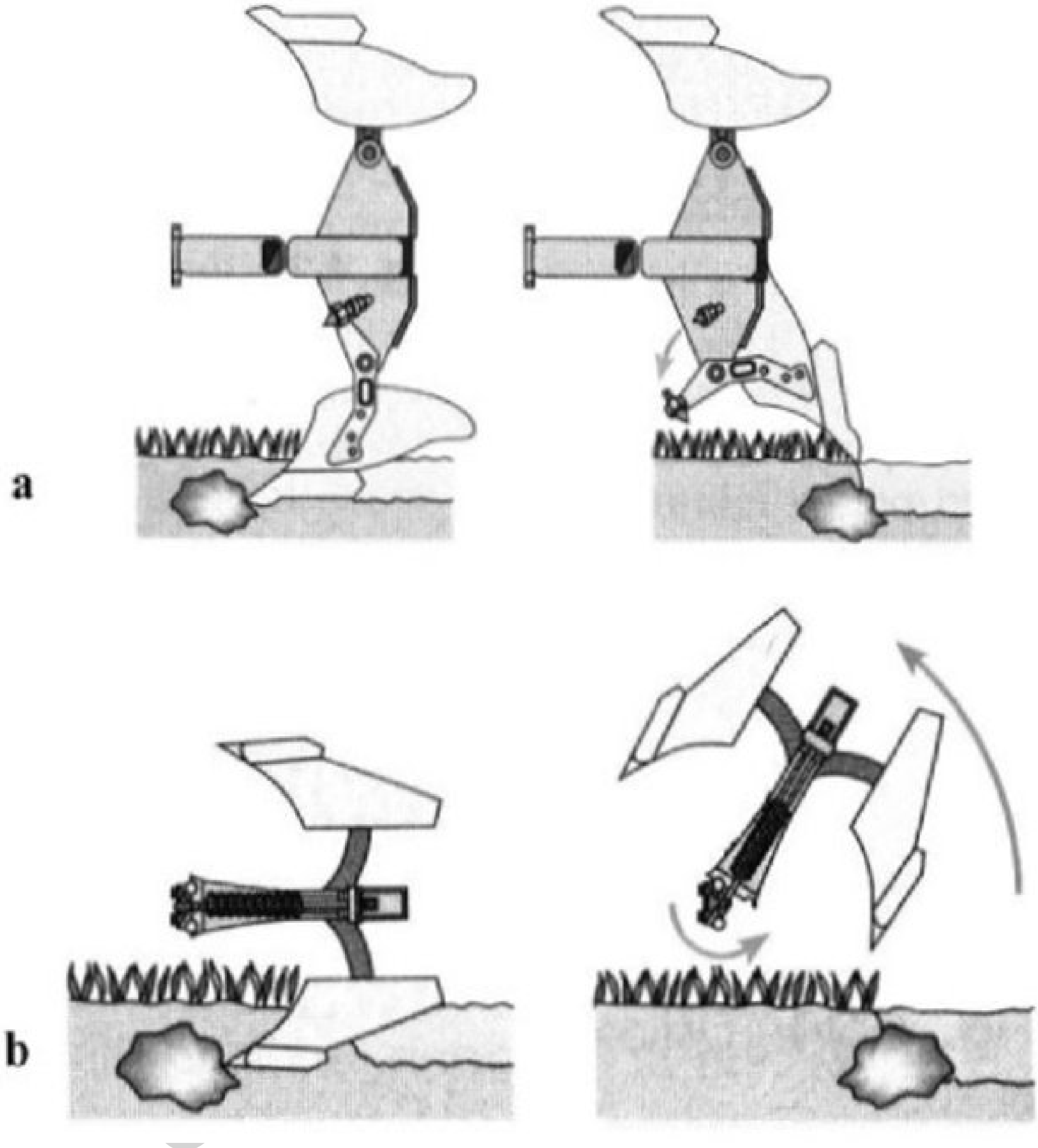

Figure 7. Examples of overload protection devices: a) breaking bolt; b) spring-trip or hydraulic reset (Peruzzi A. and Sartori L. 1997).

Moldboard plows are normally designed to turn the furrow slices only to the right. In order to save time on turns and reduce running along headlands, two-way plows were designed (Figure 8). Their frame is equipped with two sets of opposed bodies (right-hand and left-hand bodies) and is rotated through 180° at each headland, in order to turn the furrow slices towards the same side of the field travelling in both directions. The main disadvantages are the extra cost and weight of the implement.

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Biographical Sketch

Pierluigi Febo was born I Città S. Angelo (Pescara) Italy on 5th July 1950. He is married to a British citizen, and has two children. Degree: M.Sc. in Mechanical Engineering; Scholarships from 1976 to 1979 and from 1980 to 1982 at the Institute of Agricultural Engineering – University of Milan; Researcher from 1983 and Senior Researcher from 1986 at the same Institute; Associate Professor of Agricultural Mechanization from 1992 at the University of Palermo, Faculty of Agricultural Sciences; Member of CIGR (International Commission of Agricultural Engineering) from 1979; Member of EurAgEng from 1986; Member of the Italian delegation from 1979 to 1991 in OECD and EEC meetings for the studying and updating of the Codes for testing tractors and agricultural machines; Referee of the *Journal of Agricultural Engineering Research* from 1994; Chairman from 1994 of CIGR Working Group No. 1 and of EurAgEng Special Interest Group No. 12 on “Harmonization of Agricultural Engineering University Curricula”. Author of more than 140 papers published in refereed national and international journals or presented at national and international Congresses and Conferences. Research activity: ergonomics and safety in agriculture; traction and mobility of agricultural tractors and machines; choice and performances of agricultural engines, tractors and machinery; tractor mobility in paddy fields; performances of agricultural tires and tracks; soil compaction; energy saving and renewable energy in agriculture; forestry mechanization; machines and plants for agricultural and food industry.