USING SOIL CONDITIONER AND ORGANIC MULCH TO IMPROVE THE SOIL WATER RESERVE IN A QUINCE PLANTATION

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RESEARCH ARTICLE

Abstract
Over the past few decades, the world's population has been growing steadily, placing pressure on crop yields and increasing the demand for food production. Furthermore, the sustainability of fruit production is significantly impacted by issues such as water scarcity, climate change, and the loss of arable land.
Notwithstanding productivity, preserving plant biodiversity and achieving long-term sustainability have become important objectives in orchard management, especially along tree rows. Therefore, frequent tillage or chemical herbicides must be replaced with more environmentally friendly ways to eliminate weeds in tree rows. Soil mulching lowers surface evaporation and helps preserve limited supplies of water because drought, heat stress, and the careless use of water during the growing season threaten the sustainability of fruit production in arid regions.
This study aimed to compare the effectiveness of inorganic mulches, which are mainly composed of plastic-based materials, with organic, biodegradable sheep wool mulches.
Adopting appropriate water management practice systems is necessary for the efficient use of available water in regions with rainfall deficits. Soil conditioners have been shown to be effective tools for increasing soil water retention capacity, lowering cumulative evaporation and infiltration rates, and improving soil water conservation Starting from the attributes of hydrogels and the unique issues associated to rainfall area, studies on the water absorption properties of the biodegradable superabsorbent (Zeba) revealed its higher water absorption capacities. When in contact with water, it forms a gel, dehydrates and rehydrates repeatedly throughout a season, and releases the captured moisture based on plant needs, nutrient intake, and fruit crop production parameters.

Keywords: biodegradable mulches, sheep wool, crop production, Zeba, sustainable fruit growing
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INTRODUCTION

Sustainable tree row management in orchards is essential not only for healthy tree growth and quality fruit production, but also for maintaining soil quality and promoting biodiversity within orchards. Row management involves managing weeds in orchards, as they can aggressively compete with fruit trees for available nutrients and water, essential for plant growth. (Merwin, 2003) Therefore, proper weed management is vital in orchards, in order to minimize weed competition with fruit trees and ensure quality fruit production (Cavender et al, 2014; Steenwerth, Guerra, 2014) Weed control based on traditional tillage has been shown to have several negative effects on tree growth, fruit yield and quality (Granatstein et al, 2009, 2010, Neilsen et al., 2003), tree roots (Hammermeister, 2016), and soil fertility. Weeds can significantly affect tree performance, especially under organic management, where inputs are often more limited. Therefore, if weeds are not effectively controlled, they can hinder tree growth and reduce fruit production, size, and quality, which will affect the long-term economic viability of the orchard (Weibel et Häseli, 2003, Guerra, Steenwerth, 2011, Bradshaw, 2015).

Mulching is primarily used with the aim of reducing weed growth and preserving soil moisture. Additional advantages of mulching include controlling temperature variations, enhancing the physical, chemical, and biological properties of the soil, and eventually increasing orchard biodiversity. (Polverigiani et al., 2013a, b).

Covering the soil with mulch saves water by preventing surface evaporation. (Patil Shirish, 2013)

The primary goals of mulching are: reducing water evaporation and erosion (Gan et al., 2013); raising soil temperature; enhancing soil water retention [Zhou et al., 2011, El-Beltagi et al., 2022); and inhibiting weed growth (Chalker-Scott, 2007). Mulching increases plant growth, boosts crop yields, and reduces water consumption (Abdrabbo et al., 2017, Yu et al., 2018).

It is not particularly novel to use sheep wool to control the growth of weeds in plant rows (shrubs, fruit trees, protected crops, etc.). Although there was research on the use of textile mill residues prior to 1990, this valuable natural resource is now gaining new value, due to the remarkable results of its application as mulch and compost (obtained from the material's degradation on the soil). Applying sheep wool to the plant row has been shown to greatly enhance the physicochemical and microbiological properties of the soil, which serve as the foundation for boosting plant resistance to a variety of stresses.

It has been demonstrated that soil conditioners are useful instruments for improving the storage capacity of sandy soils, decreasing cumulative evaporation and infiltration rate, and increasing water holding capacity (Al–Omran and Shalaby, 1987).

According to Wallace (1986), polymers enhanced the properties of the soil. Additionally, it was demonstrated that, compared to high level polymer application, low level application produced very little improvement (Wallace, 1986). Adding polymers to the crop field also enhanced the quality of the fruit as a result of the diminished effects of water stress throughout the growth cycle (Johnson and.Piper, 1997).

Agrotechnical issues, such as water retention in the soil, are frequently brought on by droughts that alternate with periods of intense rainfall. One suitable technical solution to address these problems in agriculture is the use of hydrophilic polymers. In regions where water consumption is high and agricultural productivity may be compromised in the absence of alternative water-saving measures, this strategy is one of the most efficient ways to use water supplies. (Galeș et al, 2012).

MATERIAL AND METHOD

The experiment was conducted in an orchard that was established in the spring of 2013 in Bihor County, Romania (Latitude: 46° 57′ 55.464″ North, Longitude: 21° 44′ 8.249″ East). The orchard has a compact area of 0.70 hectares and is planted with quince in an intensive cropping system, with trees of the Bereczki variety serving as the base variety and the De Constantinopol variety serving as the pollinator variety. The orchard is planted in moist phreatic chernozem soil, whose characteristic are presented below.

A uniformity of granulometric fractions is visible at all horizons in this medium clay soil with an undifferentiated profile texture. The phreatic water affects the soil. Up to a depth of 68 cm, the humus content is low (less than 2%) in the lower horizons and medium (3.1%) in the bioaccumulation horizon. With values ranging from 7.2 to 8.6, the soil reaction is neutral to slightly alkaline. It has favourable physical characteristics, as evidenced by its medium apparent density and total porosity values. With values ranging from over 1% at the surface to 13.1% at the profile's base, carbonates are visible. This medium-sized soil is supplied with nutrients, particularly phosphorus and mobile potassium.

In accordance with the following plan, the experiment was conducted on April 15, 2013, with five trees per variant x three repetitions, for the Bereczki basic variety:

V1 - control variant
V2 - variant mulched with sheep wool
V3 - variant with Zeba application
V4 - variant mulched with sheep wool+Zeba

We selected sheep wool for mulching in the row direction since it is an organic material that is found in the areas surrounding the plantation (sheep farmers are unable to sell this product due to both market regulations that require quality standards and the current economic reorientations). Our choice to use sheep wool as mulch was also influenced by the fact that it is a complex material, consisting of 30–40% proteins, especially keratins, which provide nitrogen to the soil when decomposing, while also including 1-2% lipids, and minerals such as potassium, sodium, calcium, magnesium, and iron.

In order to improve crop performance and soil characteristics in general, the superabsorbent ZEBA [25], a soil conditioner made to increase water and nutrient efficiency, was also used. Water can be absorbed by this biodegradable superabsorbent; when it comes into contact with water, it forms a gel that repeatedly dehydrates and rehydrates throughout the season, releasing the moisture as needed by the plants.

It is made of colourless, dark-white corn starch in granular form. It absorbs 400 times its weight in water, reaches 90% absorption potential in an hour, and releases water over 12 to 15 days when plants experience moisture stress. It remains active in the soil for five months. Sheep wool mulch was spread 20 cm thick and 80 cm wide on both sides of the row after the experiment was installed. This was accomplished by deep loosening the soil at a depth of 25 cm using a modified scarifier with a Zeba hydrogel administration tank in an amount of 100 grams/tree.

The following findings, observations, and analyses were made regarding the Bereczki quince variety under study: Chlorophyll measurement using the SPAD502PLUS Digital Chlorophyll Meter. On the tenth of each month, the same six leaves from the tree crown, three leaves from one side, and three leaves from the opposite side were measured from five different trees. Two leaves were taken from the base of the crown, two from the middle, and two from the tip of the crown. The readings were then averaged.

Fruit production

After the fruits were fully harvested from each of the five trees in each variant, they were weighed in kilograms per tree using an electronic scale. The total of the five trees was then calculated, and the amount of fruit per tree was reported per hectare. A sample of ten fruits per tree was gathered and sent right away to the lab to assess the fruit quality attributes.

The weight of a fruit

An electronic scale was used to weigh 50 fruit samples, and the average weight was then calculated in grams (g).

The size of a fruit

A caliper was used to measure the height, small diameter, and large diameter of 25 fruit samples. The average of the 75 measurements was then calculated, and the size of the fruit was determined, based on the formula: $\frac{D+d+h}{3}$

The cross-section surface of the trunk

Two diameters were measured for every tree using an electronic caliper, and the average was taken by calculating the radius . The surface area of the trunk section was calculated in cm^2 using the formula $\frac{\pi R^2}{2}$. The mean of the five trees used for the measurements was determined.

Number of branches that grew yearly

The average number of annual branches grown was determined by counting all of the annual branches that grew on each of the five trees in each variant, then averaging the five trees.

Branch growth length per year

In order to determine the length of the annual branch growth, the average length of the branches of the five trees per variant was calculated after measuring the length of each annual branch on each tree.

Activities performed on the plantation

From the time the farm was established until now, neither chemical fertilizers nor irrigation have been used. Depending on the developmental stage of the trees, the maintenance of the orchard required different tasks, such as:

- Each species developed its crown during the first four years following planting. In addition to manually controlling weeds on each tree row, the soil was kept in good condition by repeatedly using the tiller and the disc at tree intervals.
- Beginning in the fifth year following planting, when the trees began to bear fruit and achieved commercial production, fruiting pruning, phytosanitary treatments, and fertilization with organic fertilizers mixed into the soil were all implemented during the vegetative rest period. Throughout the vegetation period, weeds were controlled on each tree row by using a tiller with a feeler in conjunction with manual mowing. Soil maintenance was done by repeatedly working with the tiller and the disc on the spaces between the trees.

RESULTS AND DISCUSSIONS

Fruit was harvested on October 10, 2023, with production values of 20.10 tons per hectare in the control variant (V1), 27.60 tons per hectare in the sheep wool-mulched variant (V2), 21.30 tons per hectare in the Zeba-applied variant (V3), and 30.20 tons per hectare in the sheep wool-mulched variant + Zeba application (V4).

V4 had a 50.25% production increase over V1, V3 had a 5.71% increase over V1, and V2 had a 35.71% increase over V1. (Table 1)

Table 1

Quince production and quality

Quince fruit production		Quality I	Quality II
V_1 - 24,13 kg/tree	20,10 tons/ha	V_1 – 86,32 %	V_1 – 13,68 %
V_2 - 33,13 kg/tree	27,60 tons/ha	V_2 – 94,68 %	V_2 – 5,32 %
V_3 - 25,60 kg/tree	21,30 tons/ha	V_3 – 88,24 %	V_3 – 11,76 %
V_4 - 36,25 kg/tree	30,20 tons/ha	V_4 – 97,18 %	V_4 – 2,82 %

In terms of production quality, variations could be noted in the improvement of quality I production in the sheep wool + Zeba application (V4) variant, which was 10.86% higher than the control variant (V1), the sheep wool mulched (V2) variant, which was 8.36% higher than the control variant (V1), and the variant with Zeba application (V3), which was 1.92% higher than the control variant (V1).

Quince fruit weights were as follows: 476.18 grams in the sheep wool + Zeba application (V4) variant, which was 82.50% heavier than the control variant (V1); 411.37 grams in the sheep wool mulched (V2) variant, which was 71.26% heavier than the control variant (V1); and 322.94 grams in the variant with Zeba application (V3), which was 34,31% heavier than the control variant (V1).

Table 2

Some quince characteristics

Weight	Dimension
V_1 – 288,63 grams	V_1 – 98,56 mm
V_2 – 411,37 grams	V_2 – 117,34 mm
V_3 – 322,94 grams	V_3 – 102,28 mm
V^4 – 476,18 grams	V^4 – 134,12 mm

For the quince species, the fruit size values were 134.12 mm for the variant mulched with sheep wool + Zeba application (V4), 117.34 mm for the variant mulched with sheep wool (V2), and 102.28 mm for the variant with Zeba application (V3), compared to 98.56 mm for the control variant (V1).

Assessments of the chlorophyll content, trunk surface measurements, the number of annual branches grown, and the length of these branches were conducted in order to determine the stage of water and mineral supply during the vegetation of the fruit plantations.

The relative chlorophyll content of the leaf is therefore one of the factors that establishes the level of nitrogen-based plant nutrition (Balawejder et al., 2020).

Chlorophyll determinations were carried out with the SPAD502PLUS Digital Chlorophyll Meter.

Table 3

Quince chlorophyll determinations in different months

Chlorophyll determinations in quince		
May	June	July
V_1 – 56,3	V_1 – 55,6	V_1 – 54,2
V_2 – 60,1	V_2 – 59,1	V_2 – 58,6
V_3 – 58,4	V_3 – 58,2	V_3 – 57,5
V_4 – 65,2	V_4 – 66,5	V_4 – 62,3
August	September	October
V_1 – 53,7	V_1 – 48,2	V_1 – 44,1
V_2 – 57,1	V_2 – 53,5	V_2 – 50,7
V_3 – 55,6	V_3 – 50,8	V_3 – 47,3
V_4 – 59,4	V_4 – 58,1	V_4 – 56,2

There were notable variations in the SPAD index values across all experimental variants, but the V4 sheep wool + Zeba application variant had very high values. These values showed a very good supply of mineral substances to the plant, which led to good photosynthesis. That was obvious in the weight, size, and yield of the fruits. Although the three experimental techniques had a positive impact on the growth of the trees, the data analysis did not show any appreciable variations from the control in terms of the trunk's cross-sectional area, the quantity of annual branches, or their length.

The area of the trunk section in the 10th year after planting in the Bereczki quince variety

Table 4

The area of trunk sections in the 10th year after planting in the Bereczki quince variety

Nr. crt	Variant	The area of the trunk section - 2023 -		±d (cm^2)	Significance
		Absolute (cm^2)	Relative (%)		
1	V_1 The control variant	72,41	100	0,0	-
2	V_2 The variant mulched with sheep wool	81,27	112,23	+8,86	x
3	V_3 The variant with Zeba application	76,13	105,13	+ 3,72	-
4	V_4 The variant mulched with sheep wool + Zeba application	83,14	114,82	+10,73	x

Table 5

The branches of the quince

Number of branches that have grown each year	The length indicating the growth of branches each year
V_1 - 66,3 pcs	V_1 - 62,76 cm
V_2 - 98,6 pcs	V_2 - 80,23 cm
V_3 - 84,5 pcs	V_3 - 71,14 cm
V_4 - 107,8 pcs	V_4 - 86,22 cm

CONCLUSIONS

The findings indicate that applying the three experimental variants to the quince variety grown in the studied area has a significant positive impact on fruit production and quality, as well as on tree growth.

Though the values obtained with the V4 variant, mulched with sheep wool and treated with soil improver, are higher in terms of fruit production, weight and size of a fruit, the results obtained with the V2 variant, mulched with sheep wool, show that it is viable to use sheep wool in fruit plantations because it does not require large investments and the material is supplied free of charge due to the commercial criteria related to the quality of this product.

However, more research is required to validate the findings, including a greater number of trees, long-term monitoring, and the extension of these tests to other fruit tree and fruit shrub species.

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