Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar

Spanish Journal of Agricultural Research 2008 6(3), 333-340
ISSN: 1695-971-X

Design, construction and testing of an apricot tractor-trailed harvester

A. Torregrosa[1]*, O. Chaparro[2], B. Martín[3], C. Ortiz[1], J. J. Bernad[1], E. Ortí[1], J. Gil[4] and M. Pérez[1]

[1] *Departamento de Mecanización y Tecnología Agraria. Universidad Politécnica de Valencia. Cno. Vera, s/n. 46022 Valencia. Spain*
[2] *Universidad Nacional de Colombia Sede Palmira. Carrera 32 Chapinero. Vía Candelaria. Palmira (Valle del Cauca). Colombia*
[3] *Departamento de Ingeniería de Alimentos y del Equipamiento Agrícola. Área de Ingeniería Agroforestal. Universidad Politécnica de Cartagena. Paseo Alfonso XIII, 48. 30203 Cartagena (Murcia). Spain*
[4] *ETSIA. Universidad Politécnica (UPM). Ciudad Universitaria. 28040 Madrid. Spain*

Abstract

The purpose of this research is to facilitate the mechanical harvesting of apricots (*Prunus armeniaca* L.) for industry. A tractor-trailed harvester was built to catch the fruits detached from apricot (cv. Búlida) trees by vibratory systems. This machine is a low profile catcher that can move under the trees in high-density canopies where umbrella-type harvesters cannot. The trailer is able to work under trees with as little free-trunk height as 0.35 m. The tests were done in 5- to 9-year-old apricot trees, planted in two frame, 2.5 m and 4.5 m in-the-row distances, with 6.5 m between rows in both cases. To detach the fruit, two hand-held pneumatic shakers were used. Harvest rate was 61 and 44 trees h^{-1} for each type of orchard, respectively. The main conclusion is that the trailer, together with branch-shakers, can work in narrow orchards of low canopy trees where other machines can not go in.

Additional key words: apricot harvesting, mechanical harvesting, *Prunus armeniaca,* trailed fruit harvester.

Resumen

Diseño, construcción y evaluación de un remolque recolector de albaricoques

El objetivo de este trabajo fue facilitar la recolección mecanizada de albaricoques (*Prunus armeniaca* L.) para industria. Se ha construido un remolque recolector arrastrado por tractor para recoger los albaricoques cv. Búlida derribados de los árboles mediante sistemas vibratorios. El remolque puede trabajar a muy poca altura sobre el nivel del suelo, con lo que puede moverse bajo los árboles en plantaciones de alta densidad, en las que las cosechadoras basadas en paraguas invertidos no pueden actuar. Además, el remolque se puede adaptar a árboles con alturas de tronco tan reducidas como 0,35 m. Los ensayos se llevaron a cabo en albaricoqueros de 5 a 9 años de edad y plantados en marcos de 2,5 y 4,5 m entre árboles de la fila y 6,5 m entre filas. El derribo de los frutos se realizó con vibradores neumáticos. La capacidad de trabajo del equipo fue de 61 y 44 árboles h^{-1} para cada distancia de plantación, respectivamente. La principal conclusión es que el remolque, conjuntamente con vibradores de ramas, puede trabajar en plantaciones de marco estrecho y árboles con la cruz del tronco baja donde otras máquinas no pueden actuar.

Palabras clave adicionales: cosechadora remolcada de fruta, *Prunus armeniaca,* recolección de albaricoques, recolección mecánica.

* Corresponding author: torregro@dmta.upv.es
Received: 06-11-07; Accepted: 11-06-08.

A. Torregrosa, B. Martín, C. Ortiz, J. J. Bernad, E. Ortí, J. Gil and M. Pérez are members of the SEA.

Introduction

Tree shaking is a suitable detachment technique for apricots (*Prunus armeniaca* L.) (Mady, 1982), and apricots cv. Búlida, used in the processing industry, could be harvested by commercial harvesters while maintaining industrial quality standards (Ortiz *et al.*, 2004). In 2003, Erdogan *et al*. designed and constructed an inertia type limb shaker, hydraulically powered and driven by the tractor power take-off, for the mechanical harvesting of apricots. They studied some of the properties of apricots: the time needed to shake a limb, the optimum frequency and amplitude to obtain the maximum fruit removal with the minimum reactive force, and the fruit removal percentage. They also measured the percentage of fruit damage and the harvesting rate, and compared the shaker with other harvesting systems.

In Murcia (Spain), some tests were developed in order to compare the different systems used for harvesting apricots and other fruit (Torregrosa *et al.*, 2003; Chaparro, 2004). The most common machines detach the fruit with an inertial shaker and catch it with inverted umbrellas. However, in high density orchards, these umbrella-based machines cannot operate due to the short distances between trees (~2.5 m) that hinder the umbrella from fully opening. Other machines, like the non-stop harvesters based on a pair of mirror image units, each working on one side of the row and provided with plane surfaces, can work in hedge-type orchards. Unfortunately, they need nearly 1 m of free trunk height to place the shaker and the catching planes (Torregrosa *et al.,* 2006), and most orchard trees have short trunks, less than 0.5 m in height. Therefore, the purpose of this work was to design an automatically controlled harvester that could be placed within and moved across the row to form a complete catching surface beneath the tree canopy. The catching surfaces would move under the trees in a plane parallel to the ground, to avoid any interference from overlapping branches. The catching surfaces should be cushioned to reduce fruit damage and the harvester adapted to fields with longitudinal and transverse slopes.

Although some similar machines have been patented and constructed, such as the McHugh *et al.* (1981) tree-fruit harvester, problems to solve fruit damage and fruit transference between the different planes in the machine have shown the current lack of commercial machines to harvest high-density orchard apricot crops in Spain.

Peterson *et al.* (1997, 2003), and Peterson and Bennedsen (2005) constructed a harvester for narrow-inclined trellises. In their case, the distance between trees was short, and they formed a continuous hedge, but the trees were V- or Y-shaped, aided with the posts and iron cables forming the trellis. The harvester had inclined planes that favored the catching of the fruit from a short distance. The detachment was made with an impact actuator. Two mirror image machines worked at the same time, one on each side of the row. The space between the trees was sealed with catch pans and the machines were self-propelled. A machine like this would be able to detach the apricots since not much energy is needed in this process. Also, the proximity between the catching planes and the fruit would allow to pick them carefully. However, at the moment, the training system of the high density apricot crops cultivated in Spain is free pruned.

Since a commercial harvester, such as the one required, does not exist in the European market, the design of a trailed harvester, with surfaces which can spread out, was finally planned. This paper seeks to explain the design and testing of this equipment.

Material and Methods

The trailed harvester is towed by a 50 kW tractor that moves forward between the tree rows. The trailed harvester has a chassis measuring 4 m in length and 1.7 m in width. When the longitudinal center of the trailer is in front of each trunk, the tractor stops, and the trailer operator extends the catching planes to the right side of the trailer covering the dropping area under the tree. The catching canvas is able to cover the fruit dropping area of trees that have a maximum canopy diameter of 2.5-3 m. The empty weight of the trailer is 450 kg and the maximum load capacity, 400 kg (Fig. 1).

The trailer has three floors: i) the lower, which catches the fruit falling from the top left-hand side of the canopy, and accumulates them, ii) the second floor, which is moved towards the trunk until it covers the area between the lower floor and the trunk, and iii) the third floor, which is made up of two planes that pass on each side of the trunk, and then move towards each other —closing against it— to collect the fruit that fall on the row opposite from the trailer. When all the planes are extended, the trailer covers an area of 4.0 m long by 4.4 m wide. Two additional slanted extensions have been mounted onto the third floor to increase the co-

Figure 1. Tractor-trailed harvester.

vering area. The trailer is tilted by means of differential lifting on the left and right wheels so that the fruit caught by the different surfaces can roll down to the lower floor by gravity. The trailer is unloaded by lifting and placing bins or boxes under it, after which a series of eleven traps are opened and the fruit fall.

There are two articulated arms at the rear of the chassis, and the wheels are attached at the end of these. These arms move independently on a vertical plane, each of them motioned by a hydraulic cylinder. This movement, combined with the tractor's elevator system, allows for the harvester's leveling in the longitudinal and transverse directions. The trailer's maximum height over the ground is between 0.2 and 1.22 m. This higher clearance allows the unloading of apricots into the boxes or box pallets with a minimum dropping height, preventing fruit damage.

The arm-wheel hydraulic cylinders are operated by the tractor's external oil system. Hydraulic controls are located on the left rear side of the trailer. A person walking next to the harvester with a manual branch shaker could also control the trailer hydraulic system. The external remote oil valve of the tractor remains open throughout the working day. A schematic diagram of the hydraulic system is shown in Figure 2. Valve 1 is the flow regulator. It maintains constant flow to the cylinders and keeps their movement at controlled speed with independence of the tractor's oil supply. Directional valves 2 and 3 are controlled by the person beside the trailer. Valve 7 provides a constant speed —without cavitation— in the cylinder of the right wheel when it goes down, even if the load is very heavy. Valve 6 has a similar effect on the left wheel cylinder, but it is a double valve due to the risk of having both upper and

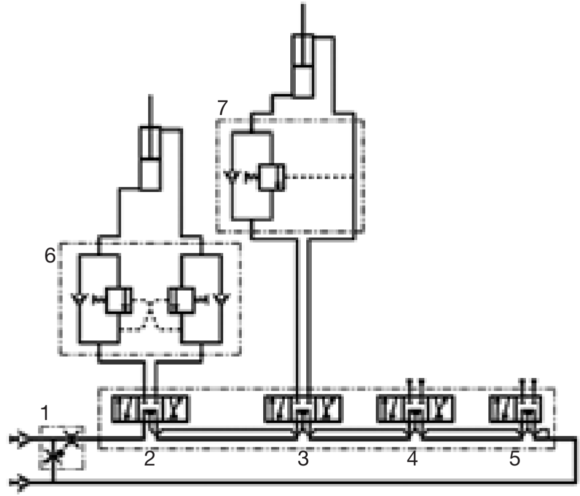

Figure 2. Schematic diagram of the trailer hydraulic system. Explanation of numbers in Material and Methods.

lower loads on the cylinder. Directional valve 4 is still not used, but it will serve to move a conveyor belt to unload the fruit.

The tractor's external supplier is always open to send oil to the trailer, but this flow is only used when needed by acting on directional valves 2 and 3. As there are tractors with open center and closed center hydraulic systems, when the trailer does not need the flow to make a movement, the oil has an open (open center) or a closed (closed center) passage to the tank, depending on the position of valve 5. In any position of remote valve 5, when directional valves 2 or 3 are moved, the oil will enter by one port of the cylinder and will exit by the other port to the tank.

The harvester's fruit catching surfaces are moved by a pneumatic system (Fig. 3). The trailer runs parallel

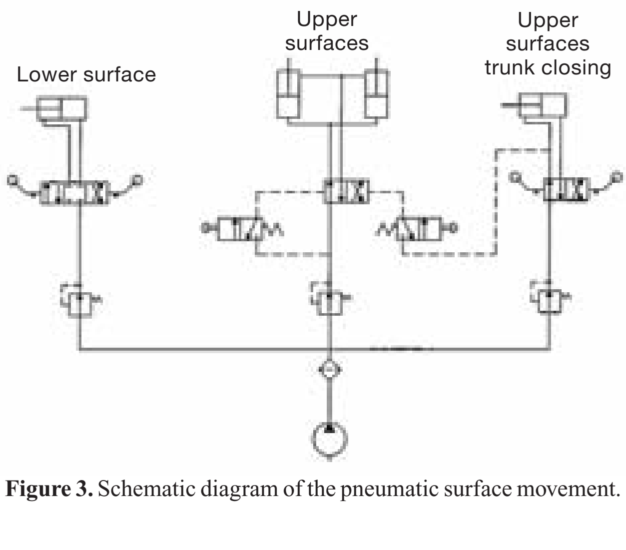

Figure 3. Schematic diagram of the pneumatic surface movement.

Figure 4. Lower surface extension out (left) and upper surfaces and additional extensions benath the tree (right).

to the tree row, close to the trunk. The space between the chassis and the trunk is covered moving the lower catching canvas from the top of the trailer until it reaches the trunk. This surface movement ranged from 0 to 0.8 m and it also displaces the upper surfaces (Fig. 4).

To cover the area under the tree top on the opposite row, two surfaces —1 m maximum each— are spread out and closed against the tree trunk. In addition, two more extensions could be used to cover a larger area. Therefore, when working, the trailer's length is 4 m and its width varies between 2.2 and 4.4 m.

All the metallic parts of the trailer that could strike with the fruit are covered by shock absorbing material to avoid damage: low density (6 kg m^{-3}), 1 cm thick, flexible polyurethane foam (Tecnholen EE-33, suplied by Tovsi S.A., Valencia). The catching surfaces are made of high density polystyrene, 5 cm thick and covered with a film of nylon (IonPlas S.L. Bonrepós, Valencia).

An electronic fruit PTR200, from SM Engineering, was used to evaluate the damping properties of the catching surfaces.

All the controls were placed on the trailer on the opposite side of the surfaces, therefore, the person operating the controls is able to see the trunk and any possible obstacle. A future self-propelled prototype could also be driven from this position.

As previously mentioned, the trailer is pneumatically and hydraulically operated, but the new prototype could be hydraulically operated only. A hydraulic system for moving the surfaces has already been designed. Nevertheless, the pneumatic system was chosen for this model because it is easier to build: the connections of the pipes are simpler, the system results in fewer oil leaks, and the air compressibility protects the structure from strikes against the trunk and branches. An air compressor lift mounted on the tractor, and operated by the tractor's power take-off, provided pressure between 0.8 and 1 MPa. The trailer was hitched behind the compressor.

To detach the fruit, two hand-held pneumatic shakers were used. One of them had a mass of 1.9 kg, 0.03 m stroke and 13 Hz frequency, while the other was 3.7 kg, 0.056 m stroke and 22.5 Hz frequency.

The tree cross was short (0.35 m). The harvester was tested during the years 2003 and 2004 in two types of orchard, a) intensive: distance between trees in the row was 4.5 m, and 6.5 m between rows, aged 6-9 years; b) super-intensive: distance between trees in the row was 2.5 m, and 6.5 m between rows, aged 5-8 years.

The trials were done in a field in Isso (Hellín, province of Albacete, Spain), UTM coordinates, x = 603455, y = 4260992, altitude 550 m, drip irrigated, no-tillage and high longitudinal (10%) and transverse (5%) land slopes.

Operation time of the harvesting system was recorded with a video camera, using 12 and 22 trees, in the intensive and super-intensive orchards, respectively.

The mass of the fruit that fell on the catching systems, on the soil, and left on the tree was measured, as well as its evolution after fridge storage. One hundred fruit were tested to evaluate the percentage of fruit damage during harvesting (number of bruised fruit). The main physical properties of fifty apricots harvested by an inverted umbrella harvester (2003 season) and fifty apricots harvested by the trailed harvester prototype (2003 and 2004 season): mass, sugar content (°Brix), firmness, and manual Magness-Taylor maximum force (N cm^{-2}), were measured.

Results

Harvest rate was 55.6 and 62.5 s tree^{-1} for the super-intensive and intensive orchards, respectively (Tables 1 and 2). Vibration duration —which depended on the number of harvested branches caught, 4-10 branches tree^{-1}— averaged 27.2 and 36.3 s tree^{-1}, respectively. The operators apply a short vibration (of less than 2 s) to each limb and the number of limbs shaken and shaking duration depended on the visual appreciation of the operator.

The operation of extending the catching surfaces required 8.1 and 5.3 s tree^{-1} in each orchard. The fastest extension took 4.0 s, but when the lowest branches interfered with the trajectory of the surfaces, the time needed to spread them reached a maximum of 31.0 s tree^{-1}.

After shaking, the surfaces were folded. This operation took 6.8 s tree^{-1} in both types of orchard, with a maximum of 13.5 s tree^{-1} and a minimum of 4.0 s tree^{-1}.

Displacement time between two trees was 14.1 s for the intensive orchard and 13.5 s for the super-intensive one, correlating with the 4.5 and 2.5 in-the-row distances.

Unloading was done after harvesting 12 trees in the intensive orchard and after 22 trees in the super-intensive. Unloading time was 105.2 s, a considerable part of which was used to place a container under the trailer (21 s). Unloading time for each set of trapdoors was between 4.1 and 5 s, lifting the trailer took 9 s and lowering it, 5.7 s (Table 3).

The overall harvesting rate was 60 trees h^{-1} in the super-intensive orchard and 51 trees h^{-1} in intensive orchard.

The prototype was tested in both ascending and descending longitudinal slopes. In the transversal ones, however, the trailer was always placed at a lower level than the harvested tree row, thus taking advantage of the positive tilting of the catching surfaces against the reception frame, which favored the fruit rolling down.

The tests showed that the trailed harvester may be used in considerable longitudinal (10%) and transverse (5%) land slopes thanks to its tilting ability, and it

Table 1. Harvest rate using the pneumatic branch shakers and the trailed harvester in the 6.5 m × 2.5 m frame

Tree	Unfolding the catching surfaces (s)	Vibration time (s tree^{-1})	Folding the catching surfaces (s)	Displacement time between trees (s)	Total time (s)
1	6.8	9.0	6.1	6.0	27.9
2	5.1	6.0	5.1	5.8	22.0
3	5.2	8.0	8.9	7.0	29.1
4	15.0	22.0	13.5	16.2	66.7
5	5.6	14.2	6.0	17.0	42.8
6	12.0	15.1	5.0	10.0	42.1
7	6.0	37.1	6.0	12.3	61.4
8	4.0	19.5	7.8	20.0	51.3
9	4.0	44.1	4.0	7.0	59.1
10	11.2	35.0	4.0	18.2	68.4
11	31.0	32.0	12.1	12.3	87.4
12	12.3	48.0	5.0	7.1	72.4
13	5.0	19.0	7.2	7.0	38.2
14	4.0	32.1	8.1	9.0	53.2
15	4.0	28.1	5.2	9.3	46.6
16	12.1	27.3	5.2	7.0	51.6
17	9.0	29.0	4.0	18.0	60.0
18	5.3	38.0	4.6	18.1	66.0
19	5.0	33.0	12.0	28.0	78.0
20	6.0	41.0	8.0	42.0	97.0
21	5.6	28.6	5.1	9.8	49.1
22	4.0	32.1	6.4	10.5	53.0
Average	8.1	27.2	6.8	13.5	55.6
SD	6.1	11.8	2.7	8.6	18.8

SD: standard deviation.

Table 2. Harvest time using the pneumatic branch shakers and the trailed harvester in the 6.5 m×4.5 m frame

Tree	Unfolding the catching surfaces (s)	Vibration time (s tree^{-1})	Folding the catching surfaces (s)	Displacement time between trees (s)	Total time (s)
1	6.0	20.0	5.2	14.2	45.4
2	4.5	18.3	5.1	15.4	43.3
3	4.0	45.3	9.0	11.1	69.4
4	6.2	23.4	8.7	21.3	59.6
5	11.4	48.5	7.2	11.2	78.3
6	4.1	28.1	7.5	16.2	55.9
7	4.0	12.5	8.1	14.2	38.8
8	4.0	55.0	8.1	12.1	79.2
9	6.8	56.0	6.1	14.3	83.2
10	4.0	37.4	5.3	11.9	58.6
11	4.0	45.0	5.3	12.8	67.1
12	4.7	46.0	6.4	14.5	71.6
Average	5.3	36.3	6.8	14.1	62.5
SD	2.2	15.2	1.4	2.8	14.8

SD: standard deviation.

was able to harvest trees with a free crossing height of 0.35 m.

The harvested fruit had an average mass of 36 g (SD 8.2 g), an equatorial diameter of 39.9 mm (SD 2.9 mm), a Magness-Taylor firmness of 45.1 N (SD 16.7 N) and a sugar content of 12.3° Brix (SD 1.9° Brix).

Table 3. Unloading time from the trailed harvester to the container, after harvesting 12 trees in the intensive and 22 trees in the super-intensive orchards, respectively

Operation	Time (s)
1. Moving the empty container from the trailer to the ground	11.0
2. Rising the trailer 90 cm	9.0
3. Placing the container under the trailer	21.0
4. Unloading the first loading section of the trailer (opening the first set of 3 trapdoors)	4.1
5. Moving the trailer to the second section	6.0
6. Unloading the second loading part of the trailer (opening the second set of 3 trapdoors)	4.2
7. Moving the trailer to the third section	10.1
8. Unloading the third loading section of the trailer (opening the third set of 3 trapdoors)	5.0
9. Placing another container	13.0
10. Unloading the fourth loading section of the trailer (opening the fourth set of 2 trapdoors)	5.0
11. Moving the trailer from the containers	11.1
12. Lowering the trailer to the working height	5.7
Total unloading time	105.2

Harvested apricots were of good enough quality to be used in the processing industry, according to the industry requirements (Torregrosa *et al.,* 2003). In the 2003 season, 24% of the fruit harvested by the trailed harvester were damaged (fruit with at least one small visible bruise), compared to 21% damaged fruit harvested by the umbrella systems used in the same orchard with wider frame plantations. In the 2004 season, 30% of the apricots had at least one small bruise after being collected by the trailed harvester (Table 4).

The damage increase for the year 2004 with respect to the 2003 campaign could have been related to the significant lower firmness of the fruit, 45 N in 2003 against 34 N in 2004.

Damping properties of the catching surfaces were significantly different. The 0.05-m thick polystyrene showed a potential damage three times higher than the 0.01 m thick polyurethane, as measured by the electronic fruit (Ortiz *et al.,* 2007).

Discussion

The harvest rate was between 51 trees h^{-1} for the intensive and 60 trees h^{-1} for the super-intensive orchards (701 and 448 kg h^{-1}worker^{-1}, respectively), both very high in comparison to hand harvesting (56 kg h^{-1} worker^{-1}, harvesting rate obtained directly from the producers).

The maximum values for the time it took to unfold and to fold the catching surfaces were due to collisions

Table 4. Fruit damage percentages and quality parameters. The *harvesting system* and *season* factors showed significant differences for all the parameters studied (mass, Magness-Taylor firmness and soluble solid content)

Harvesting system	Year	% damage	Fruit quality parameters: Mass (kg)		Firmness (N)		Soluble solid content (°Brix)	
			Average	SD	Average	SD	Average	SD
Inverted umbrella harvester	2003	21	0.049	0.013	30.5	17.4	11.8	2.0
Trailed harvester prototype	2003	24	0.040	0.082	45.1	17.2	10.7	1.9
	2004	30	0.060	0.012	34.2	20.0	12.0	2.5

with low horizontal-growing branches. This operation could be improved with adequate pruning to eliminate these branches.

Total unloading time was 105.2 s. This represents 7.9% of the total time (harvesting 22 trees and unloading) for the super-intensive orchard, and 12.3% of the total time (harvesting 12 trees and unloading) for the intensive orchard. An important percentage of the unloading time was used to place the container under the trailer (21 s, 20%). This operation needs to be improved by modifying the unloading system in order to increase the trailed harvester field's capacity.

A trap door system was chosen to avoid fruit transference between conveyors, to reduce discharge height and, consequently, damage. In a certain way, this objective was fulfilled, but the time necessary to evacuate the fruit was too long and the operation of placing the empty boxes under the machine resulted rather complicated. It is better to replace the traps by a conveyor and to discharge the harvester through its longitudinal side end.

The pneumatic motion of the catching surfaces proved to be a good solution to avoid failures in the machine when the surfaces chocked with the branches. If hydraulic motion is used in a new prototype, high attention must be paid so as to limit the system's pressure to preserve the machine components.

To avoid fruit accumulating on the catching surfaces, it is necessary to have a positive slope between the surfaces and the accumulation area of the harvester. This positive slope can only be reached with trunks 0.5 m or higher, or in transversally-tilted fields, working with the trailer in the lower side of the row.

Damaged fruit harvested by the prototype (with at least one small visible bruise) could be used in the processing industry but they could not be used in the fresh market. Damaged fruit percentage was around 24-30%.

In Spain, hand-harvesting costs are becoming an important problem for producers. Thus, the trailed harvester could be an option to grow more profitable plantations, since it can reduce harvesting costs from 0.107 € kg^{-1} of hand harvesting to 0.025-0.039 € kg^{-1} of the trailed harvester (Torregrosa *et al.,* 2006; García, 2007).

Fruit harvesters based on inverted umbrellas have two main limitations: 1) to effectively spread the umbrella they need isolated trees, and 2) since fruit are conducted to a common narrow reception point, friction between them can cause damage.

Harvesters based on extensible canvasses, like Pool and Knapp's (1967) invention, can handily pick the fruit, but the weight of these tends to curve the canvas and they become difficult to manage.

Inclined frames, like the one constructed by Peterson *et al.* (2003), need V or Y shapes, and a pair of machines must be working synchronously.

Most fruit orchards are not prepared for mechanical harvesting since they have high slopes and small free crossing heights. The trailed harvester could solve the problem in steep longitudinal and transversal slopes.

In short, the main advantages of the tractor-trailer harvester prototype are: i) it reduces apricot harvesting costs by three times, approximately, with respect to hand harvesting; ii) the fruit harvested is valid for processing; iii) it does not require specially pruned or conducted trees; iv) it can harvest trees with small free crossing heights and v) its tilting ability allows to work in highly unleveled fields.

Acknowledgments

The authors would like to thank the Spanish Ministerio de Ciencia y Tecnología for supporting the AGL2001-3075 project, the Region of Murcia's Consejería de Agricultura, Agua y Medio Ambiente for support through the Séneca AGR/2/FS/01D project. They also appreciate the contributions made by Antonio Garcia Rech (owner of the orchards), Juan José Peña (mechanic) and Celestino Gil (PhD student).

References

CHAPARRO O., 2004. Recolección mecánica de albaricoque: estudio del derribo del fruto y diseño de estructuras de recepción. Doctoral thesis. Polytechnic University, Valencia, Spain. [In Spanish].

ERDOGAN D., GUNER M., DURSUN E., GEZER I., 2003. Mechanical harvesting of apricots. Biosyst Eng 85(1), 19-28. doi:10.1016/S1537-5110(03)00024-2.

GARCÍA J., 2007. Evaluación económica y eficiencia del agua de riego en frutales de regadío. Consejería de Agricultura y Agua de la Región de Murcia. Serie de Estudios Técnicos nº 31. 115 pp. [In Spanish].

MADY R., 1982. Horticultural factors influencing fruit damage at mechanical apricot harvesting. VII Symposium on Apricot Culture and Decline. Acta Horticulturae 121, 353-363.

McHUGH C.M., WEBB B.K., GARRETT T.R., HOOD C.E., 1981. Compact, single operator tree crop harvester. T ASAE 23(1), 26-30.

ORTIZ C., MARTÍN B., TORREGROSA A., BERNAD J.J., CHAPARRO O., GIL C., 2004. Quality in apricots (cv. Bulida) for processing industry harvested by different mechanical and manual systems. Proc Ageng, Leuven, Belgium, Sep 12-16. pp. 432-433.

ORTIZ C., TORREGROSA A., BERNAD J.J., 2007. Capacidad de protección frente a daños en la fruta de diferentes superficies de recogida. Agroingeniería. Albacete, Spain, 4-6 Septiembre 2007. 6 pp. [In Spanish].

PETERSON D.L., MILLER S.S., WOLFORD S.D., 1997. Apple harvest aid for inclined trellised canopies. T ASAE 40(3), 529-534.

PETERSON D.L, WHITING.M.D., WOLFORD S.D., 2003. Fresh-market quality tree fruit harvester Part I: Sweet cherry. Appl Eng Agr 19(5), 539-543.

PETERSON D.L., BENNEDSEN B.S., 2005. Isolating damage from mechanical harvesting of apples. Appl Eng Agr 21(1), 31-34.

POOL S.D., KNAPP W.H., 1967. Mounted fruit picker. US Patent 3347032.

TORREGROSA A., MARTÍN B., BERNAD J.J., ORTIZ C., ARAGÓN R., CHAPARRO O., 2003. Recolección mecánica de albaricoque Búlida para la industria. IMIDA, Murcia. ISBN: 84-606-3433-7. [In Spanish].

TORREGROSA A., MARTÍN B., ORTIZ C., CHAPARRO O., 2006. Mechanical harvesting of processed apricots. Appl Eng Agr 22(4), 499-506.