[1.]Eugen MARIN, [1.]Marinela MATEESCU, [1.]Dragoş MANEA, [1.]Gheorghe GHEORGHE

TECHNICAL EQUIPMENT FOR WORKING THE SOIL IN THE ROW OF FRUIT TREES SIMULTANEOUSLY WITH ROOT CUTTING TO MODERATE SHOOTS GROWTH AND PRECISION FOLIAR FERTILISATION

[1.]National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, ROMANIA

Abstract: INMA Bucharest designed, produced and tested an experimental model of technical equipment for working the soil in the row of fruit trees along with root cutting to moderate shoots growth and precision foliar fertilization, within the innovative technology of fruit plantation maintenance in the rural areas. The paper presents experimental research with the aggregate of the TD 80D New Holland tractor and the ETR technical equipment for determining the qualitative working indexes of soil working and root cutting. The results obtained generate valid solutions for the achievement of a significantly improved product within the fruit plantation maintenance technology and offer to the interested economic agents an efficient product, adapted to the specific heavy conditions in the country.
Keywords: soil working, root cutting, fruit trees

INTRODUCTION

The objectives of world fruit growing in general and in Europe, in particular, are directed to reduce the growing vigour of cultivated fruit species (apple, pear, cherry, sour cherry and walnut) by mechanical interventions on the root system in order to establish intensive and super-intensive fruit plantations with high tree density per area unit (ha). On these small-scale plantations, technological works such as cuttings, phytosanitary treatments, fruit harvesting etc, can be made easier, with greater efficiency, less workforce and maintaining the same production (Hoying. 2017).

Worldwide research in fruit growing has shown that cutting a part of the tree root system, correlated with crown cutting, is beneficial, helping to keep trees down and maintaining root growth within the nutritional space of each tree.

The area of nutrition may be a field with herbicide applied and/or worked on a 1-1.4 m band under the tree rows where one can apply norms of localized irrigation (drip, micro-spraying) and fertilization (fertigation) of which only trees can benefit (Dorais et Ehret. 2008).

A root cutting equipment at a distance of 50-60-cm from the trees trunk (row axis) with high quality working indexes maintains root growth only in the nutrition space and is a control operation of fruit trees growth.

Root cuttings must be made in the side of the row by mechanically reducing their length during vegetation, on both sides of the row, alternatively, one year on one side and in the second year on the other side, in order not to compromise the stability of the fruit trees. The cut of a root should be like that of a branch, be straight, without fringes and keeps the required distance.

MATERIAL AND METHOD

The experimental researches were carried out with a technical equipment for soil working on the row of fruit trees. Together with root cuttings to moderate shoots growth and precision foliar fertilization. ETR (figure 1) was made by INMA and intended for the maintenance of fruit plantations in order to increase fructification efficiency by performing a single-pass ploughing on a strip at a distance from the trunk to maintain loose soil to the surface, cutting the root at a distance from the trunk to moderate the shoots growth and foliar fertilization.

Figure 1 - Technical equipment for working the soil in the row of fruit trees along with root cutting to moderate shoots growth and precision foliar fertilization, ETR

ETR technical equipment is designed to perform proper root cutting works in all soil types where fruit plantations are located, ranging from mild to hard and with a stony structure soil, specific to plantations located on hill areas; it is robust and has stability in the working direction by maintaining the same distance from the tree axis (Marinela Mateescu et al.. 2016).

It performs the following works in the same time:

- ploughing on a strip at a distance from the trunk to maintain a loose soil to the surface;
- root cutting at a distance from the trunk to moderate shoots growth;
- precision foliar fertilization.

The ETR technical equipment consists of a metal frame fitted with a coupling system at the three-point suspension mechanism of a wheeled tractor, a wheel for copying the soil and adjusting the working depth of a right plough body for ploughing, a support for an articulated guide and means for adjusting the cutting depth and blocking in the vertical cutting direction of a disc-type working part with a large diameter for root cutting (Marin E. et al.. 2015) and a device for precision foliar fertilization.

The main technical characteristics of the ETR technical equipment are:

— power source: 80 HP wheeled tractor
— strip width, 250 mm
— strip depth, 150..200 mm
— working depth of the large diameter disc knife, 10...250 mm
— cutting distance from the trunk, 500...600 mm

The experiments made in laboratory-field conditions to determine the qualitative and energetic indices of ETR technical equipment, were performed on the INMA Bucharest experimental plot according to the specific test procedure made for this purpose. The following measuring and control equipment and instruments were used to test the ETR equipment: metallic tape, mechanical timer, device for measuring plow depth, rulers, set squares, poles, stakes. etc.

The following qualitative working indexes were determined under laboratory conditions:

— root cutting depth;
— distance from the trunk to the root cutting disc;
— soil working depth;
— distance from the trunk to the soil working plough body.

RESULTS

— *The root cutting depth* was determined using the measuring tape by measuring the distance between the surface of the non-worked field and the rim of the large diameter disc knife active part (Figure 2).

Table 1. Average values of root cutting depth

Repetition	a cm	a_m cm	S – standard deviation cm	Cv- variation coefficient %
Working speed: 3 km/h				
1	19.6	19.42	0.29	1.49
2	19.4			
3	19.4			
4	19.2			
5	19.5			
Working speed: 5 km/h				
1	19.4	19.36	0.27	1.39
2	19.3			
3	19.6			
4	19.3			
5	19.2			
Working speed: 7 km/h				
1	19.2	19.20	0.37	1.95
2	19.3			
3	19.4			
4	18.9			
5	19.2			

Measurements were made in 5 points at intervals of 2 m between them, for three working speeds (small, medium and maximum) of the ETR technical equipment. Based on the measurements, the *average depth of root cutting* was calculated. Table 1 shows the average values of root cutting depth. The coefficient of variation is defined as the ratio between the value of the standard deviation and the average value and is given as percentage (Marin E. et al.. 2012).

Figure 2 – Measuring root cutting depth

— *The Distance from the trunk to the root cutting disc* was determined by means of measuring tape by measuring the distance between the trunk and the rim of the large diameter disc knife active part (Figure 3). Measurements were made in 5 points at intervals of 4 meters between trees for three working speeds (small, medium and maximum) of the ETR technical equipment. Based on the measurements, the *average distance from the trunk to the root cutting disc* was calculated.

Table 2 shows the average values of the distance from the trunk to the root cutting disc.

Table 2. Average values of the distance from the trunk to the root cutting disc

Repetition	d cm	d_m cm	S-standard deviation cm	Cv- variation coefficient %
Working speed: 3 km/h				
1	58	56.4	3.33	5.90
2	56			
3	54			
4	58			
5	56			
Working speed: 5 km/h				
1	60	59.3	4.51	7.61
2	58			
3	56			
4	62			
5	60			
Working speed: 7 km/h				
1	54	53.5	4.51	8.47
2	52			
3	50			
4	56			
5	54			

Figure 3 - Measuring the distance from the trunk to the root cutting disc

— *Soil working depth* was determined by means of measuring tape by measuring the distance from the level of the soil resulting from the work to the bottom of the furrow (Figure 4). Measurements were made in 5 points at intervals of 2 m between them for three working speeds (small, medium and maximum) of the ETR technical equipment. Based on the measurements, the *average soil working depth* was calculated. Table 3 shows the average values of the soil working depth.

Table 3. Average values of soil working depth

Repetition	a_l cm	a_{lm} cm	S-standard deviation cm	Cv-variation coefficient %
Working speed: 3 km/h				
1	16.2	16.12	0.45	2.80
2	16.0			
3	15.8			
4	16.4			
5	16.2			
Working speed: 5 km/h				
1	16.0	16.02	0.33	2.10
2	15.8			
3	15.6			
4	16.0			
5	15.8			
Working speed: 7 km/h				
1	15.6	15.44	0.36	2.33
2	15.4			
3	15.8			
4	15.6			
5	15.2			

Figure 4 - Measuring soil working depth

— *The distance from the trunk to the soil working plough body* was determined by means of measuring tape by measuring the distance between the trunk and the furrow wall made by the soil working plough body. Measurements were made in 5 points at intervals of 4 m between trees for three working speeds (small, medium and maximum) of the ETR technical equipment. Based on the measurements, the *average distance from the trunk to the soil working plough body* was calculated.

Table 4 shows the average values of the distance from the trunk to the soil working plough body.

Table 4. Average values of the distance from the trunk to the soil working plough body

Repetition	d_t cm	d_{tm} cm	S-standard deviation cm	Cv-variation coefficient %
Working speed: 3 km/h				
1	130	126.4	5.03	3.98
2	124			
3	124			
4	126			
5	128			
Working speed: 5 km/h				
1	128	126	3.61	2.86
2	126			
3	124			
4	128			
5	124			
Working speed: 7 km/h				
1	126	125.2	4.51	3.60
2	128			
3	124			
4	122			
5	126			

The energetic indexes determined were:

— Effective working speed V_e. in km/h

A linear space *s* was measured by means of measuring tape on the test field and the beginning and end of this space was marked with 2 stakes. When the aggregate became operational in the test field, the timer was switched on and at the exit of that respective space it was stopped and the time *t* for passing the space *s* was read out on the timer. Determinations for three working speeds were made. The operation was repeated 5 times for each working speed and based on this, the arithmetic mean was calculated.

With recorded data, the travel speed *v* was calculated with the following relation (*Tecusan et Ionescu. 1982*):

$$V_e = \frac{3.6 \times s}{t} \text{. km/h}$$

— The theoretical working capacity $W_{ef.}$ in ha/h

The theoretical working capacity was calculated with the relation (Caba et al. 2013):

$$W_{ef} = 0.1 \times B_l \times V_e \text{. ha/h}$$

where: B_l is the working width of the technical equipment, in m; V_e – working speed, in km/h.

Energetic indexes for the aggregate TD 80D New Holland tractor (http://agriculture.newholland.com. 2011) + ETR technical equipment are shown in Table 5.

Table 5. Energetic indexes for the aggregate TD 80D New Holland tractor + ETR technical equipment

Parameters determined	Value				
Travel speed, km/h	3.0	3.1	3.2	4.9	5.0
Theoretical working capacity $W_{ef.}$ ha/h	0.66	0.68	0.70	1.07	1.1

Figure 5 shows an aspect during the determination of energetic indexes for the aggregate TD 80D New Holland tractor + ETR technical equipment.

Figure 5 - Aspect during the determination of energetic indexes for the aggregate TD 80D New Holland tractor + ETR technical equipment during root cutting and soil processing works

CONCLUSIONS

— The qualitative working indexes achieved during the experimentation of the ETR technical equipment fall within the agrotechnical requirements corresponding to each individual work. The values of the variation coefficients were below 10%. which is admitted by the agrotechnical requirement, as follows:

— Variation coefficient values of root cutting depth depending on the working speed are graphically represented in Figure 6;

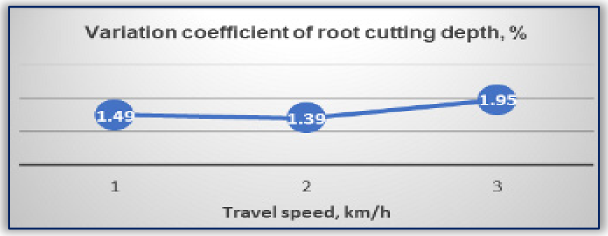

Figure 6 - Variation coefficient of root cutting depth depending on the working speed

— Variation coefficient values of the distance from the trunk to the root cutting disc, depending on the working speed, are graphically represented in Figure 7;

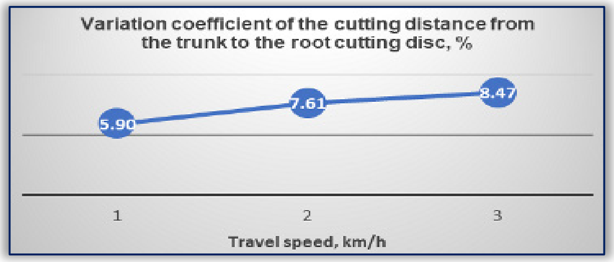

Figure 7 - Variation coefficient of the distance from the trunk to the root cutting disc depending on the working speed

— Variation coefficient values of soil working depth depending on the working speed are graphically represented in Figure 8;

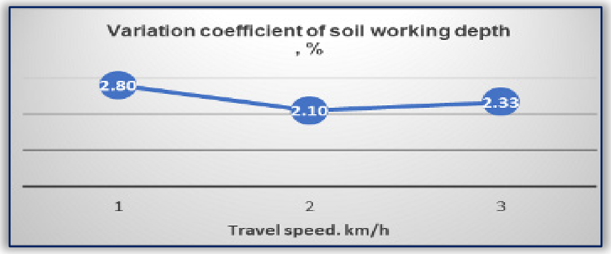

Figure 8 - Variation coefficient of soil working depth depending on the working speed

— Variation coefficient values of the distance from the trunk to the soil working plough body depending on the working speed, are graphically represented in Figure 9.

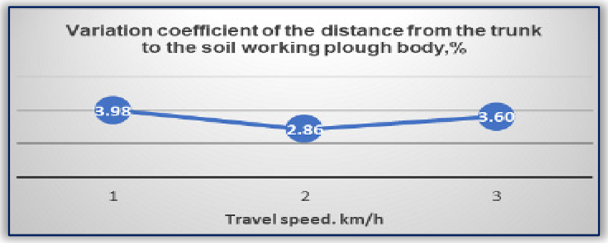

Figure 9 - Variation coefficient of the distance from the trunk to the soil working plough body depending on the working speed

— The energetic indexes achieved during the experimentation of the ETR technical equipment fall within the agrotechnical requirements corresponding to each individual work.

— Experimental research has enabled the technical and technological validation of the solutions addressed when designing the components of the ETR technical equipment;

— Experimental results make it possible to develop a useful recommendation for farmers applying innovative maintenance technology for fruit plantations.

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