Stubble potato planter for sustainable farming

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Abstract. This article presents an examination of fundamental technologies employed in agricultural crop cultivation, leading to the proposal of a strip tillage technique that integrates fertilizer application and potato planting in fields previously cultivated with winter crops, early vegetables, and intermediate crops. The article further discusses the design and technological process of a stubble potato planter, which facilitates the simultaneous execution of strip tillage, fertilization, and potato planting. The proposed technology and planter design aim to enhance the efficiency and productivity of agricultural practices.

1 Introduction

In all countries of the world, the use of resource-saving technologies and equipment is widely implemented in the direction of reducing costs and reducing the price of agricultural products, preserving and protecting soil and water, as well as biological diversity in the soil. In soil cultivation technology, special attention is paid to the composition of the cultivated soil and the supply of plant residues on its surface. This approach leads to the enrichment of the soil with easily decomposing organic substances, improvement of nutritional conditions for soil microorganisms and protection of the soil from direct sunlight, improvement of the thermal regime in the soil, restoration of its natural structure and increase in its productivity [1, 2]. In addition, the use of resource-saving equipment leads to a decrease in the degree of intensive tillage, an increase in the productivity of machine and tractor units, and a decrease in fuel consumption per unit of sown area when growing crops. Therefore, the use of such technology and technical means in growing primary and secondary crops is very promising.

2 Materials and methods

In recent years, around the world there has been an increased vulnerability of the surface soil of irrigated crop fields to water and air erosion, a decrease in the amount of microfauna and flora, affecting the structure and fertility of the soil [3]. Therefore, many countries around the world use resource-saving (no-till) technologies to maintain soil fertility and have achieved positive results in this direction. Similar technologies are widely used in the USA, Argentina,

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Australia, Brazil and Canada and make it possible to increase soil fertility and the development of microfauna and microflora in it. Using such technologies, it is possible to preserve and improve the soil fertility of the irrigated fields of our country, and create favorable conditions for the development of microfauna and microflora.

Currently, in 2023, it is planned to sow autumn cereal crops on 1 million 186.7 thousand hectares of irrigated arable land in our country [4]. Of these, 452 thousand hectares (38%) of arable land are open and flat areas, and 737.5 thousand hectares (62%) of arable land are cotton fields. Due to the unique soil and climatic conditions for farming in our republic, in order to rationally use arable land, provide the population with high-quality and abundant agricultural products, in fields cleared of early vegetables and intermediate plants, it is advisable to plant various secondary crops such as potatoes, corn, sunflower and others and receive high-quality products in large quantities.

To do this, repeat crops, including potatoes, can be planted in fields that are flat and open, and where cotton was grown and grain was harvested. Since, under local soil and climatic conditions, fall-planted grains will be fully developed in the spring months of the following year, their crops will be fully ripe in early June and harvesting will begin. The same period corresponds to the period of planting potatoes in the summer season [5]. To plant potatoes and other crops, fields cleared of grains, early vegetables and intermediate crops are cleared of plant residues, plowed without turning over the soil layer, crushed and crushed, and planting work is carried out. Such treatment of the soil of the sown area ensures complete softening of the soil, improvement of the process of its air saturation, complete burial of crop residues, pests, organic and green fertilizers with the soil. However, softening the surface of the field soil increases its erosion, causes the release of carbon from the soil into the air, which leads to an imbalance in microcommunications and the formation of a “greenhouse effect.” All this negatively affects soil fertility.

In addition, it is necessary to use a number of units for the full implementation of plowing, chiselling and crushing of the sown area. Their use, in addition to high consumption of fuel, energy, resources and various costs, leads to compaction of the soil of the cultivated field under the influence of wheels and working parts of arable, chisel and chopping units. This technology negatively affects the growth and productivity of the planted crop.

To prevent such situations, it is economically and environmentally more profitable to use resource-saving technologies and technical means that allow preserving and increasing soil fertility, taking into account the soil and climatic conditions of the lands on which winter grains, early vegetables and intermediate crops are grown. In addition, stubble, that is, the stems and roots of plants left in the place where grain is collected, partially reduces the impact of the wheels of agricultural machinery on the surface of the soil of the field, protects it, increases soil fertility, resists the growth of weeds, and also serves as a “mulch” to maintain soil moisture, protects the soil from water and air erosion.

One of the resource-saving technologies described above is the Strip-Till technology, in which the soil in the zone for sowing plant seeds is strip-cultivated to a given width b and a given depth a; if necessary, fertilizers are applied and seeds are planted in the soil of the treated strips. At the same time, since only the specified zone of the sown area is processed, i.e. the soil of the strip, the remaining 2/3 of the surface of the sown area (about 70%) is not cultivated. Fertilizers are applied to the area where plant roots are located once a year when the soil softens in autumn or spring [6]. Experiments have shown that the practical application of strip cultivation technology of cultivated lands can increase productivity by 25 % and save the consumption of mineral fertilizers by up to 50 % [7].

3 Results and discussion

Based on the technology described above, a technology was developed for planting spring potatoes in row crop fields where cotton was grown and grain harvested. This technology involves furrow cultivation of the soil to a width of 25 cm and a depth of up to 20-25 cm, application of fertilizers and sowing of potato seeds. on cultivated soil, in fields freed from grain, grown in cotton fields with rows 60, 76 and 90 cm wide. At the same time, the soil is not cultivated in beds, previously plowed fields with a furrow width of 35-65 cm. In the future, to obtain good quality potatoes It is possible to carry out watering untreated beds, softening the soil between rows of potatoes, unloading soil under potato bushes and other work.

To implement the technology for summer planting potatoes, a design and technological diagram of a combined potato planter was developed (Figure 1). This combined potato planter works when mounted with tractors of classes 0.9 and 1.4. It is designed for sowing potato seeds in two rows in row spacing with a width of 60, 76 and 90 cm. It mainly consists of three main parts: sections for softening the soil by strip plowing, equipment for applying fertilizers and a machine complex for planting potatoes.

A combined potato planting machine, consisting of soil softening sections, fertilizer metering devices and a potato planting machine complex, contains a wheel 1 and a suspension 2 mounted on a frame 3, while its moving working parts are driven by a chain drive from the main wheel.

The soil softener section of the machine (Figure 2) consists of a parallelogram suspension 4, a support wheel 6, which is installed in series from the row 5 and is designed to maintain the position of the row at the same height relative to the ground surface, cutting off plant residues in the soil, limiting the deformation zone of the soil layer. It consists of two flat disks 7, located symmetrically, and an arrow-shaped toothed soil softener 9, equipped with a seed conveyor 8.

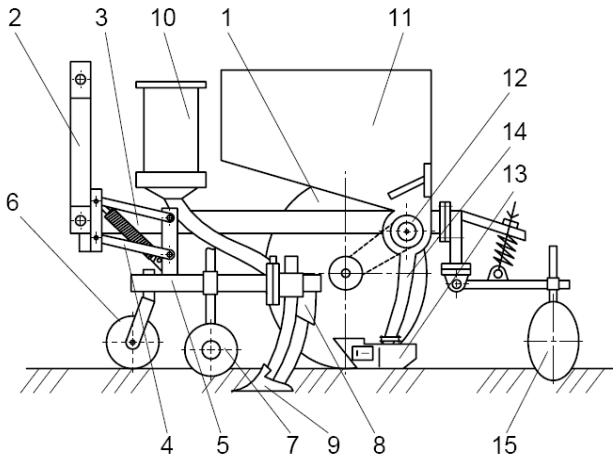

Fig.1. Design and technological diagram of a combined potato planter: 1–support-drive wheel; 2–suspension; 3–frame; 4–parallelogram hanger mechanism; 5–beam; 6–support wheel; 7–flat disk; 8–fertilizer conveyor; 9–occipital tooth; 10–fertilizer apparatus; 11–bunker; 12–disk measuring device; 13–opener; 14–seed conductor; 15–spherical disc soil digger.

The combined potato planter is equipped with two fertilizer applicators 10 type ATD-2, each of them supplies standardized balanced fertilizers through the fertilizer conveyor 8 under the wings of the arrow-shaped gear soil softener 9.

The potato planter of the machine consists of a hopper 11, a disk metering device 12, a coulter 13, a seed conveyor 14, and a soil digger made of spherical disks.

The dosing device of a potato planting machine is a sectional disk equipped with a return unit made of elastic material, which is placed in a box and installed in the lower part of the hopper.

Several cells are formed on the cylindrical surface of the cell disk. The sides of the cells are covered by the flat side walls of the disk. The lower part of the cell starts from the cylindrical surface of the disk, bends towards the inner side of the disk in the form of an involute, penetrates to a depth equal to the size of the separated potato tuber, and then rises vertically. to the cylindrical surface of the disk in the radial direction, forming a cell together with the side walls [8, 9].

A potato planter uses a seeder that is aimed into the soil at an angle that does not penetrate the soil. It is equipped with a soil-cutting scraper, which clears the path along which the planter moves, moving strips of pruning and plant residues formed on the surface of the cultivated soil to the right and left of the potato planting zone. The soil drive of the potato planter consists of two spherical disks, arranged symmetrically and located at an angle of attack opposite to each other, it is designed to deepen planted potato tubers into the soil and to fill the bed with soil.

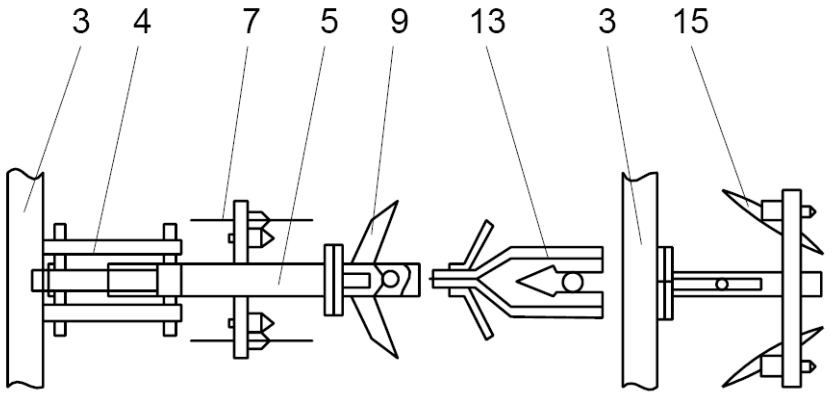

Fig. 2. The working section of a combined potato planter, which plows the field, applies fertilizer and plants potatoes: 3 – frame; 4 – parallelogram hanger mechanism; 5 – class; 7 – flat disk; 9 – occipital tooth; 13 – opener; 15 – spherical disc soil auger.

The technological process of operation of a combined potato planter, cultivating and planting potatoes, is carried out as follows. When the unit moves, two flat discs mounted on a grid create a 25 cm wide path and cut and cultivate the soil to a depth equal to the planting depth. The discs simultaneously ensure the accuracy of the width of the boundaries of the deformation zone of the treated soil. A symmetrically installed arrow-shaped tooth penetrates the soil of the cultivated strip to a depth of 20-25 cm and softens the soil. At the same time, the fertilizer measured by the fertilizer applicator is transferred to the wing base of the swept tine post by the fertilizer conveyor. The pusher of large solid pieces of earth and crop residues moves pieces of soil and crop residues on the surface of the treated soil to the right and left, leveling the soil surface. Creates conditions for high-quality operation of the seeder. The seeder, set at a given sowing depth, creates a furrow in the cultivated soil. In this case, the potato tuber, separated from the total mass of potatoes by a dispenser, enters the seed conveyor and through it into the hole of the soil bed. A spherical disc soil burrower moves the soil onto the planted potato tuber and the soil bed formed by the cultivator, partially compacting the soil.

The flat disks of the support wheel of the soil softening section of the combined potato planter ensure that the arrow-shaped tooth post and the depth of fertilizer application are set to the required depth. The spring of the parallelogram mechanism of the section ensures the movement of the working bodies, copying the topography of the cultivated land, and the pressure force necessary to immerse them in the soil [10-14].

4 Conclusions

The developed combined potato planter using Strip-till technology on the cultivated fields, where the harvest of grains, early vegetable crops and intermediate plants grown in plain and cotton fields is harvested, provides strip tillage of the soil up to 25 cm wide and up to 25 cm deep in one step. simultaneous application of fertilizers to the soil and planting potato seeds.

The use of the proposed combined potato planter allows you to save energy, resources and costs, as well as increase potato yields due to the fact that plowing harvested fields for planting potato seeds, chiseling and harrowing, as well as planting work are performed by one unit.

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