The use of crushing equipments for soil management practice in chestnut orchards

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Abstract

Chestnut orchards have an important role on the rural economy and landscape ecology of Northern Portugal. Previous studies have shown the need of new management practices in those agro-ecosystems in order to improve its productivity and sustainability and, one of the envisaged techniques is the use of new equipment that destroys the vegetation under canopy and crushes the organic residues without disturbing the soil. So, in order to get information related to the effect of that practice, on these systems, a study was carried out since 2002, where the use of that equipment (NTR) is compared with the traditional tillage (TTC), the use of irrigated seeded pasture (ISP), droughty seeded pasture (USP) and the maintenance of natural vegetation cover under canopy (NTV).

The methodology used in the trials consists of different equipment's velocity, at the PTO standard regime, which enables the breaking in different sizes of the vegetal ground surface material, especially the leaves and burs, with no or light soil mobilization increasing the transformation process of organic residues and decreasing the nutrient losses from residues removing by wind.

The obtained results related to that are now reported and the following conclusions are allowed: (i) The average area of the entire leafs were 4845.50 mm^2; (ii) Increasing the tractor's velocity from 1.12 to 3.58 km/h, keeping the PTO regime, the leaf's area increases from 1916.01 to 2417.02 mm^2, which suggests the highest recommended equipment's velocity of 2.0 km/h, corresponding to 3.79 h/ha work rate, near half of the work rate of the tine cultivator (1.92 h/ha) normally used in this region; (iii) Related to the effects on soil physical properties, soil compaction shows higher values on soil surface of NTR plots, which rise the need of new studies and the choice of a new equipment in order to confirm that result and avoid future negative impacts on soil physical conditions.

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Keywords

Weed control, residues processing, soil properties.

Introduction

Chestnut orchards have an important role on rural economy and landscape ecology of Northeast Portugal and European Mediterranean Countries (Mantas, 1994; Bounous, 1999, Fontán, 2001, Conedera *et al*. 2004). However, in the case of Northern Portugal, the intensive traditional management practices, respecting soil tillage, pruning and fertilising are affecting the sustainability of those systems. In fact, obtained results from several studies, carried out over the last ten years, shows that the cropping intensity leads to unfavourable conditions for trees growing and health. The occurrence of ink disease induced by *Phytophthora cinnamomi* seems much related to the intensity of cropping practices, mainly soil tillage operations, which is ascribed to the decreasing of organic matter and biodiversity, the damage of roots, the dissemination of the pathogen and the increasing of unfavourable soil physical conditions for root development (Martins *et al*. 1999, Portela *et al.* 1999, Marcelino *et al*. 2000). The obtained results of those studies show that the regular frequent tillages don't provide any advantages to the soil available water until 30 cm depth and on biomass production, when compared with less intense tillage practices, such as no tillage with maintenance of natural ground vegetation or with seeded pasture, under tree canopy (Raimundo *et a*l. 2000, Raimundo, 2003, Branco, 2003). So, new soil management practices are envisaged being one of them the use a crushing equipment which broke and crush organic residues and cut ground vegetation with no or light soil mobilization. This can lead to several advantages, such as weed control and water conservation, increasing organic residues decomposition, decreasing nutrient losses by wind residues removing, mainly the leaves, improving soil physical properties and ecosystem sustainability. Concerning the effect of this practice, compared with traditional one, recent studies, developed on 2003 and 2004, have shown more favourable values of soil moisture at 30 cm depth and no differences respecting fruit production and quality between the two practices (Martins *et al*., 2005).

Taking in account that smaller is the size of that material faster is its transformation into organic matter and less intense is its removing by wind, in the present study are reported the obtained results respecting to the effects of this equipment on residues crushing and on soil physical properties evaluated by the soil compaction.

Material and methods

The experimental device was established on an adult chestnut orchard in Northeast Portugal, near *Macedo de Cavaleiros* municipality and four treatments were tested: (a) NTR - no tillage using crushing equipment to control weeds and broke organic residues; (b) USP - no tillage with maintenance of droughty seeded pasture; (c) ISP - no tillage with maintenance of irrigated seeded pasture; (d) TTC - traditional tillage with tine cultivator three times a year, as reference. Each treatment has three replications and is applied on plots with near 900 m^2 area and 6 adult trees (38 years old) of *Longal* variety. On NTR treatment, the equipments illustrated on figures 1 and 2 were used at different tractors velocity and standard equipment regime and the size of broken fragments of leaves were measured in order to decide which tractor velocity is better to the equipment operation. Only the leaves were measured because the burs become almost pulverized. The mounted crushing equipment has 140 cm width work and the road side 110 cm.

Figure 1- Crushing equipment with hammers

Figure 2- Crushing equipment with knifes

To the leaf dimension determination these must be previously plunged in tray water and, after this, compressed between two absorbent cloths to become flat and get with precision its dimensions. After that, the leaves are digitalized in a scanner, and the images analysed with specific software which measure the area, perimeter, longer and smaller axes.

Related to the effects on soil physical properties, soil compaction was measured with Eijkelkamp Penetrologger device, making 30 measures in the soil under the canopy of each tree, on 3 trees by treatment.

Based on the obtained results from the leaves fragmentation tests, the best compromise between the higher work rate which comes closer to the work rate of the tine cultivator, and the smaller size of the crushed material (leafs, burs and weed), which improves its transformation into organic matter, was selected.

Results and discussion

Leaves fragmentation

Results related to the obtained dimensions of leaf fragments (figure 3) according the tractor velocity are presented on table 1, as well as the whole leaves. As it shows, the area of fragments decreases with the increasing of tractor velocity.

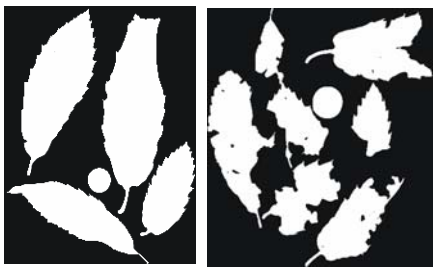

Figure 3- Whole and crushed leaves

Keeping the regime equipment, increasing the tractor velocity from 1.12 to 3.58 km/h, the leaf's area increases from 1916.01 to 2417.02 mm^2, reason why the highest recommended velocity is 2.0 km/h, which corresponds to 3.79 h/ha work rate, near half of the work rate of the tine cultivator (1.92 h/ha); The average area of the whole leafs is 4845.50 $mm^{2.}$

Table 1- Dimension parameters of leaves fragments according different tractor speed.

Leaves	Speed	Area	Perimeter	Major lenght	Minor lenght
Whole vs Crushed	(km/h)	(mm2)	(mm)	(mm)	(mm)
Whole	0.00	4845.50	402.65	139.97	52.34
Crushed	1.12	1916.01	333.05	95.80	38.66
Crushed	2.08	2292.99	339.96	92.73	45.28
Crushed	3.68	2417.02	330.49	92.27	44.43

Soil compaction

Considering that soil compaction is a result of the soil physical environment, this property was used to evaluate the effect of the different practices on that environment and was measured in the different studied practices as data reported on figure 4. Respecting the NTR practice the measuring was done after use the mounted crushing equipment (figure 1), and the obtained results show: (i) Lowest resistance at surface on TTC plots but, after 10 cm, it increases to similar values than the other treatments (figure 4); (ii) Higher values at surface on NTR plots, which may be ascribed to the compaction caused by the equipment operation; (iii) Lower values on deep layers in no tillage plots.

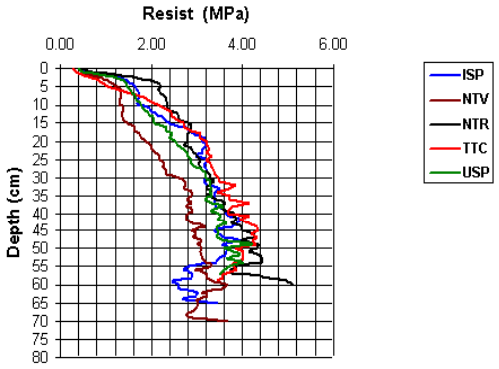

Figure 4 - Surface resistance in different situations

Conclusions

Taking in account other developed studies related to the use of the present equipment it seems a good solution to the management of soil chestnut orchards.

Related to the equipment operation, the obtained results with the mounted crushing equipment (figure 1), considering the relation between work rate and residues fragmentation, seems to be 2.0 kmh^{-1}, which is near half of the work rate of tine cultivator.

However, and considering the negative impact on soil compaction due to the mounted crushing equipment, new tests are being carried out with another kind of crushing equipment (figure 2), in order to study the effects on soil compaction and on residues fragmentation, trying to find the best solution for this kind of agricultural operation.

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