2012 RDOS Compost Evaluation Project
Sponsored by:
Southern Interior Development Initiative Trust
Regional District of Okanagan-Similkameen
Okanagan Kootenay Cherry Growers Association

Evaluation of Compost on Crop Production,
Tree Growth, Fruit Quality and Soil Fertility

Project Coordinator:

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PART I
(Executive Summary)

Introduction

It is with a grateful acknowledgment of the financial support from the Southern Interior Development Initiative Trust (SIDIT), Regional District of Okanagan-Similkameen (RDOS) and the Okanagan Kootenay Cherry Growers Association, without whom this project would not have been possible, that the work investigating the impact of various local compost products on the tree fruit industry was carried out this year. The Southern Interior Development Initiative Trust (SIDIT) is a trust created and funded by the Province of British Columbia to encourage, promote and support economic development in the Southern Interior of British Columbia. The knowledge gained this year and last year will have a significant impact on the health and production rate of local tree fruit blocks.

This project is, in part, an extension of the RDOS³ study of 2011. The two basic concepts underlying this work are:

1. To utilize local wastes (wood products, feedlot waste, fruit waste, etc) to create reliable compost sources that can be utilized by local agriculture, to identify these sources and evaluate their quality and potential as soil amendments.

2. To identify the impact of these sources on local agriculture, in particular the tree fruit industry and the alfalfa growers, and demonstrate the proper application system and rates to growers.

Under “2” above several factors are involved that can be evaluated individually but in reality are all part of a complex system. Throughout this report an attempt will be made to relate the individual observations and findings to the total picture.

The conclusions established by the study are outlined in table 1 as a set of goals and their accomplishments. Several key factors, in relation to root health and the impact of compost, were derived from the study. Most importantly they showed the impact compost had on the incidence of feeder root die-back in tree fruits both in the field and in the bioassay test.

The level of feeder root die-back is critical because it impacts the capacity of the root system to supply water during heat stress periods and to deliver nutrients from the soil. Since tree fruit production in the Okanagan Valley utilizes a high density system of production, featuring dwarfing root stocks, there is a very limited root system supporting each production unit when compared to the systems of 20 years ago. The old systems featured standard root stocks that supported very large trees with corresponding large root systems. Such systems drew food and water from a large volume of soil through roots that stretched deep into the soil.
The root die-back concern is mainly related to soil pathogens and it was clear from the results of the RDOS 2011 study that the impact of the compost was related to its influence on soil pathogen activity rather than on the nutrient value supplied through the compost. In this current study the emphasis will be as follows:

1. To compare the impact of different compost sources on various soils (utilizing the Slykhuis bioassay). The soils chosen were from the orchards that purchased OK Falls compost this year plus, for comparison, soils from other blocks showing typical tree decline.

2. To re-assess the fruit quality factors in the 2011 cherry block that showed superior fruit quality where compost was used.

3. To assess the utilization of compost for re-vitalizing stunted root systems that limit production.

Many blocks of trees that have been replanted in the past decade are under-producing for a variety of reasons. One main reason is the result of poor replant management. The specific causes range from poor soil preparation to poor post-planting management, and generally manifest in poorly developed root systems. Re-invigorating a suppressed root system is a challenge but is positively impacted by the addition of compost.

The 2011 study showed differences in response when different compost products were used. Differences between compost sources will be evaluated in more detail in this study.

What’s in the Future?

This completes two seasons of work assessing the impact of local compost on Okanagan Similkameen orchards and alfalfa fields. It was emphasized in the 2011 project report and has been noted often in committees and meetings with the tree fruit industry, that a major job will be to actually sell the importance of composting to the producer. The following describes the immediate plans to move forward:

1. The bioassay is a key component of the coordination between compost product and specific impact on crop production and quality. Plans are being implemented to offer the bioassay as a commercial service to growers. A facility has been procured in the Naramata area and will coordinate compost suppliers interested in participating.

2. It is clear from grower contacts that there is a need for field extension to work directly with growers. Assistance on the proper application of compost, rates to use and the need for supplemental follow-up, when necessary, is obviously needed, based on direct interaction with growers. There are approximately 24 growers that have been part of the complete project and the plan is to do a follow-up with each grower in early spring. This will involve direct contact, going over their individual replant data and will include discussions on nematode levels and soil chemistry.

3. It is important to continue working with the suppliers, routinely monitor their product and create a liaison between the producer of compost and the user. This contact will also act as encouragement to the producer to formulate product in a way that maximizes the efficacy of the compost so it is a positive product for agricultural needs.
Spin-offs:
There has been considerable interest from growers and field groups in the tree fruit industry with regards to the use of compost. This has resulted in enquiries and requests for presentations and individual grower sessions. Some of the spin-offs from the project are as follows:

1. Packinghouse field persons requested a small group meeting to discuss the current year’s project results and to discuss in detail specifics such as:
   a. Application techniques.
   b. Application rates.
   c. Residual effects.
2. Direct contact with the growers has been maintained and further follow-up planned for the winter/spring of 2013.
3. Contact with the various compost producers has been maintained and will be part of the winter/spring follow-up program.
4. A grower supported bioassay facility is in the planning stages in order to continue to support a microbiological standardization of the compost products.
5. The work will be presented as a poster session at the 2013 BCFGA Horticultural Meeting in Kelowna. Past experience has shown this to be a popular meeting and an excellent forum for interaction with growers to discuss the use of compost.

### Summary Table for 2012 Goals

<table>
<thead>
<tr>
<th>Goal</th>
<th>Result</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 (a)</strong> Monitor the impact compost has had on root and tree health in orchards where it was commercially applied.</td>
<td><strong>1 (a)</strong> Generally the results confirmed the 2011 project findings. The OK compost, when applied on the surface in mature blocks, stimulated feeder root development and, more importantly, reduced the incidence of die-back in the new feeder roots. However, where compost was used as a soil replacement in an Oliver cherry replant, by mixing it into the soil-replacement-system, the above advantages were not noted.</td>
<td><strong>1 (a) Very Significant:</strong> Surface applications of compost are highly recommended in decline orchards for stimulation of tree growth and in non-decline orchards as a soil maintenance strategy. There is evidence from the work in the two cherry replant blocks that using compost as a substitute for other proven treatments, i.e., fumigation, does not always work.</td>
</tr>
<tr>
<td><strong>1 (b)</strong> Apply small tests within orchards where decline was prevalent either in non-composted blocks showing decline or where compost application was not working. Determine if supplemental treatments could overcome the decline that was not addressed by the original compost treatments.</td>
<td><strong>1 (b)</strong> These trials illustrated very clearly that in some soils further field evaluations are necessary in order to supplement compost use. These mini-trials also support the fact that although local soils generally respond to compost application by reducing die-back, orchard soils can be contaminated with soil pathogens that require more specific chemical treatments.</td>
<td><strong>1 (b) Very Important</strong> These data reinforce the need to test soils prior to replanting and/or where decline symptoms are expressed. The continuous utilization of local compost will depend on it being used properly and effectively by growers and their advisors.</td>
</tr>
</tbody>
</table>
2 (a). Utilize a bioassay to determine if the application of compost is effective in the test soil.

Compare the compost application to more standard soil treatments such as fungicides and fertilizers which are routinely applied as root stimulants and protectants.

2 (a) The bioassay assessment was broken into two different segments. The Healthy Seedling Test (HST) and the infected seedling test (IST). There were obvious differences in treatment responses between the two sets. The challenge to the compost's ability to reduce or eliminate die-back was much greater in the IST test where the root disease pressure was higher.

2. Very Important

2 (a) The diagnosis of soil problems and how compost can be assessed in orchards is illustrated in this project, i.e., bio-assay results indicate the importance of soil assessment to identify and distinguish between different compost sources and to elucidate when the application of compost is not the entire answer.

2 (b). Use the bioassay for direct comparison of the impact of various composts on soil performance. Determine if the bioassay can be used to apply standards to the various sources.

2 (b). The differences between compost characteristics, in relation to their impact on seedling growth, was clearly demonstrated. Even the method of application of the compost resulted in variations in seedling growth response.

2 (b). There are many “compost” sources available locally. These can be compared to determine the best product suitable for a particular orchard soil and whether other amendments are needed in addition to compost. Method of application, i.e., incorporation into the soil or surface applied, may influence efficacy.

3. Assess 2011 blocks to determine if the improvement in tree growth responses continues into the second year. Both a root comparison and trunk diameter increase were assessed.

3. There was clear evidence that there was a carry-over effect. The root comparison in Summerland indicated a die-back control in year 2 while trunk diameter increase in the two 2011 Cawston trial blocks continued to be better in the compost treatments.

3. Useful Information for Recommendations

A common question for growers: Does the compost need to be applied yearly? It appears that the need for a follow up application isn’t always necessary.

4. Within the monetary restraints of the project some detailed additional work was carried out:

4 (a) Soil analysis was done on all replant soils at Pacific Labs in Richmond BC.

(b) Nematode analysis was done on most replant soils and (c) Quality assessment on the Oliver cherry block from the 2011 trial in an effort to determine if the quality improvement noted in 2011, where compost was used, carried over into 2012.

4 (a) Chemical analysis was done on all replant soils

(b) Nematode analysis was carried out on 17 of the soils. These analyses were done by Dr. Tom Forge, research scientist, PARC

(c) Dr. Peter Toivonen, research scientist at PARC has been monitoring the fruit from a compost treated orchard in the Oliver area. This year fruit from the compost treated trees was again of higher quality than fruit from the check trees.

4. Useful Information for Recommendations

(a) Data will be used in the spring of 2013 to advise growers on root nutrition and soil requirements.

(b) Forty-One percent of the soils had significant nematode levels. This data will be used to lobby for a nematicide that growers can use on bearing trees.

(c) Important Information

This is further evidence that the compost applications have had an effect on fruit quality parameters.
PART II

Methods:

1. Orchard Assessments:

Apples and Stone Fruits: Root assessments were recorded as per methods outlined in a previous Agriculture Improvement Fund Report\(^2\). This is basically a visual assessment covering the total root system, the succulent feeder roots and the amount of die-back on those feeders. This 2010 report gives a detailed description of the root evaluation system used. As with the bioassay evaluations three root parameters were assessed:

1. The overall root system: an estimate of the full extent of the root mass.
2. The extent of the feeder roots: the succulent white feeders at the root tips within the top 15 – 25 cm (6-8 inches) of soil.
3. The amount of dieback*.

In the orchard, roots were exposed by removing several shovels full of dirt from the surface to a depth of approximately 8-12 inches (20 – 30cm) and the above 3 root parameters within this exposed volume evaluated as outlined in the above report.

2. Bio-assay:

Seedling Test:
This technique was described by Slykhuis (1) and, simply stated, involves planting young seedlings into orchard soil that has been modified with various amendments. Seedling growth in the soil with and without amendments is compared. In this study three different compost sources were compared. The standard was the OK Falls standard from Big Horn Composting (also the standard used in the 2011 RDOS study), and was compared to Glenmore land fill yard waste product and a source out of the Freidling feed lot (Southern Plus) in Oliver. A fruit based product from the RDOS yard in Oliver composed of yard waste and tree fruit waste has been recently available and will be included in any trials that are continued beyond the finish of this project. All these products are available commercially and contain no biosolids**.

Each treatment consisted of 6 seedlings planted into a 2 litre container of orchard soil modified as indicated with compost or other soil treatments. The seedlings were allowed to grow for 6+ weeks then assessed as outlined below.

**Biosolids are processed human waste product from sewage plants.
Soil treatments:
The treatments were added into the soil and thoroughly mixed before the seedlings were planted at the following rates (unless specified otherwise):

1. Compost was mixed at a 1 part compost 2 parts soil.
2. Dithane used at the standard rate of 0.33 g. per litre.
3. MAP (mono ammonium phosphate) was mixed at 1.5 g. per litre.
4. Heat treated soil was heated to 150°F for 1 hour in an oven.
5. For application comparison compost was added as a surface application in some tests. The rate for surface application was 250 ml spread on the surface (approximately 250 square cm) of the 2 litre container prior to planting.

Two distinct bioassay test groups were run. In the first group covering samples 12-1 to 12-8 and 12-11 to 12-16 the seedlings were healthy and the test segment referred to as the “healthy seedling test (HST)”. In the second group 12-17 and 12-19 to 12-23 the seedlings used were contaminated with a dampening off condition (likely Pythium?). These seedlings were selected from the seedling trays as having distinct infection in the crown area and the test is identified as the “infected seedling test” (IST).

Visual Root Assessments:
Visual root assessments were done on roots within the bioassay containers, or on site at the orchard. The visual judgement is made of the root system of each seedling or tree within that treatment based on a 1-10 scale. The check was scored first in each case and all other treatments within that assay compared to that check. In this way the impact of the treatment or amendment was relative to un-amended orchard soil. The root score evaluation technique is identical to that described in the RDOS 2011 report where it is detailed in photos.

As mentioned above the three root parameters assessed were:

1. The overall root system.
2. The extent of the feeder roots.
3. The amount of dieback*.

Each segment is scored on a 1-10 scale with 10 being the highest. The “system” rating is indicative of the root ball that is in the ground under the tree. When assessing tree roots in an orchard a section of soil is removed from one side of the tree and the score given is representative of the presence of strong primary laterals. In the bioassay the total root system is removed and evaluated in its entirety. The “feeder” system rating is indicative of the mass of white succulent tip feeders associated with the system and “die-back” scores rate the extent of necrotic lesions associated with the newly-formed feeders in both cases. The die-back rating will always represent the proportion of the feeders that are affected. Note: For the die-back score, the higher the rating the more damage evident.

* Die-back is a normal process in the root system and reflects the dynamics of the soil and the soil inhabitants. Excessive die-back detracts from the trees ability to support itself. In a commercial planting expectations are such that a tree should produce 40+ bins of high quality fruit in order to make a commercial operation viable.
The significance given to the ratings, in relation to commercial production and tree health, is as follows in table 1.

### Table 1

**Scoring System & Relevance to Tree Health**
*(These numbers are based on several years of field observations in healthy and decline orchards)*

<table>
<thead>
<tr>
<th>System Score</th>
<th>Feeders</th>
<th>Die-back</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Commercially acceptable</td>
<td>&lt;4</td>
</tr>
<tr>
<td>&lt;4</td>
<td>Serious shortage of feeders necessary for nutrient and water uptake. Usually equated with poor tree growth.</td>
<td></td>
</tr>
<tr>
<td>4 - 5</td>
<td>Poor feeder condition. Usually indicating that the tree is in decline.</td>
<td>4 - 5</td>
</tr>
<tr>
<td>5 - 7</td>
<td>Acceptable but with concern. Roots in this condition need to be monitored closely.</td>
<td></td>
</tr>
<tr>
<td>7 - 8</td>
<td>Generally associated with good healthy tree if die-back is low.</td>
<td></td>
</tr>
<tr>
<td>&gt;8</td>
<td>Excellent feeder roots but dependent on die-back being low.</td>
<td></td>
</tr>
<tr>
<td><strong>NOTE</strong></td>
<td>The root system in the field is predetermined by replant and post plant management. The segment of the root system assessed in a field assessment is very limited. In the pot test, the results represent the entire root system and the “system” value becomes more meaningful.</td>
<td>When the die-back damage reaches a level of 4-5 this should trigger some concern. The normal response would be to monitor feeder root condition to determine if this die-back level continues to increase.</td>
</tr>
<tr>
<td></td>
<td>A die-back score of less than 4 is acceptable.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When the die-back level becomes greater than 5, corrective procedures should be initiated.</td>
<td></td>
</tr>
</tbody>
</table>

3. Further Evaluations of the Roots within the Bioassay Tests:
The root systems within each bioassay were weighed after they were harvested and visually scored. The following parameters were measured:

2. The total weight of the plant after harvesting.
3. The weight of the root mass after harvesting.
3. The above ground height of the plant.

This was an attempt to compare the practicality of recording actual total and root weights against the traditional measurement of seedling height. These data were not correlated to the visual scores, which was the same lack of correlation found by Molly Thurston in her master’s project at UBC using a similar test. These data are available but not reported here.
4. Fruit Quality Assessments:

Cherry:
Fruit quality assessment is based on standard quality parameters such as pressure, soluble solids and sugar levels. The stone fruit values were assessed by Dr. Peter Toivonen, at the Summerland Research station.

Apple: *Funding was not secured for the apple quality and fruit nutrient analysis segments.*

5. Tree Growth

Apple Tree Growth Measurements:
Growth was measured as diameter at a pre-determined height from the ground. (For details see methods in reference 2).

6. Soil Analysis:

1. A full soil-nutrient analysis was done on each soil collected for the bioassay. Testing was done by Pacific Laboratories in Richmond, BC.
2. Nematode analyses were done on 17 of the 20 soils collected from grower orchards for bioassay.

**Results and Discussion**

**General Information:**

1. **Tree growth and production:**
Funding for this year’s study did not allow for detailed tree growth assessment in all blocks. Figure 1 is one example showing data from the OTFC decline studies from 2008 and 2009 and illustrates a relationship between root health and production improvement. Based on this experience, results from this year’s (2012) root assessments can be used to suggest their impact on tree growth and production.

In the above study in 2008 and 2009, the trees were treated with fertilizers and root fungicides during that year. Roots, trees and overall block ratings were recorded. The values for root and tree scores in this chart represent an average score for the individual tree assessed as representative of the block while the block rating indicates a general assessment of the condition of the total block.
In evaluating the 2009-2010 data illustrated in figure 1 the following criteria apply. Generally, in the rating system used, a tree or block score of less than 7 indicates a condition below commercial acceptability and an average overall root score of 3 is considered a serious problem. In this study tree and block scores improved to an acceptable level over the monitored period in parallel with the improvement in average root scores, i.e., the tree score improved for the trees from a 6 (below commercial health) to a 7. The block score increased from a 5.9 to a 6.4 in 2009 and to 7.5 by mid 2010. In other words, improvement in the block health to an acceptable commercial level coincided with root improvement over the same period.

2. Assessing the quality of the compost materials:

1. Chemical analysis.

The compost producers can submit a sample to the Organic Material Review Institute (OMRI) for ratification of the product as acceptable for use in organic orchards. This ratification depends on the product meeting nutrient analysis criteria (similar to the standards set out by the regional district) and, in addition, is required to meet low Faecal Coliform and Salmonella levels. Without this OMRI classification (Appendix 1) the compost cannot be applied to organic orchards.

A copy of the OMRI status for Big Horn Contracting Ltd is shown in Appendix 1. This certification should be encouraged for all suppliers as a standard requirement before the product is recommended to local growers.

2. The bioassay test as described above should be adapted as a standard evaluation of the compost’s efficacy in the soil. This further test would be valuable for replant strategies.
**Goal 1(a):**

Monitor the impact compost has had on root and tree health in blocks that have used compost this year in the Regional District of Okanagan/Similkameen and compare it to root and tree health in blocks without compost.

Twelve blocks (6 apple blocks and 6 cherry blocks) were included in the RDOS regional study. Half received compost applications and half received no compost. Details on these blocks are outlined in (Table 2). An additional 10 blocks (some outside the RDOS region) were sponsored by CAS and are reported in this report to strengthen the conclusions.

**Table 2.**

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Block Location</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jim/Mariann Campbell Apple</td>
<td>Okanagan</td>
<td>No Compost (Purchased/not spread)</td>
</tr>
<tr>
<td>Norton Replant Check Area</td>
<td>Oliver</td>
<td>No Compost Cherry</td>
</tr>
<tr>
<td>Norton Replant with Compost</td>
<td>Oliver</td>
<td>Compost Cherry</td>
</tr>
<tr>
<td>Norton 2011 Cherry Planting</td>
<td>Oliver</td>
<td>Compost</td>
</tr>
<tr>
<td>F. McLennan Cherry</td>
<td>Oliver</td>
<td>Cherry Replant 1.5L No Compost</td>
</tr>
<tr>
<td>Parm Dhaliwal Cherry</td>
<td>Oliver</td>
<td>No compost</td>
</tr>
<tr>
<td>Nina/Wayne Richards</td>
<td>OK Falls (Vaseaux Lake)</td>
<td>Peach Block Ploughed No Compost</td>
</tr>
<tr>
<td>N&amp;W Richards</td>
<td>OK Falls (Vaseaux Lake)</td>
<td>Cherry (Lambert rows 2L) Compost</td>
</tr>
<tr>
<td>Thomas Soil + Thomas Comp</td>
<td>OK Falls</td>
<td>No compost</td>
</tr>
<tr>
<td>Neal/Louisa Carter Apple</td>
<td>Summerland</td>
<td>No compost</td>
</tr>
<tr>
<td>Steve Brown Apple</td>
<td>Summerland</td>
<td>Compost in 2011 @ 12T/acre</td>
</tr>
<tr>
<td>Neal/Louisa Carter Apple</td>
<td>Summerland</td>
<td>Compost in 2011 @ 12T/acre</td>
</tr>
<tr>
<td>Keith Carlson Cherry</td>
<td>Summerland</td>
<td>Compost</td>
</tr>
<tr>
<td>Lane Mitchell Apple</td>
<td>Summerland</td>
<td>Compost</td>
</tr>
<tr>
<td>Doug Johnson Apple</td>
<td>Summerland</td>
<td>Compost</td>
</tr>
<tr>
<td>Haithwaite Apple</td>
<td>Cawston</td>
<td>Front Fuji SW 2L No Compost</td>
</tr>
<tr>
<td>R. Brungardt Apple</td>
<td>Naramata</td>
<td>East side 2L Manure</td>
</tr>
<tr>
<td>Sam DiMaria Apple</td>
<td>Kelowna</td>
<td>No compost</td>
</tr>
<tr>
<td>Neal Dendy Cherry</td>
<td>Kelowna</td>
<td>No compost</td>
</tr>
<tr>
<td>Parmjit Gill Cherry</td>
<td>Ellison</td>
<td>No compost</td>
</tr>
<tr>
<td>Mark VonRauchaudt Apple</td>
<td>Winfield</td>
<td>Compost</td>
</tr>
<tr>
<td>Bob Nevel Apple</td>
<td>Vernon</td>
<td>No compost</td>
</tr>
</tbody>
</table>

**Note:** Yellow background represents RDOS sponsored blocks in the south Okanagan and blue background represents CAS sponsored blocks.
Root monitoring in these blocks supported the results from the 2011 project. Figure 2 shows the mid-summer average root scores for all blocks in the project. Some were treated with compost, some were treated with synthetics (fungicides or fertilizer) and some were not treated at all.

**Figure 2**

![Figure 2: Root Evaluation Averages for all Blocks Within the Study (Apple and Cherry) by Treatment for 2012](image)

Since these are mainly mature blocks the “system” scores show very little differences over the short assessment time. The feeder root system scores are indicative of current season development and die-back scores are an indication of the active pathogens in the soil.

Assessing the feeder root systems those blocks with no compost and no other amendments scored on averaged 4.6. This is considered poor and indicative of decline. Such feeder root systems are of concern and generally associated with weak trees and poor production. The compost treated blocks scored much better, averaging 5.5, which is categorized in Table 1 (page 9) as “acceptable”. The acceptability of this level of feeder root development is also dependent on the die-back levels associated with these roots. The synthetic group which received a phosphorus treatment and/or fungicide drench scored highest at 6.9, which is considered good assuming the die-back levels are not excessive.

Die-back scores have a very significant impact on interpretation of the feeder root scores. In this project the average die-back score for untreated blocks was 5.7. Table 1 suggests this level of die-back would be associated with a tree health problem. Again, this is even more of a concern when combined with the low feeder root score.
Compost treated blocks have an average die-back score of 3.5. This score, in combination with the acceptable rating for the feeder roots, indicates a healthy root condition.

The best conditioned roots in the study were those treated with phosphorus and/or a fungicide. These had combined average scores of 6.9 for feeders and 2.6 for die-back indicating a healthy system.

**Goal 1b**

*Apply small tests within orchards where decline was prevalent either in non-composted blocks showing decline or where compost application was not working. Determine if supplemental treatments could overcome the decline not addressed by the compost.*

During early observations three of the blocks were in a state of decline and were chosen for additional testing to compare the poor response to further treatments of: compost, fertilizers and fungicide. These individual test results are summarized next.

**Test Block 1:**

This is an Ambrosia check block (12-23) not treated with compost but suffering from decline. These trees had responded to phosphorus and Aliette in 2010 and 2011 but the response did not last and roots showed typical root die-back. In this test nematode levels were zero in the 2012 sample although levels a year ago indicated a nematode problem.

The root system was weak compared to normal blocks with M9 roots and the trees were shallow planted meaning that the bud union was 8-10 inches out of the soil. This planting “style” meant the root stock shank was prone to burr knot formation.

The plan in this mini trial was to use a berm, i.e., pile soil and compost around the base of the tree to cover a significant portion of the exposed root-stock shank. The impact of this technique was noticed in the Summerland Ambrosia block 12-13 where the growers had applied their compost by piling it around the trunk as described above. During initial observations in Summerland it was noticed that strong lateral roots were generated off the shank area that had been covered, thus increasing the total root “system”.

The intent in test block 1 was to duplicate the root “system” improvement seen in this Summerland orchard and subsequently improve tree vigour.

MAP and Dithane application were also tested in this trial as well as soil and compost berms. The results are summarized in Figure 3.
There were 2 evaluation times illustrated in this figure: The first evaluation was done in early summer before the treatments were applied and the second evaluation after 20 days.

Interpretation of the results is as follows:
1. For check (red bars in figure 3) the system scored slightly below 7, or below what is considered commercially acceptable. This did not change after 20 days. The feeder root score for checks dropped from 7 initially to 4.4 or from “good” to “concern” and the die-back remained above 5 or at a level where corrections are considered necessary.

Generally the MAP and MAP + Dithane treatments (dark and light blue bars respectively on figure 3) responded as expected. Systems scores remained stable and above 7, feeder root scores went up and die-back went from over 7 (serious) to acceptable in both cases. In the latter case the treatment including Dithane had a much lower die-back score than the MAP alone. This is also to be expected.

For the compost (OK Falls product) treated roots (green bars on figure 3) the systems remained stable. The feeder root scores dropped from 6 to 5.3 (but remained acceptable). The highly significant response was related to the die-back levels. These dropped from very high (over 7) to 4.3 (acceptable).

Information coming from this block, related to the berming of compost and soil, indicated that new lateral roots were generated off the shank in both cases where the shank was covered. This paralleled the results noted earlier at the Summerland block 12-13. It was
noted however, that compost had to be kept moist in order for it to be effective as a “berm”.

The impact of these new and strong lateral roots on subsequent tree growth will be assessed in summer 2013.

**Test Block 2:**
This block (12-19) is an Ambrosia block suffering from decline. Contact was made as part of the compost assessment project but the compost had not been spread by the grower and the plan was to wait until fall 2012. A treatment trial was set up based on the poor conditions of the roots (Appendix 2) as noted in the preliminary inspection. The responses are summarized in figure 4.

![Figure 4](image)

The results in this figure illustrate the following:
1. As expected, root systems were stable over the short time period of the test for all treatments. (Note that check values were only gathered at the final assessment).
2. Feeder root development shows the most dramatic response where MAP was used, scoring 5.5 (barely acceptable) initially to 8.3 (excellent) after 13 days.
3. Die-back was significantly reduced in all treatments over the trial period. Die-back was very high in the untreated check at the final assessment.

Primary and secondary root systems were showing nematode symptoms and moderate levels were found in the soil. There were also signs of fungal diseases in the feeder root system. Dieback levels in the feeders were very high in the check plus there was severe damage in the primary roots (possibly winter injury).
Recommendation to Grower:
The grower had no plan to spread the compost during the 2012 season so, based on these results, it was recommended (after the final field assessment) that this block receive an immediate phosphorus treatment followed closely with an Aliette spray. The grower had on hand two separate phosphorus products and as a result one half of the block was given MAP applied to the surface as a granule and the other half was treated with 10-52-10 (the standard water soluble form of phosphorus). This split application clearly demonstrated the ineffectiveness of the MAP as a surface applied phosphorus source.

**Test Block 3:**
A separate trial was introduced into the replanted cherry block (12-2) because, based on the above ground tree growth, the compost program did not appear to be working. Shoot extension was poor, leaves were small and yellow, and roots were not developing off the shank as expected.

The contour of the replanted area featured a high point, which was previously a problem area exhibiting very weak tree growth. A decision was made to replant the area and the replant strategy was to trench the soil out of that area and replace the original soil with a fresh soil/compost mix. This mixture was a 1:3 mix of OK Falls replacement soil mixed with OK Falls compost. When the soil replacement was complete the area was planted with healthy nursery trees.

The response during the first month was disappointing. This is evident from the initial assessment in the block on May 12 when the replant block was assessed along with the adjacent 2\textsuperscript{nd} year block. The initial and +28 day scores from this block are summarized in Figure 5.

The standard comparisons made in this test block using, compost, MAP and MAP + Dithane are summarized in Figure 5. After the initial indication that the trees were not responding well to the replacement soil the grower attempted to stimulate root growth by injecting soluble phosphorus into the root zone. Evaluations shown in figure 5 are based on root growth in the top 8-10 inches of soil and there was little development observed,

![Figure 5](image-url)

**Figure 5**
which is evident by the very weak root system scores.

Initially for Test Block 3, because of the limited root systems, it was difficult to get meaningful values for feeder roots because there were few present. Consequently, since die-back scores depend on there being a feeder root system, the same difficulty in attaining die-back data existed.

Evaluations made on this test block are difficult to interpret. The treatments, unlike in test blocks 1 and 2, were superimposed on a significantly altered system, i.e., onto a completely altered soil system of new soil and compost mix. That system had been further modified by the grower by the injection of phosphorus into the lower root zone.

The controls in this isolated test seem to have resulted in the development of a better feeder root system but die-back levels increased. Where the surface compost was added in test 3 the die-back increased to a serious level. The one consistent and expected result in test block-3-evaluation was the control of die-back where Dithane was used.

Outside the Test Block 3 area the variability in the block showed no pattern when assessed over time (Figure 6). This reflected the variability of response above ground.

Figure 6

![Block Assessment (Outside the Test Block 3)](image)

Strong nursery trees were planted and the same lot of trees did well in another area of the orchard. The only interpretation being that the soil/compost mixture was not a solution to the initial soil problem.

This block, like others in the project, is to be followed in 2013 if possible.
Goal 2a:

To utilize a bioassay test to determine if:
1. it can be used to assess the impact of various compost sources in specific orchard soils prior to replanting or in orchard decline situations.
2. it can be used as a simple, routine technique to compare the relative effectiveness of different compost sources.

The bioassay technique was successfully used in the late 1980’s and early 1990’s to assess the specific needs of a particular orchard soil when replanting was planned. This information was available to industry, government extension personnel and to federal researchers but the technique itself was never adopted as a routine means of avoiding replant disorders or diagnosing the cause of specific decline problems.

The results from this project support the premise that:
1. The technique can help assess the effectiveness of compost in individual soils.
2. It can compare different sources of compost to determine which is the most effective in a given soil.
3. It can determine if supplemental treatments are necessary to enhance compost effectiveness.

All the field data from the 2011 project and now the 2012 project indicate that the compost has a positive impact on feeder root growth and reduces die-back in the field. Since nutrient analysis (Appendix 1) indicates that compost, at the levels used, does not supply significant nutrient value, it is speculated that the impact observed with regards to feeder root stimulation and die-back reduction is related to the influence the compost has on the microbial make up in the soil.

This section summarizes the bioassay data and, based on the following two factors:
1. Compost impact is not related to a nutrient response.
2. Compost is having a clear effect on reducing die-back.

Two distinct bioassay series were run. The first series (HST set), (12-1 to 12-8 and 12-11 12-16 plus the Thomas soil) was a normal test using healthy apple seedlings for the assay. The second (IST series) used seedlings that were infected with dampening-off fungus. In the latter case it was a more stringent test of the fungicidal characteristics of the various composts since the seedlings were selected on the basis of having an established infection.

The HST Summary:
Fourteen different soils were tested using a series of treatments to determine how each soil responded. The average treatment data, summarized in Figure G2-1, gives an overview of the HST assay results. There is considerable variation between soils within a given treatment that will be examined below while looking at individual treatments.

In figure G2-1 the data includes average values for all three root categories; system, feeder root and die-back, and is sorted according to die-back scores. The treatment responses in the bioassay sort comparably to the way they sort for the same treatments in
the field (see figure 2 in section Goal 1a). In other words the general pattern for compost is it stimulates feeder roots and reduces die-back. Based on the table M-1 all treatments, on average, have acceptable die-back levels with the exceptions check and heat treated, both with scores over 5.

**Figure G2-1:**

![Summary of HST Group Data from all 9 Treatments of the 14 Replant Test Soils](image)

Comparing the overall average responses in different soils without any soil modifications, i.e., checks (Figure G2-2) the variation from soil to soil is obvious. When assessing

**Figure G2-2**

![Summary of All HST CHECK Scores for 14 Replant Soils](image)
soils in order to make recommendations it is important to look at both the feeder root score (generally best above 7) in combination with the level of die-back (best below 4) because stimulation of feeder roots is quickly negated when the new feeders are attacked by pathogens. On this basis the bioassay indicated that 28.6% of the soils were acceptable for replanting without any modification.

**The IST Summary:**

Six different soils were tested with moderately infected seedlings to challenge the treatments under disease pressure. The range of treatments were slightly different from those in the HST test group in that compost sources from the Glenmore waste facility in Kelowna and the Southern Plus feed-lot out of Oliver became available part way through the project and were utilized in the IST tests.

To maintain continuity with the HST segment all the bioassays in the IST test series were again tested against the OK Falls (Big Horn) product, which has become the standard. The results of these tests are summarized in Figure G2-3.

The most noticeable difference when comparing the HST and IST test segments is the impact on die-back control. In the HST tests only Check and Heat treatment soils (20% of the treatments) had die-back scores greater than 5 (Figure G2-1), while in the IST test 50% of the treatments had die-back scores above 5 (Figure G2-3), indicating significant root problems.

The most striking observation in the IST/HST comparison is the impact of a Dithane treatment to the soil. In the HST group the average Dithane treatment the die-back scored just over 4 and was the fifth best (Figure G2-1), while in the IST test group, where a significant infection pressure was known, the average Dithane treatment gave the best
die-back rating (3) (Figure G2-4) indicating healthy roots. This “curative” effect is consistent with all individual IST soils but one. Only soil 12-17 approached the concern level of 5.

**Figure G2-4**

In comparison to Dithane the OK Falls compost had a mixed impact on the individual soils (Figure G2-5). In this case the compost had a very positive effect on the die-back levels in only 50% of the soils while in the other 50% the compost treatments gave poor die-back control. It is concluded from this test that compost amendments have a limited effect on soil pathogens under strong infection pressure.

**FIGURE G2-5**

The un-amended soil summary (Figure G2-6) indicates that without any amendment 83% of the soils had dieback levels that were a concern. This emphasizes again the impact of Dithane in controlling potential root die-back.
Summary of the Compost Application Methods:
Incorporation of the compost into the soil was standard in Slykhuis’ original research approach and was the chosen application method in these bioassay trials. Typically in the field the compost is surface applied and seemed to work well in the 2011 orchard trials and proved effective again in 2012. However, there was a definite problem with the Oliver cherry replant block where the compost was mixed into the soil. The question was: Why were these trees not responding to the treatments?

In an attempt to answer whether or not the incorporation of the compost was resulting in a “diluted” effect, seven tests (3 in the HST segment and 4 in the IST segment) included both incorporation and surface application of compost for comparison of response. A summary of the average response in each case is shown in Figure G2-7. These results

---

**FIGURE G2-6**

Summary of Check Scores for Individual Soils in the IST Group
(Sorted by Ascending Die-back Scores)

<table>
<thead>
<tr>
<th>Root Scores (1-10 Scale)</th>
<th>12-17</th>
<th>12-21</th>
<th>12-20</th>
<th>12-19</th>
<th>12-22</th>
<th>12-23</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5.3</td>
</tr>
<tr>
<td>Feeder</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4.3</td>
</tr>
<tr>
<td>Die-back</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3.3</td>
</tr>
</tbody>
</table>

**FIGURE G2-7**

Comparison of Root Scores Between Surface Application and Mixing Compost into the Soil for HST and IST Segments

<table>
<thead>
<tr>
<th>Root Scores (1-10 Scale)</th>
<th>OK Surface</th>
<th>OK Compost</th>
<th>OK Surface</th>
<th>OK Comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST</td>
<td>Series1</td>
<td>Series2</td>
<td>Series3</td>
<td></td>
</tr>
</tbody>
</table>
come from a limited number of tests and the comparison requires further testing, but there is a trend indicating that the surface application is effective in the HST segment, i.e., under normal* infection pressure but was not as effective when the test soil was challenged with a significant infection level.

For organic growers who tend to use un-composted manures there is an added danger that there will be significant levels of pathogens in the manure. Of particular concern are the phycomycetes; Phytophthora and Pythium, as well as Cylindrocarpon and Fusarium. These pathogens are commonly found in the local area associated with tree disorders.

*Note: The term normal is used here to indicate no artificial pathogen introduction.

**Goal 2b**

*Use the bioassay to directly compare the impact of various composts on soil performance. Determine if the bioassay can be used to apply standards to the various compost sources.*

In order to compare the compost sources the various products were run side-by-side in the bioassay trials and compared directly when available (some products did not become available until mid summer and were not tested in both the HST and IST groups). The OK Falls product was used as a standard and was run as treatment #1 in all assays. Figure G2-8 is a chart presenting those comparisons.

**Figure G2-8**

*Comparison Between all Bioassay Treatments Involving the Various Compost Sources*
The two group categories HST and IST are separated by colour (HST blue and IST green). These average scores illustrate some significant properties about the products and their application. It is important to note however that the numbers that go together to make up these averages show a tremendous variation. In other words figure G2-8 tells the general story that:

1. All compost products controlled die-back in the HST test. Only the OK Falls product (rating 4.9) approached the “concern” level for commercial blocks but was much better than control.

2. The control of die-back by all compost products was relatively poor in the IST group, which suggests these products have a protectant capability but are weak as curative products, averaging about the same as check in control of die-back.

3. In both groups the compost treatments were associated with fair to good feeder root development.

4. In the HST group there were three soils where OK Falls product was tested by incorporating the compost into the soil and by surface application. In the IST group OK Falls and Oliver compost were compared by incorporation and surface application. In these tests it appeared that the surface application was better in the HST test but the surface application did poorer when the soils were challenged with infected seedlings.

General assessment:
The bio-assay needs a more objective root scoring system. Attempts to accomplish this are being researched at UBC Okanagan in a masters program by Molly Thurston. In this research there is an attempt to evaluate root mass using a computer modeling system. This technique can determine mass but at this time can not sort out feeder roots and die-back from the total mass. There may be computer models that could make that separation and could computerize the valuation system making it more objective and faster but for the present it is best done by subjective, visual evaluations.

It is a logical extension of the bioassay test to carry out determinations on the types of pathogens associated with the die-back that are so common in the root systems. One obvious group of pathogens (or part of a complex) are the plant pathogenic nematodes. Experience in the 2011 project indicated that fungal pathogens also play a role in the complex (see below under Goal 5).

**Goal 3:**

*Assess the 2011 blocks to determine if the improvement in tree growth response continues into the second year.*

The question growers always ask is; “Does the compost need to be added each year or is the effect carried over?” This question was partly answered by: (1) checking the root system in one treated block in the second spring and comparing the root scores with roots in adjoining trees that were not treated and (2) measuring the trunk diameter in three trial blocks from the 2011 study. The results are summarized below.
Root:
The Steve Brown orchard in Summerland applied a heavy application (12 tonnes per acre) in the spring of 2011. That orchard was not scored in detail but was investigated and response noted in the fall of 2011. In early spring 2012 the block was assessed for root condition (Figure G3-1).

Figure G3-1

Comparison between Compost Treated and Non Treated Root Systems in Spring of Year 2 (S. Brown Orchard Summerland)

A typical impact on the level of die-back in the spring of 2012 stands out in this evaluation. Root die-back assessment in the non-compost area indicates severe problems while in the 2011 compost treated section die-back levels are not a problem.

Trunk Diameter:
Typically in past trials trunk diameter increase was greater where compost was used. The trend was slight in the 2011 assessment but when checked in the fall of 2012 the differences in response between treatments were more pronounced (Figures G3-2, 3 & 4).

In the Cawston trials the compost impact was greater in the Ambrosia block (Figure G3-2) where the increase in diameter was over 2 1/2 times the check increase. In this trial the compost rate was the standard 4 tons per acre. In the Spartan block (Figure G2-3 there was no significant difference at this lower rate but at the 12 ton per acre rate there was a 30% higher response.

As was pointed out in the 2011 report the two blocks were quite different in their vigour and soil type. The Spartan block, prior to the 2011 treatments was much healthier looking than the Ambrosia block. The Spartan block was chosen for the 2011 trial because it had problems in its first 2 years after planting. The block had gone through a number of treatments to improve the root conditions and tree health and was a good test block to assess how the compost would impact a relatively healthy block.
The Vernon Ambrosia block had the most stunted trees with severe root problems when the test was started in 2011. Trunk diameters increased over the season in 2011. From fall 2011 to fall 2012 the compost treated trees achieved a greater increase than the check (Figure G3-4).
Also noticeable but unexplained in all blocks is the apparent negative effect the compost and phosphorus combination had on diameter increase over straight compost. This negative effect was pointed out in the 2011 report. Based on that finding it has been suggested to growers that the combination application is not recommended.

The recommendation given to growers in a replant situation or where severe decline is occurring is to apply phosphorus in order to stimulate feeder roots, wait a week, then apply the compost. When applying compost as a maintenance treatment the phosphorus treatment does not seem necessary.

**Goal 4:**

*Within monetary restraints of the project some detailed work was done as follows:*

(a) Soil chemical analysis on all replant soils.
(b) Nematode analysis done on 17 of the 23 test soils
(c) Cherry fruit quality was tested to determine if fruit grown under compost was of better quality than fruit grown without compost.

(A) Soil chemistry has major influence on soil fertility. Nutrient availability is also influenced by soil pH and even some of the chemicals recommended as treatment for soil pathogens are sensitive to soil pH. The information in Table 2 can be used in the diagnosis of any seedling growth problems or any treatment anomalies.
Many nutrient deficiencies in plants are directly related to the availability of that nutrient in the soil so assessing nutrient levels is an important part of the pre-plant preparation in replanting and in treatments necessary to counter decline.

(B) Soil pathogens can have a major impact on replant success. A lot of research has been done internationally assessing compost and its impact on soil pathogens. The 2011 RDOS project demonstrated the presence of pathogens including fungi and
nematodes. Dr. Tom Forge, Agriculture Canada nematologist, is cooperating with us and is supplying nematode counts on test soils.

Tom’s work on berry crops has shown that compost rates at the levels we are using do not directly suppress nematode numbers but that very high rates (in the 20-40 tons per acre range) can. However, as has been the experience in past work, it appears that the nematodes can cause significant damage as part of a complex involving fungi, and serve as entry points for fungi such as Fusarium spp. and a Cylindrocarpon sp. (McPhee, W. J. And D. Hewitt. 2010). Involvement of a nematode/Fusarium sp. complex has been known for more than two decades (5).

The nematode results so far received indicate 2 soils with significantly high nematode counts, both associated with problem blocks (numbers in red) and three blocks with moderate levels (numbers blue) that could be of concern (Table 3).

| TABLE 3 |
|----------|-----------------|
|          | Nematode Assay Numbers (per 100cc soil) |
| Neal/Louisa Carter | No compost |
| Steve Brown | Compost in 2011 @ 12T/acrr |
| Neal/Louisa Carter | Compost in 2011 @ 12T/acrr |
| Sam DiMaria | No compost |
| Neal Dendy | No compost |
| Parmjit Gill | No compost |
| Parm Dhaliwal | No compost |
| Haithwaite | Front Fuji SW 2L |
| R. Brungardt | East side 2L |
| F. McLennan | Cherry Replant 1.5L |
| N&W Richards | Compost Cherry (Lambert rows 2L |
| Steve Brown | Cherry Decline |
|           | 12-11B 0 |
|           | 12-12B 1 |
|           | 12-13B 12 |
|           | 12-14B 0 |
|           | 12-15B 119 |
|           | 12-16C 6 |
|           | 12-17C 416 |
|           | 12-12-5-5B 27 |
|           | 12-6-5B 5 |
|           | 12-7-8B 42 |
|           | 12-8-8B 58 |
|           | 12-9B 2 |

The nematode data on problem soils or on soils being prepared for replant and in decline orchards are extremely important in planning early growth strategies for any newly planted blocks.
Goal 5:
Monitor last year’s alfalfa trial to establish whether or not the root influences associated with the use of compost persisted and check if nodules returned to the roots.

The alfalfa growers did not choose to participate in compost application this year. Funding was not sufficient to take on the cost of application and monitoring to the degree done in 2011. However last year’s co-operator is interested to the extent that a root assessment will be carried out in the spring of 2013.

Conclusions:
Meeting the multiple objectives of weed control and optimal increased soil biological activity may require employment of different floor management strategies at different times during the life of the orchard.

This comment from a WA group, which works closely with local researchers from PARC on soil related projects specific to tree growth and health, supports the basic premise in this work. That premise is that orchard conditions are complex and variable and these soil characteristics are the basis on which soil monitoring is presented here as extremely important to orchard production and especially to organic production.

The evaluation of root systems on compost treated, chemically modified and un-amended soils are a necessary exercise to determine the full role compost can be expected to play. The more detail we gather on the impact of compost the more efficiently it can be utilized as an aid to fruit production in the area. It is clear from early data that compost products needs to be monitored properly and managed critically in order to maximize their impact on soils and tree growth. The physical properties of the compost and its food-safe characteristics are easily obtained utilizing commercial testing labs. The availability of these products and their specific activity on individual soil microbiology are just now becoming available to local growers.

Variations in soil responses to different compost products are very significant. In Goal 2, Results and Discussion, it was clear that the capabilities of compost in root health were limited when there was a high level of root pathogens in the soil. In this case Dithane was far superior and illustrated the need for soil evaluations (bioassay tests) to determine when chemical tools are needed for conventional orchards. It is also clear from the same section that the application of compost into the soil at the time of replanting may not be the best solution for organic growers.
Also differences between compost incorporated into the soil and compost topically applied needs some further investigation. Early work by Dr. John Slykhuis showed that soil amendments like fertilizers and peat often failed to correct soil disorders.

Evaluation of alfalfa has not been satisfactory thus far. There were no alfalfa cooperators available for new 2012 trials but efforts will be made to update the 2012 information at the Casorso site. The 2011 results on alfalfa were very encouraging but the logistics of application and the cost for full coverage of alfalfa fields seemed to be a deterrent to the grower.

References


Contact for laboratories used and for research collaborators.

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Dr. Tom Forge: PARC. 4200 Highway 97, Summerland B.C.  (250) 494-7711
This photo illustrates the poor condition of the roots in this block before treatment. Gnarled roots and lack of side branching (arrow) is typical of nematode damage.

Photo 2 shows the dramatic recovery of the root system a few days after treatment with compost. Some die-back is evident (arrows) but succulent new feeders are clean.