Efficacy of organic composts against apple replant disease

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Abstract

Within the Core Organic 2 Project Bio-Incrop, composts based on different organic matter were tested for their activity against apple replant disease. The trials were conducted during 2013 and 2014 in a greenhouse on potted M9-rootstock plantlets, which is the most commonly used rootstock in organic and integrated apple orchards in Europe. To prove the presence of apple replant disease, potted M9-rootstock plantlets were grown on sterilized soil and compared to plantlets grown on unsterilized soil (preliminary trial). The same unsterilized soil was then used in the trials in order to compare the efficacy of different composts against apple replant disease. The application rates of the composts tested in 2013 resulted to be too high. The high salt content of several composts negatively affected root growth, as shown by the numerous plantlets that died soon after emergence of shoot primordial. In 2014, the application rates of the tested composts were therefore considerably reduced. Nevertheless, also in 2014 no significant or at least numerically relevant increase in shoot length and shoot dry weight was recorded for plantlets grown on compost-treated soil in comparison to plantlets grown on unsterilized, untreated soil.

Keywords: Apple replant disease, compost, rootstock M9

Introduction

Recently soil exhaustion or apple replant disease has become a severe problem in apple-growing areas worldwide (Mazzola & Manici 2012). In plants affected by apple replant disease, plant growth is impaired, and yield is decreased. It can be assumed that intensive apple cultivation systems with continuously increasing plant densities and unchanged spatial arrangement of plant rows due to the use of stationary support and netting structures, may be involved in disease occurrence (Kelderer *et al.*, 2012). However, possible causal agents of the disease, and especially potential non-chemical or non-synthetic control tools have not yet been investigated in detail. Without doubt, increasing the organic matter content of soils can help to enhance soil fertility (Russel 1977), but it is not yet clear whether the addition of organic compost to the soil can actually help to prevent or reduce the occurrence of apple replant disease. In fact, contradictory results can be found in literature (Forge *et al.*, 2003; Yao *et al.*, 2006; Giordani *et al.*, 2012)

The international research project Bio-Incrop (Innovative cropping techniques to increase soil health in organic fruit tree corps), financially supported by the European Union within the call Core Organic 2, aimed at investigating possible measures for the control of apple replant disease in organic farming. Within this project, a greenhouse study on potted apple plantlets grown on replant diseased soil treated with different composts was conducted. Among the tested compost-based products, some are commercially available on the national market, others can be purchased on the regional market, and again others were specifically produced for the purpose of the trials described below.

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Material and Methods

To verify whether apple replant disease was actually present in the soil used in the trials, a preliminary trial was carried out: a replant disease soil sample was sterilized for 12 hours at 100 °C in a drying cabinet. Then M9-rootstock plantlets were planted into this soil and their growth was compared to that of plantlets grown in unsterilized, untreated replant diseased soil.

In 2013, the sector Organic Farming at the Research Centre Laimburg (Ora, South Tyrol, Italy) tested the efficacy of 11 different composts against apple replant disease in comparison to an untreated control. The tested composts were: Vermicompost 'Classico', composted cattle manure, and Vermicompost 'Special', a blend of composted cuttle and turkey manure, both from Nutriflor s.n.l. (Pergine, TN); manure compost from a livestock stable in Truden (BZ) treated in 3 different ways (respectively composted in an open compost heap, biodynamically treated, and digested by earthworms); compost consisting of composted organic waste and chopped wood from Ecorott s.r.l. (Auer, BZ); compost San Michele C/N 10 consisting of composted shredded plant material and wood, compost San Michele C/N 20, also consisting of composted shredded plant material and wood, but with a higher C/N rate; mature mushroom compost, matured for 6 months, and fresh mushroom compost, collected immediately after substrate change.

The composts were added to soil taken from an orchard affected by apple replant disease (Block 41) at the Research Centre Laimburg. In all treatments, a total of 200 g of compost per planting pot was applied: out of these 200 g, 150 g were mixed with the soil sample, and 50 g were placed directly into the root area prior to planting. Then the soil/compost mixtures were filled into 1.5-L plastic pots, and 1 apple plantlet on M9 rootstock was transplanted into each pot in March 2013.

The soil used in the trial was analysed in the laboratory. The results are shown in Table 1.

Table 1: Analysis of the soil affected by replant disease used in the trial.

	Soil texture	Humus (%)	pH	Carbonate content	salinity* mg/100g	(N) (%)	C/N ratio	P** mg/100g	K** mg/100g	Mg*** mg/100g	B** mg/kg	Fe**** g/kg Dw
Block 41	sandy silt	2,4	7,4	+++	31,5	0,15	10,0	11,0	22,5	17,0	0,6	29,85

*KCl-extract after VDLUFA **CAL-extract after VDLUFA *** CAT-extract after VDLUFA **** KW-extract after VDLUFA

Heavy metals	Fe**** g/kg Dw	Al* g/kg Dw	Mn** mg/kg Dw	Cu** mg/kg Dw	Zn** mg/kg Dw	Cr** mg/kg Dw	Ni** mg/kg Dw	Pb** mg/kg Dw	Co** mg/kg Dw	Cd** mg/kg Dw	Hg*** mg/kg Dw
Block 41	29,85	20,87	517,50	41,50	165,00	36,50	28,50	35,50	12,50	0,85	0,0425

*CAT-extract after VDLUFA **KW-extract after VDLUFA *** DMA-extract after VDLUFA

Also all the composts tested in the trial had been previously analysed in the laboratory (results not shown). Since plantlets exposed to some of the composts did not grow at all or just in a very stunted way, the salt and heavy metal content of the soil/compost mixtures in the pots was measured. The results showed that the soil/compost mixtures negatively affecting plant growth had a very high salt content. The trial was therefore repeated in 2014, by testing 9 out of the 11 products tested in 2013, and by applying lower rates (Table 2).

Table 2: Name, origin, applied rate and cost of the composts tested in the greenhouse trials on potted plants in 2014

Name of tested compost	Origin	Applied rate (g) /pot	Cost
Vermicompost	Organic cattle manure from Truden (BZ), digested by composting worms	50	95,00€/16m^3 transport for 20 km
Vermicompost + EM ceramic powder + EM-A	Organic cattle manure from Truden (BZ), digested by composting worms and combined with "Effective microorganism" (commercial amendments based on different microorganism) and ceramic powder	50 + 3 + 100ml/10l	95,00€/16m^3 transport for 20 km + 3,63/l + 36,36/kg
Compost Ecorott	Ecorott Ora (South Tyrol, Italy); Compost from organic waste and chopped wood	50	10,00€/m^3 + 95,00/16m^3 transport for 20 km
Compost S. Michele C/N 10	Agricultural Institute of San Michele all'Adige (TN); Compost from organic waste and chopped wood	50	95,00€/16m^3 transport for 20 km
Compost S. Michele C/N 20	Agricultural Institute of San Michele all'Adige (TN); Compost from organic waste and chopped wood (higher wood content)	50	95,00€/16m^3 transport for 20 km
Compost S. Michele C/N 30	Agricultural Institute of San Michele all'Adige (TN); Compost from organic waste and chopped wood (higher wood content)	50	95,00€/16m^3 transport for 20 km
Compost Selvagro	Ovale s.r.l Roma; organic compost with high carbon content	50	14€/100kg
Fresh Mushroom compost	Fresh material from a mushroom cultivation collected immediately after substrate change.	50	95,00€/16m^3 transport for 20 km
Mature Mushroom compost	Substrate from a mushroom cultivation (matured for 6 months in a compost-heap)	50	95,00€/16m^3 transport for 20 km

Also in 2014, all tested composts were analysed in the laboratory. The results are summarized in Tables 3-5.

Table 3: pH value, dry matter, ash, nitrogen, and organic substance content (%), C/N ratio, and content in water soluble salts of the composts tested in 2014 (FW=fresh weight).

Compost	pH value (in $CaCl_2$)	Dry matter (%)	Ash (% FW)	Nitrogen (% FW)	Organic substance (% FW)	C/N-ratio	Water soluble salts (as KCl) (g/L)
Vermicompost	6,9	34,6	13,3	0,72	21,2	17	3,2
Compost Ecorott	8,4	67,3	46,6	1,13	20,7	11	11,3
Compost C/N 10	7,1	62	39,9	0,91	22,2	14	1,4
Compost C/N 20	7,6	72,7	55,3	0,6	17,4	17	1,2
Compost C/N 30	7,5	61,6	46,3	0,48	15,3	19	1,1
Compost Selvagro	7,8	70,7	41,3	1,22	29,4	14	2,0
Fresh Mushroom compost	7,8	24,8	8,6	0,52	16,2	18	7,4
Mature Mushroom compost	7,7	27,4	11,8	0,59	15,6	15	3,6

Table 4: Nitrogen (nitrate, ammonium, and total N), potassium, phosphorus and magnesium content of the composts tested in 2014.

Compost	CAT/Colorimetry mg/L			CAT/ICP-OES mg/L		
	Nitrate-N	Ammonium N	N tot	Phosphorus P	Potassium K	Magnesium Mg
Vermicompost	485,3	83,5	568,9	984	1460	530
Compost Ecorott	4,0	1020,8	1024,7	65	3166	307
Compost C/N 10	190,9	5,9	196,8	154	922	505
Compost C/N 20	122,3	2,6	124,9	128	1063	466
Compost C/N 30	67,6	3,7	71,3	92	894	414
Compost Selvagro	22,7	28,1	50,8	38	1296	403
Fresh Mushroom compost	160,1	265	425,3	454	2148	412
Mature Mushroom compost	106,6	6,5	113,1	487	1801	425

Table 5: Content in heavy metals of the composts tested in 2014.

Compost	KW-extr./MW/ICP-OES g/kg TM		KW-extraction MW/ICP-OES mg/kg Dw								DMA mg/kg TM
	Fe	Al	Mn	Cu	Zn	Cr	Ni	Pb	Co	Cd	Hg
Vermicompost	6,8	6,6	474	62	372	21	13	10	1,7	0,31	0,026
Compost Ecorott	6,8	6,6	474	62	372	21	13	10	1,7	0,31	-
Compost Silvagro	18,6	11,1	423	95	191	41	19	38	5,0	0,37	0,068
Compost C/N 10	16,6	17,5	290	84	110	28	24	16	6,1	0,27	0,032
Fresh Mushroom compost	5,8	9,5	300	35	208	261	9	26	1,3	0,44	0,032
Mature Mushroom compost	11,3	13,4	379	37	176	29	14	16	4,0	0,48	0,033

Evaluations

To evaluate the efficacy of the different soil/compost mixtures in reducing apple replant disease, shoot length and shoot dry weight of the plantlets was measured at the end of May, 14 weeks after transplanting of the plantlets. Shoot length is reported as the sum of the length of all shoots per plantlet.

Statistical analysis

The data assessed in the trial were compared across treatments using 1-way ANOVAs, followed by Tukey's test for post-hoc comparisons of means ($p<0.05$), while a one-sample T-test was used to compare data between treatments (sterilized soil and not sterilized untreated soil) in the preliminary trial. All analyses were performed using the statistics program PASW 17.

Results

The results of the preliminary trial showed that the soil used in the trial was actually affected by apple replant disease. In fact, both shoot length and shoot dry weight values of plantlets grown on sterilized soil were significantly higher than those of plantlets grown on unsterilized soil (Table 6).

Table 6: Shoot length and shoot dry weight of plantlets grown on sterilized and not sterilized untreated soil (preliminary trial).

	Shoot length (cm)		Dry weight of the shoots (g)	
	Mean	stat.	Mean	stat
Sterilized soil	37,71	a	3,06	a
Untreated control	21,54	b	1,71	b

In the trial conducted in 2014, differences among treatments in both shoot length and shoot dry weight failed significance: shoot length and shoot dry weight values of plantlets grown on soil treated with the different composts were statistically comparable to those of plantlets grown on untreated soil (Table 7).

Table 7: Shoot length and shoot dry weight of potted plantlets on M9 rootstock exposed to the different treatments (composed-based treatments and untreated control).

Treatments	Shoot length (cm)		Shoot dry weight (g)	
Vermicompost	20,79	a	1,70	a
Vermicompst + EM	23,38	a	1,86	a
Compost Ecorott	22,75	a	1,69	a
Compost San Michele C/N 10	25,38	a	2,00	a
Compost San Michele C/N 20	23,85	a	1,83	a
Compost San Michele C/N 30	24,08	a	1,81	a
Compost Selvagro	21,10	a	1,83	a
Mature Mushroom compost	24,21	a	1,90	a
Fresh Mushroom compost	22,83	a	1,76	a
Untreated control	21,54	a	1,71	a

Discussion

Given the results obtained in the trial in 2014 (no significant differences among treatments), one could raise doubts whether apple replant disease was actually present in the soil used in the trial. However, the preliminary study proved that the soil used in the trial actually was replant diseased soil. The preliminary trial also showed the high fertility of the soil. By exposing the soil to 100°C over a period of 12 hours in a drying chamber, all pathogenic microorganisms, potentially present in the soil, were killed, and shoot length and shoot dry weight values of the M9-rootstock plantlets grown on this sterilized soil were almost two times higher than those of plantlets grown on unsterilized soil.

In the trial conducted in 2013, a total of 200 g of each compost was added to the amount of soil necessary to fill up a 1.5 L-volume pot. However, at this application rate, most of the tested composts resulted in stunted plant growth or in even in plant death soon after emergence of shoot primordia. The observed negative effects were due to too high a salt content of many of the tested composts. In 2014, we therefore decided to reduce the application rates (in 2014 one fourth from the rates used 2013), and we tried to avoid the direct contact between roots and pure compost. In 2014, none of the tested composts (some commercially available on the market, others prepared by following instructions available from literature), resulted in a significant or numerically relevant increase in growth of the M9-rootstock plantlets in comparison to untreated control plantlets. However, doubts exist whether results in the open field can be inferred from trials conducted on potted plants. Open-field trials were therefore carried out, and the results of these trials will be presented at the 17th International Conference on Organic Fruit Growing Ecofruit.

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