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HORIZONTAL CANOPY FOR PLUMS MECHANICALLY HARVESTED IN CONTINUOUS MOTION

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Abstract. Mechanical harvesting of plum fruit cuts drastically costs of production. 'Elena' plum trees were planted, at a high density (4 × 1.0 m and 4 × 1.5 m) and trained to a horizontal canopy. The trees, trellised on wires 1 m above the ground, created a continuous, open-texture, fruit-bearing horizontal surface, 2 × 200 m long. Plum trees planted at the distance 4 × 1.5 m and 4 × 2.0 m trained to the standard leader tree served as the control. In the fifth to seventh year from planting (2012–2014), plums from the horizontal canopy were harvested with a tractor-driven, canopy-contact harvester. Fruits from the standard leader trees, having a height of 2.8 m, were harvested with a self-propelled canopy-contact straddle harvester. The mean volume of a horizontally trained tree was 3.6 m^3, compared with 7.4 m^3 of a standard leader tree. The efficiency of mechanical fruit harvesting of control trees was 40 times higher than of hand picking. The efficiency of fruit harvesting of horizontal canopy trees was 25 times higher than of hand harvesting. The effectiveness of fruit collecting of standard leader trees was 86–94% against horizontal canopies 72–80%. Plums harvested with the small tractor-driven harvester were of good quality. After grading, 80% of them were suitable for the fresh market. Plums harvested with the large straddle harvester were of medium quality. After grading only 50% of them were suitable as dessert fruits.

Key words: *Prunus domestica*, harvesting technology, fruit quality

INTRODUCTION

Plum production in Europe is in a crisis because of the threat posed by the sharka virus (PPV), competition from high quality fruit from California, and the high cost of manual labour of fruit harvesting [Botu et al. 2013]. The problem can be partly solved

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by breeding cultivars resistant to the sharka virus. As a result of plum breading activity, the first cultivar, named 'Jojo', completely resistant to the PPV virus has been created [Hartmann and Neumuller 2013]. Dwarfing rootstocks, high density planting, new methods of training and pruning can accelerate plum-tree fruiting and increase the yield of young plantations [Brunner 1990, Wustenbergs and Keulemans 1996, Mika and Buler 2011, Day et al. 2013]. Plum cultivars grafted on dwarfing rootstocks facilitate management of plum orchards [Rozpara and Grzyb 2007]. The reasons for the trend towards high density planting (HDP) are universal: earlier returns on investment, economical use of labour, and production of high yields of quality fruits [Wertheim 1981]. Due to the high cost of plum harvesting, industrial plums can be harvested mechanically instead of by hand picking. Mechanical harvesting by means of trunk shakers has several obstacles, particularly fruit bruising and low effectiveness of fruit collection. Adaptations of trees to the machines are necessary for improving the mechanical harvesting process [Castro-Garcia et al. 2012]. In 2004–2010, the authors [Mika et al. 2012] demonstrated a possibility of plum and prune harvesting with a self-propelled, canopy-contact, straddle harvester working in continuous motion, which was designed in Poland for tart cherry harvesting [Mika et al. 2011]. After some redesigning, the machine is also suitable for harvesting plums and prunes for processing. The machine is not quite suitable for dessert fruit because some percentage of the crop is liable to be bruised. The shaken-off fruits fall from a height of 0.5 to 2.5 m. Morales-Sillero et al. [2014] implemented a similar harvester to harvest table olive cultivars, and they learned that fruit bruising was the main problem. McKenzie [1971] in New Zealand suggested that a horizontal canopy could solve the problem of mechanical fruit harvesting. Ampatzidis et al. [2012] implemented Y-trellised sweet cherries for mechanical harvesting. For the same purpose, we trained plum trees to a horizontal canopy and adapted a tractor-driven harvester, designed to harvest currents, to harvesting plums. The shaking units were redesigned and the grabbing and transporting unit was also changed. Prospective advantage of developing plum production is based on the discovery by medicine and the fruit industry of the pro-health value of plums, which contain abundant anthocyanins in the flash and skin [Stacewicz-Sapuntzakis et al. 2001, Chun et al. 2003, Stacewicz--Sapuntzakis 2013]. Fruit processing plants intend to make use of these specifics to produce numerous diet supplements [Fanning et al. 2012].

The experimental grove was established in 2008 to compare the productivity of standard leader trees with the productivity of horizontal canopy trees. These two types of trees served also to compare harvesting efficiency and fruit quality. The aim of this work was an evaluation of the growth and fruiting of plum trees and the quality of plums harvested with two different methods: mechanically and manually, for two methods of tree training.

MATERIAL AND METHODS

Plum trees of the cultivar 'Elena' grafted on *Prunus cerasifera* var. *divaricata* rootstock, clone 'Myrobalan', were planted in the spring of 2008 at the Research Institute of Horticulture ('Inhort') in Skierniewice, Poland (longitude 51°57'N, latitude 20°08'E, altitude 120 m), on a sandy-loam, dip soil with a pH of 5.5. The Skierniewice area is characterized by a Central European climate, with an annual rainfall of 507 mm and evapotranspiration of 489 mm during the growing season. The mean temperature of the coldest month of January is –3.1°C, and the mean temperature of the warmest month of July is 18.1°C.

The area of the experimental grove was 0.36 ha. Trees were planted in four 200 m long rows to facilitate harvesting trials with a tractor-driven, canopy-contact fruit harvester. In two rows, the trees were spaced at 1.0 and 1.5 m, and trained to a horizontal canopy according to McKenzie [1971]. In order to train and support the canopy, concrete poles were driven into the ground to a depth of 0.8 m, and a height of 1.2 m above the ground, and spaced at 10 m intervals. Across the rows, metal bars (4 m long) were fixed to the poles at a height of 1.0 m. Four wires were stretched along the row and fixed to the bars.

Tall maiden trees, up to 2.0 m in height, with strong lateral shoots, were planted. After planting, the tree leader was cut away 1.0 m above the ground and the lateral shoots were bent and tied to the wires forming the first tier of branches. In the summertime, new shoots were similarly bent and tied. In the second year, gaps in the canopy were filled with new shoots. Towards the end of the first year, trees formed an open texture and a well-spaced fruit-bearing horizontal surface. From the third year onward, the canopy was pruned twice a year, in the springtime and in July. Strong shoots were removed and week shoots preserved for fruiting.

In the other 2 rows, the trees spaced at 1.5 and 2.0 m were trained to the standard leader trees and served as the control for fruit picking by hand. Here, after planting, the leaders of the control trees were lightly headed (to 1.7 m from the ground) and the lateral shoots were lightly pruned. Within 2 years, a conical shape was obtained, with a strong vertical leader and short horizontal branches. To keep the tree to the required height (2.8 m) and spread (2.0 m), renewal pruning [Czynczyk et al. 1976] was introduced from the third year onward. Old branches were removed and replaced with young shoots. The control trees were pruned only in the springtime. In each row, the trees were arranged in four plots (replications), with 25, 35, or 50 trees per plot depending on the planting distance.

In the second year after planting, the inter-rows were grassed down, with frequent grass mowing in conjunction with the maintenance of 1.5 m wide herbicide strips along the rows. Trees were irrigated periodically, only in dry periods, from May to September. Mean dose of water in the summertime was 200 mm, estimated as rainfall. The irrigation system consisted of one compensating line per tree row, supplying 2.5 $l \cdot h^{-1}$ to the tree. Trees were fertilized according to soil analyses. Due to the high mineral content in the soil, fertilization rate was very low. At the start, trees received 80 kg K per ha, later only 20 kg N per ha yearly. Eight to ten sprayings were essential to control pests and diseases.

Every year, measurements of the circumference of the tree trunk were taken and converted to trunk cross-section area (TCSA). Shoot bending applied in order to train trees to a horizontal canopy induced unusual shoot growth, which was measured and compared with the standard leader trees. Renewal pruning, performed in this trial, is possible when a given fruit species has the ability to set fruit buds on young wood.

This phenomenon was studied during the three years to prove that such ability was long lasting. For this purpose, two branches were selected, on six trees, from two sides of tree canopy, to record fruit bud clusters before blooming, and the number of fruits in July. Harvesting of the fruits started when the trees had achieved the ability to produce a commercial yield (2012–2014).

Mechanical fruit harvesting on the horizontal canopy trees was accomplished with a tractor-driven harvester. The main body of the harvester was moving along the alley-way and the shaking unit in the horizontal canopy. The grabbing and transporting unit was rolling under the canopies. Prior to harvesting, several tests were done to estimate the force of fruit retention. Harvesting started when the force of retention dropped to 5–6 N. Harvesting was done at a shaker frequency of 8 Hz, a shaker finger stroke of 90 mm, and a travel velocity of 0.8 $km \cdot h^{-1}$. This harvester was not suited to the control, standard leader trees. Those trees were harvested with a self-propelled contact straddle harvester, a diesel-hydraulic driven combine. Leader trees were compared with horizontal canopy trees, and mechanical harvesting was compared with manual harvesting.

At harvest, the following records were made: the force needed to detach fruit from stem, the quantities of the fruit collected, effectiveness of fruit removal, the number of fruits remaining on the tree and lost on the ground, fruit yield per plot, harvesting efficiency in $kg \cdot h^{-1}$ and $ha \cdot h^{-1}$. The amount of fruit harvested with the machine assisted by 3 workers was compared with the amount hand picked by 3 workers. To estimate the consequence of the harvester moving along the tree row, the number of damaged shoots (broken or with the bark rubbed off) was recorded. To compare the quality of mechanically harvested fruits against that of hand-harvested fruits, a 20 kg sample of fruit was collected at random from 4 replications. Fruit quality was evaluated in the laboratory. To estimate mean fruit weight, fruit firmness, total soluble solids, acidity, anthocyanin content and antioxidant activity, 60 fruits were taken from each 20 kg sample. Firmness was evaluated with an Instron 4303 penetrometer, using a sample of 60 fruits from each treatment, whereas TSS (Total Soluble Solids), acidity, and anthocyanin content were determined using a sample of the same number of fruits collected from the ground. To estimate fruit quality, a simulation of marketing was performed after the harvest. Plums were kept for a few days in cold storage (0°C) and at room temperature (18°C). After a few days, the quality traits were determined. Three harvesting trials were performed in the years 2012–2014, after the trees had come into full bearing.

The results were statistically elaborated using analysis of variance, followed by means separation with Duncan's multiple-range t-test at $P < 0.05$.

RESULTS AND DISCUSSION

Training plum trees to a horizontal canopy altered their growth biology. After planting, the leader was headed at the level of 1.0 m above the ground. The headed leader developed only a few strong lateral shoots, which formed primary branches. On the control trees, with the leader left at 1.7 m in height, it developed almost twice as many shoots, and then numerous branches. The McKenzie [1971] idea to train trees to a horizontal canopy resulted in very uneven growth of shoots. The shoots bent to the horizontal position in the horizontal canopy induced basipetal buds to very intensive growth and depressed the growth of apical buds. The abnormal growth was the effect of shoot response to gravity [Mullins 1965 a, b]. The results obtained by Mullins [1965 b] demonstrate that to obtain regular growth of shoots it is essential to change shoot position from horizontal to aslant. This is possible when training trees to the V or Y system. These training systems have also been suggested by Ampatzidis et al. [2012]. Horizontal canopy trees developed more strong shoots and had a higher annual shoot growth (tab. 2). The differences in growth pattern were observed for many years. For this reason the trees required more pruning. Tree growth expressed as trunk cross-sectional area was not affected much by the two training systems. The most densely planted trees generated the lowest TCSA (tab. 2). This is a well known effect of tree competition when planted at high density.

High density planting introduced in this trial required intensive pruning in order to control tree spread, height and density suitable for the allotted space and ensure enough fruiting wood. The renewal pruning method, which involves cutting out branches when they have attained the age of 3 years and replacing them with one-year-old shoots, resulted in a satisfactory effect. The trees were able to set fruit buds and develop fruits on young wood (one- and two-year-old). This phenomenon was observed for 3 years (2012–2014). The results showed that the trees adapted to horizontal canopy were able to set 77% and trained to the standard leader form – 60% of fruit buds and bear fruit on young wood (tab. 1).

Table 1. Distribution of fruit bud clusters and fruits on young wood of ‘Elena’ cv. as mean values for 2012–2014

	Shoot age	Horizontal canopy (m)		Standard leader tree (m)	
		4 × 1.0	4 × 1.5	4 × 1.5	4 × 2.0
Percentage of fruit bud clusters	1-year old	27.7 b*	23.1 b	44.5 bc	41.6 b
	2-year old	69.4 c	75.1 c	53.3 cd	54.9 d
	3-year old	2.9 a	1.8 a	2.2 a	3.5 a
Percentage of fruits	1-year old	31.2 c	21.1 b	39.9 b	38.3 b
	2-year old	67.4 d	77.1 e	59.5 c	60.4 c
	3-year old	1.4 a	1.8 a	0.6 a	1.3 a

* – in all the tables, means with the same letter are not significantly different at P = 0.05

Table 2. Effect of spacing on cumulative yield, TCSA and productivity index of ‘Elena’ cv.

Treatment	Spacing (m)	Cumulative yield 2012–2014 ($kg \cdot tree^{-1}$)	Cumulative yield 2012–2014 ($t \cdot ha^{-1}$)	TCSA** 2014 (cm^2)	Annual shoot growth 2014 ($m \cdot tree^{-1}$)	Productivity index 2014 ($kg \cdot cm^{-2}$)	Load index 2014 ($kg \cdot m^{-3}$)
Horizontal canopy	4 × 1.0	23.3 a*	58.3	68.0 a	19.4 b	0.34 a	6.5 a
	4 × 1.5	25.3 a	42.1	85.5 b	26.0 c	0.30 a	7.0 a
Standard leader tree	4 × 1.5	49.5 b	82.5	85.2 b	13.2 a	0.58 b	6.7 a
	4 × 2.0	61.8 c	77.3	107.6 c	14.0 a	0.57 b	8.4 b

* – for explanations see Table 1
** – trunk cross sectional area

Trees started to bear fruit in the third year after planting. Hand and mechanical harvesting efficiencies were studied when the trees had begun to produce commercial yields in 2012–2014. Unfortunately, the yields in 2014 were interfered with by spring frosts. During the three years (2012–2014), the yield fluctuated due to variable weather conditions. The highest yield was obtained in 2012, 26 kg from the leader trained trees and 15 kg from those with a horizontal canopy (43 and 38 t·ha^{-1}, respectively). A plum yield of 20 t·ha^{-1} is acceptable in Poland as the yield giving a good return. Spring frosts in 2014 lowered the yield to nearly 5 kg·tree^{-1}. Trees planted at the lower density within the row (2.0 m) yielded a higher crop than the trees planted at the higher density. During the trial with mechanical fruit harvesting (2012–2014), the leader trained trees produced much higher yields than the horizontal canopy trees (tab. 2). The difference was mainly due to the different volumes of tree canopy. The volume of a leader tree was 7.4 m^3, whereas that of a horizontal canopy was 3.6 m^3. When cumulative yield is calculated as fruit load index to canopy volume, the leader trained trees showed significantly higher fruit load than other training systems (tab. 2). The canopy volume could be increased by training trees to a V shape because that form makes it possible to extend tree spread toward the alleyway.

The tractor-driven, canopy-contact harvester assisted by 3 workers from horizontal canopy was able to harvest with an efficiency of 1.6 t·h^{-1} (0.15 ha·h^{-1}). In the same time, three hand pickers harvested 70 kg of plums. Mechanical harvesting was thus equal to the work of 25 hand pickers. The self-propelled canopy-contact straddle harvester assisted by 3 workers from standard leader trees was able to harvest with an efficiency of 7.8 t·h^{-1} (0.22 ha·h^{-1}). In the same time, three hand pickers harvested 90 kg of plums (tab. 3).

Table 3. Efficiency of mechanical harvesting of 'Elena' cv. compared with hand picking by 3 workers employed in 2012–2014 (tree spacing: horizontal canopy 4 × 1.0–1.5, standard leader tree 4 × 1.5–2.0)

Treatment		Mechanical harvesting			Hand picking		
		Estimated yield (t·ha^{-1})	Efficiency (t·h^{-1})	Efficiency (ha·h^{-1})	Estimated yield (t·ha^{-1})	Efficiency (t·h^{-1})	Efficiency (trees·h^{-1})
2012	horizontal canopy	31.0	3.0	0.15	31.0	0.09	10
	standard leader tree	37.9	6.4	0.18	45.3	0.10	4
2013	horizontal canopy	16.5	1.6	0.15	16.5	0.07	16
	standard leader tree	41.1	7.8	0.22	27.8	0.09	6
2014	horizontal canopy	3.1	0.36	0.15	3.1	0.03	30
	standard leader tree	7.3	1.8	0.3	8.0	0.09	20

The effectiveness of fruit collection is presented in tab. 4. Mechanical harvesting of horizontal canopy trees resulted in 72–80% of the fruits being collected. Occasionally, some fruits received too strong an impact from the shaking rods and jumped out of the harvester. Some fruits were lost at the grabbing and transporting unit, which collected fruits under the canopies. The effectiveness of fruit collection from standard leader trees was 10% higher than from horizontal canopies. The resulting effectiveness of fruit collection was similar as 80–85%, which is the aim suggested by Castro-Garcia et al. [2012] in the harvesting of fruits of olive trees. Further improvement of the harvester is needed to increase its effectiveness in collecting fruits.

The quality traits of the fruits from the horizontal canopy, compared with those from the standard leader canopy, showed some significant differences (tab. 5). In 2012 the fruits from the horizontal canopy had higher levels of soluble solids, anthocyanins and antioxidant activity. These differences can be ascribed to the higher proportion of leaves to fruits. Intensive shoot growth was observed at light bearing.

Table 4. Fruit collection effectiveness of mechanical harvesting of horizontal canopy and standard leader trees of 'Elena' cv. in 2012–2014 (tree spacing: horizontal canopy 4 × 1.0–1.5, standard leader tree 4 × 1.5–2.0)

	Year	Fruits collected (kg/%)	Fruits remaining on the tree (kg/%)	Fruits lost on the ground (kg/%)	Total yield (kg/%)	Number of trees harvested	Mean yield (kg·tree^{-1})
Horizontal canopy	2012	930.0/74.2	103.2/8.2	220.6/17.6	1253.8/100	84	14.9
	2013	950.0/71.8	137.0/10.3	237.0/17.9	1324.0/100	168	7.9
	2014	310.8/80.3	27.2/7.0	49.3/12.7	387.3/100	254	1.5
Standard leader tree	2012	2830.0/91.6	59.5/1.9	201.9/6.5	3091.4/100	119	26.0
	2013	2890.0/86.0	70.4/2.1	400.3/11.9	3360.7/100	119	28.2
	2014	560.0/93.6	0.0/0.0	38.0/6.4	598.0/100	119	5.0

Table 5. Quality of 'Elena' plums hand-harvested from horizontal canopy trees and standard leader trees in 2012–2014 (tree spacing: horizontal canopy 4 × 1.0–1.5, standard leader tree 4 × 1.5–2.0)

		Date of harvesting	Mean fruit weight (g)	Total soluble solids (%)	Acidity (%)	Firmness (N)	Dry matter (%)	Total anthocyanin content (mg·100 g^{-1})	Antioxidant activity (mg Trolox ·100 g^{-1})
2012	horizontal canopy	25.09	23.7 a*	21.3 b	0.59 a	5.0 a	22.0 a	44.8 b	2.57 b
	standard leader tree	25.09	22.7 a	19.6 a	0.60 a	5.9 b	21.7 a	39.0 a	2.18 a
2013	horizontal canopy	02.10	23.9 b	15.2 a	0.69 a	6.0 b	17.0 a	29.4 a	1.81 a
	standard leader tree	02.10	19.2 a	14.8 a	0.69 a	5.0 a	16.8 a	27.7 a	2.01 a
2014	horizontal canopy	25.09	32.2 b	20.7 a	0.61 a	9.3 a	21.5 a	25.6 a	1.88 a
	standard leader tree	25.09	28.6 a	20.9 a	0.61 a	9.0 a	22.6 a	38.9 b	2.34 b

* – for explanations see Table 1

On the day of harvesting, the differences in the quality traits between the fruits harvested mechanically from horizontal canopies and standard leader trees, and also of those harvested manually, were negligible (tab. 6). Fruit appearance, texture and consumption quality were a little higher in the fruits from horizontal canopies harvested mechanically and manually. Most fruits (about 80%) were of marketable quality as dessert fruit. Only 10% of the fruits showed some evidence of bruising. Fruits preserved their good quality when stored for a few days at a temperature of 0°C. At room temperature (18°C), the quality of the fruits deteriorated after 4–6 days from harvesting regardless of the harvesting method.

Table 6. Quality of 'Elena' plums harvested mechanically (M) and manually (H) from horizontal canopy and standard leader trees after storage in a cold store and at room temperature in 2012 (tree spacing: horizontal canopy 4 × 1.0–1.5, standard leader tree 4 × 1.5–2.0)

Quality attribute	Type of harvesting and type of canopy	Days of storage					
		cold storage 0°C			room temperature 18°C		
		1	9	10	1	4	6
Appearance	Hor. Can. M.	4	3.5	–	3.5	2.5	–
	Hor. Can. H.	4	4	–	4	3	–
	L. Tree M.	3.5	–	4	4	–	2
	L. Tree H.	4.5	–	3.5	3.5	–	2.5
Sign of fade	Hor. Can. M.	1	1.5	–	1.5	2.5	–
	Hor. Can. H.	1	1	–	1.5	2	–
	L. Tree M.	1	–	1	1	–	3
	L. Tree H.	1	–	1	1	–	2.5
Texture	Hor. Can. M.	3.5	3	–	3	2.5	–
	Hor. Can. H.	3.5	3.5	–	3	3	–
	L. Tree M.	3.5	–	3.5	3.5	–	2
	L. Tree H.	3.5	–	3	3.5	–	2.5
Sweet taste	Hor. Can. M.	5	4	–	4	4	–
	Hor. Can. H.	4	4	–	5	5	–
	L. Tree M.	5	–	5	5	–	4.5
	L. Tree H.	4	–	4.5	4.5	–	4
Excellent taste	Hor. Can. M.	4	4	–	3.5	3.5	–
	Hor. Can. H.	4	4	–	4.5	3.5	–
	L. Tree M.	3.5	–	4.5	4.5	–	2.5
	L. Tree H.	3	–	4	4	–	2.5
Consumption quality	Hor. Can. M.	4	3.5	–	3	2.5	–
	Hor. Can. H.	4	4	–	4	3	–
	L. Tree M.	3.5	–	4	4	–	2.5
	L. Tree H.	3.5	–	3.5	3.5	–	2.5

Criterion values (1–5)

Appearance	1 – unappealing	5 – very attractive
Sign of fade	1 – none	5 – visible
Texture	1 – very soft	5 – firm
Sweet taste	1 – delicate	5 – very intense
Excellent taste	1 – water flash, empty taste	5 – flash true plum
Consumption quality	1 – poor	5 – very good

Tree training to a sort of flat 'wall' may increase the effectiveness of fruit collection and reduce fruit damage [Ferguson et al. 2012]. The 'wall' does not need to be horizontal, nor vertical. The optimal angle should probably be 30–40°. About 5% of the plums were infected with fungal diseases or damaged by insects. Most of the mechanically harvested fruits were without the stem. The percentage of over-ripened or under-ripened fruits depended on the time of harvest. The tractor-driven harvester did not cause any damage to the trees. The self-propelled straddle harvester caused some damage to small branches. The incidence was 2–3 branches per tree. These abrasions were unimportant because the damaged shoots were removed during renewal pruning.

CONCLUSIONS

1. The horizontal canopy induces irregular shoot growth, which is difficult to control. It has a low fruiting volume and should be replaced with an inclined fruiting walls resembling the V or Y training systems.

2. The standard leader tree is highly productive and suitable for mechanical harvesting of industrial plums. Their suitability for dessert plums is limited to prunes.

3. Mechanical harvesting of plums with a harvester working in continuous motion may increase harvesting efficiency 25 to 40 times compared with fruit picking by hand.

4. Fruit collection effectiveness of the horizontal canopies was 72–80% and from leader trees was 86–94%.

5. The small tractor-driven harvester is suitable for harvesting plums from trees trained to a thin horizontal layers.

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KORONA HORYZONTALNA DLA ŚLIWEK ZBIERANYCH MECHANICZNIE KOMBAJNEM W RUCHU CIĄGŁYM

Streszczenie. Mechaniczny zbiór śliwek obniża drastycznie koszty produkcji owoców. Drzewa śliwy odmiany ‘Elena’ posadzono w dużym zagęszczeniu (4 × 1 m i 4 × 1,5 m) i prowadzono w formie korony horyzontalnej. Gałęzie drzew przywiązane były do drutów rozciągniętych na wysokości 1 m od ziemi. Korony drzew ukształtowano w formie ciągłej płaszczyzny poziomej w dwóch rzędach 200 m długości każdy. Dla kontroli śliwy ‘Elena’ posadzono w rozstawie 4 × 1,5 m i 4 × 2 m i prowadzono w standardowej formie przewodnikowej. Od piątego do siódmego roku po posadzeniu (2012–2014) z koron horyzontalnych zbierano owoce kombajnem zaczepianym do ciągnika. Ze standardowych koron przewodnikowych, mających 2,8 m wysokości, śliwki zbierano dużym kombajnem samojezdnym. Średnia objętość koron horyzontalnych wynosiła 3,6 m^3, a prowadzonych w standardowej formie przewodnikowej – 7,4 m^3. Wydajność zbioru owoców z koron prowadzonych w standardowej formie przewodnikowej kombajnem samojezdnym była 40 razy większa niż zbiór ręczny, a z koron horyzontalnych 25 razy większa niż zbiór ręczny. Efektywność zbioru z koron w formie przewodnikowej wahała się w granicach 86–94%, a z koron horyzontalnych 72–80%. Śliwki zebrane małym kombajnem zaczepianym do ciągnika były dobrej jakości. Po przesortowaniu 80% owoców z koron horyzontalnych nadawało się na rynek produktów świeżych. Śliwki zebrane dużym kombajnem samojezdnym były przeciętnej jakości. Po przesortowaniu 50% z nich nadawało się jako owoce deserowe.

Słowa kluczowe: Śliwa domowa, technologia zbioru, jakość owoców

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