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ORIGINAL PAPER

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EFFECT OF CONDIT SOIL IMPROVER ON GROWTH, YIELD AND LEAF MINERAL CONTENT OF TWO SUMMER PEAR CVS. WITH INTERSTOCKS

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ABSTRACT

The study involving 2 pear cultivars was conducted in 2006–2016. 'Radana' and 'Clapp's Favourite' were planted in the spring 2006 in the Experimental Station next to Wrocław (south-western Poland) on Quince S_1 and Caucasian pear seedlings with 2 interstocks – 'Doyenne du Comice' and 'Pyrodwarf'. An annual dose of 3 tonnes per hectare of Condit Basic bio-fertilizer was applied onto the tree row soil surface at the beginning of March 2012, i.e., starting from the 7th year after the planting. The study objective was to evaluate effect of Condit preparation on summer pear tree cultivars which are not compatible with Quince, and to assess interstock suitability in their context. The yields obtained in the first eleven years following tree planting were the most abundant for 'Radana' on Caucasian pear and on Quince with 'Doyenne du Comice' interstock. When applied for 5 years, Condit increased the leaf surface area, however a significant difference was exhibited only by 'Radana' on the Caucasian pear. This soil improver did not affect tree growth and yielding; total chlorophyll content; foliar Mg, P, Ca, and K; and mean fruit mass across the investigated treatment combinations.

Key words: *Pyrus communis*, organic fertilizer, 'Doyenne du Comice', 'Pyrodwarf', rootstock, quality

INTRODUCTION

The most popular rootstock used in Poland for pear tree production are Caucasian pear seedlings (*Pyrus communis* var. *caucasica*). Its greatest advantages are high cold resistance and good compatibility with most cultivars. However, rootstocks derived from *Pyrus communis* have a drawback of vigorous growth and late fruit bearing [North and Cook 2008, Kumar et al. 2012, Ikinci et al. 2016]. In order to increase the profitability of pear production, cultivars on weakly growing rootstocks should be introduced into the cultivation, which enables a greater tree density per unit area. For this purpose, clones of quince (*Cydonia oblonga* Mill.), e.g. BA 29, MA, MC, S_1 are used, which can retard growth by 30 to 60% in comparison to trees grafted on pear seedlings. Quince rootstocks have low cold resistance and are incompatible with some cultivars, such as 'Radana', 'Clapp's Favourite' and 'Williams Bon Chrétien' [Sotiropoulos 2006, Sosna and Czaplicka-Pędzich 2013]. Quince S_1, which has been selected in Poland, has better cold hardiness and similar growth than quince MA. Physiological incompatibility can be avoided by using double grafting with interstock of 'Beurre Hardy' or 'Doyenne du Comice' [Musacchi et al. 2002, Iglesias et al. 2003, Sosna and Kortylewska 2013]. Pears grafted on different types of Quince grow weaker, start bearing fruit earlier, and produce larger fruits [Kviklys and Kviklienė 2005, Massai et al. 2008, Stern and Doron 2009, Ozturk and Ozturk 2014, Askari-Khorasgani et al. 2019]. Trees on pear seedlings have strong growth, which can be reduced

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by proper interstock, for example ‘Pyrodwarf’ of German origin (‘Old Home’ × ‘Bonne Luis d’Avranches’). It’s a dwarf vegetative rootstock with a high cold hardiness [Lepsis and Drudze 2011, Haak et al. 2013]. ‘Pyrodwarf’ induces low vigour, high yield efficiency, uniform fruit size and good graft compatibility with wide spectrum of pear cultivars [Jacob 2002].

Environmental pollution and excessive chemical processing of agriculture create a new dimension to the problem of rational nutrition, with direct implications for human health. Over time new ways to increase the quality and quantity of agricultural products have been sought, thus identifying new substances able to ensure high quality and efficiency [Dinu et al. 2015]. Bioproducts are used to inhabit the growth of pathogenic fungi or bacteria, stimulate plants growth and enhance yield and nutrient uptake. One of the categories of bioproducts are biostimulants. They can be composed of microorganisms, protein hydrolysates, humic substances and seaweed extracts [Calvo et al. 2014, Pylak et al. 2019]. First of all, biostimulants should be applied to high-value crops like fruits and vegetables. These products are able to counteract abiotic stress such as water deficit, soil salinization, nutrient deficiency, and exposure to too low or too high temperatures – heat, chilling or cold stress [Bulgari et al. 2019].

Biostimulants can be applied as foliar spray or to the roots. According to Hecl [2010], organic fertilizer Condit causes soil microbial activities, positively affects nutritional and health condition of plants as well as thermic, air and water regime of the soil. This biological conditioner also improves plant growth because of the optimization of soil conditions for soil microorganisms. According to research conducted in Slovakia [Tobiašová 2011], Condit Eco and Condit Mineral are advantageous in terms of soil amelioration when applied in spring and autumn, respectively. Three-year Condit application clearly contributed to a decreased heavy metal (Cd, Pb, Ni) content both in the soil and the plants cultivated within. The best effects were noted for cadmium in carrot roots [Hecl et al. 2012].

The aim of the study was to evaluate the effect of soil conditioner Condit Basic and the usefulness of an interstocks for two summer pear cultivars, which are completely incompatible with Quince.

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 south-western Poland. 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 the one-year-old trees of ‘Radana’ and ‘Clapp’s Favourite’ (*Pyrus communis* L.) pear cultivars budded on Quince S_1 (QS_1) with ‘Doyenne du Comice’ interstock (about 10 cm long), on Caucasian pear seedlings (Cps) and only ‘Radana’ on Caucasian pear with ‘Pyrodwarf’ interstock (about 10 cm long). The trees were planted with the spacing of 3.5 × 1.5 m (1905 trees ha^{-1}) and formed as a spindle crown.

An additional experimental factor, comprising the Condit Basic preparation, was introduced at the beginning of March 2012, i.e., in the 7th year following the tree planting. Over the subsequent 5 years, it was applied on an annual basis at the rate of 3 tonnes per hectare onto the soil of the pear tree rows. Condit – it’s an organic-biological fertilizer and soil improver, granulated, gray-black with soil-like odour. This preparation is manufactured in Slovakia, in a production process that involves no synthetic chemical compounds. It is made of several natural ingredients: hydrolyzed whey (a source of plant-available nitrogen upon decomposition), wheat bran, leafy hardwood sawdust, brown coal, zeolite, and nitrogen bacteria strains. It contains min. 1% of phosphorus as P_2O_5, min. 2% of potassium as K_2O (total form), and min. 60% of organic matter. The organic carbon content amounts to min. 30%, and pH_{KCl} ranges between 7.0 and 8.5. It is available in several variants: Condit Basic with 2.5% nitrogen total content, especially recommended for soils prone to biodegradation; Condit Eco (5% N), recommended for organic agriculture; and Condit Mineral (7% N), recommended as a crop fertilizer. Condit can be applied in perennial cultures, such as orchards, in late autumn or very early spring, and it does not necessitate an incorporation into the soil profile. This preparation fosters soil biological systems, triggers stable humus formation, and mitigates the consequences of soil salinity. Its annual application reduces to a substantial degree the need for supplementary mineral fertilization.

The planting pattern followed the randomised block design with three replications and 5 trees per plot. The trees were annually pruned soon after flowering, starting from the fourth year following the orchard establishment. No irrigation was applied and fruitlets were not thinned. The orchard floor management system consisted of herbicide fallow (Glifosate + MCPA) in the tree rows and sward in the alleyways – both introduced in the year of the tree planting. The chemical protection was carried out according to up-to-date recommendations of the Orchard Protection Programme. An annual dose of 50 kg N ha^{-1} in the form of ammonium nitrate was applied, starting from the 4th year following the orchard establishment. The soil was limed in 2013 with 750 kg CaO ha^{-1}, and fertilization with potassium salt equivalent to 80 kg K_2O ha^{-1} was performed in early spring 2014.

Topsoil (0–20 cm) samples were collected using Egner's soil sampler in August 2012, 2013, and 2016 – the initial years of Condit soil improver application and the year of the experiment termination. The samples were analysed in the District Chemical and Agricultural Station in Wrocław (P and K – Egner-Riehm method, Mg – Schachtschabel method, Ca – Mehlich 3 method, C-org. and humus – Tiurin method). The samples of leaves were collected for analysis of macro– and microelements and chlorophyll in 2016, in the second half of July, in three replications. A sample of 100 leaves from the middle part of the long shoots (3–4 leaves each) was collected from all trees in one replication. Total content of chlorophyll, dry matter, P, K, Mg and Ca was determined. Total chlorophyll content in fresh leaf extract was determined by spectrophotometry. Then the leaves were dried at a temperature of 60–65°C, were ground and mineralized by microwave method. The concentration of phosphorus was determined with the use of the colorimetric method with ammonium molybdate and the concentration of magnesium with the use of titanium yellow. The concentrations of potassium and calcium were determined with the use of the flame photometric method. Leaf surface area was measured using a portable ADC BioScientific Limited/AM 300 scanner.

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 $\alpha = 0.05$ level were obtained using the Duncan's multiple range test.

RESULTS AND DISCUSSION

Condit Basic did not influence significantly the soil properties (Tab. 1). Although elevated organic carbon, humus, potassium, magnesium, and phosphorus contents were noted after five years of this bio-fertilizer application, the difference with respect to the soil without Condit lacked a statistical support. The collected soil samples were also characterized by a similar reaction. In a study conducted in Slovakia, Condit application led to a significant increase in soil organic carbon, P and K, while having no effect on pH [Hecl et al. 2012]. Tobiašová [2011] noted a higher humus content in a manured soil relative to substrates treated with Condit Eco and Condit Mineral, and similar pH_{KCl} levels.

Table 1. Soil samples analysis performed at the beginning and at the end of 'Condit Basic' soil improver use

Year	Preparation	C-org. (%)	Humus (%)	pH_{KCl}	Macronutrients (mg 100 g^{-1} d.m.)			
					K	Ca	Mg	P
2012	without 'Condit'	-	0.86	6.0	10.3	15.7	16.4	3.8
	'Condit	-	0.98	6.0	9.1	14.8	15.5	1.8
2013	without 'Condit'	-	1.14	6.6	7.6	35.5	14.8	3.2
	'Condit	-	1.24	6.4	8.9	31.6	13.5	2.8
2016	without 'Condit'	0.63 a*	1.08 a	6.4 a	18.4 a	85.1 a	14.0 a	3.0 a
	'Condit	0.77 a	1.33 a	6.3 a	23.5 a	84.9 a	14.7 a	4.7 a

*means marked by the same letter within the columns do not significantly differ at $\alpha = 0.05$ according to Duncan's t-test

Table 2. Vegetative growth of two pear cvs. depending on nursery material and 'Condit Basic' soil improver

Treatment		Trunk cross-sectional area (cm^2)		Canopy volume (m^3) autumn 2016	Leaves surface (cm^2) autumn 2016
		autumn 2016	increase 2011–2016		
'Radana'/Cps	without 'Condit'	87.3 a*	46.7 a	5.0 a	202.4 a
	'Condit'	80.8 a	42.9 a	4.4 a	231.8 b
'Radana'/QS_1 + 'Doyenne du Comice'	without 'Condit'	56.7 a	23.0 a	3.2 a	187.0 a
	'Condit'	53.1 a	21.2 a	2.9 a	193.9 a
'Radana'/Cps + 'Pyrodwarf'	without 'Condit'	81.5 a	46.5 a	4.3 a	205.2 a
	'Condit'	79.3 a	45.0 a	3.8 a	208.7 a
'Clapp's Favourite'/Cps	without 'Condit'	82.5 a	46.6 a	4.9 a	171.9 a
	'Condit'	75.7 a	42.7 a	4.3 a	176.4 a
'Clapp's Favourite'/QS_1 + 'Doyenne du Comice'	without 'Condit'	52.8 a	20.9 a	3.2 a	156.7 a
	'Condit'	51.5 a	20.0 a	3.3 a	163.6 a
Mean for cultivar and rootstock + interstock (A)					
'Radana'/Cps		84.1 b	44.8 b	4.7 c	217.1 d
'Radana'/QS_1 + 'Doyenne du Comice'		54.9 a	22.1 a	3.1 a	190.5 bc
'Radana'/Cps + 'Pyrodwarf'		80.4 b	45.7 b	4.0 b	207.0 cd
'Clapp's Favourite'/Cps		79.1 b	44.7 b	4.6 bc	174.1 ab
'Clapp's Favourite'/QS_1 + 'Doyenne du Comice'		52.1 a	20.5 a	3.2 a	160.1 a
Mean for preparation (B)					
without 'Condit'		72.2 a	36.7 a	4.1 a	184.7 a
'Condit'		68.1 a	34.4 a	3.7 a	194.9 a

*means marked by the same letter within the columns for nursery material (A), 'Condit' (B) and interaction (A × B) do not significantly differ at α = 0.05 according to Duncan's t-test

The 'Radana' and 'Clapp's Favourite' trees on the Caucasian pear and a pear with the 'Pyrodwarf' interstock exhibited the most vigorous growth (Tab. 2). Many authors report vigorous tree growth on pear seedlings [Massai et al. 2008, Stern and Doron 2009, Sosna and Czaplicka-Pędzich 2013, Ikinci et al. 2014]. In the present study, 'Pyrodwarf' did not significantly inhibit the growth of the 'Radana' trees, in particular in terms of the trunk diameters. Although the crowns of those trees were smaller than in the treatment without interstock, their sizes exceeded the canopy dimensions obtained with Quince S_1. Similar results were reported by Mass [2006], Lepsis and Drudze [2011], and North et al. [2015]. In a Kumar et al. [2012] study, one-year-old pear trees of several cultivars budded on various Quince types exhibited vigorous growth when the 'Beurre Hardy' interstock was employed, compared to the trees without the interstock. The same effect was noted in Spain by Iglesias et al. [2003] for 'Conference' and the 'Doyenne du Comice' interstock. The application of Condit Basic initiated in the 7th year following the planting did not have a significant influence on the growth of the pear trees across the investigated treatments. Although an increased leaf surface area was obtained with this preparation, the effect was significant only for 'Radana' on the Caucasian pear. Other authors noted similar influence of bio-fertilizers on the growth of apple and sour cherry trees [Rozpara et al. 2015, Derkowska et al. 2017]. In some experiments, more vigorous plant growth was obtained with bio-stimulants, such as Greenburst [Abbey and Rathier 2005], Ergoplant [Świerczyński et al. 2014], and BF Quality, BF Amin, and Vinassa [Grzyb et al. 2015].

The 'Radana' trees on the Caucasian pear and on the Quince with the 'Doyenne du Comice' interstock gave the highest yields in the period of the eleven years following the planting (Tab. 3). Significantly least fruits were collected from 'Clapp's Favourite' on the Caucasian pear seedling, a rootstock with an apparently limited suitability for this cultivar. The high yielding potential of the 'Radana' pear tree was not confirmed by Sosna and Czaplicka-Pędzich [2013]. In their research, the yields of this cultivar were significantly the lowest. 'Radana' and 'Clapp's Favourite' on the Quince S_1 with an interstock were characterized by the highest cropping efficiency coefficients. Although in the study by Sotiropoulos [2006], the 'William's Bon Chretien' pear tree budded on the Pyrus communis seedling gave very good yields, it exhibited a low productivity due to the high vigour. Iglesias et al. [2003] reported yield reduction associated with the 'Doyenne du Comice' interstock – an observation not confirmed by the present experiment. Contrary to that, a strong positive effect of an interstock on the yield was noted by Musacchi et al. [2002] in an experiment with 'Beurre Hardy' and Quince BA 29. On the other hand, Sosna and Kortylewska [2013] did not obtain a significant influence of the 'Doyenne du Comice' interstock on the fruit bearing of pear trees on Quince S_1. Most authors noted significant, yet varied rootstock effects on the yielding of the investigated pear tree cultivars. Some of the reports mention an improvement associated with rootstocks from the *Cydonia* genus [Maas 2006, Haak et al. 2013, Askari-Khorasgani et al. 2019], whereas in other studies rootstocks from the *Pyrus* genus appeared to have an advantage [Massai et al. 2008, Stern and Doron 2009, North et al. 2015, Ikinci et al. 2016]. According to Mészáros et al. [2019], less vigorous rootstock–scion combinations contributed to higher yields of young trees, however in later seasons the yields tended to be moderate. By contrast,

Table 3. Yielding, mean fruit weight and crop efficiency coefficient (CEC) of two pear cvs. depending on nursery material and 'Condit Basic' soil improver (year of tree planting – the spring 2006)

Treatment		Cumulative yield (kg tree^{-1})		Mean fruit weight (g)		CEC (kg cm^{-2})	
		2008–2016	2012–2016	2009–2016	2012–2016	2006–2016	2012–2016
'Radana'/Cps	without 'Condit'	66.1 a*	50.6 a	158 a	173 a	0.76 a	1.08 a
	'Condit'	62.7 a	51.7 a	158 a	170 a	0.78 a	1.21 a
'Radana'/QS_1 + 'Doyenne du Comice'	without 'Condit'	56.4 a	43.4 a	149 a	158 a	0.99 a	1.89 a
	'Condit'	58.1 a	44.0 a	146 a	153 a	1.09 a	2.08 a
'Radana'/Cps + 'Pyrodwarf'	without 'Condit'	50.4 a	39.2 a	159 a	172 a	0.62 a	0.84 a
	'Condit'	59.0 a	49.5 b	155 a	168 a	0.74 a	1.10 a
'Clapp's Favourite'/Cps	without 'Condit'	19.8 a	15.1 a	195 a	183 a	0.24 a	0.32 a
	'Condit'	19.0 a	16.2 a	192 a	180 a	0.25 a	0.38 a
'Clapp's Favourite'/QS_1 + 'Doyenne du Comice'	without 'Condit'	55.6 a	47.9 a	192 a	177 a	1.05 a	2.29 a
	'Condit'	46.2 a	42.0 a	195 a	180 a	0.90 a	2.10 a
Mean for cultivar and rootstock + interstock (A)							
'Radana'/Cps		64.4 c	51.2 c	158 b	172 b	0.77 b	1.15 b
'Radana'/QS_1 + 'Doyenne du Comice'		57.3 bc	43.7 b	148 a	156 a	1.04 c	1.99 c
'Radana'/Cps + 'Pyrodwarf'		54.7 b	44.4 bc	158 b	170 b	0.68 b	0.97 b
'Clapp's Favourite'/Cps		19.4 a	15.7 a	194 c	182 c	0.25 a	0.35 a
'Clapp's Favourite'/QS_1 + 'Doyenne du Comice'		50.9 b	45.0 bc	194 c	179 c	0.98 c	2.20 c
Mean for preparation (B)							
without 'Condit'		49.7 a	39.2 a	171 a	172 a	0.73 a	1.28 a
'Condit'		49.0 a	40.7 a	169 a	170 a	0.75 a	1.37 a

*for explanations see Table 2

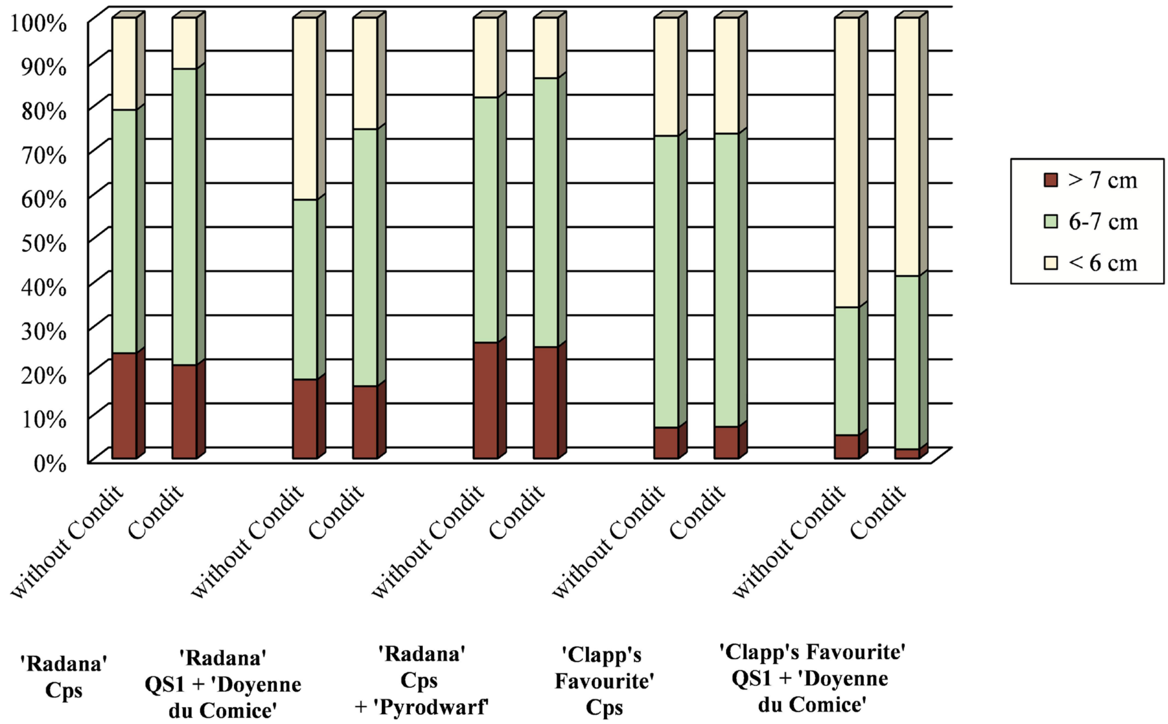

Fig. 1. Influence of nursery material and 'Condit Basic' soil improver on the fruit size of two pear cultivars (mean for 2015–2016)

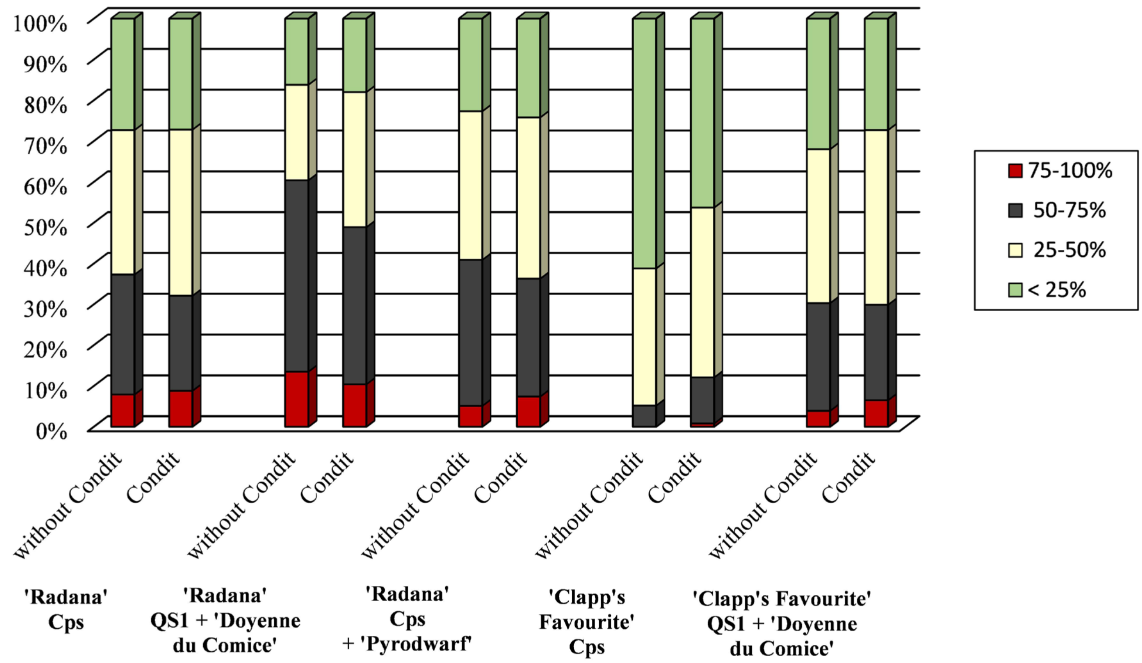

Fig. 2. Influence of nursery material and 'Condit Basic' soil improver on the fruit colouring of two pear cultivars (mean for 2015–2016)

combinations resulting in more vigour usually led to higher yields in the later seasons. The fruit bearing was not affected by the 5 years of Condit Basic application, with the exception of 'Radana' pear trees with 'Pyrodwarf' interstock, which exhibited significantly higher yields in the 2012–2016 period. The organic fertilizer employed in the experiment also did not influence the tree productivity. Conversely, in another experiment the Condit bio-fertilizer significantly increased by 20% the yield of the 'Darselect' strawberry. At the same time, the fraction of the non-marketable fruits decreased significantly due to limited rotting [SADEF 2011]. Yields of wheat and triticale were also positively affected by this preparation [Mečiar 2011]. Organic fertilizers and soil conditioners had no influence on 'Topaz' apple yields in the Grzyb et al. [2015] research, whereas Humus Active combined with Aktywit PM fostered the fruit bearing of the 'Ariwa' cultivar. The yield of 'Topaz' apples increased non--significantly when bio-products were employed [Mosa et al. 2018], and the Vinassa preparation had a positive influence on the fruit bearing of 'Debreceni Bötermö' sour cherry trees [Rozpara et al. 2015].

Not only the cultivar, but also the rootstock determined the fruit quality. The fruits of the 'Clapp's Favourite' pear tree were significantly heavier. The lightest pears were obtained from 'Radana' on the Quince S_1 with 'Doyenne du Comice' interstock (Tab. 3). The fruits from the trees growing on this interstock were also smaller. On the other hand, they exhibited an improved colouration (Fig. 1 i 2). Many authors mention a lack of a significant rootstock effect on mean pear mass [Haak et al. 2013, Sosna and Czaplicka-Pędzich 2013, Sosna and Kortylewska 2013, Ikinci et al. 2014, Askari-Khorasgani et al. 2019]. Conversely, Iglesias et al. [2003], Kviklys and Kvikliene [2005] and Ozturk and Ozturk [2014] reported a positive influence of rootstocks from the *Cydonia* genus on the mass and size of pears. The Condit Basic bio-fertilizer did not affect the fruit mean weight, size, and colouration. On the other hand, a relationship between the pear yield and quality was noted for the 2012–2016 period – namely, bearing of heavier fruits by poorly yielding trees. An application of the BF Quality, BF Amin, and Tytanit preparations increased mean apple weight in the Grzyb et al. [2015] study, whereas Rozpara et al. [2015] obtained a similar effect of the Humus UP, Tytanit, and Vinassa bio-fertilizers on sour cherry yield quality. Mean fruit mass, size, and colouration improved after foliar treatments of 'Red Delicious' apple trees with the Biozyne and Triacontanol bio-stimulants [Zubair et al. 2017].

The leaf chemical analyses revealed varied influence of the cultivar and rootstock on the dry matter, total chlorophyll, and major macronutrient contents (Tab. 4). The 'Radana' cultivar exhibited higher foliar chlorophyll concentration, but a significant difference was obtained only with respect to 'Clapp's Favourite' on Quince S_1 with an interstock. The chlorophyll content was not affected by the rootstock within the individual cultivar. The trees growing on the Caucasian pear seedlings appeared to have developed greener leaves, but this observation could not be statistically confirmed. No pertinent information was found in the available literature. For both cultivars, the dwarf Quince S1 was associated with significantly higher calcium contents. In the case of magnesium, a similar pattern was noted only for 'Clapp's Favourite'. The leaves of 'Radana' on the Caucasian pear had a higher concentration of potassium. On the other hand, the type of the rootstock had no effect on the phosphorus content. Similarly varied results with regard to the rootstock influence on macronutrient contents in pear tree leaves were noted by other authors. In the Lewko et al. [2004] experiment, the leaves of pear maidens budded on Quince S_1 had more K, Ca, and Mg relative to the concentrations obtained with the Caucasian pear, whereas the P content was lower. Increased P and decreased Mg foliar contents were reported also by North and Cook [2008] for pear trees on rootstocks from the *Pyrus* genus. On the other hand, Ikinci et al. [2014] noted higher K, Ca, and Mg concentrations in the leaves of the 'Santa Maria' cultivar growing on a pear seedling. At the same time, as in the present study, a rootstock type had no influence on P concentration. Elevated phosphorus and calcium contents were obtained in the leaves of pear trees on Quince MA grown in Serbia, when compared to Quince BA 29. The leaf nutrient status was determined to a higher degree by the cultivar than by the rootstock [Milošević and Milošević 2016]. The Condit Basic bio-fertilizer did not have a significant effect on the dry matter, total chlorophyll, and K, Mg, Ca, and P contents in the leaves of the investigated pear tree cultivars.

Table 4. Content of dry matter, chlorophyll and macronutrients in leaves of two pear cvs. depending on nursery material and 'Condit Basic' soil improver (2016)

Treatment		Dry matter (%)	Chlorophyll (mg 100 g^{-1} f.m.)	Macronutrients (g kg^{-1} d.m.)			
				K	Ca	Mg	P
'Radana'/Cps	without 'Condit'	44.0 a*	239.3 a	18.37 a	6.68 a	2.25 a	0.86 a
	'Condit'	45.5 a	303.0 a	14.22 a	7.38 a	2.55 a	0.70 a
'Radana'/QS_1 + 'Doyenne du Comice'	without 'Condit'	48.1 a	267.0 a	11.03 a	8.23 a	2.63 a	0.74 a
	'Condit'	46.2 a	247.3 a	13.33 a	8.53 a	2.73 a	0.58 a
'Radana'/Cps + 'Pyrodwarf'	without 'Condit'	45.1 a	280.3 a	15.15 a	7.29 a	2.33 a	0.81 a
	'Condit'	44.9 a	244.7 a	16.09 a	7.52 a	2.18 a	0.84 a
'Clapp's Favourite'/Cps	without 'Condit'	46.4 a	251.7 a	20.09 a	6.89 a	1.93 a	0.79 a
	'Condit'	47.9 a	191.3 a	16.17 a	7.40 a	2.07 a	0.76 a
'Clapp's Favourite'/QS_1 + 'Doyenne du Comice'	without 'Condit'	49.3 a	222.0 a	15.47 a	9.83 a	2.58 a	0.60 a
	'Condit'	48.3 a	190.3 a	17.53 a	10.61 a	2.77 a	0.69 a
Mean for cultivar and rootstock + interstock (A)							
'Radana'/Cps		44.8 a	271.2 c	16.30 b	7.03 a	2.40 bc	0.78 ab
'Radana'/QS_1 + 'Doyenne du Comice'		47.2 ab	257.2 bc	12.18 a	8.38 b	2.68 c	0.66 a
'Radana'/Cps + 'Pyrodwarf'		45.0 a	262.5 bc	15.62 ab	7.41 ab	2.26 ab	0.82 b
'Clapp's Favourite'/Cps		47.2 ab	221.5 ab	18.13 b	7.15 a	2.00 a	0.78 ab
'Clapp's Favourite'/QS_1 + 'Doyenne du Comice'		48.8 b	206.2 a	16.50 b	10.22 c	2.67 c	0.65 a
Mean for preparation (B)							
without 'Condit'		46.6 a	252.1 a	16.02 a	7.78 a	2.35 a	0.76 a
'Condit'		46.6 a	235.3 a	15.47 a	8.23 a	2.46 a	0.71 a

*for explanations see Table 2

In Bulgarian research, the leaves of peach trees subjected to organic fertilization with Biohumus had significantly higher concentrations of chlorophyll, potassium (1.2 and 1.8 kg fertilization levels), phosphorus (1.8 kg), calcium (0.6, 1.2, and 1.8 kg), and magnesium (1.2 kg) than in the control treatment, in which that fertilizer was not employed [Staneva et al. 2019]. According to Świerczyński et at. [2014], foliar application of the Ergoplant bio-stimulant does not affect the leaf chlorophyll content of pear maidens growing in a nursery.

CONCLUSIONS

An interstock derived from the 'Doyenne du Comice' cultivar enables the cultivation of 'Radana' and 'Clapp's Favourite' on Quince S_1. The trees growing on this rootstock exhibited significantly less vigour and had higher cropping efficiency coefficients. 'Radana' on the Quince with interstock gave similar yields, but developed significantly smaller fruits than with the Caucasian pear rootstock, although with an improved colouration. The interstock had a clearly positive effect on both the yield of the 'Clapp's Favourite' pear trees on the Quince, and on the yield's quality.

'Radana' on Caucasian pear seedlings with 'Pyrodwarf' interstock developed smaller crowns, but its yields were smaller, with the fruits of a quality similar to that obtained with the trees without the interstock. Considering the higher costs of 3-component nursery trees, the application of this interstock for 'Radana' is economically unjustified.

The Condit Basic soil improver applied for 5 years on healthy, non-degraded soil did not have a significant effect on the mature pear trees with well-developed root systems in terms of their growth, yielding, and the crop quality, regardless of the investigated cultivar.

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REFERENCES

Abbey, T., Rathier, T. (2005). Effects of mycorrhizal fungi, biostimulants and water absorbing polymers on the growth and survival of four landscape plant species. J. Environ. Hortic., 23(2), 108–111.

Askari-Khorasgani, O., Jafarpour, M., Hadad, M.M., Pessarakli, M. (2019). Fruit yield and quality characteristics of "Shahmiveh" pear cultivar grafted on six rootstocks. J. Plant Nutr., 42(4), 323–332. https://doi.org/10.1080/01904167.2018.1555592

Bulgari, R., Franzoni, G., Ferrante, A. (2019). Biostimulants application in horticultural crops under abiotic stress conditions. Agronomy, 9, 306, 1–30. https://doi.org/10.3390/agronomy9060306

Calvo, P., Nelson, L., Kloepper, J.W. (2014). Agricultural uses of plant biostimulants. Plant Soil, 383, 3–41. https://doi.org/10.1007/s11104-014-2131-8

Derkowska, E., Sas Paszt, L., Głuszek, S., Trzciński, P., Przybył, M., Frąc, M. (2017). Effects of treatment of apple trees with various bioproducts on tree growth and occurrence of mycorrhizal fungi in the roots. Acta Sci. Pol., Hortorum Cultus, 16(3), 75–83. https://doi.org/10.24326/asphc.2017.3.8

Dinu, T.A., Alecu, I.N., Tudor, V., Stefan, M., Micu, M.M. (2015). Biostimulators impact analysis on the quality and quantity of agricultural products. J. Biotech. Abstracts 208(6), 359. https://doi.org/10.1016/j.jbiotec.2015.06.359

Grzyb, Z.S., Piotrowski, W., Sas Paszt L. (2015). The residual effects of various bioproducts and soil conditioners applied in the organic nursery on apple tree performance in the period of two years after transplanting. J. Res. Applic. Agric. Eng., 60(3), 109–113.

Haak, E., Tiirmaa, K., Univer, N. (2013). The performance of pear rootstocks in the north European climatic conditions. Acta Hortic., 981, 401–404. https://doi.org/10.17660/ActaHortic.2013.981.63

Hecl, J. (2010). Effect of selected amendments on cadmium content in the soil and its transfer into crops. Agriculture, 56(2), 52–58.

Hecl, J., Šoltysová, B., Danilovič, M. (2012). Influence of the organic fertilizer Condit on the content of heavy metals and soil chemical properties. Agric. Conspec. Sci., 77(3), 119–126.

Iglesias, I., Asin, L., Montserrat, R., Vilardell, P., Carbo, J., Bonany, J. (2003). Performance of some pear rootstocks in Lleida and Girona (Catalonia NE-Spain). ITEA Producción Vegetal, 99(1), 147–156.

Ikinci, A., Bolat, I., Ercisli, S., Kodad, O. (2014). Influence of rootstocks on growth, yield, fruit quality and leaf mineral element contents of pear cv. 'Santa Maria' in semi-arid conditions. Biol. Res., 47(1), 1–8. https://doi.org/10.1186/0717-6287-47-71

Ikinci, A., Bolat, I., Ercisli, S., Esitki, A. (2016). Response of yield, growth and iron deficiency chlorosis of 'Santa Maria' pear trees on four rootstocks. Not. Bot. Hort. Agrobot., 44(2), 563–567. https://doi.org/10.15835/nbha44210501

Jacob, H.B. (2002). New pear rootstocks from Geisenheim, Germany. Acta Hortic., 596, 337–344. https://doi.org/10.17660/ActaHortic.2002.596.52

Kumar, C.J., Uday, S., Shashi, S. (2012). Effect of rootstock and interstock on plant vigour of pear. Inter. J. Farm Sci., 2(1), 29–35.

Kviklys, D., Kviklienė, N. (2005). Vegetative and seedling rootstock effect on pear fruit internal and external quality. Sodininkystė Daržininkystė, 24(2), 11–19.

Lepsis, J., Drudze, I. (2011). Evaluation of seven pear rootstocks in Latvia. Acta Hortic., 903, 457–461. https://doi.org/10.17660/ActaHortic.2011.903.62

Lewko, J., Ścibisz, K., Sadowski, A. (2004). Mineral element content in the leaves of rootstocks used for pears and of maiden trees budded on them. Acta Sci. Pol., Hortorum Cultus, 3(2), 147–152.

Mass, F. (2006). Evaluation of *Pyrus* and *Quince* rootstocks for high density pear orchards. Sodininkystė Daržininkystė, 25(3), 13–26.

Massai, R., Loreti, F., Fei, C. (2008). Growth and yield of 'Conference' pears grafted on quince and pear rootstocks. Acta Hortic., 800, 617–624. https://doi.org/10.17660/ActaHortic.2008.800.82

Mečiar, L. (2011). Influence of selected agrotechnical elements on the yield forming of winter wheat and triticale. Agrochémia (Nitra), 15(4), 15–18.

Mészáros, M., Laňar, L., Kosina, J., Náměstek, J. (2019). Aspects influencing the rootstock-scion performance during long term evaluation in pear orchard. Hort. Sci. (Prague), 46(1), 1–8. https://doi.org/10.17221/55/2017-HORTSCI

Milošević, T., Milošević, N. (2016). Estimation of nutrient status in pear using leaf mineral composition and deviation from optimum percentage index. Acta Sci. Pol., Hortorum Cultus, 15(5), 45–55.

Mosa, W.F.A.E.G., Sas Paszt, L., Frąc, M., Trzciński, P., Przybył, M., Treder, W., Klamkowski, K. (2018). Effect of some bioproducts on the growth, yield and fruit quality of apple trees. Hort. Sci. (Prague), 45(3), 111–118. https://doi.org/10.17221/75/2017-HORTSCI

Musacchi, S., Ancarani, V., Grandi, M., Sansavini, S. (2002). Comparative field performance of cvs. Sensation Red Bartlett and Cascade grafted to six quince and pear clonal seedling rootstocks. Acta Hortic., 596, 385–388. https://doi.org/10.17660/ActaHortic.2002.596.60

North, M.S., Cook, N.C. (2008). Effect of six rootstocks on 'Forelle' pear tree growth, production, fruit quality and leaf mineral content. Acta Hortic., 772, 97–103. https://doi.org/10.17660/ActaHortic.2008.772.11

North, M., de Kock, K., Booyse, M. (2015). Effect of rootstock on 'Forelle' pear (*Pyrus communis*) growth and production. South African J. Plant Soil, 32(2), 65–70. https://doi.org/10.1080/02571862.2014.981881

Ozturk, A., Ozturk, B. (2014). The rootstock influences growth and development of 'Deveci' pear. Turk. J. Agric. Nat. Sci., 1(special issue), 1049–1053.

Pylak, M., Oszust, K., Frąc, M. (2019). Review report on the role of bioproducts, biopreparations, biostimulants and microbial inoculants in organic production of fruit. Rev. Environ. Sci. Bio/Tech., 18, 597–616. https://doi.org/10.1007/s11157-019-09500-5

Rozpara, E., Pąśko, M., Bielicki, P., Sas Paszt, L., Głowacka, A. (2015). The influence of some bio-products on the growth, yielding and fruit quality of 'Debreceni Bötermö' sour cherry trees cultivated in an organic orchard. J. Res. Applic. Agric. Eng., 60(4), 76–79.

SADEF – experimentation department (2011). CONDIT – efficiency trial on strawberry crop. Tribotechnologies, 1–14.

Sosna, I., Czaplicka-Pędzich, M. (2013). Wzrost i owocowanie drzew sześciu odmian gruszy w zależności od zastosowanej podkładki [Growth and fruiting of trees on six pear cultivars depending on applied rootstock]. Episteme, 19(3), 441–451.

Sosna, I., Kortylewska, D. (2013). Estimation of interstock and intermediate stock usefulness for summer pear cvs. budded on two rootstocks. J. Hort. Res., 21(1), 79–82. https://doi.org/10.2478/johr-2013-0011

Sotiropoulos, T.E. (2006). Performance of the pear (*Pyrus communis*) cultivar William's Bon Chretien grafted on seven rootstocks. Austral. J. Exp. Agric., 46(5), 701–705. https://doi.org/10.1071/EA04132

Staneva, I., Kornov, G., Akova, V. (2019). Effect of some bioproducts on chlorophyll content and main nutrients in peach leaves. Hortic. Sci. Pap., ser. B, 63(1), 41–46.

Stern, R.A., Doron, I. (2009). Performance of 'Coscia' pear (*Pyrus communis*) on nine rootstocks in the north of Israel. Sci. Hortic., 119(3), 252–256. https://doi.org/10.1016/j.scienta.2008.08.002

Świerczyński, S., Stachowiak, A., Świerczyńska, I., Golcz-Polaszewska, M. (2014). Influence of rootstock, cultivar and Ergoplant biostimulant on the growth of maiden pear trees in nursery and physiological compatibility. Acta Sci. Pol., Hortorum Cultus, 13(6), 3–14.

Tobiašová, E. (2011). Vplyv organických hnojív na vlastnosti pody pod repou cukrovou [Influence of organic fertilizers on soil properties under sugar beet]. Listy Cukrov. Řepař., 127(11), 352–355.

Zubair, M., Banday, F.A., Waida, U.I., Baba, J.A., Hussain, S.S., Rehman, M.U. (2017). Effect of bio-stimulants on improving floral characteristics, yield and quality of apple cv. Red Delicious. Brit. J. Appl. Sci. Technol., 21(2), 1–9. BJAST.33634