Ekhagastiftelsen

Ansökan 2015-11

Ground cover management in organic apple orchards in South Africa: Trade-offs between above- and belowground ecosystem services

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Half-time Report

1. Project kick-off meeting 12.-16. September 2016, Stellenbosch, South Africa

Schedule: Visits to potential field sites (Monday (12.09., half day): Tuesday (13.09. full day) and Thursday (15.09., half day). Meeting at Stellenbosch Institute for Advanced Study (STIAS): Wednesday, Thursday afternoon, Friday morning

After the initially identified organic apple farm in the Western Cape went out of production last year (Elgin Organics, for details: http://www.elginorganics.com/), the project partners searched for new organic apple growers. We realized that organic apple production in the Western Cape was even rarer than we originally anticipated. We therefore visited growers in the Western Cape that were not certified organic growers, but either established sustainable approaches or cultivated fruits under organic principles without certification. The following section provides an overview of the farm we visited during the kick-off meeting.

1.1. Field site selection

<u>Farm Spier (12.09.2016)</u>

A single old, abandoned pear orchard managed with short term, high density cattle grazing was visited (Fig. 1). However, we quickly decided that abandoned orchards cannot be included in the project.

Figure 1 Abandoned pear orchard on farm Spier

Farm Petervale (12.09.2016)

A single apple orchard cultivated without pesticides for production of apple juice that is exclusively sold on the farm (no picture) and a single small abandoned pear orchard grazed by donkeys and cattle (Fig. 2) were visited.

Figure 2 Abandoned pear orchard on farm Petervale

Farm Bokveldskloof (13.09.2016)

A single pear orchard which was no treated with pesticides, but received compost (Fig. 3) and a single pear orchard managed with pesticides (incl. Glyphosate), but only organic fertilizer (Fig. 4) were visited.

Figure 3 Pear orchard which was no treated with pesticides on Farm Bokveldskloof

Figure 4 Pear orchard which was treated with pesticides on Farm Bokveldskloof

Farm Tierhoek (15.09.)

The owner (Mr Bruce Gilson) started farming in 1998. By now approx. 24-30 ha are in production (total farm size = 180 ha) and are certified as organic since 2005. The grower cultivates 6 ha of apricots, 2 ha plum, 1.5 ha quinces and 1.4 ha peaches. Most fruits are used for drying or canning, but apricots and plums are also packed.

All orchards are irrigated throughout summer on demand with drippers (apricot “imperial” & “bulida”, plum & quince) or micro-jets (apricot “super gold”, peach). All orchard ground cover is managed by mechanically cutting of weeds under tree canopies 4-5 times a year and removal of the cut material, working rows are only cut 1-2 times a year. The grower uses his own compost, but also has to buy additional compost to satisfy nutrient demand. The grower further applies certified organic fertilizer, chicken manure and liquid guano as fertilizers.

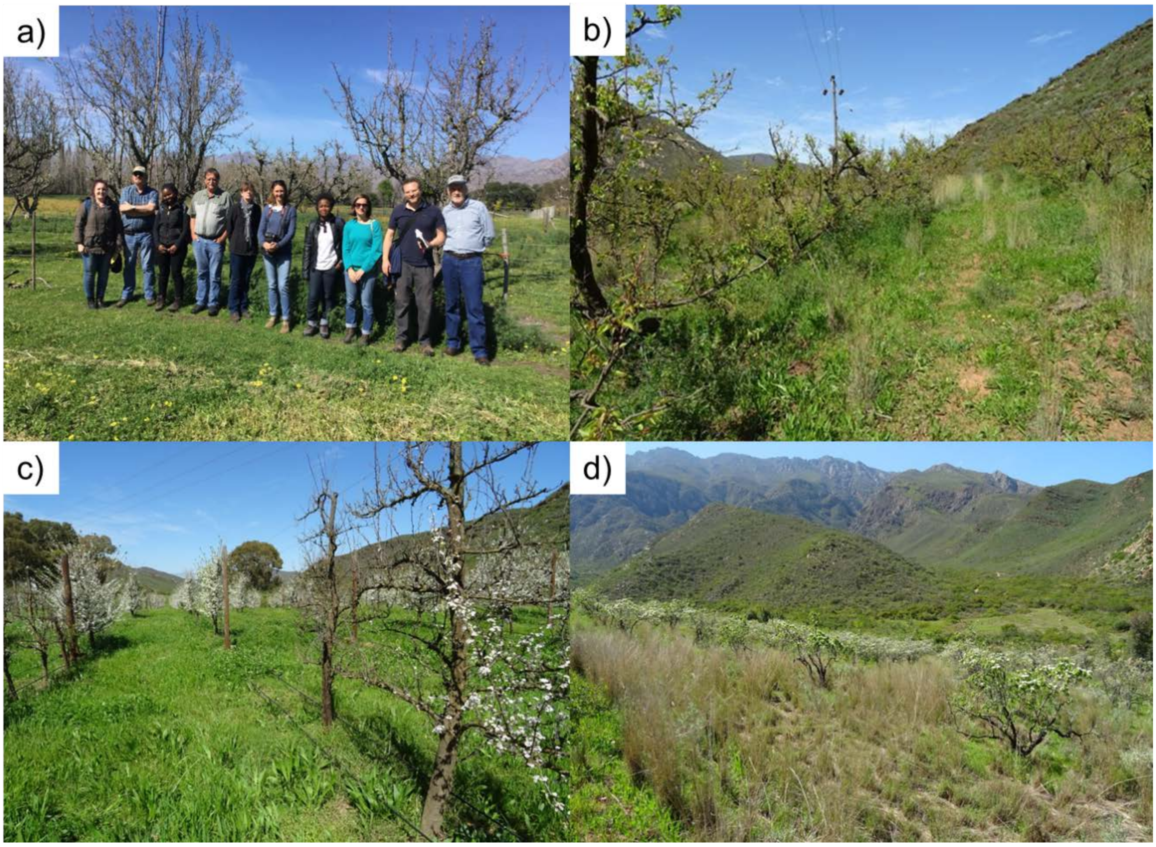

Figure 5 a) the researcher team at their visit to Farm Tierhoek, b) apricot orchard, c) plum orchard and d) quince orchard

1.2. Planning meeting

The consortium quickly concluded that it will be impossible to select eight certified organic apple orchards after the main organic apple grower in the region recently sold his farm, which then was immediately converted to conventional (http://www.elginorganics.com/). The consortium also realized that several of the non-certified, but more sustainably managed orchards were located at very different altitudes or on very different soils. We therefore decided to focus on the fully-organic (since 2005) certified farm Tierhoek. The owner was very supportive and interested in our research and we involved him in the design and research questions from the start of our project. The consortium decided to work on eight organic orchard sites in the four cultivated pome fruits that were available on the farm (two sites of each: apricot. peach, plum and quince). These fruits share several economically important pests with apple and suffer from the same competition for nutrients and water as apple trees in organic orchards. As being part of the pome fruit group (subtribe Malinae of the family Rosaceae) they all share important traits with apple trees.

The consortiums discussion resulted in priority criteria for the selection of sites within a fruit species: 1.) identical rootstock, 2.) identical fruit variety, 3.) approx. identical planting age. In addition to the eight selected organic sites we included two conventional orchard sites on a neighbouring farm (two apricot sites). These ten orchards were sampled in November/December 2016. In addition to our original proposal, we plan a second sampling campaign in June 2017. The decisions to add conventional sites as a reference and include a second sampling date will strengthen our results compared to the original proposal.

The ground cover treatments that were established between the eight organic orchards are: a) business as usual = 4-5 cuts under the canopy with removal of material and 1-2 cuts in the working row versus b) mow & blow: 4-5 cuts under the canopy and 1-2 cuts in the working row with addition of the cut material ("living mulch") under tree canopies. The first treatment was established in October 2016, so that our sampling in November/December 2016 reflects short-term and our sampling in May 2017 longer-term effects of the ground cover treatments.

Most sampling focuses on the treatment impact area under the tree canopy and the fruit tree rhizosphere. Samples for microbial measures, soil properties and nematodes are derived from joint soil sampling and identical soil. Natural enemies and their prey were collected in different microhabitats. Additional funds for this subproject were granted to K. Birkhofer and F. Arvidsson (both Lund University) in form of a Minor Field Study grant.

2. First Sampling Campaign (November/December 2016), Tierhoek organic farm

2.1. Treatment establishment

Mulch treatments were established in October 2016 in eight organic orchard sites (Fig. 6a&b). On average, mulch covered an area of approximately 1m² at a height of 24cm immediately after treatment establishment (Fig. 6b).

Figure 6 a) control plot without added mulch under the canopy, b) treatment plot with mulch from cutting the working rows added under the canopy to supress weeds.

2.2. First results

2.2.1. Soil properties

Table 1 Basic soil properties at the site level

	Soil texture			
	Clay (%)	Silt (%)	Sand (%)	WHC (mm/m)
QUINCE 1	21	26	53	90.2
QUINCE 2	19	28	53	110.1
PLUM 1	13	16	71	114.8
PLUM 2	11	16	73	103.5
PEACH 1	17	22	61	94.7
PEACH 2	21	24	55	127.2
APRICOT 1	13	16	71	145.2
APRICOT 2	13	16	71	141.1
APRICOT CONVENT.	7	6	87	121.4

Quince and peach is cultivated on less sandy soils, with plum and apricot growing on more sandy soils. The apricot sites in the conventional orchards have the highest sand content. The water holding capacity of soils is by far highest at the organic apricot sites, with lower and variable values at the other sites.

2.2.2. Collembola

Collembola (springtails, Fig. 7) are an important group soil mesofauna that contribute to the decomposition of organic matter. Collembola were sampled from litter bags at organic and conventional apricot sites and then identified to the finest possible taxonomic level by Charlene Janion-Scheepers. The average number of Collembola was 0.5 individuals per litterbag in organic control sites, 2.0 individuals in organic treatment sites and 15.5 individuals in conventional sites (all apricot). Interestingly, bycatch organisms from litterbags (pseudoscorpiones, spiders, beetles) were only observed in litterbag at organic apricot sites (not at the two conventional sites).

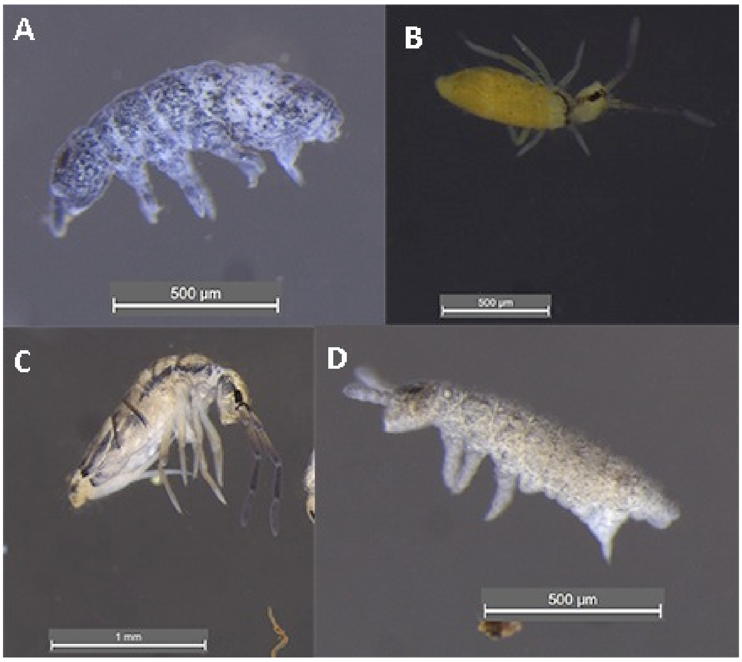

Figure 7 Collembola sampled from apricot sites A: Brachystomella sp., B: Seira sp., C: Entomobrya sp., D: Hypogastrura sp.

2.2.3. Web-building spiders and prey

Web-building spiders contribute significantly to the suppression of important pests in fruit tree orchards and therefore play a key role among the natural enemy fauna. There is a strong relationship between structural properties of habitats and their richness and abundance, due to the construction of retreats and capture webs attached to structural elements. Web-building spiders and their prey were hand collected from all orchard sites for 90 minutes in the morning and for a second 90 minute period in the afternoon between 01 and 28 November 2016. All samples were then transported to the University of the Free State in Bloemfontein and identified by F. Arvidsson (Lund University) under supervision of S. Louw and C. Haddad (both University of the Free State).

The species richness of web-building spiders was more than twice as high in organically managed orchard sites compared to conventionally managed sites (Fig. 8

left panel, P=0.049) and this diversity effect was even more pronounced for the Shannon index (Fig 8 right panel, P=0.001).

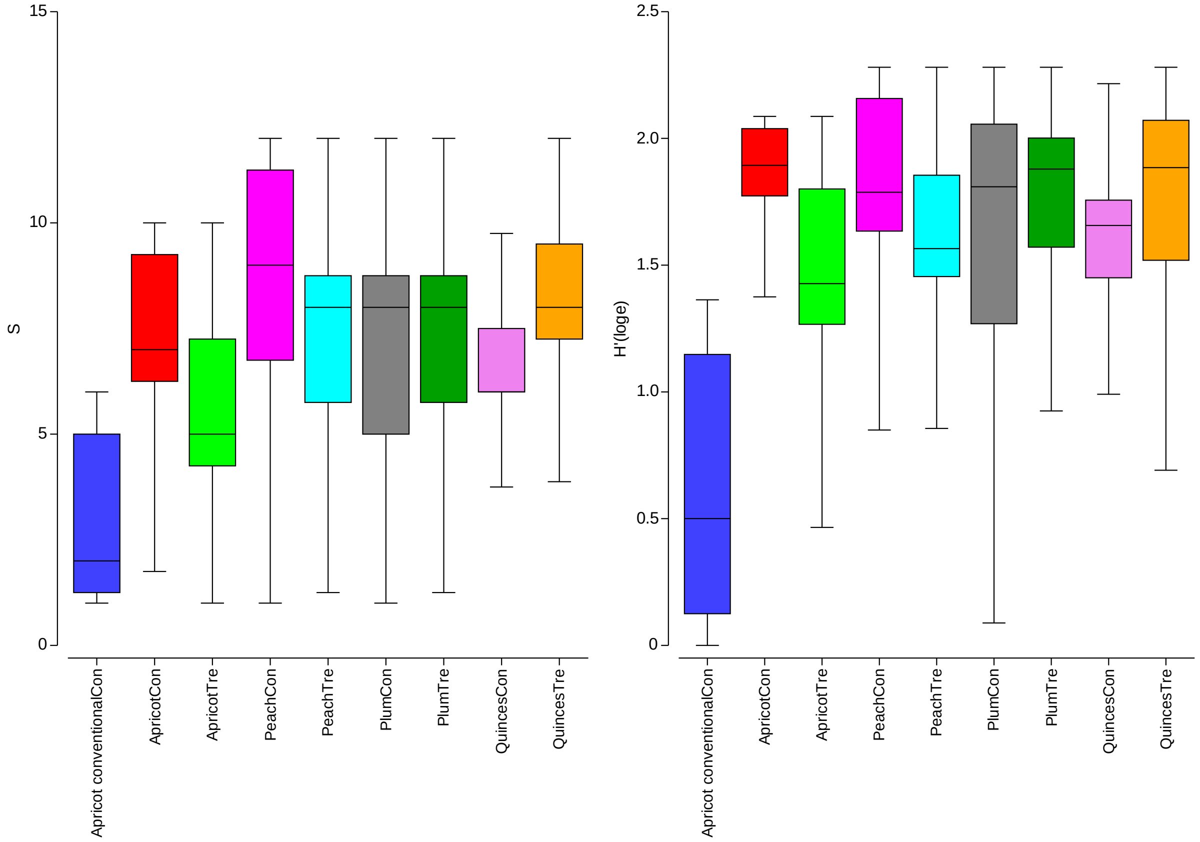

Figure 8 Boxplot (median ± 75 and 25 quartiles as boxes, min and max values as whiskers) of species richness (S) and Shannon index (H') of web building spider communities in different fruit orchards (apricot, peach, plum and quinces) and control (con) and ground cover treatment (tre) sites.

The ground cover management treatment affected the species richness of spiders significantly, but this effect did depend on the fruit type (Fig. 8, P=0.022 for species richness and P=0.030 for Shannon index). While adding mulch resulted in less diverse web-building spider communities in organically managed apricot and peach sites, it led to more diverse communities in organically managed quince sites and had no effect on spider diversity in plum sites.

Both, the species richness and Shannon index were lowest in the canopy and higher under the canopy and in the working rows (Fig. 9, P<0.001 for both diversity measures).

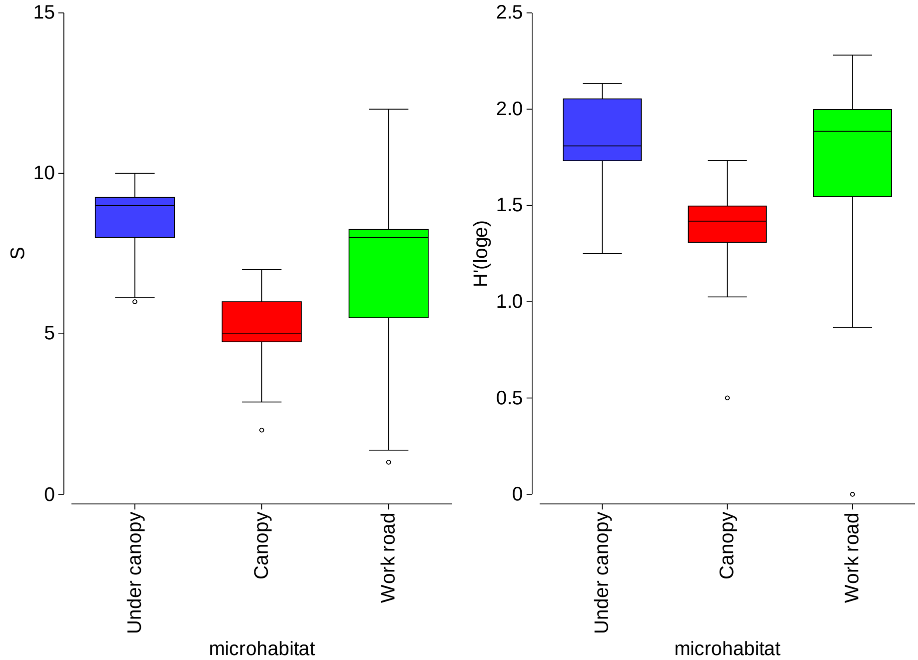

Figure 9 Box plot of species richness (S) and Shannon index (H') of web building spider communities under the fruit tree canopy, in the canopy and in the working rows between trees.

The community composition of differed significantly between different fruit tree species, but depending on microhabitat (Fig. 10, P=0.023).

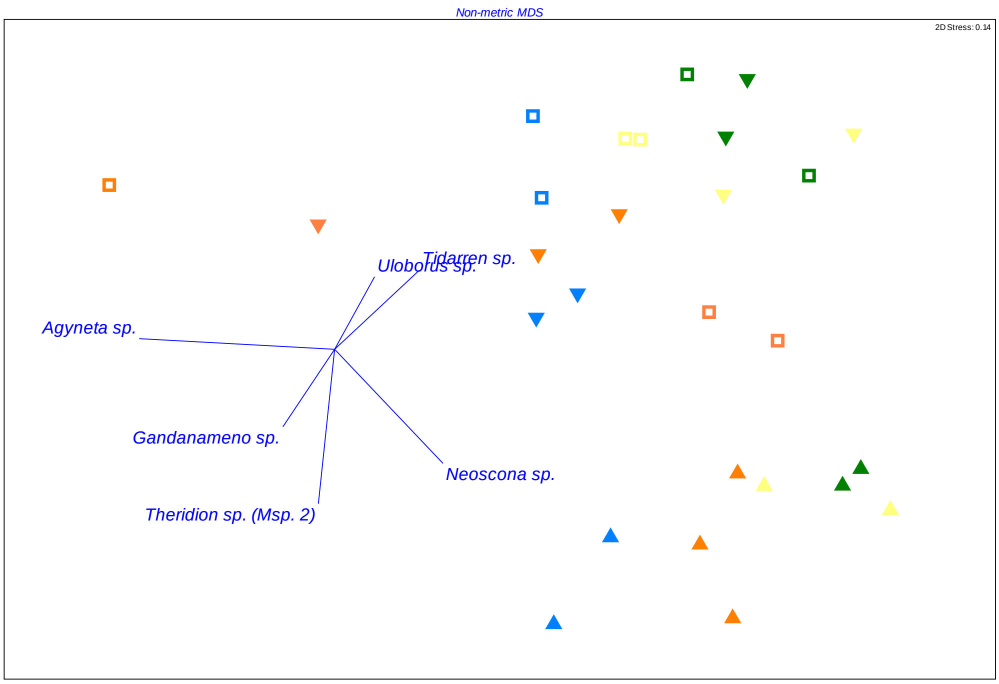

Figure 10 Non-metric multidimensional scaling ordination based on Bray-Curtis similarities and web-building spider species data in apricot (orange), peach (yellow), plum (blue) and quince (green) orchards and under the canopy (▼), in the canopy (▲) and in the working row (□). Vectors are added for spider species with multiple correlation coefficient >0.3 to axis scores of study sites.

Spider communities in the canopy of fruit trees were characterized by high abundances of *Neoscona* sp., *Theridion* sp. (morphospecies 2) and *Gandanameno* sp.. In contrast, communities under the canopy and in the working rows were characterized by higher abundances of *Tidarren* sp. and *Uloborus* sp.. Apricot and plum orchards had more *Agyneta* sp. individuals compared to peach and quinces.

The composition of prey in spider webs differed significantly between fruit types depending on microhabitat (P=0.008). Most hymenopteran prey was caught under or in the canopy in all orchards (Fig. 11). Thrips (Thysanoptera) were only common spider prey in plum orchards and to a lesser extent in quince orchards (Fig. 11). While Diptera prey was very common in or under the canopy of fruit trees in conventionally managed orchards, it was far less common under organic management (with the exception of apricot canopies, Fig. 11). Hemiptera prey was common under organic management, but equally to hymenopteran and thrips prey was almost absent from spider webs in conventionally managed sites (Fig. 11).

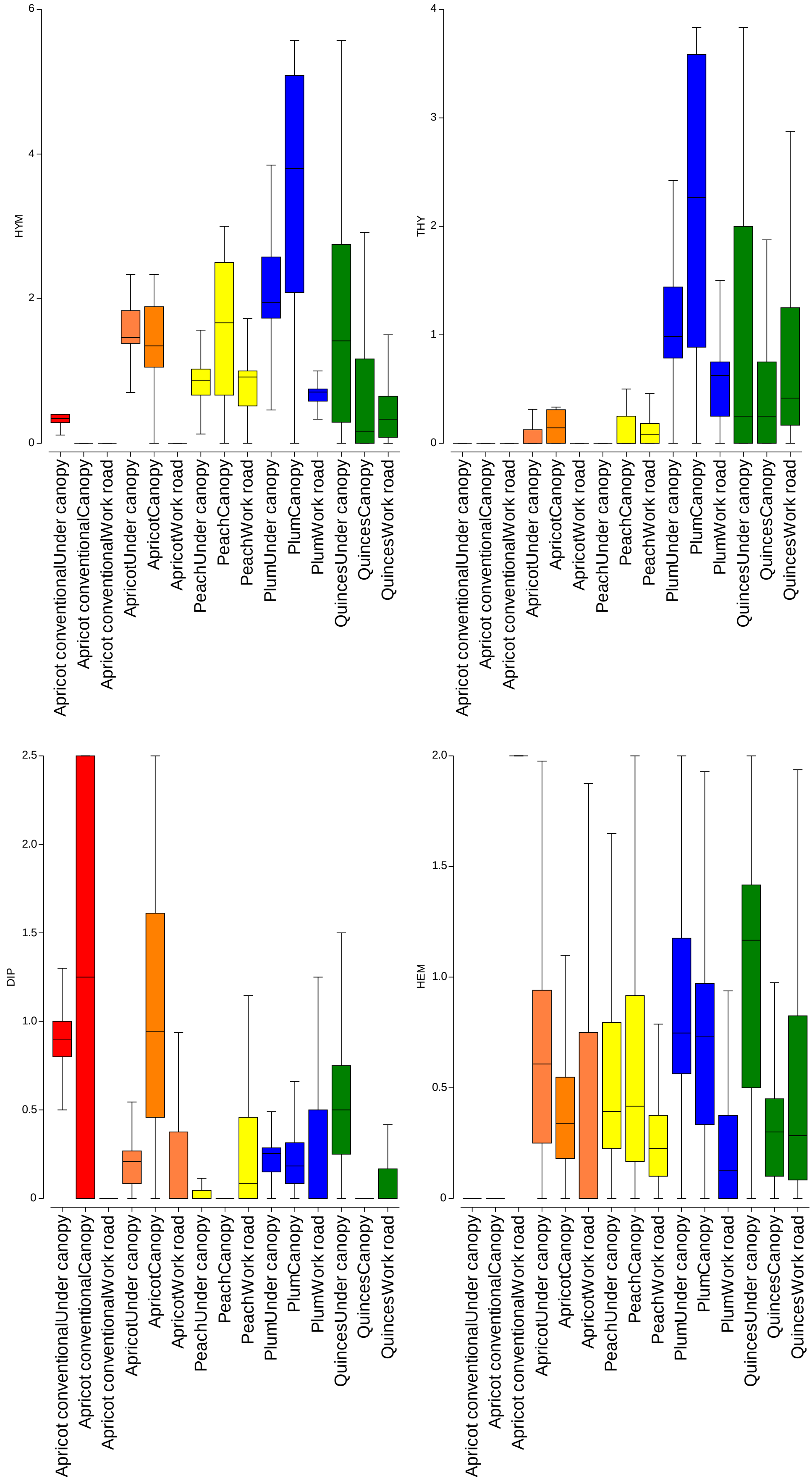

Figure 11 Box plots for Hymenoptera (HYM), Thysanoptera (THY), Diptera (DIP) and Hemiptera (HEM) prey in spider webs per fruit type and microhabitat.

2.2.4. Nematodes

The success of nematodes as bio-indicators is reflected in their ability to provide information regarding succession and fluctuations in decomposition pathways in the soil food web, fertility, nutrient status and acidity of soil as well as the effects of soil pollutants. Through routine analysis of the soil nematode fauna one can rapidly assess responses to management practices in addition to environmental stress which in turn provides one with decision making conditions for remediation and conservation. Nematodes are thus one of the preferred tools for the assessment and monitoring of actual ecological

Soil samples were collected from the root zone of five randomly selected trees from within the 20 x 20 m plot area designated to each fruit type. These subsamples were transported back to the laboratory where they were thoroughly mixed to comprise one sample per plot per fruit type. Nematodes were extracted from the soil samples by means of the Cobb's decanting and sieving method, in combination with a modified Baermann funnel. The extracted nematodes were counted and identified to genus level. The nematodes were then categorised into various feeding groups.

<u>Nematode community structure</u>

Figure 12 shows the identified nematode genera on the y-axis and the log transformed (log10) nematode population densities for nematodes present in 250 ml of soil on the x-axis.

In peaches the treatments for both the peach plots indicated higher population levels than the controls (Table 2 and Fig. 12). This could be due to the health of the randomly selected trees as well as the mulch treatment itself. In the first plot treatment three bacterial feeding genera, one fungal-feeding, three plant feeding and one omnivorous genera were present. In the control four bacterial feeding nematode genera were present while 1 plant feeding, 1 omnivorous and 2 predatory genera were present. This is the only sample in which the cp-3 predatory genus *Tripyla* occurred. In the second treatment plot 3 bacterial feeding, 3 fungal feeding, 1 plant feeding, 1 predatory and 2 omnivorous genera was present in the soil samples collected. The presence of these genera which occupy all trophic levels in the soil food web explains the satisfactory soil health status of this treatment as described under the nematode faunal profile section of this document. Only one plant feeding genus, *Tylenchus* sp., occurred in the control of plot two. Since only one genus was present all other results for this plot are negligible. The presence of *Meloidogyne* sp. and *Xiphinema* sp. in the treatment plots are of concern since these plant parasitic nematodes cause significant damage at high population rates to the roots of trees which can lead to substantial economic losses. Monitoring is recommended to the grower for these plots due to the high numbers of these pests.

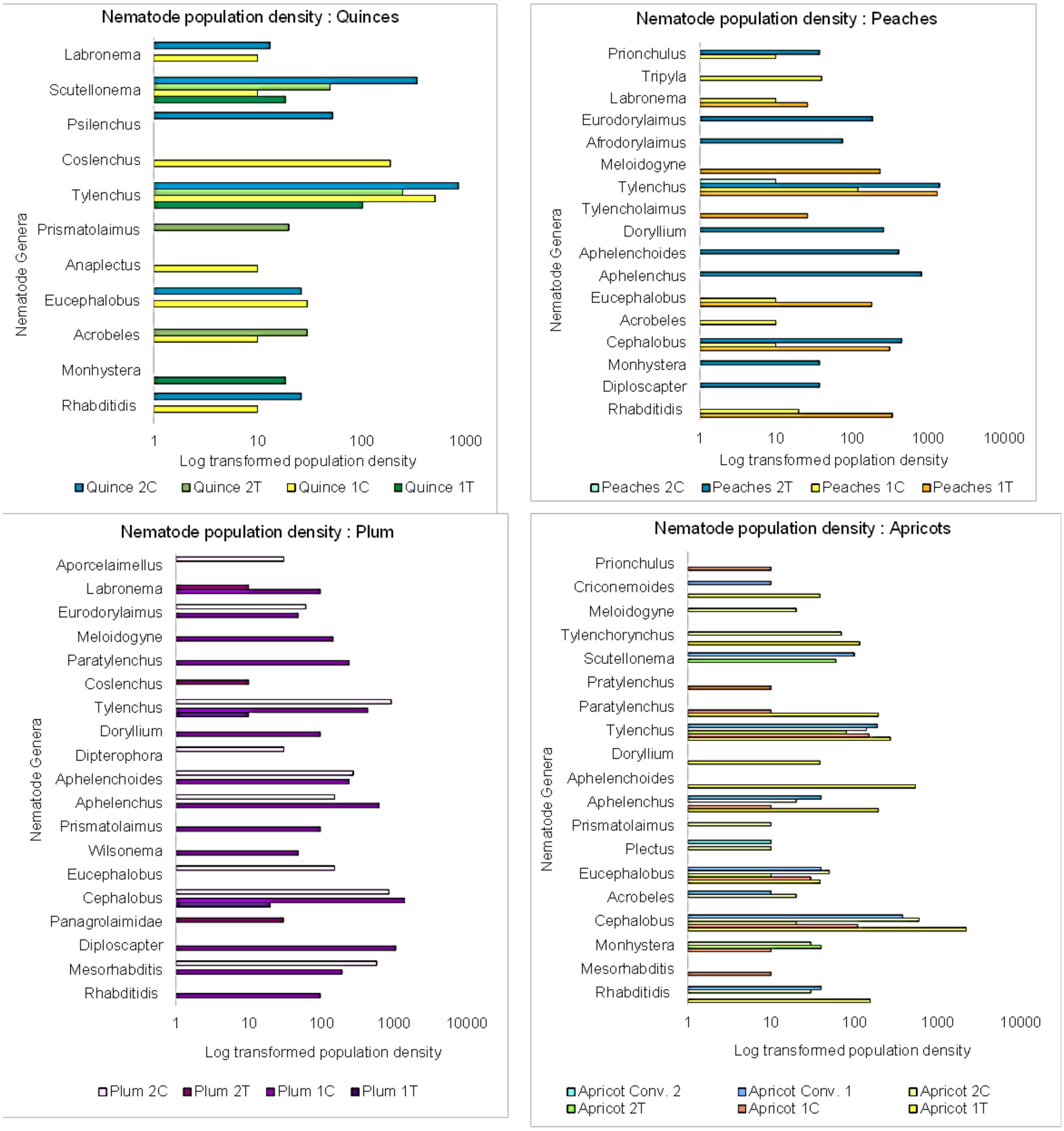

Figure 12 Nematode populations for the Quince (top left), Peach (top right) plots. The data was log transformed in order for all population densities to be visible on the

In plum orchards, the treated plots indicted significantly less nematodes present than the control plots. The treatment 1 population consisted of a group of bacterial feeding nematodes and one group of plant-feeding nematodes (*Tylenchus* sp.). For the treatment from the second plot these same groups were present in addition to an omnivorous genus, *Labronema* sp. The control plots indicated significantly higher population densities compared to the treatment plots. Both of the control plots also express higher levels of diversity. In the first control plot six bacterial feeding genera were present, three fungal feeding genera, three plant feeding genera and two omnivorous genera. In the second control plot three bacterial feeding, three fungal feeding, one plant feeding and two omnivorous genera were present. Of the plant feeding nematodes present in the first control plot, two are considered of economic importance on plums. These genera include *Paratylenchus* sp. and *Meloidogyne* sp. These orchards should be monitored continually to prevent an accumulation of these plant-parasitic nematodes.

The first apricot treatment plot consisted of three bacterial feeding nematode genera, three fungal feeding genera, three plant feeding genera and one omnivorous genus. The second treatment plot comprised three bacterial feeding, zero fungal feeding and two plant feeding genera. The first control treatment consisted of four bacterial feeding, one fungal feeding, three plant feeding genera and one predatory genus, *Prionculus* sp. The second control plot had an impressive number of bacterial feeding genera present totalling seven different genera. This is the highest number of bacterial feeding genera in all of the fruit types and treatments. Only one fungal feeding and three plant feeding genera were also present, no omnivorous or predatory nematodes-

The first conventional apricot orchard also had four bacterial feeding, one fungal feeding and three plant feeding genera present but in comparison to the first control of the organic orchards, the genera were different. The second conventional orchard had an extremely low number of nematodes present with only the bacterial feeding genus *Plectus* sp. being observed. *Criconemoides* sp., *Meloidogyne* sp., *Paratylenchus* sp., *Pratylenchus* sp. and *Tylenchorynchus* sp. are all considered parasitic on apricots. A further growth of these populations needs to be prevented in order to ensure sustainable fruit production.

<u>Nematode faunal profile</u>

A faunal profile can be defined as “a graphical representation of the condition of the food web in relation to its structure and enrichment as indicated by weighted nematode faunal analysis”. Food webs can be defined in the following terms and under the following conditions: their qualification as ‘basal’ indicates a food web that is stressed due to a limitation of resources, and adverse environmental conditions. A ‘structured’ classification describes food webs in which resources are reasonably plentiful, or where recovery from stress is happening. An ‘enriched’ state entails a disturbance of the food webs concerned, with an increased number and variety of resources becoming available, due to organism death or turnover, or due to advantageous shifts in the environment. Accordingly, in referring to ‘enriched’ and ‘structured’ conditions, one is not referring to soil chemical or physical characteristics, but to biological characteristics specifically referring to the soil food web. Thus, a soil can be ‘healthy’ in terms of chemical and physical soil characteristics, but ‘unhealthy’ when taking the biology component into account. The nematode faunal analysis was calculated for each fruit type plot and is illustrated graphically in Fig. 13. An explanation for the quadrants is given in Table 2.

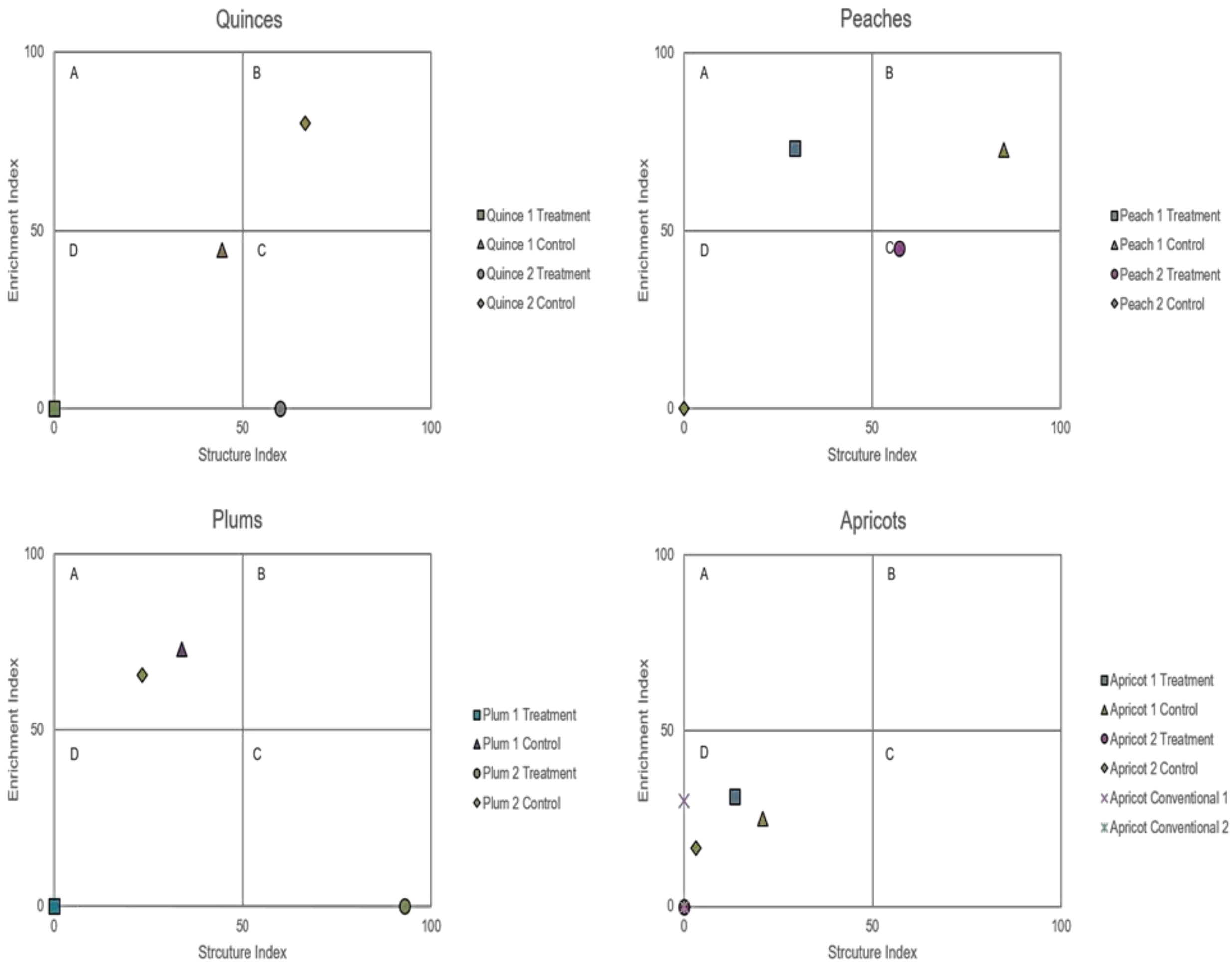

Figure 13 Nematode faunal analyses for each plot.

Table 2 Interpretation of the nematode faunal analysis and implied condition of the soil food web (after Ferris 2001)

General diagnosis	Block A	Block B	Block C	Block D
Enrichment / Soil nutrient status	Nutrient enriched	Nutrient enriched	Moderate	Depleted
Disturbance of system	High	Low to moderate	Undisturbed	Stressed
Food web condition	Unstable Disturbed	Developing	Stable Structured	Degraded
Decomposition channels	Bacterially dominated	Balanced	Fungal dominated	Fungal dominated

In quinces the plot 1 Quince treatment is a severely stressed soil system with no structure or enrichment. This can be ascribed to the extremely low population density and the fact that the nematode families present do not have any influence on the enrichment or structure trajectories. The Control treatment for the first Quince plot has a much better soil health profile even though it still falls within Quadrant A (Fig. 13). Decomposition is dominated by bacterial decomposition pathways. The control indicates enriched and structured conditions with a balanced decomposition pathway and a developing soil food web. The treatment in the second plot indicates a stable and structured soil food web with moderate enrichment. The decomposition pathways are fungal dominated. In contrast the control indicates a severely stressed system with no enrichment or structure. This result is due to the low number of nematodes present in only one nematode genus which is a root hair feeder and has no influence on the faunal analysis profile.

The first treatment plot in peaches has a faunal analysis result indicating enriched conditions with limited structure and bacterial dominated decomposition pathways. The soil food web is currently still unstable. The control plot indicates nutrient enriched conditions with structure and a developing soil food web. The decomposition pathways are also balanced. The second treatment indicates that the soil food web is currently stable, there is moderate enrichment and fungal decomposition pathways are dominant. The control on the other hand indicates a critically stressed system with no structure or enrichment. This result is due to the extremely low nematode abundance and low diversity present.

The treatment in the first plum plot indicates no enrichment or structure indicating a severely stressed system (Fig. 13 & Table 2). The control indicates enrichment and minimal structure with bacterially dominated decomposition pathways and an unstable food web. The control for the second plot indicates almost the same soil health profile as the control for plot one. The soil food web is still unstable, but conditions of enrichment and minimal structure exist with bacterial dominated decomposition pathways. The treatment indicates no enrichment but a high structure index. This system is dominated by fungal decomposition and a stable food web.

All of the apricot plots be it organic or conventional reveal data points located in Quadrant D (Fig. 13). These plots are all dominated by fungal decomposition. The treatment and control for plot one indicates depleted soil nutrient status and a stressed system with a degraded soil food web. The treatment for the second plot in the organic orchard indicates acute levels of stress within the soil system with no enrichment or structure. The control indicates low structure and enrichment with a stressed system and degraded soil food web. In the conventional orchard the first plot indicates low enrichment with absolutely no structure. The results for the second plot indicate a critically stressed system with no structure or enrichment. This is attributable to only one genus being present in extremely low numbers.

2.2.5 Microbial communities

The diversity of microbial communities is related to the provision of belowground ecosystem services and key groups are analysed using state-of-the art, yet relatively inexpensive methods. Approximately 300 g of rhizosphere soil was collected from each tree (5 per plot) and placed in plastic bags on ice packs for transfer to the lab in Bloemfontein. A total of 90 soil samples were thus collected from the 18 subplots. For each of the five analytical procedures, sub-samples were made from the original 90 samples by combining 5 subsamples (trees) in each subplot. Thus with 2 subplots = 2 per treatment (= 18 composite samples in total).

<u>Fluorescein-diacetate analysis (FDA analysis)</u>

The rate of FDA hydrolysis (breakdown) in soil is considered a suitable index of overall soil enzyme activity. Bacteria and fungi both produce extra-cellular enzymes to decompose organic matter, and the amount of enzymes in a sample is indicative of the presence, and viability, of the microbial biomass. FDA is hydrolysed by a number of different enzymes, such as proteases, lipases, and esterases. Generally, a correlation between FDA hydrolytic activity and other soil biological parameters such as active C can be found. The ability to hydrolyze FDA is widespread among soil organisms. The product of this conversion is fluorescein which can be quantified using spectrophotometry.

The means of apricot, plum, quince and conventional apricot orchards did not differ significantly from each other but were significantly different from peach orchards (Fig. 14). No statistically significant differences ($P<0.05$) are evident between treatment and control plots for any of the fruit types.

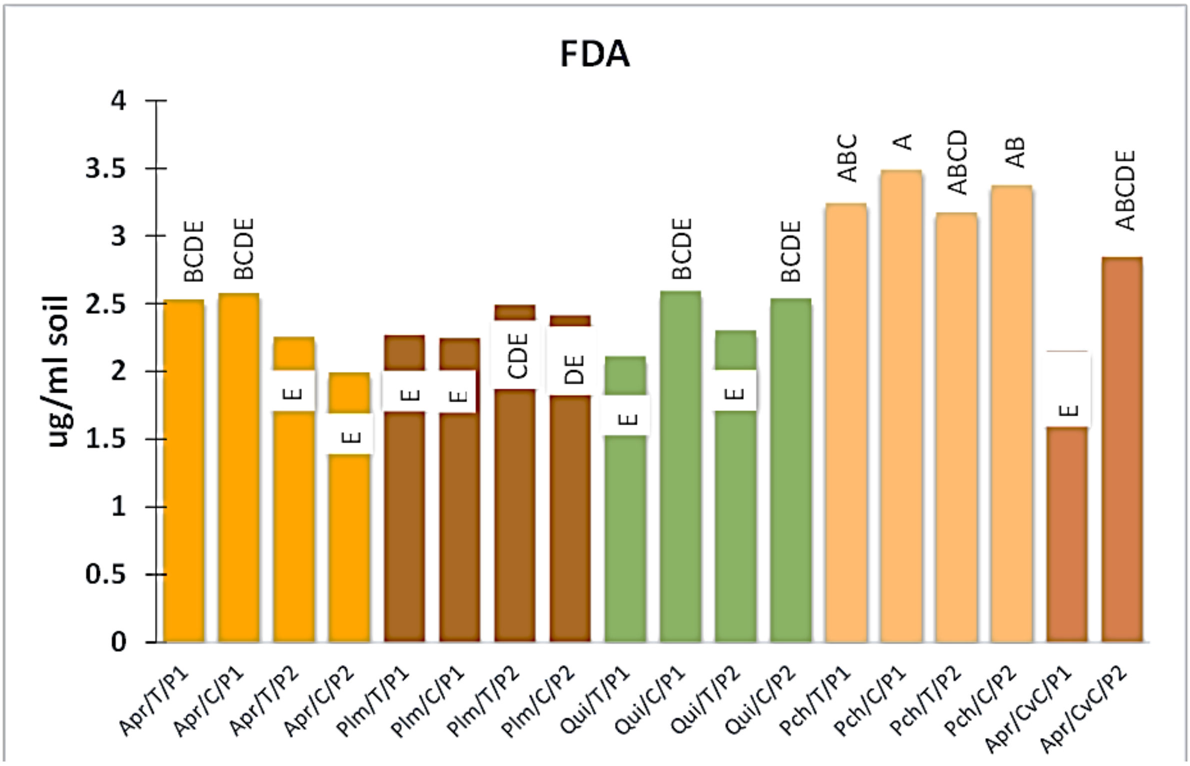

Figure 14 Results of Fluorescein-diacetate analysis in apricot (Apr), plum (Plm), quince (Qui) and peach (Pch) plots under control (C) or treatment (T) conditions. CvC stands for the conventionally managed plots.

Active Carbon (AC)

The procedure measures the fraction of organic matter in a form readily utilizable as energy source by microorganisms. It measures the fraction of C and nutrients in total % organic matter (%OM) that is readily biologically available for soil organisms and plants. Much of the total %OM is in the form of highly stabile “humus’ and is not readily available as “food” for the many beneficial microbes in soil. Humus only very slowly releases carbon for soil microbes and nutrients for plant growth. The method shows a response to soil management sooner than total organic matter changes can be detected. AC is therefore more quickly responsive to soil management practices. For this reason, AC is considered a “leading indicator” of %OM and can inform growers earlier about detrimental conditions. AC is positively correlated with aggregate stability, biological activity and crop yield.

Statistically significant differences are evident in subplots between Treatment (T) and Control/Conventional (C) plots for plum (plot 1), quince (plot 1 & 2) and peach (plot 2).The four organic orchards did not differ significantly from each other in terms of active C. The two plots in the conventional apricot orchard had significantly ($P<0.05$) less active C than most plots in the four organic orchards with almost 55% less C than in the organic apricot orchard (Figure 15).

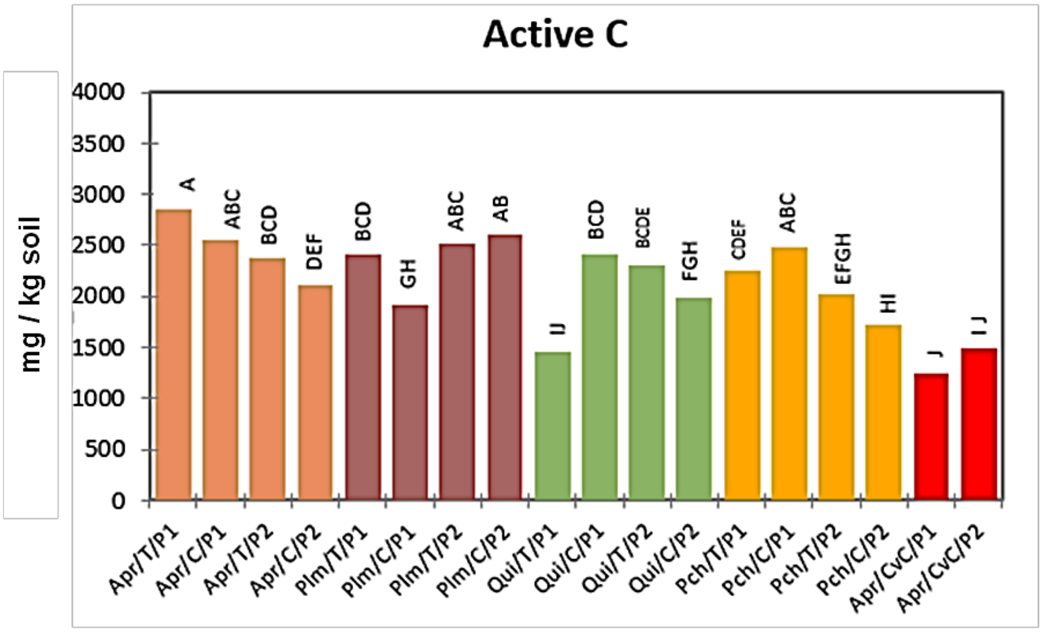

Figure 15 Results of active carbon analysis in apricot (Apr), plum (Plm), quince (Qui) and peach (Pch) plots under control (C) or treatment (T) conditions. CvC stands for the conventionally managed plots.

Biolog analysis

Community–level physiological profiling (CLPP) has been demonstrated to be effective at distinguishing spatial and temporal changes in microbial communities.

The Biolog EcoPlate™ assay allows testing of a number of ecologically relevant C substrates in soil in order to differentiate between microbial communities present that are able to utilize these substrates. The EcoPlates contain carbon substrates that are known to be plant root exudates or that have previously been found to have a high discriminatory power among soil communities. Communities of organisms will give a characteristic reaction pattern called a metabolic fingerprint. These fingerprint reaction patterns rapidly and easily provide a vast amount of information from a single Biolog MicroPlate. In applied ecological research, EcoPlates are used as both an assay of the stability of a normal population and to detect and assess changes based upon a variable introduced to the environment. Such changes could be determined by both biotic and abiotic factors.

The 31 carbon sources in each of the three replications per plate are allocated to six carbon groups: Ten carboxylic acids, seven carbohydrates, six amino acids, four complex carbon, two amines, and two phosphate-carbons. Carbon substrate utilisation patterns are a measure of microbial diversity and are used to characterise and classify the heterotrophic microbial communities that colonise a particular substrate. Tetrazolium salt is used as an indicator dye that turns blue when the particular carbon source to which it is bound is metabolized. A portion (1 g) of each of the 18 composite soil samples was suspended in 100 ml of sterile, distilled water and shaken on an orbital shaker for 20 min at 20 °C and then incubated at 4 °C for 30 min. 150 µL of each soil suspension was then inoculated into each well of an EcoPlate and incubated at 25 °C. The rate of utilization was indicated by the reduction of the tetrazolium, a redox indicator dye that changes from colourless to purple. The colour development was recorded with a microplate reader (spectrophotometer, BioTek EL X808, A.D.P) at 590 nm, starting at 24 h, and then every 24 h until 72 h. The average well colour development (AWCD) was calculated for each sample by dividing the sum of the optical density data by 31 and data subjected to dendogram and principal component analyses (PCA). AWCD is an indication of inoculum density.

The individual AWCD readings for the 16 plots in the organic orchards and the plot totals were significantly greater than that of the 2 plots in the conventional Apricot orchard at 24, 48 and 72 hours (Figure 16). This is therefore a pronounced indication that the conventional apricot soils had very low microbial density. The AWCD readings for Treatment and Control plots in the four organic orchards indicated no differences between Treated and Control plots. It is probably too early to expect differences between Treated and Control plots.

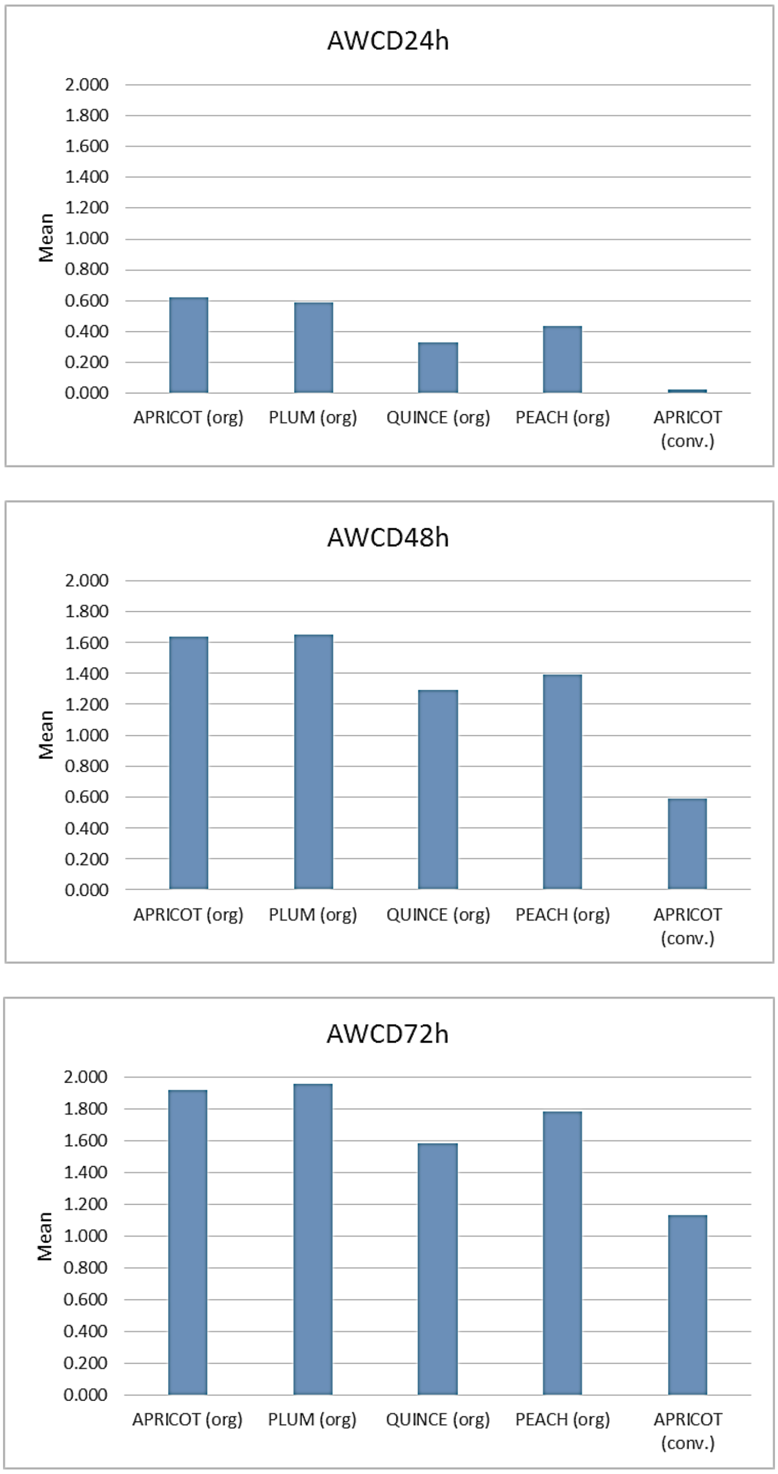

Figure 16 Average well colour development (AWCD) in different fruit type orchards after 24, 48 and 72 hours

The total AWCD readings (combination of 4 plots/orchard) indicated that soils from apricot and peach orchards had the highest inoculum density (Fig. 17). It is open to speculation why this should be the case, but this result is related to organic matter in the soils and probably physical and chemical soil factors (ongoing analyses).

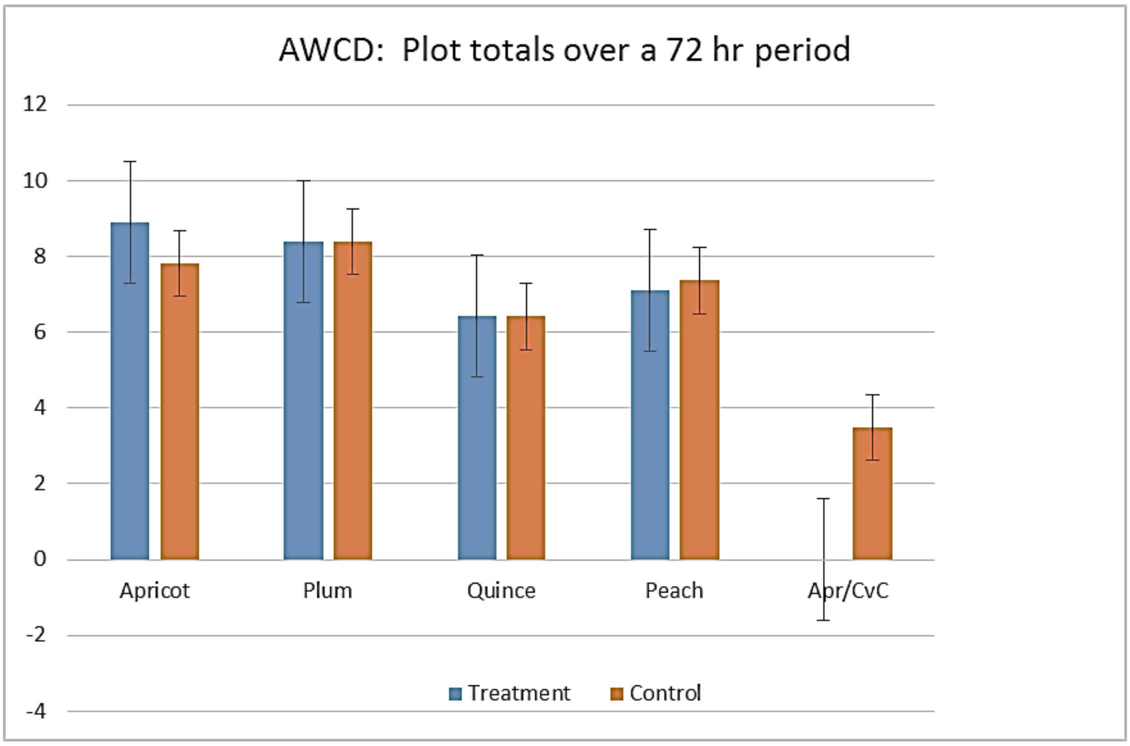

Figure 17 Average well colour development (AWCD) in treatment and control plots of different fruit type orchards over 72 hours

The CLPP profiles of individual plots confirm that there are differences between the 18 orchards in terms of the relative utilization of the individual 31 carbon sources expressed as a percentage of total carbon utilization. The differences between the 16 organic orchards however are less pronounced than differences between them and the two conventional apricot plots (Fig. 18).

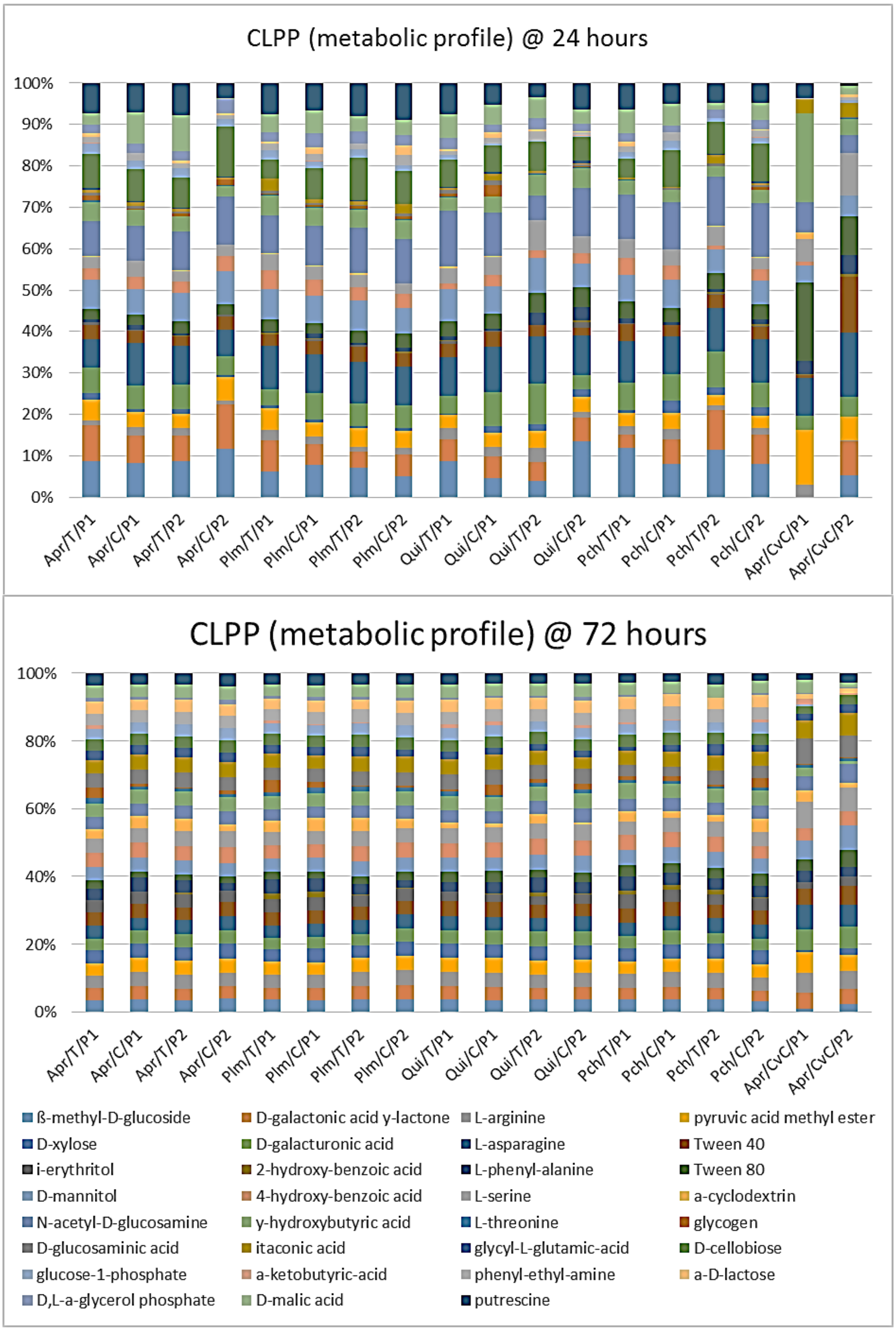

Figure 18 Community–level physiological profiles (CLPP) of the individual study plots after 24 and 72 hours. Coding stands for apricot (Apr), plum (Plm), quince (Qui) and peach (Pch) plots under control (C) or treatment (T) conditions. CvC stands for the conventionally managed plots.

Principal component analysis indicated that the two conventional apricot plots were dissimilar but that their dissimilarity to the organic orchards was far greater (Fig. 19).

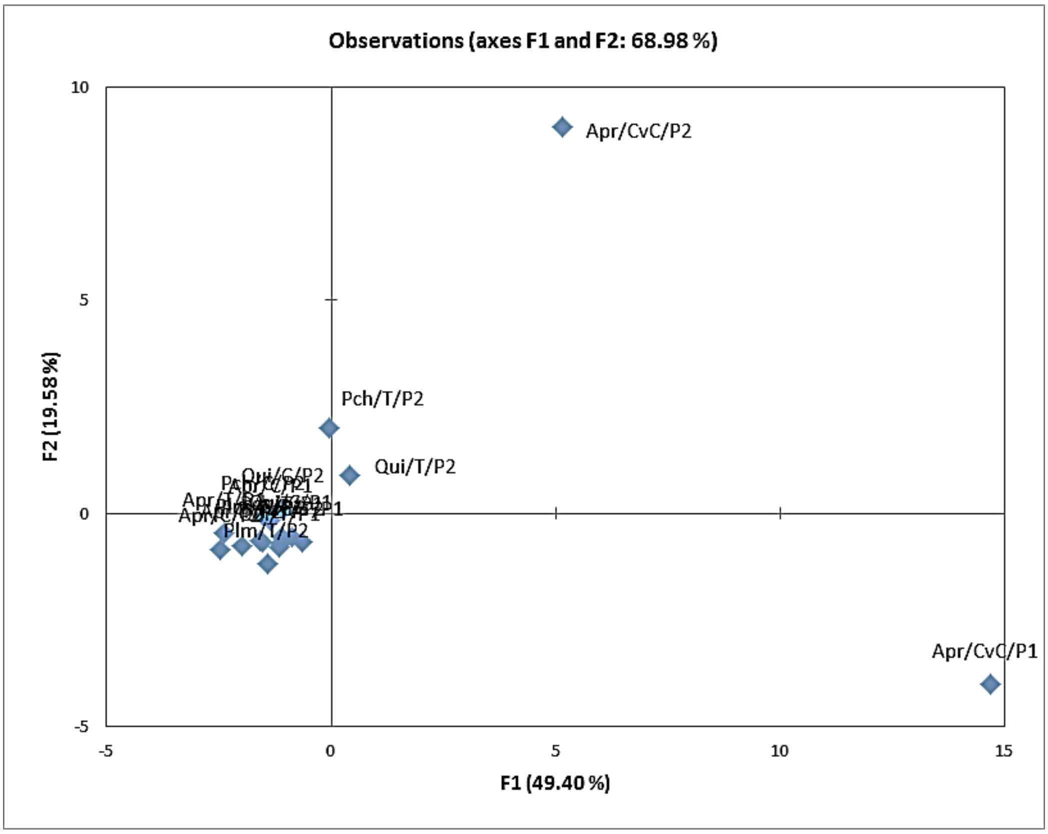

Figure 19 Principal component analysis based on the community–level physiological profiles (CLPP) Coding stands for apricot (Apr), plum (Plm), quince (Qui) and peach (Pch) plots under control (C) or treatment (T) conditions. CvC stands for the conventionally managed plots.

Phospho-lipid fatty acid analysis (PLFA)

Phospholipid fatty acids are components of the membranes of all organisms and each species has a characteristic fatty acid pattern. To obtain fatty acid profiles, the fatty acids are extracted from soil and the fatty acid pattern is used to determine community composition. The biomass of groups such as gram-negative bacteria, gram-positive bacteria, actinomycetes, fungi and other soil organisms can be estimated by determining the concentration of so-called signature fatty acids which are specific for a given group. PLFA patterns have been used to study the effect of a range of factors on soil microbial communities, e.g. pH or acid rain in forest soils, heavy metal addition or soil amendments. The effect of environmental factors on microbial community structure can also be assessed by PLFA. Examples include effects of management and crop rotation, the introduction of foreign bacterial strains, heavy metal pollution, biosolid application, plant species or salinity.

Although there are significant differences between subplots in terms of microbial biomass these differences are not consistent. For example, in peach plots there is no significant difference between treatment and control in study plot 1, but differences are significant in study plot 2 (Fig. 20).

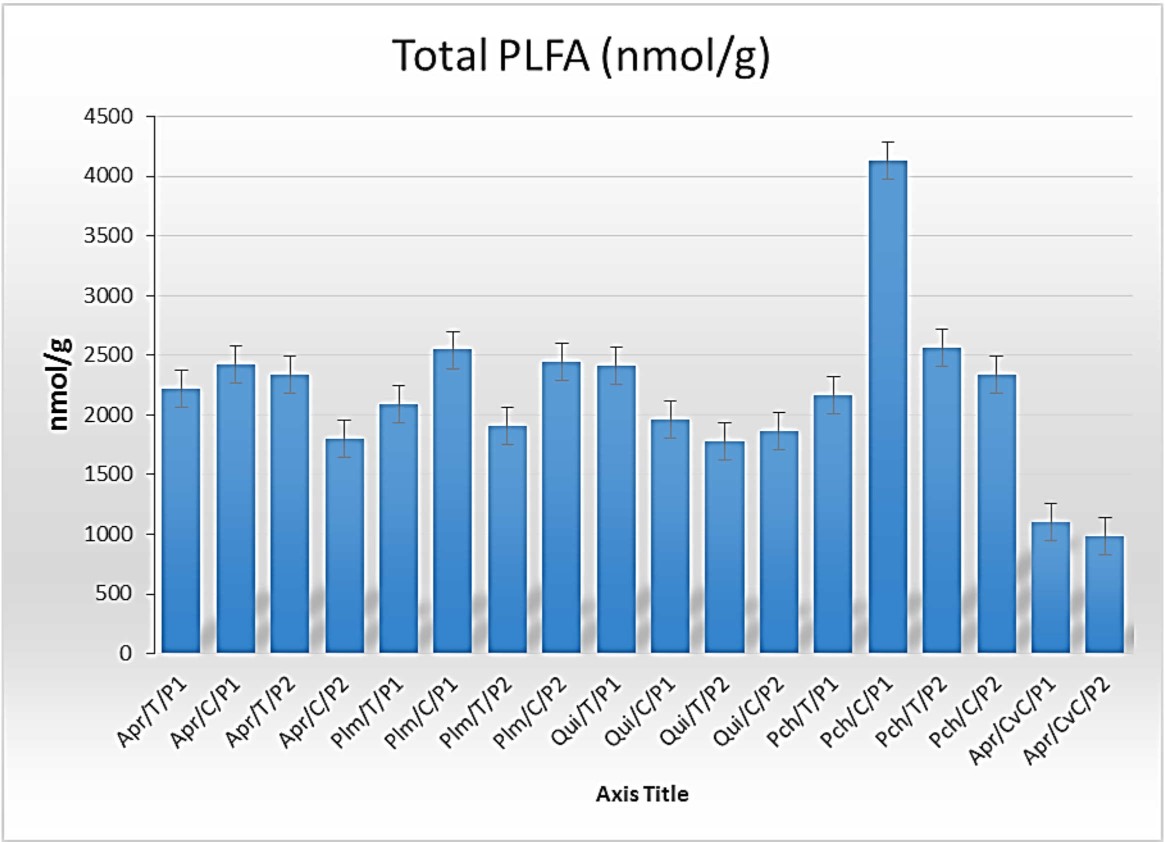

Figure 20 Microbial biomass as estimated with the PLFA method in the individual study plots. Coding stands for apricot (Apr), plum (Plm), quince (Qui) and peach (Pch) plots under control (C) or treatment (T) conditions. CvC stands for the conventionally managed plots.

In quince in plot 1 treatment microbial biomass is also higher than in control plots. In plum, in plot 1 and plot 2, the opposite applies with control microbial biomass being greater than in treatment plots. The largest difference between treatment and control plots is evident in peach.

The low microbial biomass in the conventional apricot orchards is consistent for active C, Biolog and PLFA measures. Signature lipids for general bacteria and fungi are consistent with total PLFA differences between subplots with peach control plots in plot 1 having by far the highest bacteria and fungal biomass. The conventional apricot orchard soils have virtually no bacteria compared to the organic subplots and these plots therefore have the the largest fungal:bacterial ratio of all 18 treatments (Fig. 21). This strong disparity might be an indication that conventional apricot orchard soils are acidic (bacteria do not like low pH soils but fungi do).

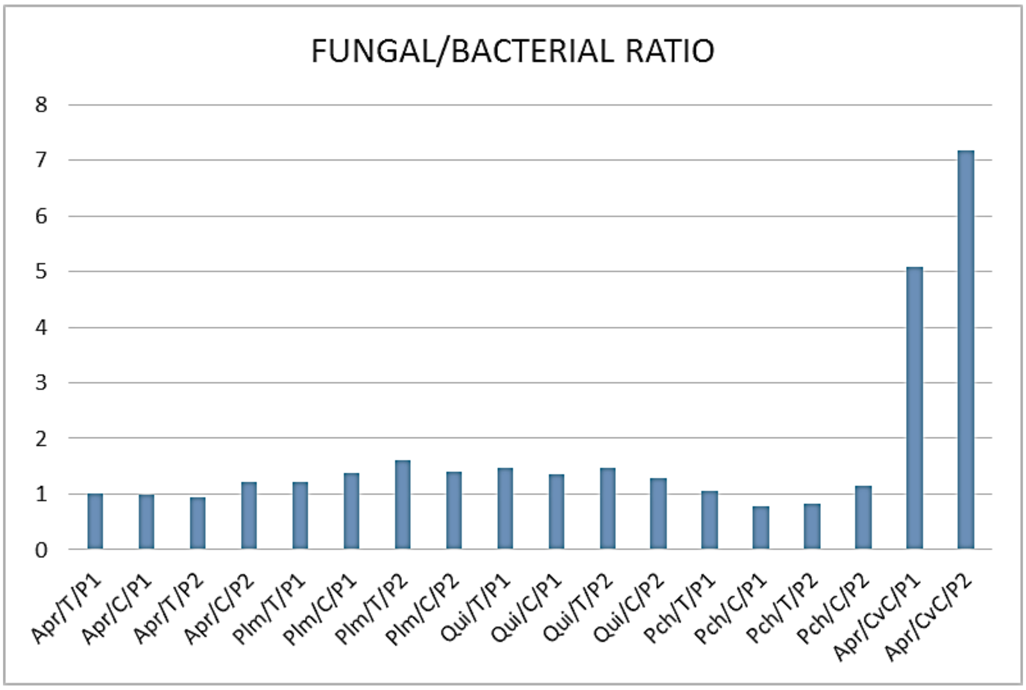

Figure 21 Fungal:Bacteria ratios in individual study plots based on PLFA analysis. Coding stands for apricot (Apr), plum (Plm), quince (Qui) and peach (Pch) plots under control (C) or treatment (T) conditions. CvC stands for the conventionally managed plots.

3. Analyses in progress

Table 3 shows the ongoing analyses that were part of the 1st sampling campaign. The decomposition sampling in the first campaign failed, but will be repeated in the 2nd campaign.

Table 3 Analysis from sampling campaign 1 still ongoing.

Task	Timeline
Soil properties	
Nutrients (NPK)	ongoing
pH	ongoing
Microbial diversity	
NGS	ongoing
Decomposition	
Tea bags	2nd campaign
Biocontrol	
EPN/EPF	ongoing
Aboveground Diversity	
Pitfall traps	ongoing
Grasshoppers	ongoing
Weeds	ongoing
Production	
Yield	ongoing
Growers	
Interviews	ongoing

4. Outlook

Parts of the vast amount of samples produced in the first campaign are still processed and the consortium aims for having these analyses finished by the time of the second sampling campaign. Conclusions and final recommendations will only be formulated after all samples from the first and second campaign are analysed. The second project meeting will partly be used to discuss joint analyses and frameworks. Interviews with farmer are scheduled for the coming months and a first subset of organic and environmentally concerned growers has been identified and contacted. There is a minor change in coordination, as Klaus Birkhofer has been appointed as faculty professor at the BTU Cottbus-Senftenberg in Germany. He will remain associated to Lund University and has full access to all project accounts. Lund University will remain the administrating institution for this project and K. Birkhofer will still be in charge of coordinating the project. The field work is performed in South Africa, so that there are no disadvantages in terms of scientific quality or dissemination due to his new employment situation outside of Sweden. After a 2nd sampling campaign in June 2017, a closing meeting is scheduled for October 25-27. Due to the considerably higher number of researchers from South Africa in the consortium we plan to hold this meeting in Stellenbosch. This will also give us the opportunity to invite local growers to the meeting.