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Living mulches in-rows as an alternative for herbicide fallow in a pear *Pyrus communis* L. orchard

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Abstract: Weed control and replenishing soil moisture and fertility are important areas in fruit production. The number of studies focused to determine whether living mulches in tree rows can fulfil these tasks increases recently. In the paper the results of an 11-year experiment on the effect of two such mulches (*Trifolium repens* L. and *Agrostis capillaris* L.) on the growth, yield, and fruit quality of three pear cultivars ('Alfa', 'Dolores', 'Amfora') in relation to herbicide fallow are presented. In the experiment, a single sowing of covering plants without additional treatments was used. A statistically significant reduction in yield (20–22%) was found for both mulches used, which was related to weakening the vegetative growth of trees. The average fruit mass did not change significantly, but the percent share of large fruits increased significantly (about 17%) in the *A. capillaris* mulch. Fruits from trees growing in *T. repens* contained significantly more soluble solids and Ca. However, that mulch became heavily infested with weeds after a few years. The obtained results allow us to recommend the use of the living mulch *A. capillaris* in the tree rows of a commercial pear orchard. The 'Dolores' and 'Amfora' cvs are particularly recommended.

Keywords: orchard floor management; growth; yield; fruit quality

Modern agriculture, including horticulture, is expected not only to produce high-quality crops but also to preserve biodiversity and soil quality (Singhal et al. 2020). Creating toxic-free environment is one of the strategic tasks of the European Green Deal programm (COM/2019/640 final). However, the most common method of orchard floor management in commercial orchards is to keep herbicide fallow in tree rows for weed control (Granatstein, Sánchez 2009; Paušič et al. 2021). The main adventage of that method is its reliability, low price, and ease and speed of application (Bokszczanin et al. 2021). But effects of herbicide application could disturb the reproduction cycles of earthworm (Gaupp-Berghausen et al. 2015). In the scientific literature there are also reports of the inhibitory effect of herbicides on nitrogen transformations in the soil (Hoagland et al. 2008).

One of the best alternatives to herbicide fallow is the use of mulches (Mia et al. 2020). Regardless of the form of mulch (organic, synthetic or living) they improve soil moisture conditions (which saves water needed for irrigation) and limit the growth of weeds (Żelazny, Licznar-Małańczuk 2018; Kiprijanovski et al. 2019; Hussain et al. 2020). The overall impact of their use on the orchard environment is heterogeneous, depending on such factors as the mulch material used, soil conditions or orchard age. Synthetic mulches (black foil or agrotextile) are very effective in inhibiting weeds in the early growth stage of fruit trees (Hussain et al. 2020), but with long-term use of black foil, the soil under it must be fer-

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tilized (Neilsen et al. 2014). Its old remains require disposal, and cracking plastic contaminates soil with microplastic particles. Use of organic mulches enriches the soil with organic matter, which improves its quality and this can positively affect the growth and yield of fruit trees (Solomakhin et al. 2012; Neilsen et al. 2014; Kiprijanovski et al. 2019; Bokszczanin et al. 2021; Lisek, Stępień 2021). The difficulty is the selection of bedding material suitable for the conditions of a given orchard (Lisek, Stępień 2021). That kind of mulches effectively inhibit the growth of the weeds but only when they have the right thickness (Granatstein, Sánchez 2009). In thick organic mulch, small rodents willingly hibernate which increases the risk of damage to tree roots (Granatstein, Mullinix 2008).

The essence of living mulches (LMs) is to introduce additional herbaceous perennial species into the rows of trees, protecting the soil surface and accompanying it throughout the growing season. The cover plant reduces the leaching of nutrients from the soil by retaining them in its tissues, and through its decomposition, it supplements the soil with nutrients (Żelazny, Licznar-Małańczuk 2018). Its roots improve the structure of the soil what creates a favourable environment for soil microorganisms (Hoagland et al. 2008). LMs are also effective in controlling weed growth, although they do not completely stop them (Tzortzi et al. 2015; Singhal et al. 2020). However, as competitors for water and nutrients, cover vegetation affects tree growth, so use of LMs is recommended for older orchards (Mia et al. 2020). An increase in the population of rodents that damage the trunks of fruit trees was observed with LMs (Sullivan et al. 2018).

Up to now, most studies on the effect of LMs on tree growth, yield, and fruit quality have been conducted in apple orchards (Zhang et al. 2010; Licznar-Małańczuk 2015; Tahir 2015; Slatnar et al. 2020). They showed a differentiated effect of LMs on the tested parameters, dependent on cover plant species, the care mode of LM and the cultivar used. Only a few reports on the use of LMs in a pear orchard have been published so far (Sosna et al. 2009; Czaplicka-Pędzich, Sosna 2012; Paušič et al. 2021).

The aim of the experiment was to evaluate the effect of the use of two different LMs in rows on yielding, tree growth, and fruit quality of three pear cultivars on a Caucasian pear rootstock in comparison with herbicide fallow. It is an attempt to answer the question of whether this non-chemical method of soil cultivation in a commercial orchard can be an alternative to the most commonly used herbicide fallow.

MATERIAL AND METHODS

The experiment was conducted in the years 2006–2016 at the Fruit Experimental Station located in Samotwór near Wrocław (51°06'12"N, 16°49'52"E) in SW Poland. That area is located in a midlatitude, temperate, transitional (maritime–continental) climate zone characterized by a high frequency of polar air masses and a dominating western flow. The mean annual temperature is about 9 °C and the average sum of precipitation is slightly less than 600 mm. The rainfall regime is dominated by continental features, with maxima occurring in July (Szymanowski et al. 2019). The orchard was located on a fawn soil consisting of slightly sandy, light clay over medium clay and representing the 3rd class of the Polish economical soil classification.

The research was carried out on one-year-old trees of three cultivars (cvs) of *Pyrus communis* L. budded on Caucasian pear seedlings: 'Alfa', 'Amfora' – summer and winter cvs, respectively, of Czech origin (Korba et al. 2013; Paprštein, Sedlák 2021) and 'Dolores' – autumn cultivar of Polish origin (Lisek, Rozpara 2010). The trees were planted with a spacing of 3.5 × 1.2 m (2381 trees/ha) and formed as a spindle crown. Before planting the trees at the end of March 2006, in October 2005 the field was thoroughly weeded of persistent weeds (Glyphosate 3.7 L/ha + MCPA 2 L/ha) and fertilized with phosphorus and potassium in a dose of 120 kg K_2O and P_2O_5. Deep plowing was done before winter.

The planting pattern followed the randomised split-plot design with 4 replications and 3 trees per plot. The trees were annually pruned soon after flowering, starting from the fourth year after the orchard establishment. No irrigation was applied, and fruitlets were not thinned. The orchard floor management system consisted of herbicide fallow (Glifosate 3.7 L/ha + MCPA 2 L/ha) in the tree rows (control) and sward in the alleyways, both introduced in the year of the tree planting. Living mulches of white clover *Trifolium repens* L. and common bent *Agrostis capillaris* L. were sown in the rows of trees at the end of June 2007. They were not mowed throughout the time of the experiment. The chemical protection was carried out according to up-to-date recom-

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mendations of the Orchard Protection Programme for commercial orchards. An annual dose of 50 kg N/ha in the form of ammonium nitrate was applied, starting from the 3rd year following the orchard establishment. The soil was limed in 2011 with 750 kg CaO/ha, and fertilization with potassium salt equivalent to 80 kg K_2O/ha was performed in early springs 2009 and 2013. No additional fertilization of trees with mulches in rows was applied.

During 11 years, tree growth and fruit yield per tree as well as mean fruit weight, size, and skin colouration were assessed annually. Each year in mid-October, the extent of vegetative growth was assessed by measuring trunk circumference 30 cm above bud union and calculating TCSA values as well as their two-year increments. In autumn 2016 tree height and canopy width in two directions were recorded. Volume of canopy was calculated using a formula for cone volume. The last set of TCSA together with the 2007–2016 fruit yield sums were used to calculate of crop efficiency index (CEI), which were obtained at the end of the study. For the purpose of data collection, each cultivar was harvested following a single-picking schedule, and the fruit from each tree were collected into separate boxes. To determine external crop quality, sample of 20 fruits per each tree was taken and from each experimental treatment 3 boxes of pears for grading were randomly selected. This was followed by weighting the fruit, and in 2012–2016 fruit diameters and skin coloration (only 'Dolores' – the other cultivars do not create a blush) were recorded. Annual harvests were used to calculate alternate bearing indexes.

In 2016, 4–5 pieces of fruit were randomly collected from each replication for chemical analysis of the biological value of the fruits. In juice of fresh fruit, immediately after harvest, the content of soluble solids was determined, using an Abbe refractometer, and of vitamin C with the titration method (PN-90/A-75101/11). The concentrations of some macronutrients were determined in dry mass using the P – colourimetric method with ammonium molybdate, Mg – titanium yellow (universal method developed by Nowosielski), K and the Ca – flame photometric method. The detailed courses of the all analyzes done are described in the work by Komosa (1992). Units used to present values of these parameters are given in Table 1.

Table 1. Biological value of three pear cvs fruit depending on in-row living mulch (2016)

Treatment		Soluble solids (°Brix.)	Vitamin C (mg/100 g f.m.)	Macronutrients (g/kg d.m.)			
				K	Ca	Mg	P
'Alfa'	*Trifolium repens*	11.83^{b}	10.83^{a}	9.18^{a}	1.53^{a}	0.45^{a}	0.48^{a}
	Agrostis capillaris	11.30^{ab}	9.00^{a}	8.69^{a}	1.24^{a}	0.40^{a}	0.45^{a}
	herbicide fallow	10.53^{a}	8.90^{a}	10.29^{a}	1.34^{a}	0.48^{a}	0.62^{a}
'Dolores'	*Trifolium repens*	15.97^{b}	10.97^{ab}	6.88^{a}	1.39^{a}	0.25^{a}	0.49^{a}
	Agrostis capillaris	13.60^{a}	8.47^{a}	7.92^{a}	1.18^{a}	0.22^{a}	0.41^{a}
	herbicide fallow	14.47^{a}	11.77^{b}	8.82^{a}	1.35^{a}	0.28^{a}	0.71^{b}
'Amfora'	*Trifolium repens*	9.37^{b}	14.77^{b}	8.75^{a}	1.54^{b}	0.85^{a}	1.02^{a}
	Agrostis capillaris	8.37^{ab}	10.90^{a}	9.33^{a}	1.08^{a}	0.87^{a}	0.95^{a}
	herbicide fallow	7.70^{a}	11.60^{a}	9.42^{a}	1.16^{a}	0.95^{a}	0.98^{a}
Mean for orchard floor management (A)							
Trifolium repens		12.39^{b}	12.19^{b}	8.27^{a}	1.49^{b}	0.52^{a}	0.63^{a}
Agrostis capillaris		11.09^{a}	9.46^{a}	8.65^{a}	1.17^{a}	0.49^{a}	0.60^{a}
Herbicide fallow – control		10.90^{a}	10.76^{ab}	9.51^{a}	1.29^{a}	0.57^{a}	0.77^{b}
Mean for cultivar (B)							
'Alfa'		11.22^{b}	9.58^{a}	9.39^{a}	1.37^{a}	0.44^{b}	0.51^{a}
'Dolores'		14.68^{c}	10.40^{a}	7.87^{a}	1.31^{a}	0.25^{a}	0.51^{a}
'Amfora'		8.48^{a}	12.42^{b}	9.17^{a}	1.26^{a}	0.89^{c}	0.98^{b}

$^{a-c}$Means marked by the same letter within the columns for orchard floor management (A), cultivar (B) and interaction (A × B) do not significantly differ at $P \leq 0.05$ according to Duncan's multiple *t*-test

d.m. – dry mass; f.m. – fresh mass

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The collected experimental data were subjected to statistical analysis based on the analysis of variance (ANOVA) approach involving a model appropriate for the split-plot design. Significant differences at the $\alpha \leq 0.05$ level were obtained using Duncan's multiple range test using the software Statgraphics.

RESULTS AND DISCUSSION

Comparison of vegetative growth parameters. After 11 years of the experiment, the cross-sectional area of tree trunks was smaller in LM *Agrostis capillaris* when compared to the control and LM *Trifolium repens* (Table 2). This allows us to conclude that *A. capillaris* limited the growth of trees. The cvs differed significantly in this aspect: 'Dolores' had the thickest trunks and 'Amphora' the thinnest. Weak growth of this Czech cv. was previously reported by Sosna and Czaplicka-Pędzich (2013).

The largest, statistically significant two-year increase in trunk thickness was observed in trees growing in *T. repens*, while the use of *A. capillaris* resulted in a reduction of that parameter (Table 2). The trunks of 'Dolores' grew the most intensively, and the other showed significantly smaller growths. The obtained result differs from the one reported by Sosna et al. (2009) which showed no significant effect of LMs on the growth of pear trees of 'Harrow Sweet' and 'Winter Forelle' cvs in the first two years after their introduction. A similar lack of an effect from grass mulch on the growth of apple trees was noted by Granatstein and Mullinix (2008). But other authors showed that grassy LMs weakened the growth of apple trees (Tahir et al. 2015), regardless of the year of their introduction into the tree rows (Licznar-Małańczuk 2015).

In rows *A. capillaris*, the volume of the crowns of 'Alfa' pear trees was lower than in the other variants, but in general, the method of orchard floor management had no significant effect on this parameter. The tested cvs differed in canopy size. It was found to be significantly lower in the 'Amfora'. A decrease in crown volume in the presence of LMs composed of several grass species was noted in apple orchards (Tahir et al. 2015).

The method of orchard floor management had no significant effect on the alternate bearing index of the pear orchard tested, but value of this parameter depended on the cultivar (Table 2). The 'Dolores'

Table 2. Vegetative growth of three pear cvs depending on in-row living mulch

Treatment autumn 2007		Trunk cross-sectional area (cm^2)			Canopy volume (m^3) autumn 2016	Alternate bearing index (0–1)
		autumn 2007	autumn 2016	increase 2014–2016		
'Alfa'	*Trifolium repens*	5.7^{a}	84.4^{b}	18.6^{b}	5.4^{b}	0.53^{a}
	Agrostis capillaris	6.3^{a}	70.6^{a}	11.9^{a}	4.2^{a}	0.41^{a}
	herbicide fallow	6.0^{a}	92.1^{b}	17.3^{b}	6.1^{b}	0.40^{a}
'Dolores'	*Trifolium repens*	6.1^{a}	105.8^{b}	23.9^{b}	4.8^{a}	0.64^{a}
	Agrostis capillaris	7.5^{a}	91.1^{a}	17.5^{a}	4.5^{a}	0.63^{a}
	herbicide fallow	5.7^{a}	99.8^{ab}	18.8^{ab}	4.1^{a}	0.58^{a}
'Amfora'	*Trifolium repens*	4.1^{a}	59.0^{a}	14.6^{a}	3.1^{a}	0.38^{a}
	Agrostis capillaris	5.1^{a}	61.6^{a}	14.1^{a}	3.1^{a}	0.42^{a}
	herbicide fallow	4.4^{a}	63.6^{a}	11.4^{a}	3.3^{a}	0.45^{a}
Mean for orchard floor management (A)						
Trifolium repens		5.3^{a}	83.1^{b}	19.0^{b}	4.4^{a}	0.51^{a}
Agrostis capillaris		6.3^{a}	74.4^{a}	14.5^{a}	3.9^{a}	0.49^{a}
Herbicide fallow – control		5.4^{a}	85.2^{b}	$15{,}8^{a}$	4.5^{a}	0.48^{a}
Mean for cultivar (B)						
'Alfa'		6.0^{b}	82.4^{b}	15.9^{a}	5.2^{b}	0.45^{a}
'Dolores'		6.4^{b}	98.9^{c}	20.1^{b}	4.5^{b}	0.62^{b}
'Amfora'		4.5^{a}	61.4^{a}	13.4^{a}	3.2^{a}	0.42^{a}

$^{a–c}$Means marked by the same letter within the columns for orchard floor management (A), cultivar (B) and interaction (A × B) do not significantly differ at $P \leq 0.05$ according to Duncan's multiple t-test

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showed a significantly higher propensity to yield every other year compared to the Czech cvs. There are no reports on this subject in the available literature.

Quantity and quality of yield and crop efficiency index. A statistically significant reduction in yield (20–22%) was found for both mulches used when compare to herbicide fallow (Table 3). Both 'Dolores' and 'Amfora' gave higher yield than 'Alfa', but there were no important difference between 'Amfora' and 'Dolores' in terms of cropping. A statistically significant yield reduction after introducing *A. capillaris* and *T. repens* was observed also in 'Harrow Sweet' and 'Winter Forelle' pears (Sosna et al. 2009). However, with a different composition of LM (multi-species mixtures of grasses and legumes), the reduction in the yield of pear 'Williams' was statistically insignificant compared to herbicide fallow (Paušič et al. 2021). In apple orchards, a decrease in yields was repeatedly confirmed in relation to grassy mulches (Granatstein, Mullinix 2008; Zhang et al. 2010; Tahir 2015, Żelazny, Licznar-Małańczuk 2018). On the other hand, mulches consisting of various species of legumes showed no significant effect on yield (Tzortzi et al. 2015).

The cited experiments differed in the orchard age when LM was introduced. Also, there were different species in the composition of the LM, the mode of its care varied, and there were different periods of experiment maintenance, which may cause ambiguity in the effects reported. Research by Slatnar et al. (2020) showed that the decrease in yield was the largest in the earliest variant of sowing the LM, i.e., already in the second year after tree planting. According to Żelazny and Licznar-Małańczuk (2018), the decrease in yield in the presence of LM is permanent.

The pear cvs tested differed significantly in terms of average fruit mass (Table 3). The lightest ones came from 'Alfa' trees, and the heaviest ones were from 'Amfora' trees, which was also confirmed by other researchers (Sosna, Czaplicka-Pędzich 2013; Lipa et al. 2018). But the method of orchard floor management had no significant effect on this feature. At the same time, the *A. capillaris* mulch significantly increased the percentage of large fruit (over 7 cm in diameter) in 'Amfora' and 'Dolores'. So, the *A. capillaris* mulch

Table 3. Quantity and quality of yield and crop efficiency index (CEI) of three pear cvs depending on in-row living mulch (year of tree planting – spring 2006)

Treatment		Fruit quality				CEI (kg/cm^2) 2006–2016
		cumulative yield (kg/tree) 2007–2016	mean fruit mass (g) 2007–2016	% of fruit with diameter >7 cm	% of fruit with blush over ½	
'Alfa'	*Trifolium repens*	26.3^{a}	156^{a}	43.4^{a}	0.0^{a}	0.31^{a}
	Agrostis capillaris	32.7^{a}	159^{a}	43.4^{a}	0.0^{a}	0.46^{a}
	herbicide fallow	39.1^{a}	167^{a}	48.3^{a}	0.0^{a}	0.42^{a}
'Dolores'	*Trifolium repens*	60.4^{a}	221^{a}	41.5^{a}	4.4^{a}	0.57^{a}
	Agrostis capillaris	64.3^{a}	230^{a}	49.3^{b}	3.8^{a}	0.71^{a}
	herbicide fallow	77.6^{a}	215^{a}	39.2^{a}	6.4^{a}	0.78^{a}
'Amfora'	*Trifolium repens*	62.4^{a}	239^{a}	49.1^{b}	0.0^{a}	1.06^{a}
	Agrostis capillaris	54.4^{a}	252^{a}	56.7^{c}	0.0^{a}	0.88^{a}
	herbicide fallow	73.7^{a}	240^{a}	40.5^{a}	0.0^{a}	1.16^{a}
Mean for orchard floor management (A)						
Trifolium repens		49.7^{a}	205^{a}	44.7^{a}		0.65^{a}
Agrostis capillaris		50.5^{a}	214^{a}	49.8^{b}		0.68^{a}
Herbicide fallow – control		63.5^{b}	207^{a}	42.7^{a}		0.79^{a}
Mean for cultivar (B)						
'Alfa'		32.7^{a}	161^{a}	45.0^{a}		0.40^{a}
'Dolores'		67.4^{b}	222^{b}	43.3^{a}		0.69^{b}
'Amfora'		63.5^{b}	244^{c}	48.8^{a}		1.03^{c}

$^{a-c}$Means marked by the same letter within the columns for orchard floor management (A), cultivar (B) and interaction (A × B) do not significantly differ at $P \leq 0.05$ according to Duncan's multiple t-test

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had a beneficial effect on the quality of the crop. The method of orchard floor management did not significantly affect the fruit colouration. Sosna et al. (2009) reported an increased share of small fruits in the cultivation of both pear cvs in a grassy mulch and of apple trees in the mulch of *Phacelia tanacetifolia* Benth. and *Ornithopus sativus* Brot, but Licznar-Małańczuk (2015) did not confirm these observations in apple trees growing in *Festuca ovina* L. Several authors reported a significant increase in the number of well-coloured fruit in apple trees in various LMs (Sosna et al. 2009; Licznar-Małańczuk 2015; Tahir et al. 2015).

LMs in rows had no significant effect on the calculated CEI (Table 3). But the tested cvs showed significant differences in this parameter; its highest value was found for 'Amfora' and the lowest for 'Alfa'. In the older apple orchard, the long-term presence of LM had no significant effect on this factor (Slatnar et al. 2020). But in the first years of fruiting, pear trees of the 'Harrow Sweet' and 'Winter Forelle' on a quince S1 growing in mulches *A. capillaris* and *T. repens* showed a lower CEI (Table 3) compared to herbicide fallow (Sosna et al. 2009). This proves the inhibition of growth and a decrease in the fertility of young trees growing in these mulches. This is not surprising as the quince is a dwarf rootstock with a weak root system, so LMs sown in rows are too strong competitors for water and nutrients for tree roots.

Biological value of fruit. In each of the tested pear cvs, the presence of mulch *T. repens* caused a significant increase in the soluble solids content of the fruit compared to the control (Table 1). *A. capillaris* application had no such effect. Pear cvs also significantly differed in terms of the concentration of soluble solids; the highest content was found in 'Dolores' pear fruit, and the lowest in 'Amfora', which was not confirmed by Lipa et al. (2018). But 'Alfa' fruits were similar in extract content as in Konopacka et al. (2014). The obtained results are in line with the conclusions of Slatnar et al. (2020), who indicated no significant effect of *Festuca ovina* L. mulch on the content of total sugars in apples compared to herbicide fallow. A higher content of soluble solids in fruits from trees growing in *T. repens* may indicate their earlier ripening in this mulch, which should be taken into account when planning the harvest time. Pears harvested too late will be stored worse and shorter.

The content of vitamin C did not differ significantly between the control and each of the LMs, although such a difference was noted between the tested mulches (Table 1). More of this vitamin was found in fruits from 'Amfora' trees, especially growing in *T. repens* That aspect was not so far studied in relation to effects of the LMs application. But it is interesting, that Arzani et al. (2008) found a higher than in our studies contents of ascorbic acid in pears of both Asian and European varieties.

Both, the method of orchard floor management and the tested cvs had no significant effect on the K content in fruits (Table 1). Application of *T. repens* mulch resulted in a significant increase in Ca content (Table 1). But the tested cultivars did not differ significantly in this aspect. The Mg concentration in fruit did not differ significantly among variants of in-row floor management but depended on the cultivar (Table 1). LM caused a significant decrease in the P content in the fruit, which was most pronounced in the 'Dolores' pear (Table 1). In the study by Czaplicka-Pędzich and Sosna (2012), *T. repens* and *A. capillaris* mulches had no effect on the content of K, Ca, Mg, and P in the fruit of young pear trees.

Thus, the use of *T. repens* mulch in a commercial pear orchard could be beneficial due to the higher content of sugars, Ca, and vitamin C in the fruit, despite limiting the yield. However, keeping it in a monoculture is difficult, and it is attractive to rodents (Sullivan et al. 2018). According to Hoagland et al. (2008), legumes are too competitive for fruit trees. Paušič et al. (2021), testing LM with different botanical compositions, recorded that grasses are better suited for creating long-term LM in a pear orchard ('Wiliams' on Quince MA rootstock) than herbs or legumes because their coverage was more complete and the decrease in yields remained small for years. Our own research proved that although the presence of *A. capillaris* had a significant limiting effect on the growth of trees and reduced their yield, it also increased the number of large fruits, which makes the harvested crop more commercially valuable. It should be emphasized that nowadays, the trick is to sell profitably, not just to produce. Weakening the growth of strongly growing pear trees, especially on a rootstock such as the Caucasian pear seedlings, can also be considered an advantage, not a disadvantage.

CONCLUSION

The introduction of an LM in rows into an orchard is in line with the assumptions of sustainable agricul-

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ture. Moisture, fertility, and biological activity of the soil under the trees are maintained, and its presence allows a decrease in the use of herbicides.

However, for orchard practice, the yield and quality of fruit are the most important. The issue of the impact of LM on these parametres in a pear orchard has so far been poorly recognized, especially in relation to the longer than 3–5 years of orchard treatment. The effect on the alternate bearing index has not been analyzed so far. Our long-term experience showed the lack of LMs influence on the alternate bearing index, which has been documented for the first time. This is a beneficial property of LMs. Our research showed also that in the pear orchard, after 11 years of the experiment, a statistically significant reduction (20–22%) in the cumulative yield occured in LM when compared to herbicide fallow, which can be partly related to the weakening of the vegetative growth of trees. But the internal quality of fruit, manifested by a higher content of soluble solids and Ca increased in the presence of *T. repens* mulch, while with the use of *A. capillaris* mulch, the external quality of fruit was improved, expressed by a higher percentage (17%) of large pears.

As long-term growth of white clover could be problematic due to overgrowth by persistent weeds, it seems that for a commercial pear orchard on a Caucasian pear seedlings, the use of *A. capillaris* mulch in the rows of trees can be more recommended. In order to minimize the adverse effect of cover plants on fruiting, they should be introduced into the rows of trees in 3–4 years after orchard planting. Among the cvs tested, the well-yielding and large-fruiting pear trees 'Dolores' and 'Amfora' are worth recommending.

Taking into account the modern trend in orcharding to use dwarf rootstocks, which show different growth and yield dynamics, it would be worth testing the effect of LMs on yielding and fruit quality in a dwarf pear orchard.

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