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A RESEARCH ON DETERMINATION OF TECHNICAL AND ECONOMICAL CHARACTERISTICS OF DIFFERENT PRUNING METHODS APPLIED ON CITRUS

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ÖZET

All the pruning operations in Türkiye are performed by hand tools, and for this reason high level of labor per hectar is required in the pruning. Recently growers have come across important problems because of the increases in labor cost and the decreases in the number of skilled pruning workers. However, investigations on the pruning have been very important to get quality fruit and more yield. In this study, effects of different pruning methods applied in the citrus pruning were searched in terms of solving these problems. In addition to these, influences of limb diameter and cutting edges openness of clippers on cutting force were also studied in laboratory.

The research was carried out with three pruning methods including simple hand tools, pneumatic effective pruning system and pruning machine. The pruning methods were compared in terms of costs and working capacity and physical effects of pruning machine on the soil were also searched. Two pneumatic clippers with 34 and 43 mm cutting edges openness were used for determining the effect of limb diameter and cutting edges openness on cutting force.

The results have shown that cost of pruning with machine was the highest compared to the other methods, whereas it had the highest pruning capacity. Pruning with hand tools was the cheapest pruning method comparing to the others. Soil compaction caused by a heavy the pruning machine was determined by measuring penetration resistances. The level of resistance has been determined too high for crop growth and root elongation. It was also noted that cutting force increased with the increment of limb diameter. In addition, it was also determined that the cliper with big cutting edges openness needed less cutting force than the clipper with small cutting edges openness.

INTRODUCTION

In citrus growing, when cultural operations such as pest, disease and weed control, pruning, irrigation and fertilization are not done in a proper order, effects of these operations are reduced or disappeared. Citrus pruning has been considered as one of the

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cultural operations which have the least necessity. Consequently many citrus growers think that pruning is the most easily dispensed one of cultural operations. Recently, citrus pruning has been very important to get more yield and more quality fruit. Pruning is cutting and bending applications to give a desired shape, rejuvenate and get more production (Yılmaz, 1987). In unpruned citrus orchard use of machine and equipments, which increases working speed and efficiency, will be difficult extremly. The movement of sprayer, harvester, picking trucks and tillage or other equipments in orchard may be improved by removing the branches that prevent management operations.

Simple hand tools, semi-mechanized pruning systems and full-mechanized pruning machines are applied for pruning. According to mechanization level of countries, pruning operations have been done by using one or two of these equipments.

Pruning with simple hand tools requires high manpower. In this method, hand saw, shear, long-handled lopper and ladder have been used. The growers have used saws and clippers operated by compressed air, hydraulic and electric in semi-mechanized pruning. Only movement of knives has been powered in this pruning (Tuncer and Özgüven, 1989). Machines used in full-mechanized pruning are self-propelled or mounted on tractor chassis. Majority of pruning in Türkiye is done with hand tools, semi-mechanized pruning is applied very little. However pruning with machine isn't applied.

In recent years, the growers have faced to important difficulties because of the decrease in the number of experienced pruners and the increases in labor costs. This problem is going to be more important in terms of both cost and time in future. By taking these problems into consideration in this study, pruning system being relevant to the conditions of Türkiye was searched by comparing the working capacity and cost of different pruning methods applied in the citrus pruning and physical effect on the soil of full-mechanized pruning machine which has heavy construction were searched too.

MATERIALS AND METHODS

Materials

This study was carried out at the citrus orchard which has medium texture soil being clayey and loam and belongs to a private agricultural management at Abdioğlu village depentdent on Adana. This region has typical mediterranean climate. The research was carried out on 2005 Domestic orange and Ruby Red greypfruit trees. They were average 26 years old, their spaces are 8x6 m and 7x7 m and average height 6.72 m, canopy diameter 7.25 m and trunk diameter 0.28 m.

Saws, shears and long-handled clippers were used for hand pruning. Pneumatic effective pruning system which consists of power source (2), air compressive unit (1), air tank (5), hoses and hose-winding pulley (6), cutter movement unit (7) and saw and clipper (8,9) has 4 exist units (Figure 1). Universal 445 tractor with 33 kW motor power was used as power source.

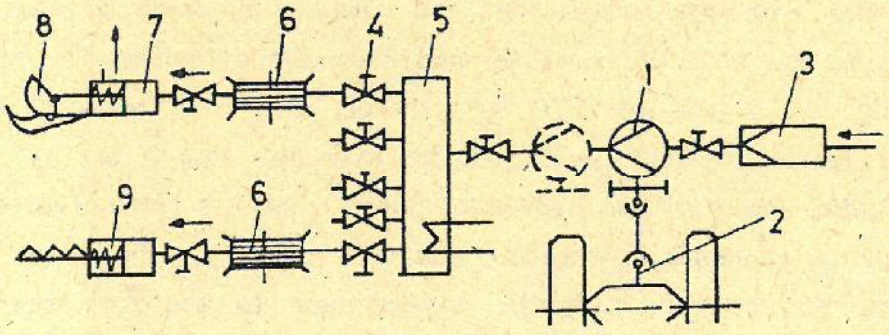

Figure 1. Pneumatic effective pruning system

The working speed of pneumatic saw was 1200 strok per minute. Clippers which have cutting edges openness (average 40 mm) cut a material with mechanical push-effect. There was a safety system to prevent the closing of pneumatic clipper by itself.

TH9 type pruning machine used for full-mechanized pruning was mounted on MF 285 tractor. The pruning machine consisted of a boom which carried cutting wheel with circular saws and main chassis. This machine is able to prune a tree at different angles

(between 50° and 188° from the horizontal). The machine has maximum cutting height of 7.60 m for hedging, 5.20 m for topping of trees and maximum transport height of 2.87 m (Figure 2).

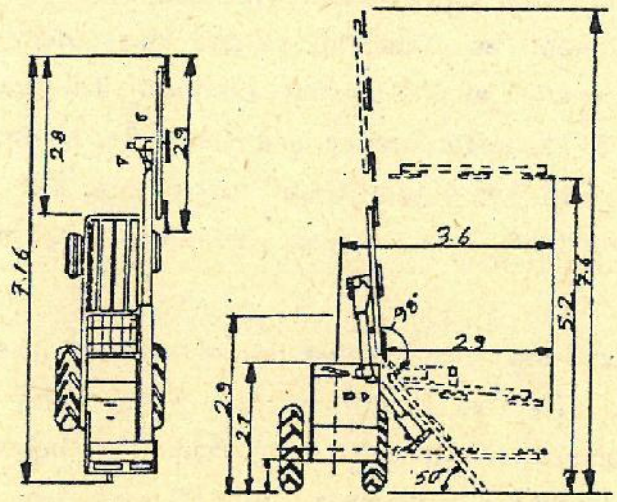

Figure 2. The angles of cutter system on working position of pruning machine.

The hydraulic system on the pruning machine is the main link among the PTO (1), saws (2) and hydraulic cylinders. The hydraulic pump (3) is run by PTO of tractor, flow of pressured oil is directed from hydraulic pump to the hydraulic motor (5) by means of hydraulic hoses (4) and hydraulic motor transmits flow of pressured oil back to mechanical rotating power (Figure 3). The drive chain transmits power from hydraulic motor gear to the saw gear. All the saws are linked together by means of the chains. The cutter of pruning machine has four circular saws of diameter 500 mm. Each of the saws on the ends of rotating arms is run by a saw motor.

In order to make a clean cut and at the same time pull the brush away from the top of the tree, the system must perform three movements in relation to the wood to be cut: saw rotation, cutting wheel rotation and forward movement of machine.

Methods

The orchard treatments were completed in three groups a follow:

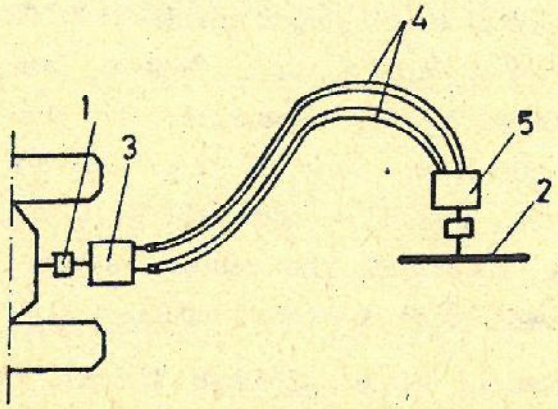

Figure 3. Hydraulic power transmission of pruning machine

- Conventional pruning,
- Semi-mechanized pruning,
- Full-mechanized pruning.

In the conventional pruning used simple hand tools, 20 skilled pruners were employed. The pruners worked for hedging on ground and for topping on tree. Two workers were employed for pneumatic effective pruning. One of them was experienced pruner and the other one was helping worker who performed the jobs such as removing the cut branches and the driving tractor. Pneumatic saw and clipper were used for topping and, hand shear and long-handled clipper for henging. TH9 type pruning machine was run 6 times at the same row for full pruning of trees that have vigor vegetative growth.

Determination of Working Capacity and Cost of Different Pruning Methods

Working capacity of pruning methods was calculated with general formulas used to determine working capacity of agricultural machines. The working capacity of the pruning with simple hand tools was calculated per pruner. The pneumatic system wasn't be able to be used in full capacity, due to the presence of one hose on the system. But the results of pruning were modified according to the full working capacity. Pruning machine was operated by a man who did both driving and pruning simultaneously.

It was accepted that systems were run with full capacity for comparing the costs of pruning methods. 2500 TL/h as labor cost for pruning was taken into account. General formulas were used to calculate the costs of farm machines and equipment (Işık and Tuncer, 1989). In calculations, interest rate, fuel price and oil price were accepted 40 %, 1100 TL/l and 3300 TL/l, respectively. As if the prunings were done with the rented machine and equipments, 25 % costal value was added to overall inputs.

Determination of Effect of Limb Tickness on Cutting Force

Cutting force treatments were carried out at the laboratory of Department of Agricultural Mechanization, Faculty of Agriculture, University of Çukurova. Two pneumatic clippers with 34 and 43 mm cutting edges openness were used to cut limbs with different diameter. The pressure of pneumatic system was raised up to 12.5×10^5 Pa at intervals 2.5×10^5 Pa. At the end of measurements, the maximum limb diameter which can be easily cut by each clipper and effect of cutting edges openness on cutting force were determined.

Determination of Soil Penetration Resistance

In this experiment, physical effect of pruning machine on the soil was searched in terms of soil compaction. Penetration resistance in the soil was measured by using a recording penetrometer with a digital read-out. The diameter of cone on Bush Recording Penetrometer was 12.83 mm and it's angle was 30^o. The cone resistance was measured at intervals 3.5 cm. The maximum penetration depth of the penetrometer was 52.5 cm and the maximum penetration force was 3800 kN/m^2. The measurements were repeated 10 times on track of tractor, under canopy of tree and between tracks for determination of the penetration resistance.

CONCLUSION

According to the results, working capacities of conventional and semi-mechanized pruning methods were determinede as 0.84 and 7.5 trees per hour, respectively. The working capacity of pruning with machine was 23 tree/h and this capacity was higher than working capacity of conventional and semi-mechanized pruning methods, 2638 % and 206.7 %, respectively (Table 1).

Table 1. The working capacity and cost of pruning methods

Pruning Methods	Cost TL/tree	Working Capacity (tree/h)
Conventional	3364	0.84
Semi Mechanized	4310	7.5
Full Mechanized	4454.4	23

Labor and machine costs per tree were taken into consideration in comparing of the costs of pruning methods. The cost per tree was calculeted 3364 TL/tree for the hand tools, 4310 TL/tree for the pneumatic pruning system and 4454.4 TL/tree for pruning with machine (Table 1).

It was shown that the most expensive one was the full-mechanized pruning. It costed 32.4 % and 3.35 % more when compared to conventional and pneumatic effective pruning methods, respectively. Of the pruning methods the cheapest pruning method was conventional pruning.

According to the regreassion analysis which was done to calculate the effect of limb diameter on cutting force, statisticaly a linear the relationship (94 %) between cutting force and limb diameter was found (Figure 4). It was determined that cutting force was increased with the increment of limb diameter.

In addition, the limbs at the same diatemeter were cut by using pneumatic effective hand clipper and long-handled clipper with 34 and 43 mm cutting edges openness in order to determine the effect of cutting edges openness on cutting force. It was also determined that the pneumatic hand clipper needed more cutting force than the pneumatic long-handled clipper and it was 1.3 times higher than the pneumatic long-handled clipper.

Penetration resistance dependent on profile depth of the soil was measured as Mpa for determination of physical effects of pruning machine on the soil (Figure 5).

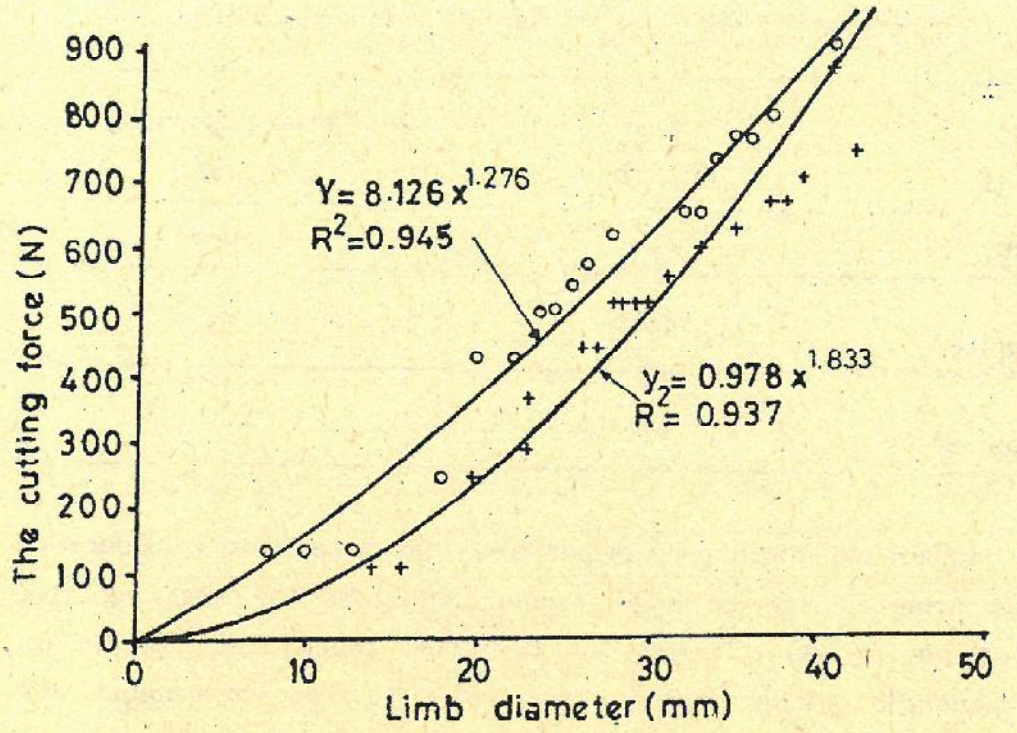

Figure 4. The relationship between cutting force and limb diameter

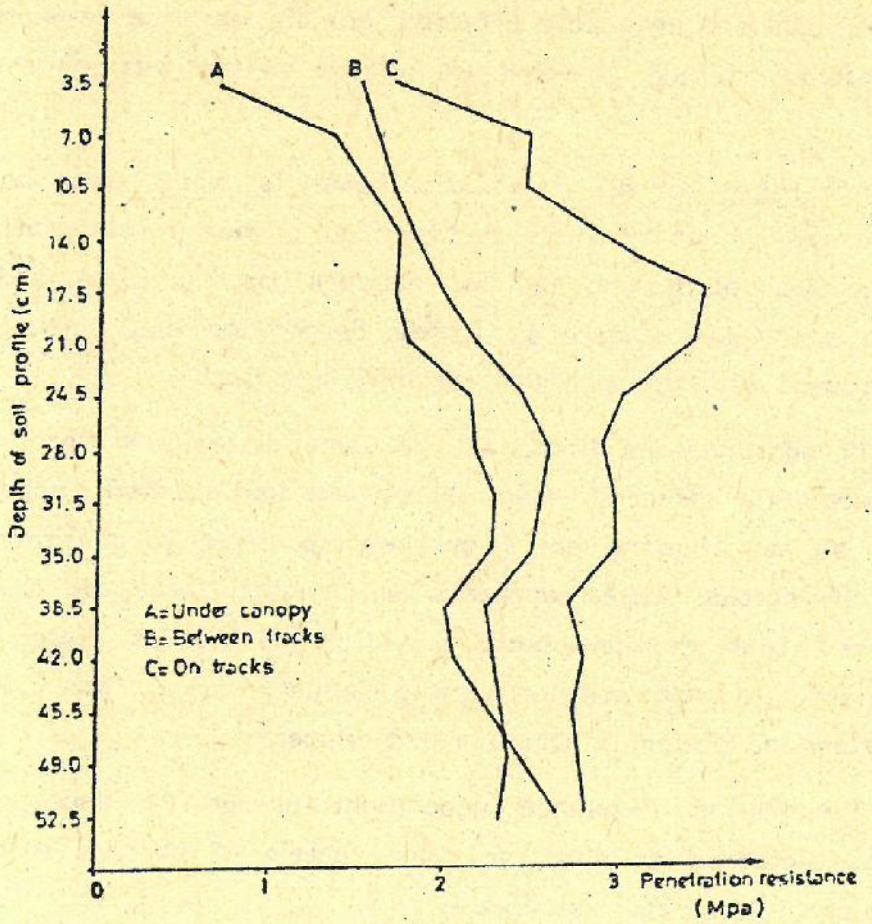

Figure 5. The variations of penetraiton resistance to depth of soil profile

The highest penetraiton resistance was found 2.56 Mpa in both the area between tracks of pruning machine and under the tree canopy. However this measured soil penetration resistance wasn't too high for crop growth and root elongation. Buscher and Sojka (1987) have indicated that if soil penetration resistance was higher than 3 Mpa, crop and root grofth were prevented. As a result, the measurements taken from the tracks of pruning machine, especially in depth of 17.5-21 cm soil profile, the penetration resistance was found 3.45-3.38 Mpa, which was rather high. This high value does not allow healty crop growth and root elongation. After pruning with machine, the soil must be tillaged by orchard equipments such as cultivator and harrow to prevent soil compaction.

Although, pruning with machine had the highest working capacity, it's usage is not available under Türkiye conditions now. Only big farmers can afford to have them. However the pruning machines operated by compressed air, electric and hydraulic can be bought easily by growers. The speed and efficency of these tools may be increased by using them in conjunction with a mobile platform on the tractor or self-propelled. In addition, tractor which high operation cost, can be used as a power source in early spring when pruning is intensively done. Therefore, the using period of a tractor can be prolonged during a year.

ÖZET

TURUNÇGİLLERDE UYGULANAN FARKLI BUDAMA YÖNTEMLERİNİN TEKNİK VE EKONOMİK YÖNDEN İRDELENMESİ ÜZERİNE BİR ARAŞTIRMA

Günümüzde turunçgil yetiştiriciliğinde diğer bitki türlerinde olduğu gibi daha çok, daha kaliteli ve daha erken ürün elde edebilmek amacıyla hastalık ve zararlılarla savaş, sulama, gübreleme gibi kültürel işlemlerin yanı sıra budama uygulamaları da gittikçe artan bir önem kazanmaktadır.

Türkiye'de budama işlemleri yoğun iş gücü gerektiren geleneksel budama yöntemiyle yapılmaktadır. Mekanik etkili alet ve ekipmanların kullanımı henüz yaygınlaşmamış olup makinalı budama hiç yapılmamaktadır. Oysa budama işinin yoruculuğu, her geçen gün artan deneyimli iş gücü gereksinimi ve işçi ücretleri üreticileri ilerde büyük sorunlarla karşı karşıya getirecektir. Çalışmada bu sorunlar dikkate alınarak turunçgil budamasında uygulanan farklı budama yöntemleri ekonomik ve iş verimi açısından araştırılmıştır. Ayrıca bu çalışmaya ek olarak ağır yapılı budama makinalarının yaygınlaşması halinde toprak üzerinde yaratabileceği fiziksel etkiler ve pnömatik etkili el makası ve uzatma kollu makas kullanarak kesme kuvvetine dal kalınlığının etkisi saptanmaya çalışılmıştır.

Adana-Abdioğlu köyünde özel bir tarım işletmesine ait turunçgil (altıntop ve portakal) bahçesinde yürütülen budama çalışmaları; geleneksel (basit el aletleri), yarı mekanize edilmiş (pnömatik etkili kesiciler) ve tam mekanize edilmiş budama yöntemleri olmak üzere başlıca üç grupta tamamlanmıştır. Kesme kuvvetine dal çapının etkisini saptamaya yönelik olarak yapılan çalışmada, sırasıyla 34 ve 43 mm kesme ağız açıklığına sahip pnömatik el makası ve uzatma kollu makas kullanılmıştır.

Yöntemler arasında budama giderleri, makinalı budamada geleneksel ve yarı mekanize edilmiş budama yöntemlerine kıyasla en yüksek değere ulaşmış olmasına karşın bu yöntemin iş başarısının diğerlerine göre daha yüksek değerde olduğu belirlenmiştir. En ekonomik budama yönteminin ise geleneksel budama yöntemi olduğu saptanmıştır. Buna karşın adı geçen yöntem en düşük iş verimine de sahiptir.

Ağır yapılı budama makinasının toprakta oluşturduğu penetrasyon direnci 3.45 Mpa gibi oldukça büyük bir değere ulaşmıştır. Bu değer bitki büyümesini ve kök gelişimini olumsuz yönde etkileyen toprak sıkışıklığına neden olmuştur. Bu nedenle budamanın makina ile yapılması halinde budamadan sonra toprağın mutlaka kültüvatör, diskaro vb. bahçe ekipmanlarıyla kabartılarak işlenmesi gerekmektedir.

Dal çapı kalınlığının kesme kuvvetine olan etkisini saptamak için yapılan laboratuvar çalışması sonucunda istatistiksel olarak dal çapı kalınlığı ile kesme kuvveti arasında % 94 gibi büyük bir değerde doğrusal bir ilişki olduğu saptanmıştır. Bu analiz sonucunda dal çapı kalınlığının artmasıyla gerekli kesme kuvvetinin de arttığı ortaya konmuştur. Diğer taraftan aynı kalınlığa sahip dalı kesmek için pnömatik el makasının uzatma kollu makasa göre 1.3 kat daha fazla kesme kuvvetine gereksinimi olduğu saptanmıştır.

Oldukça büyük ekonomik yüke sahip budama makinaları günümüz Türkiye şartlarına uygun olmamakla birlikte ileriki yıllarda ortaya çıkabilecek sorunları göz önüne alarak makina konstrüksiyonunun hafifletilmesi ve bahçe düzenlerinin iyileştirilmesi gerekmektedir. Fakat şu anki koşullarda geleneksel budama yöntemine göre çalışma hız ve etkinliğini artıran mekanize edilmiş kesicilerin kullanımı daha uygun olacaktır.

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