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Market Overview in Terms of the Offered Solutions of Equipment and Machines for Planting Seedlings with a Covered Root System

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The market review in terms of the offered solutions and the design of devices intended for planting seedlings with a covered root system was made under Doktorat Wdrożeniowy program. There are many solutions on the market for this type of work, from the simplest - manual, to highly advanced structures, often aggregated with vehicles such as an agricultural tractor or a tracked excavator. The article covers a full cross-section of the market, so as to show both the simplest and the most economical to produce them, as well as the more technologically advanced ones.

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1. Introduction

Manual work performed in forestry consumes considerable energy resources, while being at the same time often burdensome and not ergonomic work. For many years, research has been conducted in this matter, while at the same time manufacturers, both larger and smaller companies, are introducing solutions to the market to improve the quality of work. The market offer is richer from year to year, while the designs of devices for planting plants offered today are very diverse in terms of the degree of complexity, production costs or the possibility of supporting the operator's work [23].

2. Models review

The various designs of planting devices are shown below. The presentation was made from the simplest, handheld devices available on the market.

First, the device will be described, a tool that is now commonly used in Finland. A significant advantage is the manual planting of seedlings with the use of manual staffs.

It is a lightweight and compact design. The device is made of steel, requires a pre-prepared facility, or is intended for planting seedlings in soft ground, due to manual operation and limitations related to the applied force driving the tool into the ground.

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The device consists of a body in the form of a cylindrical tube, which ends with three arms at the bottom. When folded, the arms form a cone, which is to facilitate driving the device into the soil. After the device is driven into the pipe, the seedling is placed in the pipe, and the operator's task is to open the above-mentioned lever through a system of levers. three arms. This will allow the seedling to exit the pipe and embed it in the prepared facility. It is highly probable that after the seedling has been planted, the planting is done with the operator's foot.

The average planting capacity, given according to various sources, using the above-mentioned equipment is approximately 150 seedlings per hour. The unit cost of purchasing such a device is at the level of EUR 200-500, while it is possible to buy such a device directly on one of the Chinese advertising portals for about USD 12 per piece, but this price is valid for a minimum purchase of 100 pieces (data valid as of February 25, 2022).

The figure below shows the construction of the discussed device and a simplified diagram of operation [1, 7, 10].



Fig. 1. The construction of a manual staff for planting seedlings, at the same time showing a simplified process of operation [1]

A similar solution as described above is a manual planter, with the difference that it is a wheeled planter. All the work is done manually: advance the device, feed the seedling to the feeder, plant it in a given place and crush the facility after blowing it up.

The construction of the device is based on a steel frame made of a pipe. Two road wheels, a grooving mechanism – preparing the planting place, a planting mechanism and a pressing mechanism are attached to this frame.

The device allows you to adjust the planting within the row spacing from 8 to 15 cm, the distance between the seedlings from 2 to 51 cm, while the planting depth can be set from 0 to 3 m. The weight of the described planter is 9 kg, while the manufacturer priced the device at \$ 200 in single-row option. There is also a two-row, three-row, four-row, six-row and eight-row option.

The figure below shows the construction of the discussed device [2, 7, 12, 13].



Fig. 2. The construction of a hand-operated, push-over plant for planting seedlings [2]

Another example of a machine design for planting seedlings is the Damcon brand design. It comes in several variants – from single-row to four-row. Thus, the device is operated by one, two, three or four

operators. Each operator has a tray for seedlings within his reach. The seedling is picked up by the operator during planting and manually placed in the facility. Then two discs press down on the planting site.

It is a fairly simple and compact structure, mounted on the rear of the farm tractor. The operator does not have a roof at his disposal. The structure is made of steel profiles with a rectangular cross-section.

When it comes to efficiency, it depends largely on the speed of the operator's work and the type of trees planted, which is also related to the speed of the tractor. Generally, the producer states that for the single-

row version the capacity is from 4,000 to 5,000 trees per day, while for the four-row version the capacity is 16,000 to 20,000 trees per day.

The design requires an agricultural tractor with a power of at least 20 HP (single row version) or more than 85 HP (four row version).

The figure below shows the construction of the discussed device [3, 10, 14, 16].



Fig. 3. Damcon brand structure, mounted on the rear linkage of the tractor, single-row version [3]

Another example of a planting machine is the RZS-1 / RZS-2 grooved forestry planter. It is a type mounted planter on the upper or three-point linkage of the agricultural tractor. The device was constructed on the basis of a platform, which includes a place for the operator and a place for a resource of seedlings. Planting seedlings is done manually on a prepared facility by inserting the seedling by the operator. Immediately behind the planting site, the pressing wheels, set at an angle to each other, converging to the ground, compact the planting place.

The planter is designed for planting trees with both open and covered root systems. According to the manufacturer, the root ball should not exceed 8 cm in diameter. Planting takes place in the stubble-cutting areas where the height of the remaining stumps does not exceed

the height of the tractor chassis to which the machine is attached. The tractor required to work with this type of planter should have a power of at least 50 kW, front-wheel drive and a hydraulic system.

According to the manufacturer's assurances, the daily capacity of the planter is 8,000-12,000 pieces for one-year-old pine and 6,000-10,000 pieces for two-year-old pine. The producer also gives the yield by specifying the area that can be covered with seedlings at the level of 0.6-1 ha (depending on the characteristics of the terrain).

The RZS-1 planter is operated by one operator, while the RZS-2 version by two operators. The operator controls both the lifting / lowering of the platform and the planting depth. The figure below shows the construction of the discussed device [4, 12, 20].



Fig. 4. Construction of the RZS-2 planter mounted on a tractor [4]

Another, this time quite advanced planting device is the Risutec ASP-720. According to the manufacturer Risutec ASP-720 is the most efficient planting device for large plantations. It has the possibility to seed eucalyptus, pine and other subtropical seedlings with a pot. It can be used on slopes of up to 15 degrees and is available in two versions, with 360 and 720 seedling capacities. Suitable for excavators over 18 tons.

The device is mounted e.g. on the excavator boom. It is equipped with a tray for seedlings, an element preparing the facility, a planting staff and an element for compacting the place after planting the seedlings. The weight of the device is 2,600 kg, and seedlings can be planted at a depth of up to 450 mm.

The figure below shows the construction of the discussed device [5, 6, 8, 9, 17, 18, 19].



Fig. 5. The structure of the Risutec ASP-720 planting device suspended on the arm of a tracked excavator [5]

Yet another device is the GNKp planter, which is intended for planting all tree species with a stem length of up to 60 cm, also on unscrewed clearings. This is made possible by two rubber wheels between which the worker places a seedling. When turning, the wheels

tighten and feed the seedling into a slot in the soil made with the help of a coulter and a coulter. Two metal press wheels clamp the soil around the seedling (Fig. 6) [11, 15, 20, 21].



Fig. 6. Construction of the GNKp planter [22]

The planter has the following parameters:

- dimensions: 2350 mm (length), 2150 mm (working width), 2230 (height),
- weight: 850 kg,
- number of rows: 1,
- planting depth: <250 mm,
- planter operator: tractor operator + 1 or 2 people,
- minimum tractor power: 70 HP,
- capacity: approx. 1000 seedlings / h.

3. Summary

The market offers (current list as of March 2022) many different planting structures. There are the simplest handheld devices that are far from being ergonomic. On the other hand, they are light, easy to use and cheap both in production and operation.

High-tech designs are also available. They have tools that will prepare the facility for planting seedlings and

complete planting, and they also have trays for seedlings. This allows the operator to work uninterrupted and efficiently, while ensuring the comfort of work, e.g. from the excavator's cab.

There is also a third group of planters: quite simple constructions, but combining the work of the machine (hanging the device e.g. on a tractor) with human work (manually feeding the seedling into the soil).

There is also a significant discrepancy in the offered functionalities of planting machines, the demand for power and efficiency. If you take into account only the designs offered by the market that require an external drive, the power requirement ranges from 15 to

120 kW. At the same time, devices that require the greatest power demand are by no means the most efficient.

The efficiency of the offered devices ranges from 800 to 40,000 seedlings per 8-hour working day. The discrepancies in this field, as in the case of power demand, are related to the capabilities of the machines; on what substrate they can plant, whether they allow the facility to be prepared and whether they are equipped with a tray for seedlings. The most efficient are multi-row devices, which are aggregated with the agricultural tractor, while the planting process is performed at the same time by several operators. However, this requires, among others previously prepared land for this type of cultivation.

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