Manufacturing a prototype swing mechanical arm Weeder for orchard trees

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Abstract

The main objective in the current research was development a Weeder with controlled swing mechanical arm to control and remove the weeds intra-rows orchards tree. The swing mechanical arm constructed from steel, ground wheel carried the arm. The DC Electric motor with 12 V was used as the source of the power to operate the rotary blades Weeder. Three rotational speed 1600 rpm, 2200 rpm and 2600 rpm was adjusted and controlled by the short resistor circuit. A prototype electric Weeder evaluated under three forward speed 3.2 kmh^{-1}, 4.1 kmh^{-1} and 5.7 kmh^{-1} at three rotational speed 1600 rpm, 2200 rpm and 2600 rpm for weeder and two different blades. The result indicated that it could be able to use the electric power produced from the tractor to operate of the electric weeder. The electric Weeder with controlled swing mechanical arm may be applied to control of the weeds in citrus orchards tree field. The rotational speed 2600 rpm and forward speed 3.2 km.h^{-1}gave the maximum weeding efficiency under orange orchards tree field conditions. The blades weeder was more effective in controlling weeds than the Tines. The electric Weeder may be able to reduce the power requirement for weed control compared to other weeds control methods. The development an electric weeder may be ideal for weeding under orchard trees.

Keywords: Electric Weeder, mechanical weed control, orchard tree.

Introduction

Washington navel orange (*Citrus sinensis* L. *Osbeck*) is one of the most important species in the genus citrus. In Egypt Washington navel orange ranked first among the species of citrus. It occupies about 35 % of the total cultivated area of citrus, since its acreage reached about 79,426 ha with total production of 1,663,284 tons per year according to the last census, issued by Ministry of Agriculture, Egypt (2015). Egypt is one of the world's leading orange producers and exporters. The orchard row middles typically require mowing several times per year to provide access through the planting for workers and equipment, to reduce vole habitat, and to reduce moisture in tree canopies. The challenge now lies in producing a machine that can mechanically remove the weeds between standing plants in the row, whilst causing minimal damage to the crop. The aim of weed control is to kill weeds or suppress them long enough for the crop to gain a competitive advantage. The effectiveness of weeding is inversely related to the weed growth stage at the time of treatment. Weed management in organic or low-input growing systems entails integrating preventive and curative methods (Bàrberi, 2002). To avoid crop damage, intra-row weed control is best delayed until the crop plants are sufficiently developed, but at this time the weeds are usually too big to be controlled effectively. Intra-row weed control often needs to be conducted one or two weeks after crop emergence. Thus cultural practices and weed control prior to crop emergence (pre-emergence weed control) before crop emergence are critical in terms of maintaining weeds at a low density level in the early crop stages (Ascard and Fogelberg, 2008). Cultivators with rigid blades that cut off the weeds one to two cm below the soil surface are the most commonly used machines for inter- and intra-row weed control. Cultivators can be equipped with finger weeders or elastic tines for both inter and intra-row

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weed control (Cloutier et al., 2007; van der Weide et al., 2008). Elastic tines can act as both torsion weeders and vibrating tines, which differ depending on how the tips of the tines have been set (Cloutier et al., 2007; Peruzzi et al., 2007). A finger weeder is made up of a pair of disks that have peripheral fingers and can be inclined in relation to the soil surface. The disks rotate when they make contact with the soil. The fingers can be made of rubber-coated iron (hard-finger) or of plastic (soft-finger) (Cloutier et al., 2007). The finger weeders uproot weeds and lift them out of the crop row. The working speed can range from 4 to 12 km h^{-1}. Torsion weeders consist of a pair of spring tines per row, pointing into the crop from either side of the row but under the crop leaves. Tines with different diameter (ranging from 4 to 8 mm) can be interchanged, according to the crop growth stage and sensitivity to mechanical damage. Generally torsion and finger weeders are more selective than spring-tine harrows, especially in broad-leaved crops (Bleeker et al., 2002; Ascard and Fogelberg, 2008). Bleeker et al. (2002) observed a tendency for better weed control but also a greater crop plant reduction with the torsion weeder compared to the finger weeder. Fontanelli et al. (2015b) combined the use of the same intra-row cultivator used by Raffaelli et al. (2010) and the rolling harrow for post-emergence weed control in spinach planted in 20 cm wide spaces between rows on raised beds. Melander and Rasmussen (2001) found that the brush weeder was more effective in controlling weeds than the cultivator, but only slightly better, and the cultivator was cheaper both in terms of investment and use (Melander, 1998). Laser weeding prototypes have been developed for laboratory applications or for the greenhouse (Mathiassen et al., 2006; Marx et al., 2012b; Ge et al., 2013). Laser weeding robots can improve labour productively, solve the shortage of the labour force, improve the environment of agricultural production, improve work quality, reduce energy waste, improve resource utilization, and help farmers to change their traditional working methods and conditions (Ge et al., 2013). The advances in technology have created wide opportunities for weed management, and precision agriculture may become a key element of modern weed control (Bajwa et al., 2015).

Objectives

The objective of this research was therefore to develop a swing mechanical arm with an electric Weeder for identifying orchards trees trunk locations, allowing a soil engaging tool to mechanically remove weeds in the row, whilst circumventing the orchards trees. Non-Chemical Weed Management in citrus Orchards swing arm may be used to mow vegetation under trees and even up close to the tree trunks.

Material and Methods

A swing mechanical arm with an electric Weeder was manufactured in laboratory of Agric. Eng. Dept., and evaluated in Washington navel orange (*Citrus sinensis L. Osbeck*) field, farm research, faculty of agriculture, Kafrelsheikh University, Egypt. A prototype electric Weeder consisted of two main parts. The first part is swing mechanical control arm that made from steel with 1800 mm length. The swing mechanical arm carried the electric Weeder and designed as hanged arm tracked under the orchard trees. The horizontal marker wheel with 90 mm diameter constructed at 1500 mm from the hanged joint to the rolling point of the horizontal wheel. The horizontal wheel employed to reject the blades Weeder narrow the trees. The ground depth wheel constructed at distance 1500 mm from the fixed point of the arm to adjust the height of Weeder blades. The second part consisted of an electric Weeder included the electric motor with 12 DC volte and 3 Ampere rotated at maximum rotational speed 2665 rpm. The short resistor circuit constructed to control of the rotational speed. The three rigid Tines fixed on the Teflon disk with diameter 80 mm and 20 mm thickness. The disk fixed on the electric motor shaft with screw in horizontal position as shown in figure 2. The rigid tines length 230 mm arranged at angle 135 ° degree between each other. Also two blades with 120 mm length were set in 180 ° degree on the disk drive of electric motor. The tractor model Foton 254 with engine power 18.5 kW used to operate a Weeder under field conditions. The Digital tachometer Laser HP-2234C was used to measure the rotational speed of development was mounted between the front and rear wheel tractor in three hatch point frame. To quantify the extent of weed infestation, the number and species of weeds were counted in 0.5 m^2 areas for each plot. A wood frame with measurements of 1000 mm by 500 mm was used as a guide and was placed centered electric weeder. The dry battery 12 Volts was connected with the tractor generator. The tractor generator used to recharging the battery during the operation of a development Weeder under field conditions. The hanged swing mechanical arm on two orchards trees trunk on the row centerline. The graduate cylindrical used to measure the fuel consumption for each treatment conditions.

Procedure

Laboratory test

The electric power from the tractors' dry battery was evaluated to operate the weeder DC motor. The battery remaining rated and capacity was measured by using the Tektronix Oscilloscope Model TPS 2024. State of Charge (SOC) is defined as the remaining capacity of a battery and it is affected by its operating conditions such as load current and temperature. SOC is a critical condition parameter for battery management. Accurate gauging of SOC is very challenging, but the key to the healthy and safe operation of batteries Strunz K, and H. Louie (2009) and Young K. et.al, (2013). The SOC determined by the following formula: SOC= (Remaining capacity/Rated capacity).

The experimental carried out under orange (*Citrus sinensis L. Osbeck*) field conditions in farm research of faculty of agriculture, Kafrelsheikh University, Egypt. A prototype electric Weeder evaluated under three forward speed 3.2 kmh^{-1}, 4.1 kmh^{-1} and 5.7 kmh^{-1} at three rotational speed 1600 rpm, 2200 rpm and 2600 rpm for weeder. Full implement testing was conducted to observe how well the implement was able to distinguish orchards trees trunk and circumvent them. Light implement frame adjustment an electric weeder under orange trees citrus for weeding. The base frame serves as tool carrier for swing mechanical arm. This structure allows the independent lifting of one side and also height adjustments in depth wheel and tractor hydraulic system. All trees within this frame were counted. Weed population densities were measured in the intra-row region.

The weeder efficiency was calculated by using the following formula:

$$W_{eff} = \frac{W_{after}}{W_{before}} x100$$

W_{eff}= weeder efficiency, %, W_{befor} and W_{after} are the number of weeds before and after weeder operating in orange field.

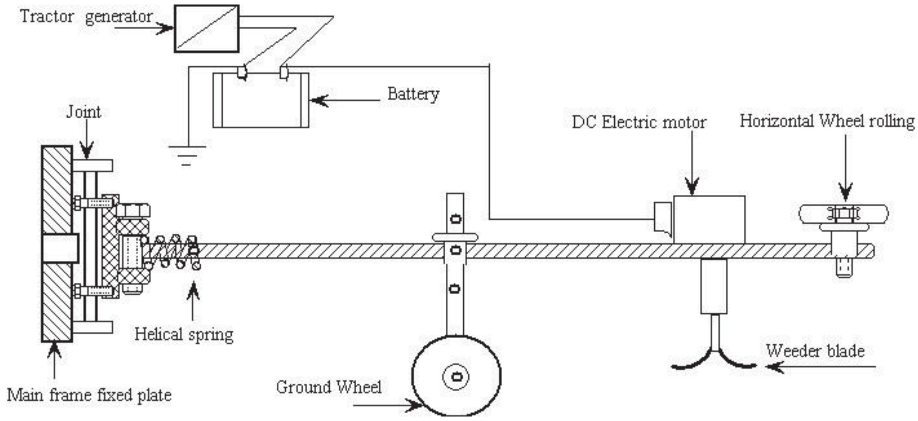
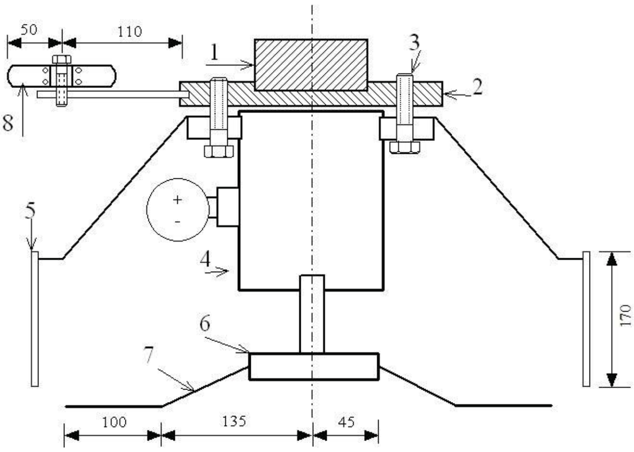


Figure 1: Display the sketch diagram of a manufacturing swing mechanical arm with electric Weeder.



1-Swing mechanical arm | 2-Fixed plate | 3-Bolts | 4- DC motor
5- Protecting plate (P. glass) | 6-Teflon disk | 7-Blades | 8-Wheel marker

Figure 2: Display the sketch diagram for the cross-sectional in developed Electric Weeder.

Figure 3: Display a manufacturing swing mechanical arm with electric Weeder in laboratory and field conditions.

Results and Discussion

The result for laboratory test indicated that the electric power for development weeder at different rotational speed 1600, 2200, and 2600 rpm increased due to increase the rotational speed. The operating of weeder with blade required more electric power compared to the operating of the weeder with three tines. State of Charge (SOC) of the battery was found at the range between the values of 0.749 to 0.847. This result indicated that, the dry battery will be saving during the operating of the electric weeder as shown in figure 4. Table 1 presents the average of fuel consumption and weeder electric power for a development weeder under citrus orange tree field conditions. The increasing of rotational speed tends to increase the electric power requirement. Also, the blades required more power compared to Tines. The maximum electric power was 73.2 W for blades compared to 57.1 W for Tines at forward speed 5.7 kmh^{-1} and rotational speed 2600 rpm. It noticed that, there was non-significant effect of rotational speed and type of blades on fuel consumption. On the other hand, manufacturing swing electric Weeder may be operating by the tractor without more fuel consumption. The electric power produced from the tractor generator able to operate the Weeder.

Table 2 illustrates the number of weeds in row orchards tree before and after treatment with a manufactured swing electric weeder. The increasing of rotational speed tends to decrease the number of weeds. Also, the blade gave low number of weeds compared to the Tines under all treatment conditions. Figure 5 indicate the increasing of forward speed tends to decrease the weed efficiency. The maximum weed efficiency was 100 % at forward speed 3.2 kmh^{-1} and rotational speed 2600 rpm for blades and Tines. The forward speed 5.7 kmh^{-1} gave the lower values of the weed efficiency. On the other hand the blades with 180^{o} degree set produced the high weed efficiency compared to three Tines with 135 ^{o} degree setting. The minimum value of weed efficiency for blades was 89.5 % compared to 85.2 % for Tines at forward speed 5.7 kmh^{-1} and rotational speed 2600 rpm. As well as the increasing of weeder rotational speed tends to increase the weed efficiency. The weed efficiency at 5.7 kmh^{-1} forward speed and blades with 180^{0} degree were 89.5%, 94.7% and 95.8 % for rotational speed 1600 rpm, 2200 rpm and 2600 rpm respectively. The Tines gave the above same trend for the operating electric weeder.

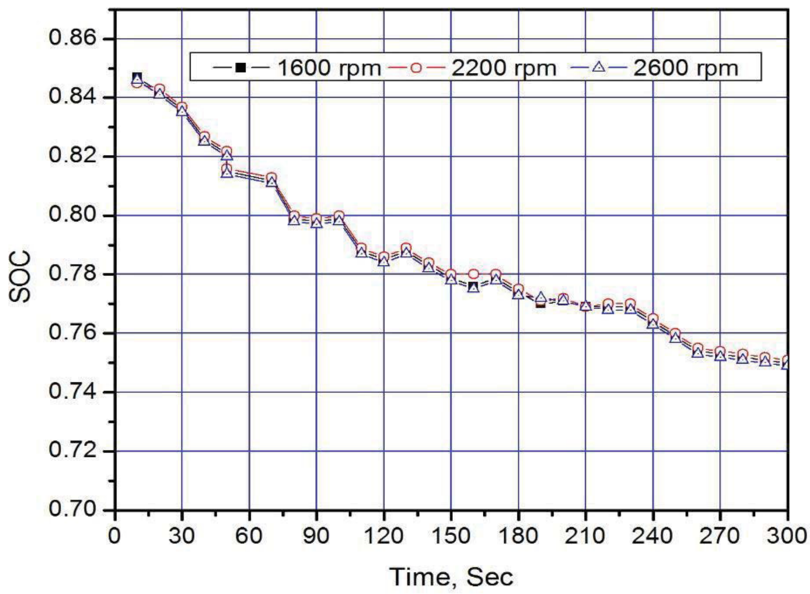


Figure 4: present the SOC for manufacturing swing mechanical weeder arm at different rotational speed.

Table 1: Display the average of fuel consumption, weeder electric power for a development weeder under citrus orange tree field conditions.

treatment		Fuel consumption,Lh-1		Electric power, W	
Forward speed, kmh^{-1}	Rotational sp., rpm	Tines	Blades	Tines	Blades
3.2	1600	7.20	7.19	43.5	66.1
	2200	7.18	7.19	48.2	67.3
	2600	7.20	7.20	51.3	69.2
4.1	1600	7.95	7.96	46.5	68.1
	2200	7.95	7.96	48.2	69.3
	2600	7.96	7.96	51.3	69.8
5.7	1600	8.64	8.66	48.5	66.1
	2200	8.64	8.64	48.9	69.9
	2600	8.64	8.64	57.1	73.2

Table 2: Display the number of weeds before and after operating the manufactured development weeder under citrus orange tree field conditions.

treatment		Number of weeds before trail		Number of weeds after trail	
Forward speed, kmh^{-1}	Rotational sp., rpm	Tines	Blades	Tines	Blades
3.2	1600	80	86	4	0
	2200	72	55	2	0
	2600	97	39	0	0
4.1	1600	91	63	6	4
	2200	83	47	5	2
	2600	68	56	5	1
5.7	1600	54	38	8	4
	2200	62	48	7	2
	2600	82	57	3	3

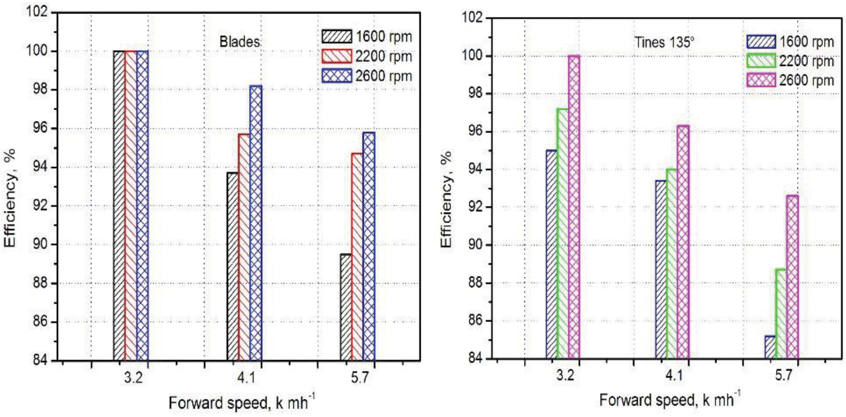


Figure 5: present the weed efficiency for manufacturing swing mechanical weeder arm at different forward speed and rotational speed in orange trees field.

Summary and conclusions

The rotational speed and forward speed affected on the weeder efficiency. As well as, the increasing of forward speed reduce the weed control under orange field conditions. The blades weeder was more effective in controlling weeds than the Tines. Also, the power requirement of the swing mechanical arm with electric weeder could be operating with the tractor without increasing of the fuel consumption. The operating of weeder with blade required more electric power compared to the operating of the weeder with three tines.

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