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Research Article

Effect of Mulching Soil with Garden Waste on Weed Growth

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Abstract:

This study aims to reduce the growth of weeds among orchard trees using an orchard tree waste chipping machine after developing it under three levels of cutting length ratio (≤3 cm - 3 to 5 cm - ≥5 cm), four levels of cutting diameter ratio (≤1 cm - 1 to 3 cm - 3 to 5 cm - ≥5 cm), four levels of distribution efficiency and four levels of cutting efficiency. The study was conducted at forward speed (1.8 km/h), moisture content (40%), number of knives 32, and rotation speed 2600 rpm for the cylindrical chipper. The evaluation was conducted regarding the effect of distribution efficiency, cutting efficiency (%), and cutting length ratios (%). The results can be summarized as follows: Increasing distribution efficiency from 75 to 95% and cutting efficiency from 85 to 95% led to a decrease in the amount of weeds, and increasing the percentage of cutting length and cutting diameters led to an increase in the amount of weeds at a moisture content of 40.0% (gram weight) and the number of cutting knives 32.

1. Introduction

Improper disposal of waste wood has a detrimental effect on both aquatic and terrestrial ecosystems. Burning waste from orchard trees releases greenhouse gases into the atmosphere, causing various human health problems. By utilizing technology to divide the cut vine stems and branches into pieces less than 10 cm long and then incorporating them into the soil between rows of plants annually, it becomes possible to reuse the cut pruning material as organic fertilizer. This approach helps reduce the losses mentioned above and contributes to environmental conservation (Fouda et al., 2024).

In Egypt, agricultural residues, mainly orchard trimming residues, pose a significant environmental and agricultural challenge in Egypt to reduce environmental pollution and provide organic fertilizers to the soil to improve its physical and chemical properties, reduce the growth of weeds among orchard trees, and increase its ability to keep water for the longest possible period, especially with the limited water resources. Chopping agricultural residues to feed the remnants is becoming increasingly recognized as a sustainable trend in Egypt (Awad et al., 2022; El Ghobashy et al., 2023).

Mechanical treatment is the primary approach to using raw materials in various processes. Using pruning residues is beneficial for both the environment and the economy. Horticultural crop production holds a significant position within the various branches of agricultural cultivation. In contrast to other crops, horticultural trees are perennial plants that require annual or periodic pruning to enhance their production's quality and quantity (Fedrizzi et al., 2012).

Historically, orchard pruning residues were disposed of by burning or using various machinery. The immediate combustion process prevents the potential for reutilizing these residual materials and engenders ecological concerns (Spinelli et al., 2014). Details for weed species of the study area have been described elsewhere (Atay et al., 2013).

The complete elimination of weed competition in orchards is possible with residual herbicides, but it may not be desirable for economic and environmental reasons (Merwin et al., 2003). Apple trees require proper orchard floor management (OFM) to ensure good protection against weeds, availability of nutrients, good growth and yield of trees, and high-quality fruit (Atay et al., 2017).

Without the use of contemporary farm equipment, commercialized agricultural production may be difficult to achieve. The agricultural wastes, which might include crop residues and crop leftovers were defined, along with their varieties, the harms they cause to plants, animals, and the environment, as well as their economic uses in industry, agriculture, and various therapies. and animal dung, that are typically connected to the production and processing of food and fiber on farms, feed lots, ranches, ranges, and forests (Fritz et al., 2012).

Weeds compete with cultivated plants for light, water, and nutrients, have an allelopathic effect, and increase the risks caused by diseases and pests, including rodents and spring frosts during the flowering of fruit trees (Lipecki et al., 2006).

Benefits of cutting include achieving a relatively uniform product, reducing the bulk of fibrous materials for easier handling and transportation, and converting the product into forms and different types of food that consumers want for different purposes from basic ingredients. Cutting improves the product's digestibility, allows for more precise ingredient mixing, and is a pre-treatment for raw materials before they are canned, frozen, and dehydrated. Additionally, it aids in speeding up the diffusion processes involved in solvent extraction and dehydration (Rosario et al., 2021).

Crop leftovers are thought to be the most important issue Egyptian farmers face, particularly after harvest. Every year, Egyptian farmers burn roughly two to three tons of feed. In order to dispose of it and free up time for the next crop's preparation, 5.87 million tons of corn stalks and rice straw, respectively, are needed. Appropriate farm equipment and machinery are also crucial components of contemporary agricultural production operations. Thus, the degree of use of these inputs is referred to as mechanization (Iya et al., 2005).

The performance of the machine was assessed in terms of cutting height, cutting efficiency, increased cutting energy, and field capacity and efficiency. Experimental research examined the performance of several machines (self-propelled harvesters and shredders) used to remove field crop residues (corn stalks and barley straw) from land as a function of machine forward speed. According to the experimental results, the energy requirements were within the ideal range when the following conditions were met: (a) corn was removed using a shredder machine, and barley straw was removed using self-propelled harvesting; (b) forward speeds were between 3 and 5 km/h and 2 and 4 km/h for the removal of corn stalks and barley straw, respectively (Fouda et al., 2012).

Clear the soil of the agricultural remains. Agricultural producers face a number of significant challenges, particularly after harvesting long-stalk plants. The removed plant, plant conditions (density and moisture content), machine type, and forward speed all affect how efficient a machine is. The ratio of a machine's productivity in the field to its theoretical maximum productivity is known as the field efficiency. As forward speed increased, the field efficiency declined. A trailer-mounted shredder. It was discovered that the forward speed was 2.8 km/h and the minimum height of corn stubs was 15 cm (Sridhar et al., 2018).

Using four different drum speed settings (1000, 1200, 1400, and 1600 rpm), 48 and 68 knife counts, and three feeding rates (600, 800, and 1000 kg/h) in order to measure the average weight length, fuel consumption, power consumption, energy consumption, and machine performance efficiency. The average length cut weight, which ranged from 6.608 to 10.627 mm, (Fouda et al., 2014).

They came to the conclusion that approximately 8600 balers, 5150 shredders, and 5200 choppers are needed for the management of Egyptian leftovers. In order to make the job of tillage equipment easier in reduced tillage or direct tillage techniques, rolling cutting coulters were used to cut plant remnants that were left on the soil surface (Magalhaes et al., 2007).

It was said that a self-propelled harvester is advised for the removal of rice straw, while a shredder machine is advised for the removal of residues from both cotton and sunflower stalks. For the removal of rice straw, cotton stalks, and sunflower stalks, the suggested advance speeds are 4 to 5.5 km/h, 2.8 to 4.8 km/h, and 2.1 to 3.2 km/h, respectively. Therefore, field crop residue removal needs to receive the attention it needs, keeping in mind the immediate advantage of speedy soil clearing for the following crop, which might significantly raise Egypt's agricultural intensification ratio (Morad and Fouda, 2009).

The research aims to reduce the growth of weeds among orchard trees using an orchard tree waste chipping machine after developing.

2. Materials and Methods

The locally developed cutting machine was used on a private farm in Al-Shaarawy village, Delingat Center, Beheira Governorate. It has 32 loosely connected blades to cut orchard tree pruning waste, suitable for cutting large diameter branches and scattering them between tree rows. The pruning waste cutting machine was operated by a PTO shaft, and it is suspended behind the tractor between the orchard tree rows, where it cuts the pruning waste as it moves between the orchard tree rows and leaves the cutting residues on the soil surface. The tractor was used to operate the machine, which is a 92-horsepower Belarusian four-wheel drive machine. -The field experiment was conducted on an area of 5 acres to evaluate the operating parameters that affect the energy and power requirements for cutting fruit tree waste. To achieve the objectives of this study, the cutting machine was used according to the following variables speeds of the drum 2600 rpm. The experiment was conducted and statistically designed as a factorial complete randomized block design with three replications.

2.1. Machine chopping

The components include the main frame, cutting drum, cutting knives, and gearbox. The chopping machine's length, width, and height measured 160 cm, 56 cm, and 90 cm, respectively. The cutting drum is fabricated using a steel shaft measuring 50 mm in diameter and 1400 mm in length. The cutting drum is supported on the frame by two bearings. The mechanism operates through the use of a pulley and belts that are connected to a gearbox. Two iron flanges were welded on both sides of the cutting drum, with diameters and thicknesses of 25 cm and 12 mm, respectively. Knives of a particular type were employed in the present study to cut the orchard residues. These knives were equipped with 32 sharp edges. They are made from steel sheets. The knife drum length dimensions were 120 cm width, 20 cm, and the thickness were 16 mm. As shown in Figures (1, 2)

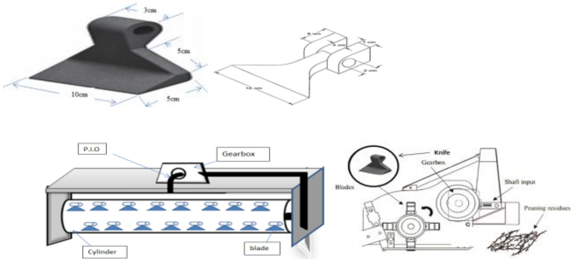
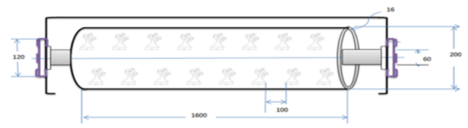


Figure 1. Machine for shredding orchard tree waste



Dimensions in mm Scale: 1: 10

Figure 2. Machine chopping modification.

2.2. Measurements

2.2.1. Cutting length percentage

Theoretical and actual lengths of cut:

The theoretical lengths of cut L_{th} was calculated using equation (1), according to **Srivastava et al. (2006).**

$$L_{th} = \frac{60000\, V_f}{N_k n_c} \quad \ldots (1)$$

Where:

L_{th} = Length of cut, cm; n_C = Rotational speed of cutter head, rpm, and

V_f = The velocity of feeding, m/s (feeding mechanism peripheral speed);

N_K = Knives number on the cutter head.

Following each chopping treatment, laboratory analysis involved random sampling of chopped material in 1 kg increments. The samples were subsequently separated into three categories (<30, 30-50, and ≥50 mm) using sieves to detect the actual average cutting length (Lac). The weight of each cutting length in the sample was measured and expressed as a percentage relative to the total weight of the sample.

2.2.2. Chopping efficiency

Three samples each of 1 kg of cutting crop material were fed into the chopper for each treatment; after completing the chopping operation, the output materials were weighted, and the chopping efficiency was calculated according to equation (2):

$$\text{Chopping efficiency} = \frac{W_{output} - W_{uncut}}{W_{in}} \% \quad \ldots (2)$$

Where**:**

W_{out}: output mass, kg; W_{in}: input mass, kg and

W_{uncut}: un-chopped mass after chopping process, kg.

Chopping efficiency was determined using equation (3) according to **FAO, (1994).**

Chopping efficiency = 100 **–** un-chopped remnants..(3)

2.2.3. Machine productivity (L_{th})

The productivity of the machine was determined using equation (4).

$$\text{Machine productivity } (L_{th}) = \frac{W}{t} \quad \ldots (4)$$

Where

W = Weight of crop residues, ton; *t* = machine operating time, h.

2.2.4. Moisture contents

The moisture contents of the plants were determined using the standard oven method. The samples underwent oven-drying at a temperature of 105°C for 24 hours. The determination of moisture percentages was conducted on a wet basis according to equation (5):

$$\text{Moisture content, \%} = \frac{(M_W - M_d)}{M_W} \times 100 \quad \ldots (5)$$

Where: M_W is the sample's mass before cutting, kg; and, M_d is the mass of the cut sample, kg.

$$\text{Distribution efficiency} = \frac{\text{uncovered area}}{\text{covered area}} \% \quad \ldots (6)$$

3. Results

3.1. Effect of chopping efficiency on Weed growth

Data in Figure 3 illustrate that weed growth decreased with increasing chopping efficiency. Results show that the minimum weed growth was 15 plants/m^2 obtained with a chopping efficiency of 95%, forward speed of 1.8 km/h, cutting knife speed of 2600 rpm, and tree-branches moisture content of 40%, while the maximum weed growth was 76 plants/m^2 obtained with a chopping efficiency of 85%, forward speed of 1.8 km/h, cutting knife speed of 2600 rpm, 36 knives, and tree-branches moisture content of 40%.

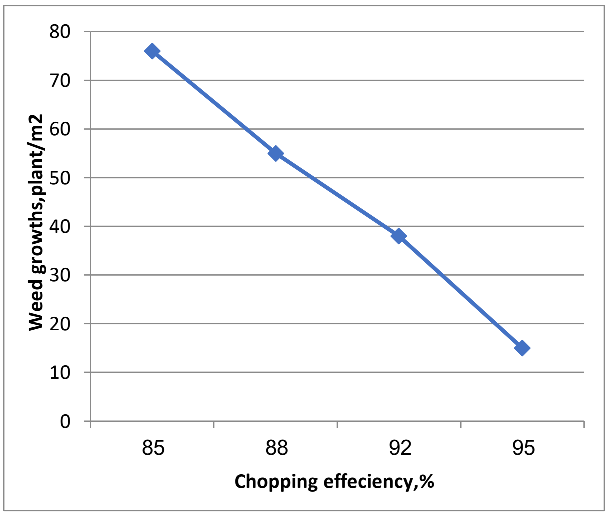


Figure 3. Effect of chopping efficiency on Weed growth.

3.2. Effect of Distribution density on Weed growth

Data in Figure 4 illustrate that weed growth decreased with increasing distribution density. Results show that the minimum weed growth was 14 plants/m^2 obtained with a distribution density of 96% at forward speed of 1.8 km/h, cutting knife speed of 2600 rpm, and tree-branches moisture content of 40%, while the maximum weed growth was 65 plants/m^2 obtained with a distribution density of 74%. at forward speed 1.8 km/h, cutting knife speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%.

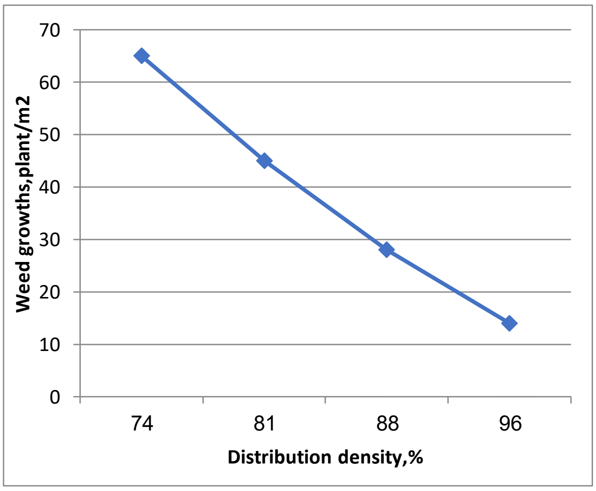


Figure 4. Effect of Distribution density on Weed growth.

3.3. Effect of cutting length on Weed growth

Data in Figure 5 illustrate that weed growth increased with increasing cutting length. Results show that the minimum Weed growth was 13 plants/m^2 obtained with a cutting length ≤ 3 cm at forward speed 1.8 km/h, cutting knives speed 2600 rpm, and tree-branches moisture content of 40%, while the maximum Weed growth was 55 plants/m^2 obtained with a cutting length ≥ 5 cm. at forward speed 1.8 km/h, cutting knives speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%.

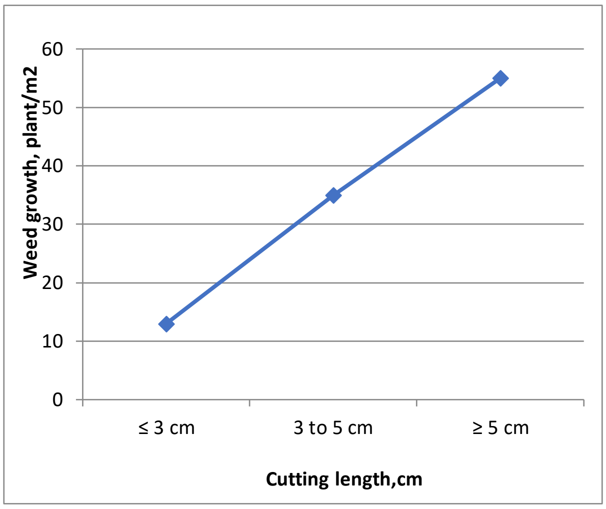


Figure 5. Effect of cutting length of tree-branches on weed growth.

3.4. Effect of cutting diameter on Weed growth

Data in Figure 6 illustrate that weed growth increased with increasing the cutting diameter. Results show that the minimum Weed growth was 13 plants/m^2 obtained with the cutting diameter ≤1 cm at forward speed 1.8 km/h, cutting knives speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%, while the maximum Weed growth was 55 plants/m^2 obtained with the cutting diameter ≥ 5 cm. at forward speed 1.8 km/h, cutting knives speed 2600 rpm at 36 knives, and tree-branches moisture content of 40%.

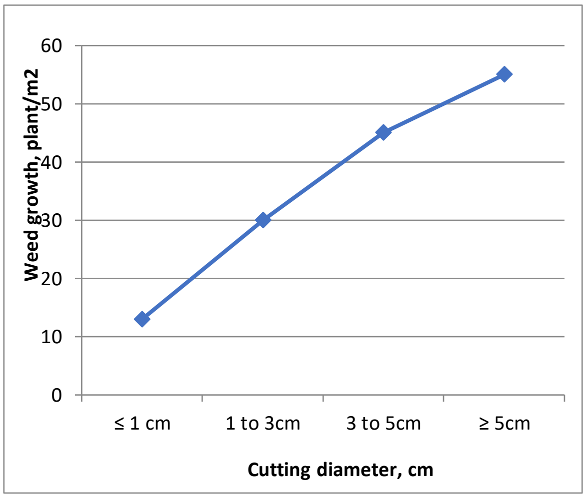


Figure 6. Effect of cutting diameter of tree-branches on weed growth.

3.5. Effect of machine productivity on weed growth

Figure 5 illustrate that weed growth decreased with increasing productivity. Results show that the minimum weed growth was 15 plants/m^2 obtained with the productivity of 1.196 kg/m^2 at forward speed 1.8 km/h, cutting knives speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%, while the maximum weed growth was 85 plants/m^2 obtained with the productivity of 0.92 kg/m^2, at forward speed 1.8 km/h, cutting knives speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%.

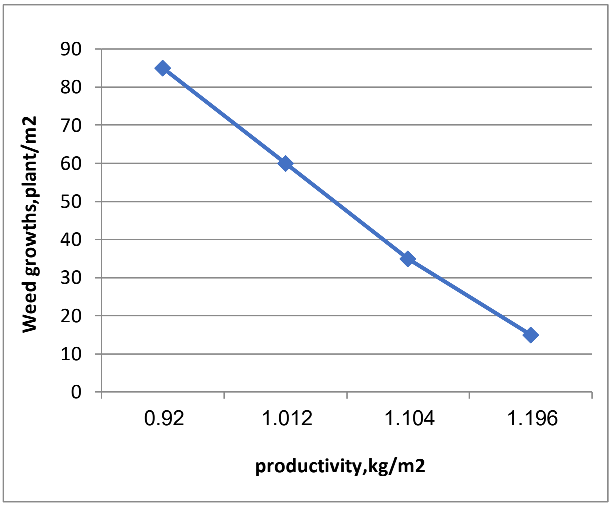


Figure 7. Effect of productivity on weed growth.

3.6. Effect of number of knives on Weed growth

Data in Figure 8 illustrate that weed growth decreased with increasing the number of knives. Results show that the minimum weed growth was 13 plants/m^2 obtained with the number of knives 32 at forward speed 1.8 km/h, cutting knives speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%, while the maximum weed growth was 108 plants/m^2 obtained with the number of knives 16, at forward speed 1.8 km/h, cutting knives speed 2600 rpm, 36 knives, and tree-branches moisture content of 40%.

Figure 8. Effect of number of knives on weed growth.

5. Conclusions

The performance of the pruning shear was affected by the rotation speed of the knife. Modifying the thickness of the cylinder carrying the knives from 8 mm to 16 mm increased its durability to withstand cutting orchard tree branches up to 5 cm thick and protect them from damage because they operate at a speed of 2600 rpm. The chairs carrying the cylinder were modified by increasing the inner diameter from 35 mm to 60 mm to withstand the weight of the cylinder and the load on the cylinder when cutting. The knife's weight increased from 500 grams to 1240 grams of 30Mn5 steel alloy, and the number of knives increased from 16 to 32. After the machine was modified, the cutting length ratio ≤ 3 cm increased from 69.5% to 75.3%, cutting efficiency from 85% to 95%, weed quantity from 55 to 13 plants/m^2 at 40% moisture content with the modified knives.

6. Reference

Atay, E.; Gargin, S.; Esitken, A.; Atay, A. N.; Altindal, M.; and Emre, M. (2017). Orchard performance worsens as weed competition increases: A long-term field study under Mediterranean conditions. Acta Scientiarum Polonorum Hortorum Cultus, 16, 13–18. Accessed on 15/9/2024.

Atay, E.; Guzel, P., Gargin, S.; Esitken, A.; Senyurt, H.; Atay, A. N.; Altindal, M.; and Calhan, O. (2013). Determination of important parameters for weed control in intensive apple orchards: Species and its density. IOBC/WPRS Bulletin, 91, 439–442. Accessed on 15/9/2024.

Awad, M.; Fouda, O.; Abd El-Reheem, S.; Al-Gezawe, A.; Cottb, M.; and Okasha, M. (2022). A new seed drill for planting peas on a raised-bed. INMATEH - Agricultural Engineering, 68(3): 681–692. Accessed on 15/9/2024.

El Ghobashy, H.; Shaban, Y.; Okasha, M.; Abd El-Reheem, S.; Abdelgawad, M.; Ibrahim, R., Ibrahim, H.; Abdelmohsen, K.; Awad, M.; Cottb, M.; Elmeadawy, M.; Fathy, W.; and Khater, E. (2023). Development and evaluation of a dual-purpose machine for chopping and crushing forage crops. Heliyon, 9(4), e15460. Accessed on 15/9/2024. Accessed on 15/9/2024.

FAO, (1994). Proceedings of the Regional Expert Consultation on Modern Applications of Biomass Energy, FAO Regional Wood Energy Development Programme in Asia, Report No. 36, Bangkok. Accessed on 15/9/2024.

Fedrizzi, M.; Sperandio, G.; Pagano, M.; Pochi, D.; Fanigliulo, R.; and Recchi, P. (2012). A prototype machine for harvesting and chipping of pruning residues: first test on hazelnut plantation (*Corylus avellana* L.). International Conference of Agricultural Engineering, CIGR-Ageng, July 812, Valencia, Spain. Accessed on 15/9/2024.

Fouda, T. Z.; Ghonim, A. F.; Drbala, A. A.; and El-ries, A. M. (2014). Utlization Of Shredding Machine To Prepare Haulm Of Potattes Row Materials. Egyptian Journal of Agricultural Research, 92(4), 1543-1557. Accessed on 15/9/2024.

Fouda, T.; and Eltarhuny, M. M. (2012). Utilizatinon of self-propelled harvester and shredder machines for removing some field crop residues. Accessed on 15/9/2024.

Fouda, T.; Ghoname, M.; Salah, S.; Aboegelal, M.; and Soltan, M. (2024) Development Of A Machine Chopping The Orchard Tree Remnants, As A Solution For Sustaining Circular Economy And Environmental Protection In Horticulture. "Scientific Papers Series Management, Economic Engineering in Agriculture and

Rural development", Vol.25(1)2025 which will be displayed by the end of the month of March 2025 on the wesite:http://managementjournal.usamv.ro/index.php/scientific-papers/curren

Fritz, B. K.; Hoffmann, W. C.; Czaczyk, Z.; Bagley, W.; Kruger, G.; and Henry, R. (2012). Measurement and classification methods using the ASAE S572. 1 reference nozzles. Journal of Plant Protection Research, 52(4). Accessed on 15/9/2024.

Iya, S. A. (2005). Computer Modeling for Planning and Assessing Profitability of Mechanized Maize Production System in the Savanna Belt, Nigeria. PhD. Thesis, Department of Agricultural Engineering University of Ilorin. Accessed on 15/9/2024.

Lipecki, J. (2006). Weeds in orchards—Pros and cons. Journal of Fruit and Ornamental Plant Research, 14, 13–18. Retrieved from http://www.inhort.pl/files/journal. Accessed on 15/9/2024.

Magalhaes P. S.; Bianchini A.; and Braunbeck, O. A. (2007). Simulated and experimental analysis of a toothed rolling coulter for cutting crop residues. Bio systems Engineering. 96 (2), 193-200. Accessed on 15/9/2024.

Merwin, I. A. (2003). Orchard-floor management systems. In D. C. Ferree & I. J. Warrington (Eds.), Apples: Botany, production and uses (pp. 303–318). Cambridge: CABI Publishing. Accessed on 15/9/2024.

Morad, M.; and Fouda, T. (2009). Energy and cost required for removing residues of some field crops using different implements Egypt. Journal of Applied Sciences, 24(3). Accessed on 15/9/2024.

Rosario, D. K.; Rodrigues, B. L.; Bernardes, P. C.; and Conte-Junior, C. A. (2021). Principles and applications of non-thermal technologies and alternative chemical compounds in meat and fish. Critical reviews in food science and nutrition, 61(7), 1163-1183. Accessed on 15/9/2024.

Spinelli, R., Lombardini, C., Pari, L. & Sadauskiene, L. (2014). An alternative to fi eld burning of pruning residues in mountain vineyards. Ecological Engineering, 70, 212–216. Accessed on 15/9/2024. Accessed on 15/9/2024.

Sridhar, N.; and Surendrakumar, A. (2018). Performance evaluation of rotary and flail shredders. Accessed on 15/9/2024.

Srivastava, A. K.; Goering, C. E.; Rohrbach, R. P.; and Buckmaster D. R. (2006). (rev.) Hay and forage harvesting. Chapter 11 in Engineering Principles of Agricultural Machines, 2nd ed., 325-402. St. Joseph, Michigan: ASABE. Copyright American Society of Agricultural and Biological Engineers. Accessed on 15/9/2024.