ISSN 1644-0692
www.acta.media.pl

ACTA Acta Sci. Pol. Hortorum Cultus, 14(6) 2015, 163-174

SUITABILITY OF BLUE FESCUE (*Festuca ovina* L.) AS LIVING MULCH IN AN APPLE ORCHARD – PRELIMINARY EVALUATION

Maria Licznar-Małańczuk
Wrocław University of Environmental and Life Sciences

Abstract. The living mulch is one of the orchard floor weed control option suitable for the organic production, which especially adds orchard biodiversity. The covering plant competes with the fruit tree, what can result in the reduced growth and yield. At the Fruit Experimental Station of the Wrocław University of Environmental and Life Sciences, in a young apple orchard mulched with blue fescue (*Festuca ovina* L.), the growth, cropping, and fruit quality were evaluated. In spring 2009, trees of the 'Ligol' cv. budded on the M.9, M.26, and P 60 rootstocks were planted, and in the following four years (2010–2013) blue fescue was being sown in the tree rows. Prior to the introduction of the living mulch, a herbicide fallow was maintained. The sowing of blue fescue as early as in the second year following the tree planting caused a significant decrease of the total yield per tree obtained in the first four years of the cropping. On the other hand, it contributed to an improved coloration of the fruits. Postponing of the cover plant sowing until the third and fourth year following the orchard establishment mitigated the negative influences of the living mulch on the tree growth and yielding, as well as on the fruit quality. As in addition blue fescue satisfactorily protects the soil from weed occurrence, its application in form of a late-sown living mulch could be considered as a promising alternative to the herbicide fallow.

Key words: cover crop, grass, rootstock, growth, cropping

INTRODUCTION

Around the world, various species of *Festuca* (fescue) are commonly grown as a component of forage crops. Communities consisting of *Festuca ovina* L., *Festuca rubra* L., and *Agrostis capillaris* L. are widespread in the Great Britain [Hulme et al. 1999]. *Festuca arundinacea* Schreb. performs better in the Mediterranean climate [Fiorio el al. 2012]

Corresponding author: Maria Licznar-Małańczuk, Department of Horticulture. Wrocław University of Environmental and Life Sciences, pl. Grunwaldzki 24a, 50-363 Wrocław, e-mail: maria.licznar-malanczuk@up.wroc.pl

and in some regions of the United States [Schiavon at al. 2013]. Species of *Festuca* are frequently found in those apple-growing regions [Merwin 2003]. The standard orchard floor management system is based on the grass sod maintained in the inter-row area [Granatstein and Sánchez 2009]. *F. rubra* L. – together with *Poa pratensis* L. [Neilsen and Hogue 2000, Kühn and Lindhard Pedersen 2009] or *Lolium perenne* L. [Bone et al. 2009] – is a typical component of drive alleys. More vigorous *F. arundinacea* Schreb. can be introduced in between the rows of some more strongly growing fruit trees [Belding et al. 2004, Sánchez et al. 2007, Glenn and Newell 2008]. In addition, *F. ovina* L. [Zebarth et al. 1993] and *F. longifolia* Thuill. [Belding et al 2004] are suitable for fruit or berry plantations.

Permanent soil protection obtained by its mulching is one of the principles of conservation agriculture [Scopel at al. 2013]. Maintained in the tree rows, under the tree canopies, species of *Festuca* can be expected to suppress weeds, while not competing substantially with the fruit crop. In effect, the living mulch may be an alternative to a herbicide fallow or mechanical weed control [Tworkoski and Glenn 2012]. In practice however, due to its water and nitrogen needs, such a mulch oftentimes negatively affects the tree growth and yielding. Lakatos and Bubán [2000] observed a rapid decrease of water content in the soil maintained under *F. pseudovina* Hack. ex Wiesb. Licznar-Małańczuk [2012] reported similar moisture reduction caused by *F. ovina* L.

Fruit trees respond differently to different grass species, but in general the competition impairs yield rather than vegetative growth, under insufficient leaf nitrogen content [Tworkoski and Glenn 2001]. An introduction of *F. rubra* L. and *Poa pratensis* L. into the rows of young apple trees contributed to the retardation of the shoot growth, and brought the reduction of the first-quality fruit yield in respect to a herbicide fallow [Andersen at al. 2013]. Similar results pertaining to the tree growth were obtained by Atucha et al [2011] in the first years after the sowing of *F. rubra* L. The mixture of *F. longifolia* Thuill. and several *Trifolium* species sown under eighteen-year-old cherry trees also resulted in the yield reduction, which was linked to the increasing domination of the more nitrogen-demanding, grass [Sanchez et al. 2003]. On the other hand, no significant yield decrease was noted after the introduction of three *Festuca* species into the rows of ten-year-old apple and peach trees. The only significant observation was the reduction of the mean apple weight under the influence of *F. rubra* L. and *F. rubra* var. *comunicata* L. Gaudin mulches [Tworkoski and Glenn 2012]. Regarding another important aspect of apple fruit quality, i.e. the extent of red skin color, it tends to be improved when the trees are undersown with a grass mulch [Kühn and Lindhard Pedersen 2009, Licznar-Małańczuk 2012].

Despite the variability of weed floristic compositions between orchards, the introduction of the same floor management system leads to similar changes within the weed communities [Miñarro 2012]. When no cover crop biomass is present, a proliferation of broadleaf weeds can be observed [Fredrikson et al. 2011]. In contrast, grasses, being good competitors, prevent the establishment of most weeds [Calkins and Swanson 1995]. In the open field several grass species provided a similar degree of the weed suppression, which was comparable to that attained with herbicides. Under greenhouse conditions the protection given by *F. rubra* L. living mulch occurred to be even more effective [Tworkoski and Glenn 2012]. The application of *F. ovina* L. also brought a satisfactory effect in this regard [Licznar-Małańczuk 2012, 2014].

In the cultivation of mulched fruit trees, specific goals are hard to obtain without proper management of the cover crop species [Bordelon and Weller 1997]. During the orchard establishment, it is also necessary to consider the differences between rootstocks pertaining to their tolerance towards the competition from the living mulch [Granatstein and Sánchez 2009]. The aim of this study was the evaluation of a *Festuca ovina* L. living mulch – in particular, its influence on the weed suppression, as well as on the growth, yield and fruit quality of apple tree cv. Ligol budded onto three different dwarf and semi-dwarf rootstocks.

MATERIAL AND METHODS

The experiment was conducted at the Fruit Experimental Station of the University of Environmental and Life Sciences in Wrocław (Poland), in Samotwór (51°06'12''N, 16°49'52''E). Two-year-old apple trees cv. 'Ligol' budded on a dwarf M.9, as well as semi-dwarf M.26 and P 60 rootstocks were planted in spring 2009 on haplic luvisol formed from silty light loam. The chosen tree spacing was 3.5 × 1.2 m (2380 trees × ha^{-1}). The experiment was established following a split-plot design with four replications. During the four subsequent vegetation seasons, extending over the 2010–2013 period, the living mulch of blue fescue (*Festuca ovina* L.) of the 'Noni' and 'Sima' cvs. was being established in the tree rows (50 kg seeds × ha^{-1} in the 1:1 cvs. ratio). The blue fescue was introduced in the main plots, in the second, third, fourth, and fifth year following the tree planting. It was sown under the tree crowns, in 1 m wide strips, always in spring. In the experimental design, each main plot consisted of three subplots planted with apple trees on the M.9, M.26, and P 60 rootstocks, respectively. Each subplot contained five trees.

Prior to the introduction of the living mulch, and as a control treatment, a herbicide fallow was maintained in April and July. It was based of the mix of glyphosate and MCPA (2-methyl-4-chlorophenoxyacetic acid) at the dose of 4 + 2 l × ha^{-1}, with exception of the spring 2010 (the only glyphosate – 8 l × ha^{-1}). The only in the second year following the each blue fescue introduction, dicotyledonous weeds were treated with a herbicide based on MCPA applied at the dose of 2 l × ha^{-1}. Beginning from the third year following the orchard establishment, annual mowing of the living mulch was performed in the rows. In the year of the orchard establishment, permanent grass sod was introduced between the tree rows. It was mowed several times per vegetation season. The trees were trained into the form of a slender spindle. Once a year, starting from the spring 2009, they were fertilized with nitrogen. The fertilizer was applied on an individual tree (10 g N × $tree^{-1}$) in 2009 and 50 kg N × ha^{-1} was spread on the whole orchard area in next seasons. Plant protection was carried out in accordance with up-to-date recommendations in the Orchard Protection Program. Throughout the whole experiment, the weather conditions were favorable for the apple tree cultivation. The only exception was the year 2011, when a late-spring frost (-2°C, recorded on May 3rd) caused a partial flower damage.

In 2009–2013, the data pertaining to per-subplot fruit yield and quality, as well as per-tree growth and survival were being collected. As the measures of the fruit quality, the fruit weight, size and the extent of blush were selected. The fruit size was evaluated as a mean weight of 20 apples per subplot. In order to estimate the extent of the blush, apples from a 15 kg sample per subplot were sorted into three classes: < ¼, ¼–¾, and > ¾ of the total skin surface area. Then, the same sample was sorted into three classes of the fruit diameter: less than 7.5; 7.5–8.5, and over 8.5 cm. As a measure of the tree growth, trunk cross sectional area (TCSA) and its increment were calculated from the diameter obtained 30 cm above the budding height. The crop efficiency coefficient (CEC) was evaluated from the total apple yield up to 2013. At the end of the same year, the number of dead trees was recorded.

On each subplot, the blue fescue living mulch and weed taxa coverages were assessed. For this purpose, a noninvasive method of plant population estimation, conforming to the methodology of Lipecki and Janisz [2000], was employed. The assessments covered each species, in some cases – genus, of the weeds. The share of the subplot surface occupied by each taxon was expressed using a discrete percentage scale: 0, 1, 20, 40, 60, 80, and 100%. The evaluation of the weed cover was made in August 2013; in case of blue fescue, it took place in 2014, i.e. one year after the last sowing of the living mulch.

The data concerning the yield, fruit quality and growth of the trees were evaluated statistically, using the two-way analysis of variance for a split-plot design. In order to, at least approximately, fulfill the assumptions of the analysis of variance, logarithmic or exponential transformations were applied to some of the data. As the data pertaining to the living mulch and the weed species cover did not distinguish between the tree rootstocks, they were analyzed using one-way analysis of variance for a randomized-block design. Prior to this analysis, some of data were subjected to the angular transformation. Significant differences of the treatment means were calculated according to the Duncan's test, at the confidence level of 95%.

RESULTS

The growth of the apple trees budded onto the M.9 rootstock was significantly lower in relation to the one observed for the M.26 and P 60 rootstocks (tab. 1). The year of the blue fescue sowing did not affect the growth of the trees. The trunk cross-sectional areas and their increase up to the end of the fifth year following the planting were comparable among the rootstocks. In the first four years of cropping, there were no significant yield differences between the orchard floor management treatments among the apple trees growing on the same rootstock (tab. 2). However, when only the living mulch effects were considered, the trees occurred to yield better in the herbicide fallow than when accompanied by blue fescue introduced soon after the tree planting. Such significant differences were not noted in case of the living mulch that had been sown in later years despite of the herbicide fallow occurred to be the only floor management system under which the total yield (2010–13) exceeded 40 kg per tree. The effect of the living mulch was especially pronounced in the fourth year of the cropping (2013), when a significant difference between early-introduced grass and the control treatment was noted. Due to

Table 1. The growth and the mortality of the apple tree 'Ligol' cv. depending on the year of the blue fescue sowing and the rootstock. up to the year 2013

Specification			Trunk cross-sectional area (TCSA) (cm^2) spring 2009 *	autumn 2013	increase spring 2009–autumn 2013	Number of dead trees up to the end of 2013
Rootstock M.9	control – herbicide fallow		2.41	16.00 a	13.59 a	–
	year of the blue fescue sowing	2nd (2010)	2.46	12.86 a	10.39 a	1
		3rd (2011)	2.57	17.06 a	14.49 a	–
		4th (2012)	2.45	14.25 a	11.80 a	–
		5th (2013)	2.73	15.47 a	12.75 a	–
Rootstock M.26	control – herbicide fallow		2.51	20.63 a	18.13 a	–
	year of the blue fescue sowing	2nd (2010)	2.28	16.47 a	14.19 a	–
		3rd (2011)	2.23	22.64 a	20.41 a	–
		4t (2012)	2.49	21.29 a	18.80 a	–
		5th (2013)	2.39	21.96 a	19.58 a	–
Rootstock P 60	control – herbicide fallow		2.84	23.43 a	20.59 a	–
	year of the blue fescue sowing	2nd (2010)	2.56	18.12 a	15.56 a	–
		3rd (2011)	2.67	21.44 a	18.77 a	–
		4th (2012)	2.67	22.04 a	19.37 a	–
		5th (2013)	2.89	22.45 a	19.55 a	–
Average across all rootstocks	control – herbicide fallow		2.59	20.02 a	17.44 a	–
	year of the blue fescue sowing	2nd (2010)	2.43	15.81 a	13.38 a	1
		3rd (2011)	2.49	20.38 a	17.89 a	–
		4th (2012)	2.53	19.19 a	16.66 a	–
		5th (2013)	2.67	19.96 a	17.29 a	–
Average across all years of the blue fescue sowing	rootstock	M.9	2.52 a	15.13 a	12.60 a	1
		M.26	2.38 a	20.60 b	18.22 b	–
		P 60	2.73 a	21.49 b	18.77 b	–

Within individual columns the means marked with varied small letters differ significantly according to the Duncan's test at the confidence level 95%
* – statistical evaluation for the rootstock only

the differences within the yields, despite the similar growth rates, crop efficiency coefficient was significantly lower in case of earlier sowing – i.e. in the second and the third vegetation season after the planting of the trees – than in the rows where blue fescue had been introduced one year later, or where the herbicide fallow was maintained. The significant better cropping was obtained on the P 60 rootstock, but the trees on the M.9 tended to have the highest crop efficiency coefficient (CEC) values.

The year of the blue fescue sowing had no substantial influence on the mean fruit weight and the share of large-sized apples, but significant weighty one fruit (mean for 2010–13) was noted on the trees budded onto the M.26 rootstock (tab. 3 and 4). Only in two years, in one treatment, mean apple weight below 200 g was observed. Fruits of such a poor quality were obtained from the rows sown with the living mulch already in the second year after the planting of the trees. The early introduction of the living mulch had also a clear impact on the blush on the apple skin. It contributed to a significant reduction of the share of the apples with lower than 25% of the blushing skin area.

Table 2. The yield and the crop efficiency coefficient of the apple tree 'Ligol' cv. depending on the year of the blue fescue sowing and the rootstock, in the years 2010–2013

Specification			Yield (kg × tree^{-1})					
			2010	2011	2012	2013	Total 2010–2013	Crop efficiency coefficient (CEC) 2013 (kg × cm^{-2})
Rootstock M.9	control – herbicide fallow		4.2 a	4.9 a	22.1 a	12.5 a	43.7 a	2.81 a
	year of the blue fescuesowing	2nd (2010)	3.9 a	1.6 a	12.7 a	4.2 a	22.4 a	1.65 a
		3rd (2011)	4.8 a*	3.7 a	17.3 a	3.2 a	29.0 a	1.70 a
		4th (2012)	4.4 a*	3.8 a*	18.0 a	8.5 a	34.6 a	2.48 a
		5th (2013)	5.4 a*	1.6 a*	20.2 a*	6.2 a	33.3 a	2.21 a
Rootstock M.26	control – herbicide fallow		3.9 a	3.1 a	21.3 a	10.3 a	38.6 a	1.90 a
	year of the blue fescuesowing	2nd (2010)	3.4 a	1.2 a	13.0 a	1.6 a	19.2 a	1.15 a
		3rd (2011)	4.3 a*	2.5 a	13.6 a	6.6 a	26.9 a	1.20 a
		4th (2012)	3.5 a*	3.0 a*	18.4 a	12.3 a	37.1 a	1.84 a
		5th (2013)	4.2 a*	2.7 a*	20.2 a*	6.0 a	33.0 a	1.50 a
Rootstock P 60	control – herbicide fallow		2.9 a	3.9 a	22.8 a	8.6 a	38.1 a	1.64 a
	year of the blue fescuesowing	2nd (2010)	3.6 a	1.9 a	16.0 a	3.1 a	24.5 a	1.34 a
		3rd (2011)	4.4 a*	4.9 a	20.9 a	3.1 a	33.3 a	1.55 a
		4th (2012)	3.9 a*	3.8 a*	21.3 a	12.8 a	41.9 a	1.91 a
		5th (2013)	4.9 a*	1.8 a*	22.8 a*	8.7 a	38.2 a	1.71 a
Average across all rootstocks	control – herbicide fallow		3.6 a	4.0 a	22.1 a	10.5 c	40.1 b	2.12 c
	year of the blue fescuesowing	2nd (2010)	3.6 a	1.6 a	13.9 a	3.0 a	22.0 a	1.38 a
		3rd (2011)	4.5 ab*	3.7 a	17.3 a	4.3 ab	29.7 ab	1.48 ab
		4th (2012)	3.9 ab*	3.5 a*	19.2 a	11.2 c	37.9 b	2.08 c
		5th (2013)	4.8 b*	2.0 a*	21.1 a*	7.0 bc	34.8 b	1.80 bc
Average across all years of the blue fescue sowing	rootstock	M.9	4.5 b	3.1 ab	18.0 a	6.9 a	32.6 a	2.17 b
		M.26	3.8 a	2.5 a	17.3 a	7.4 a	31.0 a	1.52 a
		P 60	3.9 a	3.3 b	20.8 b	7.3 a	35.2 b	1.63 b

* – data up to the year of the blue fescue sowing
Within individual columns. the means marked with varied letters differ significantly according to the Duncan's test at the confidence level 95%

Table 3. The mean fruit weight of the apple 'Ligol' cv. depending on the year of the blue fescue and the rootstock, mean for 2010–2013

Specification			Mean fruit weight (g)				
			2010	2011	2012	2013	Mean 2010–13
Average across all rootstocks	control – herbicide fallow		319 a	261 b	211 a	249 b	260 a
	year of the blue fescuesowing	2nd (2010)	309 a	190 a	196 a	247 b	235 a
		3rd (2011)	308 a*	270 b	218 a	237 ab	258 a
		4th (2012)	300 a*	254 b*	205 a	205 a	241 a
		5th (2013)	294 a*	251 b*	209 a*	255 b	252 a
Average across all years of the blue fescue sowing	rootstock	M.9	309 a	245 a	199 a	235 a	247 a
		M.26	312 a	247 a	217 b	246 a	256 b
		P 60	279 a	243 a	207 ab	235 a	246 a

Explanation see table 2

Table 4. The quality of the fruits of the apple 'Ligol' cv. depending on the year of the blue fescue and the rootstock, in the year 2013

Specification			Percentage of fruit with blush on the skin surface			Percentage of fruit with diameter (cm)		
			> ¾	¼–¾	< ¼	> 8.5	7.5–8.5	< 7.5
Average across all rootstocks	control – herbicide fallow		12.4 a	63.7 a	23.9 b	46.4 a	41.5 a	12.1 a
	year of the blue fescue sowing	2nd (2010)	22.4 a	69.2 a	8.4 a	42.2 a	40.7 a	17.1 a
		3rd (2011)	19.5 a	74.6a	5.9 a	40.4 a	43.6 a	16.0 a
		4th (2012)	8.6 a	67.0 a	24.4 b	29.1 a	40.7 a	30.2 a
		5th (2013)	11.0 a	65.9 a	23.1 b	51.5 a	38.0 a	10.5 a
Average across all years of the blue fescue sowing	rootstock	M.9	12.7 a	66.2 a	21.0 b	39.0 a	39.2 a	21.8 a
		M.26	18.0 a	68.6 a	13.4 a	44.1 a	39.0 a	16.9 a
		P 60	13.5 a	69.5 a	17.0 ab	42.6 a	44.6 a	12.8 a

Within individual columns. the means marked with varied small letters differ significantly according to the Duncan's test at the confidence level 95%

Table 5. The percentage of the soil surface under the weed species (2013) and living mulch sod (2014) in the tree rows. depending on the year of the blue fescue sowing

Species		Year of blue fescue sowingand the age of the living mulch sod			
		2nd (2010) 4–year old	3rd (2011) 3–year old	4th (2012) 2–year old	5th (2013) 1–year old
Annual weeds	*Cerastium arvense* L.	13.7 a	16.8 a	–	–
	Chamomilla spp. = Matricaria spp.	–	–	–	3.8
	Chenopodium album L.	–	–	–	5.7
	Conyza canadensis (L.) Cronq.	–	–	–	2.0
	Echinochloa crus-galli (L.) P.B.	–	–	12.1 b	4.1 a
	Epilobium adenocaulon Hausskn.	–	–	–	10.6
	Geranium pusillum L.	–	–	–	1.8
	Lamium purpureum L.	–	–	–	2.3
	Medicago lupulina L.	–	2.0	–	–
	Poa annua L.	–	–	56.7 a	30.0 a
	Polygonum aviculare L.	–	1.8 a	2.0 a	–
	Senecio vulgaris L.	–	–	–	43.5
	Stellaria media (L.) Vill.	–	1.8 a	8.8 ab	23.5 b
Perennial weeds	*Artemisia vulgaris* L.	2.3 a	11.8 a	–	–
	Equisetum arvense L.	–	1.8 a	1.8 a	11.8 a
	Glechoma hederacea L.	–	36.7	–	–
	Lolium perenne L.	2.3	–	–	–
	Malva sylvestris L.	10.1 a	–	38.5 a	–
	Poaceae – others species	5.8	–	–	–
	Sonchus arvensis L.	3.5	–	–	–
	Taraxacum officinale Web.	12.2 ab	33.5 b	4.2 a	28.3 b
	Trifolium repens L.	18.6 b	23.5 b	16.8 b	2.3 a
Living mulch	*Festuca ovina* L.	83.3 c	61.8 ab	78.3 bc	58.5 a

Within individual rows. the means marked with varied letters differ significantly according to the Duncan's test at the confidence level 95%

In the fifth year following the tree planting, the weed species' diversity was substantial only in the one-year-old blue fescue (tab. 5). Such a high number of species – in particular the annual ones – was not observed in the rows that had been protected by the living mulch for longer periods of time. In case of the three- and four-year-old living mulches, only a few perennial species, such as: *Taraxacum officinale* Web., *Trifolium repens* L., and *Glechoma hederacea* L.; were recorded. Due to the varied weed occurrence and the differences pertaining to the age of the living mulches, the degree of soil coverage by the blue fescue took values between 58 and 85%. The differences pertaining to the blue fescue domination were noted in 2014 – one year after the last introduction of the living mulch to the orchard. It is expected, however, that they will diminish with time.

DISCUSSION

A fruit tree growing together with other vegetation is a relatively poor competitor [Merwin 2003]. The limited competitive ability of the tree stems from its lower efficiency of soil nitrogen uptake compared to the one found in grass sod [Sanchez et al 2003, Atucha et al 2011]. In the presented experiment, the competition of the blue fescue sown in the second year after the planting of the apple trees led to the significant yield reduction not only in comparison to the herbicide fallow, but also to the trees in the rows sown with the living mulch in the fourth and fifth year after the orchard establishment. Similarly as in the study by Sosna [2009], with the delayed grass sowing, the fruit yield did not differ significantly from the one obtained under the purely chemical weed control. Among other factors that can mitigate the negative consequences of the living mulch competition Granatstein and Sánchez [2009] mention a proper choice of the cover species and planting of the trees grafted on more vigorous rootstocks. The obtained results corroborate the suitability of the semi-dwarf M.26 and P 60, as well as the dwarf M.9 rootstock. Up to the fifth year following the orchard establishment, there were no significant growth of the tree differences among the floor management treatments. The trees showed more intensive growth than in another study pertaining to the same cultivar, which was also mulched with blue fescue, yet budded on more dwarfing rootstocks: P 22 i P 16; as well as on the semi-dwarf P 2 [Licznar-Małańczuk 2012].

The introduction of the living mulch as soon as in the second or third year following the tree planting had a substantial influence on the apple coloration. The significant reduction of the share of poorly colored apples, also reported by other researchers [Kühn and Lindhard Pedersen 2009, Licznar-Małańczuk 2012], can probably be linked to the weak ability towards soil nitrogen uptake found in fruit species [Atucha et al 2011], as well as more intensive synthesis of anthocyanins within the fruits obtained from the trees accompanied by the living mulch [Slatnar et al 2014]. Moreover, in the conditions of reduced cropping the amount of light reaching each fruit was bigger, contributing to their coloration. On the other hand, the experiment did not confirm the negative influence of the fescue mulch on the fruit size and mean weight – the phenomenon reported by other authors [Tworkoski and Glenn 2001, Sosna et al. 2009]. In the year of the most abundant tree yielding (i.e. the third year of the cropping) the fruit mean weight was the lowest, but did not fall substantially below the 200 g threshold. One year later, when the yields were low, the share of over-sized apples (diameter > 8.5 cm) was above the norm, often exceeding 40% irrespective of the year of the blue fescue sowing.

Basing the apple tree culture on a large-fruited cultivar and a vigorous rootstock, as well as delayed sowing of the cover plant can be considered as three strategic factors mitigating the negative influence of the living mulch on the fruit tree. In the presented study, a postponed introduction of blue fescue resulted in non-significant differences of the crop efficiency coefficients in relation to the control. In contrast – in a similar way as in the experiments by Neilson and Hogue [2000] or Atucha et al. [2011] – the value of CEC was significantly lower in the treatments where the apple trees had to compete with the living mulch at a very young age. In the presented experiment, during the five years of cultivating the apple trees in the blue fescue mulch, there were no occurrences of rodent-related tree losses. The proper choice of the cover crop can contribute to the regulation of rodent activity in the orchard [Granatstein and Sánchez 2009]. Last but not least, as in other experiments involving the *Festuca* genus [Licznar-Małańczuk 2012, 2014, Tworkoski and Glenn 2012], the prolonged maintenance of blue fescue in the tree rows occurred to be an effective weed suppression method. Whereas post-emergency non residual herbicides control the weeds only during the vegetation season, a living mulch provides a permanent weed suppression and additionally contributes to the soil conservation in an orchard [Atucha et al 2011].

CONCLUSIONS

1. The introduction of blue fescue into the rows of apple tree cv. Ligol contributes to the reduction of the cumulated four-year yield only when the living mulch is sown as early as in the second year following the orchard establishment, the year of the sowing had no significant influence on the tree growth also in case of the significant dwarfing M.9 rootstock.

2. When sown up to the fifth year following the orchard planting, blue fescue does not cause size and mean weight reduction of fruits of the large-fruited cultivar. The introduction of the living mulch as early as in the second or third year resulted in significantly smaller share of poorly colored fruits.

3. After five years of observations of the mulched orchard, it can be stated that blue fescue covers the soil surface well, contributes to the elimination of annual weeds and to a satisfactory degree controls the population of perennial ones.

4. With the proper choice of the year of *Festuca ovina* L. introduction, the maintenance of the living mulch in a semi-dwarf orchard planted with a large-fruited cultivar can be viewed as a promising simple measure aimed at the reduction of chemicals in agricultural environment in a way that does not bring negative impacts on the tree growth, yield, and fruit quality.

REFERENCES

Andersen, L., Kühn, B.F., Bertelsen, M., Bruus M., Larsen, S.E., Strandberg, M. (2013). Alternatives to herbicides in an apple orchard, effects on yield, earthworms and plant diversity. Agricult. Ecosyst. Envirom., 172, 1–5.

Atucha, A., Merwin, I.A., Brown, M.G. (2011). Long-term effects of four groundcover management systems in an apple orchard. HortSci., 46(8), 1176−1183.

Belding, R.D., Majek, B.A., Lokaj, G.R.W., Hammerstedt, J., Ayeni, A.O. (2004). Orchard floor management influence on summer annual weeds and young peach tree performance. Weed Technol., 18, 215−222.

Bone, N.J., Thomson, L.J., Ridland, P.M., Cole, P., Hoffmann, A.A. (2009). Cover crops in Victorian apple orchards: Effects on production, natural enemies and pest across a season. Crop Protec., 28, 675−683.

Bordelon, B.P., Weller, S.C. (1997). Preplant cover crops affect weed and vine growth in first-year vineyards. HortSci., 32(6), 1040–1043.

Calkins, J.B., Swanson, B.T. (1995). Comparison of conventional and alternative nursery weed management strategies. Weed Technol., 9, 761−767.

Fiorio, S., Macolino, S., Leinauer, B. (2012). Establishment and performance of bluegrass species and tall fescue under reduced-input maintenance in a temperature Mediterranean environment. HortTechnol., 22(6), 810−816.

Fredrikson, L., Skinkis, P.A., Peachey, E. (2011). Cover crop and floor management affect weed coverage and density in an establishing Oregon vineyard. Hort Technol., 21(2), 208−216.

Glenn, D.M. Newell, M.J. (2008). Long-time effects of sod competition on peach yield. Hort Technol., 18(3), 445−448.

Granatstein, D., Sánchez, E. (2009). Research knowledge and needs for orchard floor management in organic tree fruit systems. Inter. J. Fruit. Sci., 9, 257−281.

Hulme, P.D., Pakeman, R.J., Torvell, L., Fisher, J.M., Gordon, I.J. (1999). The effects of controlled sheep grazing on the dynamics of upland *Agrostis–Festuca* grassland. J. Applied Ecol., 36, 886–900.

Kühn, B.F., Lindhard Pedersen, H. (2009). Cover crop and mulching effects on yield and fruit quality in unsprayed organic apple production. Europ. J. Hort. Sci., 74(6), 247−253.

Lakatos, T., Bubán, T. (2000). Effectiveness of different groundcover materials to preserve soil water content in a young apple orchard. Acta Hort., 525, 425−426.

Licznar-Małańczuk, M. (2012). Zastosowanie żywych ściółek w sadzie jako alternatywnego sposobu pielęgnacji gleby w porównaniu z ugorem herbicydowym. Monogr. 154, UP, Wrocław.

Licznar-Małańczuk, M. (2014). The diversity of weed species occurring in living mulch in an apple orchard. Acta Agrobot., 67(1), 47–54.

Lipecki, J., Janisz, A. (2000). Rozmieszczenie przestrzenne oraz zmiany w występowaniu niektórych chwastów w sadzie jabłoniowym Gospodarstwa Doświadczalnego Felin koło Lublina. Acta Agrobot., 53(2), 85−104.

Merwin, I.A. (2003). Orchard-floor management systems. In: Apples: botany, production and uses. Ferree, D.C., Warrington, I.J. CABI Publ., Cambridge, 303−318.

Miñarro, M. (2012). Weed communities in apple orchards under organic and conventional fertilization and tree-row management. Crop Protect., 39, 89−96.

Neilsen, G.H., Hogue, E.J. (2000). Comparison of white clover and mixed sodgrass as orchard floor vegetation. Can. J. Plant Sci., 80, 617−622.

Sánchez, E.E., Giayetto, A., Cichón, L., Fernández, D., Aruani, M.C., Curetti, M. (2007). Cover crop influence soil properties and tree performance in an organic apple (*Malus domestica* Borkh) orchard in northern Patagonia. Plant Soil, 292(1−2), 193−203.
Sanchez, J.E., Edson, Ch.E., Bird, G.W., Whalon, M.E., Willson, T.C., Harwood, R.R., Kizilkaya, K., Nugent, J.E., Klein, W., Middleton, A., Loudon, T.L., Mutch, D.R., Scrimger, J. (2003). Orchard floor and nitrogen management influences soil and water quality and tart cherry yields. J. Amer. Soc. Hort. Sci., 128(2), 277−284.
Schiavon, M., Barnes, B.D., Shaw, D.A., Henry, J.M., Baird, J.H. (2013). Strategies for converting tal fescue to warm-season turf in a Mediterranean climate. Hort Technol., 23(4), 442−448.
Slatnar, A., Licznar-Malanczuk, M., Mikulic-Petkovsek, M., Stampar, F., Veberic, R. (2014). Long-term experiment with orchard floor management systems: Influence on apple yield and chemical composition. J. Agric. Food Chem., 62(18), 4095–4103.
Scopel, E., Triomphe, B., Affholder, F., Macena Da Silva, F.A., Corbeels, M., Valadares Xavier, J.H., Lahmar, R., Recous, S., Bernoux, M., Blanchart, E., de Carvalho Mendes, I., De Tourdonnet, S. (2013). Conservation agriculture cropping systems in temperate and tropical conditions, performances and impacts. A review. Agron. Sustain. Dev., 33, 113–130.
Sosna, I., Licznar-Małańczuk, M., Czaplicka, M. (2009). Wstępna ocena wpływu żywych ściółek na wzrost i owocowanie drzew jabłoni i gruszy. Zesz. Probl. Post. Nauk Roln., 536, 197−203.
Tworkoski, T.J., Glenn, D.M. (2001). Yield, shoot and root growth, and physiological responses of mature peach trees to grass competition. HortSci., 36(7), 1214−1218.
Tworkoski, T.J., Glenn, D.M. (2012). Weed suppression by grasses for orchard floor management. Weed Technol., 26, 559–565.
Zebarth, B.J., Freyman, S., Kowalenko, C.G. (1993). Effect of ground covers and tillage between raspberry rows on selected soil physical and chemical parameters and crop response. Can. J. Soil Sci., 73, 481−488.

WSTĘPNA OCENA ZASTOSOWANIA KOSTRZEWY OWCZEJ (*Festuca ovina* L.) JAKO ŻYWEJ ŚCIÓŁKI W SADZIE JABŁONIOWYM

Streszczenie. Ściółkowanie roślinami okrywowymi, które zwiększa bioróżnorodność upraw sadowniczych, jest jednym ze sposobów ograniczenia zachwaszczenia w sadzie odpowiednim dla zrównoważonej produkcji. Żywa ściółka stanowi jednak konkurencję wobec drzewa owocowego, co może prowadzić do ograniczenia jego siły wzrostu i owocowania. Wzrost, plonowanie i jakość owoców oceniano w młodym sadzie ściółkowanym kostrzewą owczą (*Festuca ovina* L.) na terenie Stacji Badawczo-Dydaktycznej Uniwersytetu Przyrodniczego we Wrocławiu. Odmianę 'Ligol' na podkładkach M.9, M.26 oraz P 60 wysadzono wiosną 2009 r. W kolejnych czterech latach po założeniu sadu (2010–2013) w rzędach drzew wysiewano kostrzewę owczą. Do roku jej wprowadzenia zastosowano ugór herbicydowy. Wysiew kostrzewy owczej już w drugim roku po posadzeniu jabłoni istotne obniżył sumę plonu z drzewa w pierwszych czterech latach owocowania, ale przyczynił się do poprawy wybarwienia owoców. Opóźnienie wysiewu rośliny okrywowej do trzeciego lub czwartego roku po założeniu sadu pozwoliło uniknąć jej negatywnego oddziaływania na plonowanie i wzrost jabłoni, a także jakość owoców wielkoowocowej odmiany jabłoni. Dodatkowo zadowalające zabezpieczenie gleby przed zachwaszczeniem przez darń pozwala na rozważenie ściółkowania kostrzewą owczą jako alternatywy – ten sposób pielęgnacji gleby kilka lat po założeniu sadu mona stosować zamiast ugoru herbicydowego.

Słowa kluczowe: roślina okrywowa, trawa, podkładka, wzrost, plonowanie

Accepted for print: 6.10.2015

For citation: Licznar-Małańczuk, M. (2015). Suitability of blue fescue (*Festuca ovina* L.) as living mulch in an apple orchard – preliminary evaluation. Acta Sci. Pol. Hortorum Cultus, 14(6), 163–174.