ISSN 1454 - 8003
Proceedings of 2016 International Conference on Hydraulics and Pneumatics - HERVEX
November 9-11, Baile Govora, Romania

SMART ROOT CUTTING MACHINE USED IN BIOTECHNOLOGY FOR DIRECTING THE GROWTH OF ROOT SYSTEM IN ORCHARDS

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Abstract: *Worldwide the trends of evolution in the field of horticulture are the easy maintenance for plantations, with as small volume of work, control of nutrients, water treatment and maintenance of trees. Thereby have appeared intensive and superintensive orchards. In order to make easier maintenance operation and harvesting, the trees must be small sized, planted in rows with a high density. Irrigation is done with fertilizers on a certain area, along of the root system. The agricultural machines have developed properly with the appearance of new specific machines, among which are controlled machines for establishing load of inflorescence of fruit and controlled cutting machine for root system. Quality of the works done by cars must comply with the technology fitted in the limits imposed by the orchard technologist. In order to obtain quality work it is necessary to have high precision machines, with the possibility to precise control of the working tool. This can be done using distance, horizontality, and angle sensors that send the position of the working tool to an automatic control system, than through a hydraulic system it corrects the tool position, keeping it in a field of required working technology.*
This automatic control, via the hydraulic system, corrects the tool position, keeping it in a field of the required working technology.

Keywords*: horticulture, root system, hydraulic systems, intelligent control systems, biotechnology*

1. Introduction: Trends in world fruit production

World pomiculture in general and in Europe in particular, tends to reduce the growth vigor of cultivated fruits species, and to establish intensive and superintensive orchards, with high density of trees per unit area (ha).
This major objective is new trend in the world fruit production. This objective can be achieved primarily through the creation of low vigor vegetative rootstock on which are grafted different varieties of crops, of high biological value and outstanding productive performance.
The major aim of this trend is to reduce the vigor and growth of different varieties and fruit species, such as apple, pear, cherry, and walnut. On such trees (orchards), with low size, can be easier to work, with greater efficiency and less technological workforce, such as cutting, phytosanitary treatments, fruit harvesting, etc.
Recent research in pomiculture has shown that is beneficial cutting a portion of the root system of the trees, coupled with cuts made in the crown. They contribute to the preservation of low waist trees and maintaining root growth within the nutritional space of each tree.
Only on a strip of soil beneath rows, maintained free of weeds (not all over the orchard), are applied the rules of localized irrigation (drip, micro sprinkler) and fertilization (fertigation), thus increasing the efficiency of water and fertilizer used and consumed almost only by the crop plants (trees).
The equipment for cutting the roots at a distance of 50-60 cm from the trunk of the tree (strip of the row), it only maintains the growth of the rootstock roots, under the projection on ground of the tree crown.
It has been demonstrated through research that cutting the root system is stimulating the growth of multiple branches. This cutoff, increases root mass and capacity to absorb water and mineral salts from the irrigated and fertilized soil.

The Equipment for cutting the roots is recommended only for high density orchards with reduced vigor rootstocks, where the root system of rootstocks is quite shallow and quite easy to cut the roots, that usually do not exceed 3-4cm in diameter and no deeper than 40-60cm.

2. Romanian specificity in the evolution of fruit growing

In our country were planted intensive and superintensive orchards. Most of them are investments with European money, and were built with specific breeds for intensive and super intensive orchards, from import, without making a prior acclimatization. The results that followed have created dissatisfaction among fruit growers, who publicly demanded the introduction of a variety of acclimatization stages, before being brought into the country, a situation that is found in animal breeds. Along with orchards were brought a wide range of machines for maintenance and harvesting. From these, root cutting machines should be adapted to the circumstances of fruit growing in Romania, with heavy soil (clay) and hilly specific arboriculture, where soils are also with different textures and harder penetration. At the Institute of Maracineni were planted intensive and superintensive orchards, where the behavior of different breeds of fruit is monitored, and are tries to adapt a wide range of machines to the conditions of Romania.

Fig. 1. Picture of an superintensive orchard from ICDP Pitesti-Maracineni

In fig. 1 is present a picture from Maracineni Institute, of a superintensive orchard. It can be observed irrigation system applied in the row of plants, containing micro sprinklers that irrigate an area along the row. Nutrients that are applied in the irrigation water are found in that area, so that the root system should be conducted properly.

3. Romanian proposal for smart root cutting machine

Modern technologies of cultivation of orchards require development control of the plant root system in the soil. This machine can cut roots that are getting further away from the area where irrigation water and fertilizers are applied. In intensive and superintensive orchards watering is carried out on a belt along the plant row. The root cutting machine is a device worn by a tractor, and is equipped with a knife that penetrates the soil up to a depth of 60 cm and cuts the roots at a certain distance from the row. In practice, it has been observed that due to soil profile, elasticity of the working tractor system, resistance to advancing uneven soil knife, cuts are inconsistent.
Through collaboration between INOE 2000-IHP with ICDP Pitesti-Maracineni it has been proposed root cutting machine with a smart control of positioning the working tool, against and among the trees and ground. It starts from a root cutting machine, equipped with a hydraulic system with raw

control, and finalizing with an innovative machine with intelligent positioning and maintaining cutting tool, ultimately proving the functionality. In order to achieve the cutting roots machine is needed research in the field of machine building in collaboration with pomiculture and informatics. These domains are in the area of industrial research, experimental and experimental development.
In the country there are no production of such root cutters, but we know that there are a blade which adapts to rippers blades, which are used in farming, that are used in vegetable growing, which cuts the roots vertically without the possibility of adjusting the distance from a reference point.
Internationally there are a wide variety of root cutters. RAMONT STAR SRL imports from UE the car model with the following characteristics PKH working depth 65cm, necessary power 62 HP, and dimensions of 135cm x 190cm x 195cm (fig. 2). This machine is equipped with an adjustable cutting position, which can be done rough by hand by the tractor driver, and brings the knife into the work area, by manual controlling of the hydraulic cylinders.[1]

Fig. 2. Root cutting machine presented by company Ramont Star SRL, Model PKH [1]

Worldwide there are known Italian and Spanish companies (Jympa) which produce root cutting machines.
This machine came from the need to control the knife position against the root system and guarantee this position. The achievement of this smart machine in Romania is an absolute novelty. It is part of the worldwide trend to introduce smart machines that work to help workers and to increase the quality of agricultural works.

Fig. 3. Root cutting machine during work

The following adaption proposal starts from shredder of roots, carried by tractor as shown above, which has an hydraulic drive system for adjusting the distance from the row of trees and a cutting depth operated from the tractors hydraulic distributor, gross adjustments made by the tractor driver in work in order to protect the most developed branches, and in the end is sought a smart demonstrator who installed on the tractor it measures the distance to the ground and among the

trees, and automatically regulates the distance regardless of the position of the tractor. All components and the general solution are for the global scale, because smart systems are a leading technology.
The equipment that cuts roots at a distance of 50-60 cm from the trunk of the tree (the shaft line), it maintains growth of the root system under the tree crown's projection on the ground. The cutting roots machine is passing among the trees with the working body, which can tilt at an angle under the roots, trimming the roots in the soil which are getting away from the line row of the trees.
It starts from a machine that cuts at maximum depth of 65 cm. As soon as the machine begins cutting it can be observed that the size of the knife which is out of the soil varies from 40 cm to 58 cm (fig 4). This is because of the soil profile on which the tractor is running and the resistive force of the knife in the soil that gives a component that tends to lift the entire assembly and rotate it towards the longitudinal shaft of the tractor. The situation is shown in the images below. Notice how the depth of cut on the left of the knife into the soil shrinks. Therefore the machine does not realize the plan of cutting provided.

Fig. 4. The comparison on root cutting machine of cutting depths, depending on the position of the working apparatus

To eliminate these drawbacks it must be achieved an intelligent control and maintain the cutting depth. It will be used probes to measure the distance from cutting knife from the ground, devices measuring horizontally off the cutting machine, intelligent probes in front of the row of trees. All these data introduced in the intelligent controller command of the hydraulic cylinders that will hold the position of the knife in predetermined areas.[3][4][5]
For measuring horizontality of the machine it will be used a SMART Controller, a sensor for tilt on two axes Level Bar, experimental products from INOE 2000 IHP with following characteristics: 9-28 VDC/50mA Supply, Resolution angle of 2 degrees, Measurement range: adjustable $1^0 \div 3^0$.[3][4][5]

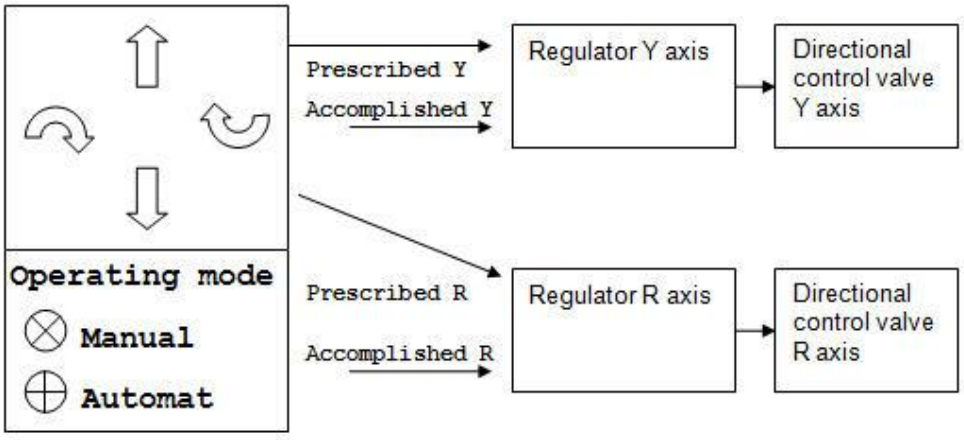

Fig. 5. Automation scheme for the smart root cutting machine taken from the header's ground tracking system of the combine grain harvester [2]

In fig. 5. is presented the scheme of automation control system of the cutting knife. The signals are taken from sensors located on probes and from the clinometer and this orders the machines positioning cylinders Y and the rotational axis R to keep the cutting parameters, imposed by the orchard technologist. If Y and R are the various measured quantities, then they must take values in range of $Y_{min}<Y<Y_{max}$ and $R_{min}<R<R_{max}$.[2]
The two research centers have a very good research expertise in areas of the proposed theme, combining more than 40 years in servo hydraulic systems the HYDRAULICS AND PNEUMATICS RESEARCH INSTITUTE INOE 2000-IHP and with experience in orchard domain Maracineni Research Institute and Production for orchard.
From INOE 2000 – IHP experience it has been resolved the issue of positioning equipment for washing glass beside of solar panel.

Fig. 6. Washing photovoltaic panels machine with smart distance control from the panel, made of INOE 2000-IHP [6]

Fig. 7. Combine harvester, equipped with smart header for tracking the configuration of the soil, made of INOE2000-IHP in collaboration with Semanatoarea SA and INMA Bucharest [7]

Another project RELANSIN 2004-2007 realized by INOE 2000 - IHP in collaboration with SC Semanatoarea SA where the aim was that the combine harvester's cutting machine and cutting table to fallow the soil profile. The project was realized through the use of probes that can see the distance from the soil, and an automation system that are keeping the distance by operating the lift of cylinder of the cutting table, which revolves around an axis, which are connecting the cutting table to the combine.

Conclusions

Modern biotechnology controls all aspects of fruit development from planting trees rootstock to the choosing of the breeds, the design of future plantations, choosing the future vigor of trees, trimming the branches, directing the branches and stems. Of great importance to intensive and superintensive orchards is directing the root system by controlling development, by trimming their roots in the soil similar to pruning. This is to respond to the irrigation system and the application of fertilizers. The machines brought in Romania have demonstrated the need for adapted machines in

our orchards with heavy soils (clay) in hilly soils with different textures and penetration heavier than the cutting device.

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