FINAL REPORT

ALASKA SOIL AND PEONY PLANT NUTRIENT STUDY – PHASE 2

2011 ALASKA GROWN SPECIALTY CROP COMPETITIVE GRANT PROGRAM

SUBMITTED TO

ALASKA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF AGRICULTURE

SUBMITTED BY

ALASKA PEONY GROWERS ASSOCIATION, INC.

TABLE OF CONTENTS

Appendices

TABLE OF CONTENTS (CONT'D)

ABBREVIATIONS & ACRONYMS

%	percent
~	approximately
Al	aluminum
B	boron
Ca	calcium
Cu	copper
Fe	iron
K	potassium
Mg	magnesium
Mn	manganese
Mo	molybdenum
N	nitrogen
P	phosphorus
ppm	parts per million
S	sulfur
Zn	zinc

SUMMARY

A two-year study was designed and conducted to develop baseline nutrient needs for Alaska peonies. Soil and leaf samples were collected from peony farms located throughout Alaska, and the sample data were compared to sample data collected from peony farms located in the lower 48 states. The data from the project were compiled with data collected in an earlier phase of work and used to evaluate best sampling methodologies, differences between upper and lower leaf nutrient concentrations, correlation between co-sampled soil and leaf samples, changes in leaf nutrient concentrations throughout a growing season, differences between healthy and poorly-performing plants, differences between three Alaska regions, and evidence for a general nutritional improvement in Alaska peonies between 2010 and 2014.

INTRODUCTION

Background

In 2009, many grower members of the Alaska Peony Growers Association (APGA) were experiencing poor plant vitality (stunting, necrosis of the leaf tips, thin cupped leaves with wavy edges, interveinal chlorosis) and high mortality rates in their young peony fields. Since the literature available in the public domain does not provide the sort of nutrient data APGA growers were seeking, APGA applied for and received an Alaska Grown Specialty Crop Grant to compare soil and tissue nutrient concentrations in Alaska peonies with peonies in the continental U.S. The study was not designed to be a rigorous scientific study because it relies on farmers with only a limited amount of time and training. However, APGA felt that if the results could be reproduced year after year in strong healthy peonies, the validity of the results would become increasingly reliable. The hope was that leaf analyses could provide guidelines for our growers to evaluate the presence and cause of potential nutritional problems.

The results from that first phase of study[1] suggest that while soil nutrient levels from healthy peony fields (from both Outside and Alaska farms) vary over a wide range of concentrations (often more than an order of magnitude depending on the nutrient), the nutrient content in healthy peony leaves (e.g., from the Outside Growers' plants) have much more constrained concentration ranges. The concentrations of all the major nutrients (N-P-K-Ca-Na-S) in peony leaves varied by only a factor of one or two in healthy plants, and the concentrations of the trace elements (Fe-Al-Mn-B-Cu-Zn)

[1]Richards, D., 2010. *Determining a Baseline of Existing Fertility Applications in Alaskan Peony Production compared to Oregon Peony Production, final report* prepared for the Alaska Peony Growers Association, Inc. and submitted to the Alaska Department of Agriculture under the Specialty Crop Competitive Grant, December 29, 2010.

generally varied between factors of five and six. These results suggested that tissue sampling could provide a better means to assess peony nutrient deficiencies than soil sampling alone.

Project Objectives

In 2011, APGA was awarded a follow-up Specialty Crop Competitive Grant to continue the first nutrient study. Phase 2 of the project involved collecting samples for another two growing seasons to address the following goals:

1. Supplement the data from the Phase 1 project and identify preliminary target nutrient levels in support of a longer-term goal to establish reliable target leaf nutrient levels (shortage, below normal, normal, above normal, and excess) for our growers.

2. Analyze if differences between new (upper) and basal (lower) peony leaves can assist in identifying nutrient deficiencies.

3. Identify potential soil nutrient deficiencies from co-sampled soil samples.

Project Approach

The approach taken for the project involved the following activities:

1. Following the approach used by New Zealand peony growers to monitor nutrient levels, the project team decided that all growers would collect one soil and one leaf sample at the disbudding stage using the uppermost fully formed leaf plus one soil sample when the plants are being cut down in the fall. The fall soil sampling was designed primarily for the growers' use in identifying fertilization requirements for the following spring.

2. Outside growers would collect only one leaf sample at the disbudding stage for comparison purposes.

3. Three Alaska growers would collect soil and leaf samples every two weeks throughout the growing season using both the basal and uppermost fully formed leaves for analysis. This task would provide the comparisons between basal and upper leaves envisioned by the proposal as well as changes in nutrient levels across a growing season.

In 2012, 14 Alaska and five Outside farms signed up to collect upper leaves at the disbudding stage. However, only one of the five Outside growers and 10 of the 14 Alaska growers that had signed up to collect the disbudding-stage samples collected their samples. In addition, of the three Alaska growers assigned to collect samples every two weeks, none of them were able to collect the entire set of samples.

In the 2013 growing season, Alaska encountered a long wet spring followed by a record-setting warm June which resulted in normal spring-time activities (weeding, fertilizing, spraying, etc.) being conducted over a shortened timeframe and, in many cases, alongside harvest activities. In addition, the extremely hot weather that blanketed the state during the harvest season reduced the peony bloom season from a normal 4 to 6 week period to 2 weeks. Since the grant work is largely carried out voluntarily by our grower members, sample collection is only one of many tasks that a grower needs to accomplish during the summer. However, few, if any, farms were prepared for the increased labor needed to handle the shortened timeframe for spring maintenance and for cutting stems at harvest time. The unfortunate outcome of these weather anomalies was that the growers were not able to collect the necessary samples for our project.

Thus, the second year of sampling was postponed until 2014. Before starting the 2014 sampling program, the research committee reviewed the results from the 2012 events and identified methods to enhance the program. First of all, the sampling program was simplified to address our relatively poor completion rate (81%) in 2012. In order to improve our completion rate, the project was modified in two important ways.

- The sampling scheme was simplified by dropping the biweekly and end-of-season sampling events in order to focus on assessing the nutritional status of the peonies at their dis-budding stage.

- APGA hired UAF researcher and APGA member Dr. Mingchu Zhang to collect all of the Alaska samples, compile the 2014 data, and prepare a large portion of the data evaluation and project report. This relieved the individual growers from taking the time to collect the samples, ensured that all the samples were collected, and enabled uniform sampling protocols to be used at each farm.

One other problem with the 2012 sampling had involved deciding which peony plants to include in the composite leaf samples. The growers were not certain if they were to collect leaves from poorly performing plants or healthy plants or both. For the 2014 season, separate samples were collected from poorly performing plants and reasonably healthy looking plants from each participating farm based on a visual inspection at the time of sampling. In addition to tracking samples by healthy and not-healthy, samples were tracked by variety. Sets of “good” and “poor” Sarah Bernhardt samples were collected from all but two of the 21 Alaska farms and sets of “good” and “poor” sets of Duchesse deNemour samples were collected from 16 farms.

Twenty-three growers signed up to participate in the project, including eight from the Interior, four from south-central, nine from the Kenai Peninsula, and four from Outside. All of the Alaska samples

were collected by Mingchu Zhang and Bob Van Veldhuizen between the end of June and the middle of July. Of four Outside growers who agreed to collect samples, only two submitted samples.

Definitions

The following terms are used in this report using the definitions below.

Bottom (basal) leaf (leaves). Samples of peony leaves collected from the oldest leaves plus petiole at the bottom of the plant.

Composite leaf sample. A sample of leaves collected from 10 to 20 different plants within one variety or block, generally equal to about two cups of leaves.

Composite soil sample. A soil sample collected from 10 to 20 different locations within the field or block of peonies. Sampling depth was generally from three to six inches below ground level.

Outside data (growers). Peony data or a peony grower from the continental United States.

Target range. A nutrient's range of concentrations obtained from Outside peony plant leaves.

Tissue sample. Leaf sample.

Upper leaf (leaves). Samples of peony leaves collected from the first full leaf plus petiole at the top of the plant.

Analytical Laboratory

All samples collected for this project were analyzed by Brookside Laboratory located in New Bremen, Ohio.

DATA COMPILATION AND ANALYSIS

Appendix A contains a compilation of all the analytical data that has been obtain from the 2010, 2012, and 2014 growing seasons. Data obtained from each farm are referenced by a location identifier rather than by farm name for privacy purposes.

Nutrient Target Ranges

The principle thesis of the APGA studies is that the nutrient content in healthy Alaska peonies should mimic the nutrient content in peonies that have grown for many years in the lower 48 states. For that reason, this project attempted to collect tissue samples from Outside peony growers each

year that Alaska samples were collected. Adelman Peonies, Hollingsworth Peonies, Oregon Perennials, and A-1 Peonies have generously collected samples in our support.

Chart 1 and Table 1 summarize the data obtained from Outside peonies, including the upper and lower range of concentrations as well as the average concentration for each nutrient. These data are referred to as our "target ranges" and are used for comparison purposes to evaluate data from Alaska plants.

Comparison of 2010 and 2012 Basal Leaf Sample Data

Chart 2 shows the range of 2012 data obtained from basal leaves in comparison to the range of the 2010 samples, all of which were from basal peony leaves. In general, the range for each nutrient is smaller in 2012, possibly due to the smaller number of samples collected in 2012. The average concentrations are practically identical between the two years for N-P-K and the same or higher in 2012 for the other nutrients except for copper and zinc.

2012 Upper Leaf Concentrations Week 0 thru Week 10

Three farms (ZUMA, PEONY, and MERLOT) collected composite upper leaf samples approximately two weeks apart starting when the peonies were at the disbudding stage ("Week 0"). Chart 3 provides bar charts for each individual analyte to illustrate the compositional changes over time in the upper leaves for the three farms.

The major elements generally had similar concentration trends across the growing season for all three farms. In general, the upper leaf data from the three farms show:

- *Decreasing nitrogen and phosphorus concentrations.* These elements may decrease in plant tissue through the growing season due to high demand during the flowering and seed-forming stages and/or due to soil nitrogen depletion.

- *Increasing calcium and magnesium concentrations.* The increases in these elements do not appear to be related to fertilization schedules and suggest instead that they become more available to the plants as the soil warms, rainfall increases, or due to other environmental factors. ZUMA, and possibly the other two farms, also show increasing sulfur concentrations through the season.

- *No consistent trend for potassium concentrations*. In general, it appears that potassium concentrations remain relatively stable in the upper peony leaves throughout the growing season.

A possible effect from two different fertilization approaches may show up in these charts. PEONY applied about twice the amount of granular fertilizer than ZUMA at the beginning of the season whereas ZUMA applied a second fertilization mid-season via fertigation. Although ZUMA's two-stage application system appears to have resulted in more consistent nitrogen concentrations over the growing season, it does not appear to have appreciably maintained the phosphorus concentrations. ZUMA also applied high-phosphorus water soluble fertilizer as a foliar spray before week 8, but without an appreciable increase in the upper leaves.

The concentration trends for the minor elements are not as consistent between the farms as the major elements. Zinc concentrations at the three farms decreased during the season, but the cause is not known. Aluminum and iron increased at PEONY and MERLOT, but not at ZUMA. As with calcium and magnesium, the increases in aluminum and iron may reflect increased availability as the season progresses. In contrast to the other farms, ZUMA iron concentrations were relatively low and manganese concentrations relatively high throughout the season. High manganese levels are known to impede iron uptake and this antagonistic effect may explain the consistently low iron levels at ZUMA.

Comparisons of 2012 Co-Sampled Upper Leaf, Lower Leaf, and Soil Concentrations

One farm (ZUMA) collected composite samples of upper leaves, lower leaves, and soil approximately every two weeks in 2012. Chart 4 provides individual charts for each nutrient showing the target range for peony leaves and the upper leaf, lower leaf, and soil data from each of the 2012 sampling events.

Based on this set of data, it appears that:

1. The differences between upper and lower leaf concentrations appear negligible for most nutrients.

2. Potassium, aluminum, and iron are the exception to this pattern and appear to have consistently higher concentrations in bottom leaves.

3. Both mobile and immobile nutrients have similar concentration trends in the upper and lower leaves through the growing season.

4. Co-sampled soil data do not vary directly with the tissue data, most likely due to a time lag between a change in soil concentration and the resultant effect on the plant.

2014 Good vs Poor Plants and Soil

In 2014, the project involved collecting two sets of composite soil and tissue samples from Sarah Bernhardt plants and/or Duchesse deNemour peonies from each participating farm. One set was from plants that appeared visually healthy (referred to as "good") and the other set was from plants that did not appear healthy (referred to as "poor"). The purpose in tracking these four data sets was to see if potential nutritional needs could be identified in the tissue and/or soil analytical data. "Good" and "poor" plants are based on a visual evaluation of a plant's health at the time of the sampling event. It does not necessarily signify a superior propensity for increased stem count or bud size, two important factors to peony growers.

Charts 5 thru 9 are graphs used to make these evaluations, and Appendices B and C contain individual charts for each participating grower. Charts 5 and 6 compare the range of nutrient values for all the "good" and "poor" Alaska Duchesse and Sarah plants, respectively, with the target ranges. Chart 7 provides histograms of the entire Alaska 2014 data set, Chart 8 shows correlations between soil pH and plant nutrient values, Charts 9 and 10 show regional differences between the good and poor Duchesse and Sarah data sets, respectively, and Appendix D contains a separate more detailed report concerning regional differences. Chart 11 compares the change in nutrient ranges for farms that participated in all three of the sampling events for this project (2010, 2012, and 2014). Table 2 summarizes correlations between the 2014 soil and tissue nutrient concentrations. These data are discussed further in the following sections.

Comparison of the Average 2014 Good and Poor Tissue Data with Target Ranges

Charts 5 and 6 show the average nutrient values for the target, good, and poor plants for Duchesse and Sarah samples, respectively. For the most part it appears that the average Alaska concentration for each nutrient is generally within a factor of two of the target range except for aluminum and iron. The good and poor average values for aluminum and iron are approximately half the average target value for both Alaska Duchesse and Sarah plants. The average aluminum value is still within the target range, but the average Alaska iron concentration is even below the target iron range. Alaska soils tend to have relatively low pH and high organic matter levels which typically act to make iron more available. As such, the cause of endemic low iron in Alaska peonies is not known. Since low iron occurs in both good and poor plants, the benefit of adding iron is a topic for further study.

Although the average Alaska concentration is similar to the target range, it is often the case that the upper end of the good Alaska plants is below the upper end of the target range and/or the lower end of the good Alaska plants is below the lower end of the target range. For the purpose of this study, analyte concentrations in poor plants that are outside the target range but within the range of the good Alaska plants are assumed to be of less concern than analyte concentrations that fall

outside both the target range and the range for good Alaska plants. For poor Sarah plants, calcium, magnesium, sulfur, aluminum, and manganese concentrations are most notably at the low end of the spectrum and would therefore be of most concern. For Duchesse plants, phosphorus, potassium, magnesium, sulfur, aluminum, manganese, and zinc all appear to be of potential concern. Deficiencies in one or more of these analytes may contribute to poor plant vigor in some fields.

These data suggest that all in all, the nutrient composition of Alaska peony plants is similar to peonies in the lower 48. The individual charts in Appendix B show that in general, each farm has only one or two nutrients that may need to be boosted to enhance the health of their plants.

2014 Tissue Histograms

Chart 7 shows histograms for each nutrient and the counts for "good" Duchesse and Sarah Bernhardts and for "poor" Duchesse and Sarah Bernhardts. The first glance at these charts, again, indicates that the ranges for good and poor plants are almost the same. But if you take a closer look, and think in terms of "the odds", these charts become more informative. Take nitrogen for example. The "odds are" that the more nitrogen in your peony leaves, the better the chances are for your plants to appear healthy. And if your peonies contain less than 2 percent nitrogen, there's a pretty good chance that your plants will not appear healthy. Boron is another good example, where it appears that the odds are pretty good your plants will not appear healthy if their leaves contain more than 50 ppm boron, but the odds are pretty good that they will look healthy at 40 ppm boron.

Correlation Between 2014 Soil and 2014 Tissue Data

To evaluate whether soil concentrations correlate with the health of the plant, soil to plant correlation coefficients were calculated. Correlation coefficients (r) identify the tendency for a variable (in this case, the plant concentration) to change in value as another variable (soil concentration) changes in value. A correlation of 1 or -1 means that the plant's nutrient concentration correlates exactly with the soil's concentration (e.g., as the soil concentration increases, the plant concentration either increases or decreases). A correlation of 0 means that no correlation exists between the nutrient's soil concentration and the plant concentration. Values between 0 and 1 or -1 show an increasing tendency for the soil and plant concentrations to vary together. R values greater than about 0.8 (or -0.8) are considered to indicate a strong correlation whereas r values less than 0.5 (or -0.5) are considered to indicate only a weak correlation.

Table 2a summarizes the results of correlation calculations between soil nutrient concentrations and plant nutrient concentrations for the 2014 samples. The column called "All Plants" shows the r values between each nutrient's concentration in a soil sample with the corresponding plant sample

for all 2014 samples. In general, the data show only a weak correlation between the soil and plant concentrations for all of the nutrients; the highest correlation is 0.55 for aluminum.

Additional correlations shown on Table 2a were calculated between the following data sets:

- "good Duchesse plants" and "good Duchesse soil"
- "good Sarah plants" and "good Sarah soil"
- "poor Duchesse plants" and "poor Duchesse soil"
- "poor Sarah plants" and "poor Sarah soil".

Of all the analytes, only aluminum had r values above 0.5 for all four data sets. One interesting observation is that the soil magnesium concentration has a strong correlation with the plant magnesium concentration in Sarah plants ($r > 0.8$) but not in Duchesse plants ($r < 0.45$).

These calculated correlations agree with the soil data included on Chart 4 where a visual inspection shows that soil concentrations do not vary consistently with changes in leaf concentrations. What this means to the peony farmer is that a single soil analysis is of limited value for assessing problems associated with unhealthy plants at any specific point in time. Yearly data and careful record keeping will be of much greater value to assess a changed soil condition and its subsequent impact on plant health.

Soil pH is well known to have a significant control on plant uptake of nutrients. Soil pH values were plotted against tissue analyte concentrations for the four peony classifications with the expectation that good and poor peonies would form distinct clusters. Chart 8 contains the graphs for tissue analyte concentrations plotted against soil pH, and show that in almost every case, good and poor peonies largely plot in overlapping regions of the graphs. Some nutrients do have an apparently slight increase of poor plants plotted at the lower end of their concentrations, such as nitrogen, calcium, magnesium, boron, iron, and manganese. These differences are more easily discerned, however, on the histograms shown on Chart 7.

Table 2b lists the r values for the correlation between soil pH and plant nutrients, and Chart 8 includes trend lines for selected correlations to illustrate the difference between strong and weak and positive and negative correlations. The nitrogen chart illustrates a trend line showing no correlation between the analyte and soil pH. The phosphorus, magnesium, and copper charts illustrate trend lines with strong positive correlations between the analytes and soil pH. The aluminum and boron charts show trend lines with strong negative correlations between the analytes and soil pH.

For some analytes, Duchesse and Sarah form slightly different concentration clusters on the graphs. Phosphorus, calcium, magnesium, and boron show this apparent clustering most clearly. Duchesse plants tend to have higher calcium, magnesium, and boron concentrations and lower phosphorus concentrations than Sarah plants at any given pH.

Conclusions based on the 2014 correlation studies are preliminary in nature and would require additional data to confirm or support them, but potentially significant and/or interesting findings include:

- Co-sampled soil and plant tissue show only weak to no correlations between soil nutrient and plant nutrient concentrations.
- Only phosphorus and aluminum are significantly correlated with soil pH for soil with pH values of 6.0 or greater. Phosphorus correlates relatively well with pH for both Sarahs and Duchesse plants whereas aluminum has a relatively strong negative correlation with pH only for the Duchesse plants.
- Two plant samples with a soil pH of 7.8 and 8 respectively were both classified as poor while two plant samples with soil pH of 7.5 and 7.7 were both healthy, suggesting that the upper limit for healthy peony plants may be in the neighborhood of 7.7.
- Good and poor plant nutrient concentrations largely overlap for all the nutrients shown on Chart 8, but as seen on the histograms in Chart 7, poor plants appear to be relatively more abundant at lower concentration levels of nitrogen, calcium, magnesium, boron, iron, and manganese.
- The optimum target range for some analytes might depend upon the specific peony variety, based on the apparent tendency noted on Chart 8 for Duchesse and Sarah plants to have different phosphorus, calcium, magnesium, and boron concentrations.

REGIONAL COMPARISONS

Charts 9 and 10 show potential regional differences in the nutrient make up of Duchesse and Sarah peony plant tissue, respectively, based on the 2014 data. Appendix D contains a detailed report discussing regional differences in both soil and peony tissue data.

The nutrient concentrations in peony tissue, especially for nitrogen, demonstrate a fairly even range for both good and poor sites for both the Sarah Bernhardt and Duchess cultivars. For example, in the MatSu area, the good sites had a tissue nitrogen concentration of 2.23% for the Sarah Bernhardt

cultivar and 2.10% for the Duchess cultivar. In contrast, the poor sites only had a nitrogen concentration of 1.75% for the Sarah Bernhardt cultivar and 1.65% for the Duchess cultivar. For the interior and Kenai Peninsula, the difference between good and poor sites in terms of nitrogen concentration was narrow. However, that was most likely due to a higher supply of nutrients from the soil in the interior and Kenai Peninsula. The potassium concentrations appear to be negatively related to the nitrogen concentration in peony tissue, meaning high nitrogen concentrations are accompanied by low potassium concentrations in the peony tissue. For phosphorus, there is no clear trend.

For the micronutrient concentrations in the peony tissue, a high calcium concentration is associated with the good sites in all three regions for both cultivars. Since calcium can enhance the cell wall strength, the high nitrogen in the peony tissue corresponding with the high calcium concentration was good for plant growth for all growers in all regions. The magnesium and boron concentrations also correspond with the good and poor sites, meaning the good sites had higher apparent magnesium and boron concentrations in tissues than did the poor sites. For zinc and copper, the gap between the good and poor sites is not as large as for the other micronutrients. However, for the iron concentration, there is a large gap between the good and poor sites, especially for the Sarah Bernhardt cultivar. Iron is an essential element for chlorophyll production. The high iron concentration in tissue helps the photosynthesis process of the peony plants.

COMPARISON OF 2010-2012-2014 PARTICIPANTS DATA

Chart 11 summarizes data for the five farms that participated in all three years of the field studies, and Appendix C contains separate charts for each of these participants. The data on Chart 11 suggest that the concentration ranges have improved over the years as the peonies have matured, with nutrient ranges becoming tighter and increasingly similar to the target ranges except for aluminum, iron, and manganese. The Alaska concentration ranges for these three elements extend below the target ranges and their averages are about half of the target averages.

DISCUSSION

SUGGESTIONS FOR USING THE APPENDIX B GROWER CHARTS

Appendix B contains the individual grower charts for the 2014 participants. Growers who did not participate in the study but collect their own tissue samples should construct a similar chart for analyzing their data.

First, before analyzing the data, the grower should write out the major problem with their peonies. List problems like weak stems, excessive bud blast, leaf mottling, etc. Don't worry about individual

plants, think about an entire block of plants. When your problems are firmly in mind, study your tissue chart and note which nutrients are outside or near the bottom of their target concentrations.

1. If none of the analytes appear to be out of line, then turn to other environmental factors such as drought, flooding, cold soil, pests, etc. as a probable source of the problem.
2. Look for nutrients that are below (or above) the target range, especially those that are outside the range for both of your poor plants if you had both Sarah and Duchesse samples.
3. If both poor samples have a similar nutrient deficiency, research that nutrient for its effect on plant growth, signs of its deficiency, and cause of its deficiency. Although you won't find much information specifically for peonies, data pertaining to potatoes or other ornamentals may be useful.
4. If your good and poor samples both have a similar nutrient concentration, then that nutrient is most likely not a concern even if they are both outside the target range.
5. To optimize plant vigor, consider adjusting your fertilization program if your plants have nutrient levels that fall outside or near the margins of the target ranges. Study what could cause a deficiency in the plant uptake since it is not always the case that the cause is a soil deficiency in the same nutrient (e.g., as discussed in previous sections, high manganese concentrations can inhibit iron uptake, or high soil pH will inhibit aluminum mobility). In some cases, more than one year may be needed to see a change in the plant after adjusting the soil nutrient levels.
6. Develop a sampling program for your farm to track year-to-year changes in soil and plant nutrient levels. Collect samples every year at the same time in the plant growth cycle (we used the disbudding stage for our studies, but any convenient time will work, such as at the end of harvest or early spring after the plants have *x* number of leaves, etc). Transfer the laboratory data into a chart of some sort (either make a table in Excel or on a piece of paper, or make a graph like the ones in this report), and add on to the chart every year so you can easily identify changes in nutrient levels.

LESSONS LEARNED

1. Co-sampled soil nutrient data are only weakly correlated, if at all, with the nutrient content of peony leaves. This finding may be unexpected, but it is consistent with the findings in the first phase of this project. The report from the 2010 study indicates that low phosphorus conversion from soil to tissue and low to moderately-low boron conversion from soil to tissue are potentially significant problems in Alaska fields. This is not to imply that soil data

are not important, but rather to stress that regular soil sampling will be of more use to the grower.

2. Both mobile and immobile nutrients have similar concentration trends in the upper and lower leaves through the growing season, and based on our 2012 data, little additional information is gained by collecting samples from both sets of leaves. This finding is based on samples from one field for one growing season, and it may be advisable to confirm this finding in future studies.

3. Overall, 2014 samples from Alaska peony leaves have similar nutrient content as lower 48 peony leaves except possibly for aluminum, iron, and manganese. Individual farms have other deficiencies and/or excesses.

5. The approach for conducting both phases of this project was modified each year which, although not ideal or preferable from a consistency standpoint, has resulted in improved methodology for future studies, either by APGA for additional statewide studies or by individual growers. For all future projects, we highly recommend the following: a) have only one person collect all the samples, if possible, for consistency purposes, b) sample and track healthy and not-healthy plant tissue separately, and c) sample and track by variety if possible.

PROJECT BENEFICIARIES

The findings from this project are of benefit to all the Alaska peony growers, but most especially to the growers who participated in the sampling events. The participants have a base from which to continue long-term monitoring of their fields, and non-participants have a blueprint for evaluating their fields. Each grower can compare sample results from their own peony fields with data from other healthy peonies, including both Outside and Alaska peonies.

PROJECT SUPPORT

APGA would like to thank the Alaska Division of Agriculture for their continuing support of APGA research.

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TABLES

Table 1. Range and Average Concentrations from Lower 48 Peony Plant Tissue Samples

Nutrient	High Concentration	Low Concentration	Average Concentration
N (%)	4.3	1.5	2.6
P (%)	0.69	0.15	0.33
K (%)	1.5	0.73	1.1
Ca (%)	2.3	0.68	1.3
Mg (%)	0.54	0.18	0.36
S (%)	0.42	0.15	0.23
Al (ppm)	160	13	58
B (ppm)	46	5.0	25
Cu (ppm)	14	4.0	7.0
Fe (ppm)	139	58	98
Mn (ppm)	102	25	44
Zn (ppm)	67	23	40

Table 2. Correlation coefficients (r) between 2014 Co-Sampled Soil and Leaf Analyses

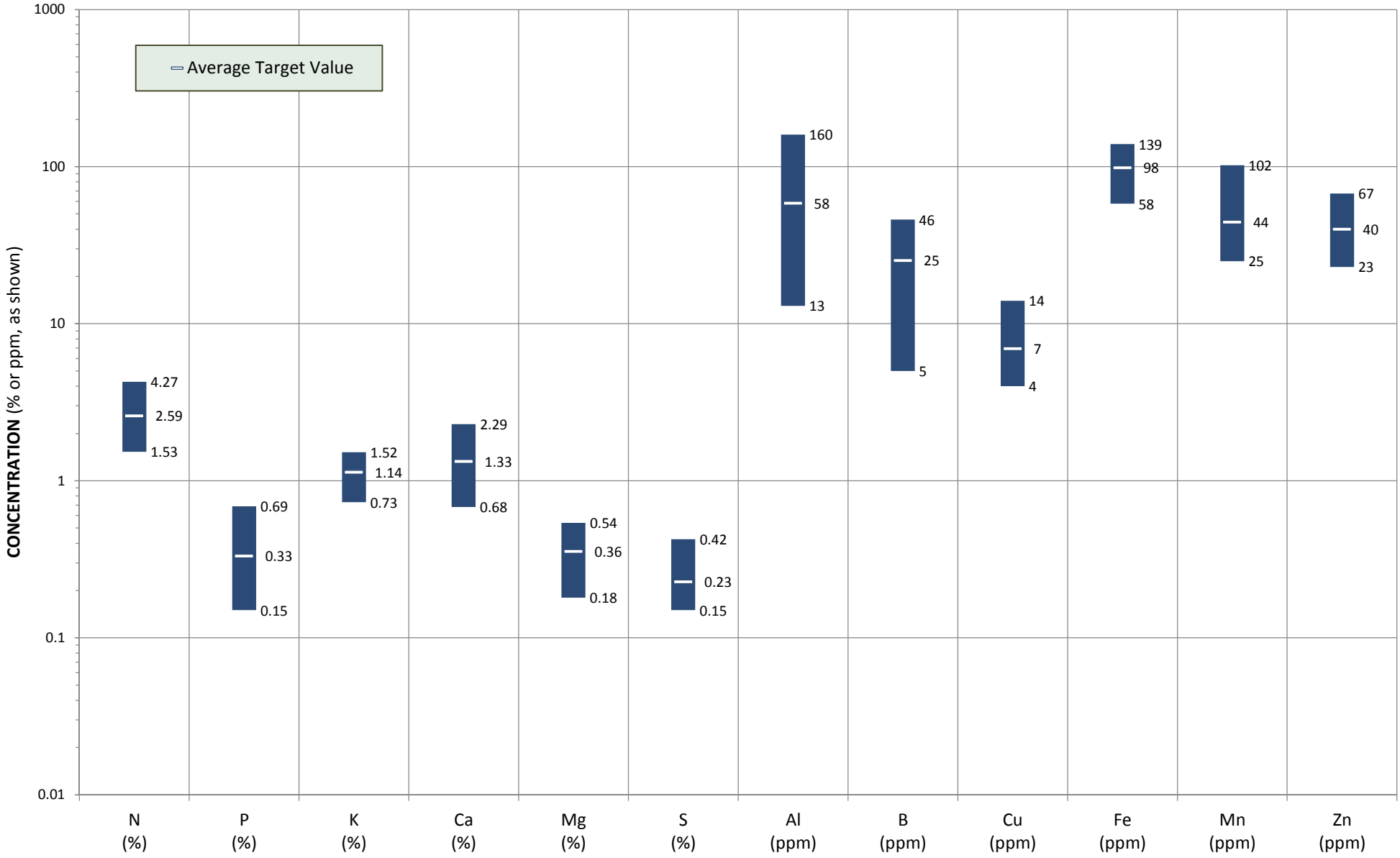
a. Soil analyte vs tissue analyte concentrations	All Plants	Duchesse - Good	Sarah - Good	Duchesse - Poor	Sarah - Poor
Nitrogen (Soil ppm/Tissue %)	0.24	0.46	0.31	0.06	0.21
Phosphorus (Soil ppm/Tissue %)	0.32	0.43	0.17	0.16	0.56
Potassium (Soil ppm/Tissue %)	0.23	0.65	0.20	0.32	0.11
Calcium (Soil ppm/Tissue %)	0.11	-0.04	0.36	0.26	0.46
Magnesium (Soil ppm/Tissue %)	0.45	0.42	0.80	0.35	0.87
Sulfur (Soil ppm/Tissue %)	0.14	0.06	0.17	0.25	0.02
Aluminum (Soil ppm/ Tissue ppm)	0.55	0.58	0.50	0.62	0.51
Boron (Soil ppm/ Tissue ppm)	0.34	0.26	0.36	0.45	0.41
Copper (Soil ppm/ Tissue ppm)	0.15	0.39	0.11	0.38	0.15
Iron (Soil ppm/ Tissue ppm)	0.11	0.12	0.14	0.14	0.13
Manganese (Soil ppm/ Tissue ppm)	0.06	0.42	-0.20	0.33	-0.07
Zinc (Soil ppm/ Tissue ppm)	0.27	0.36	0.34	0.05	0.61

b. Soil pH vs tissue concentrations	All Plants	Duchesse - Good	Sarah - Good	Duchesse - Poor	Sarah - Poor
Nitrogen (Soil pH/Tissue %)	0.05	-0.05	0.13	0.04	0.18
Phosphorus (Soil pH/Tissue %)	0.64	0.65	0.53	0.60	0.80
Potassium (Soil pH/Tissue %)	0.18	0.15	0.01	0.35	0.10
Calcium (Soil pH/Tissue %)	-0.17	-0.36	0.18	-0.33	0.17
Magnesium (Soil pH/Tissue %)	0.27	0.15	0.64	0.02	0.72
Sulfur (Soil pH/Tissue %)	0.22	-0.02	0.38	0.11	0.47
Aluminum (Soil pH/ Tissue ppm)	-0.53	-0.71	-0.43	-0.55	-0.40
Boron (Soil pH/ Tissue ppm)	-0.33	-0.50	-0.29	-0.18	-0.36
Copper (Soil pH/ Tissue ppm)	0.12	0.49	0.14	0.41	0.07
Iron (Soil pH/ Tissue ppm)	-0.12	-0.43	0.07	-0.23	0.12
Manganese (Soil pH/ Tissue ppm)	-0.21	0.06	-0.45	-0.04	-0.32
Zinc (Soil pH/ Tissue ppm)	-0.12	-0.21	-0.10	-0.07	-0.02

correlation coefficient $\geq |0.5|$

CHARTS

Chart 1. Range and Average Concentrations from Lower 48 Peony Plant Tissue Samples



Blue vertical bars represent the range of values in tissue samples from Outside Growers' plants, 2010 - 2014.

Chart 2. Comparison of 2010 and 2012 Bottom Leaf Analyses

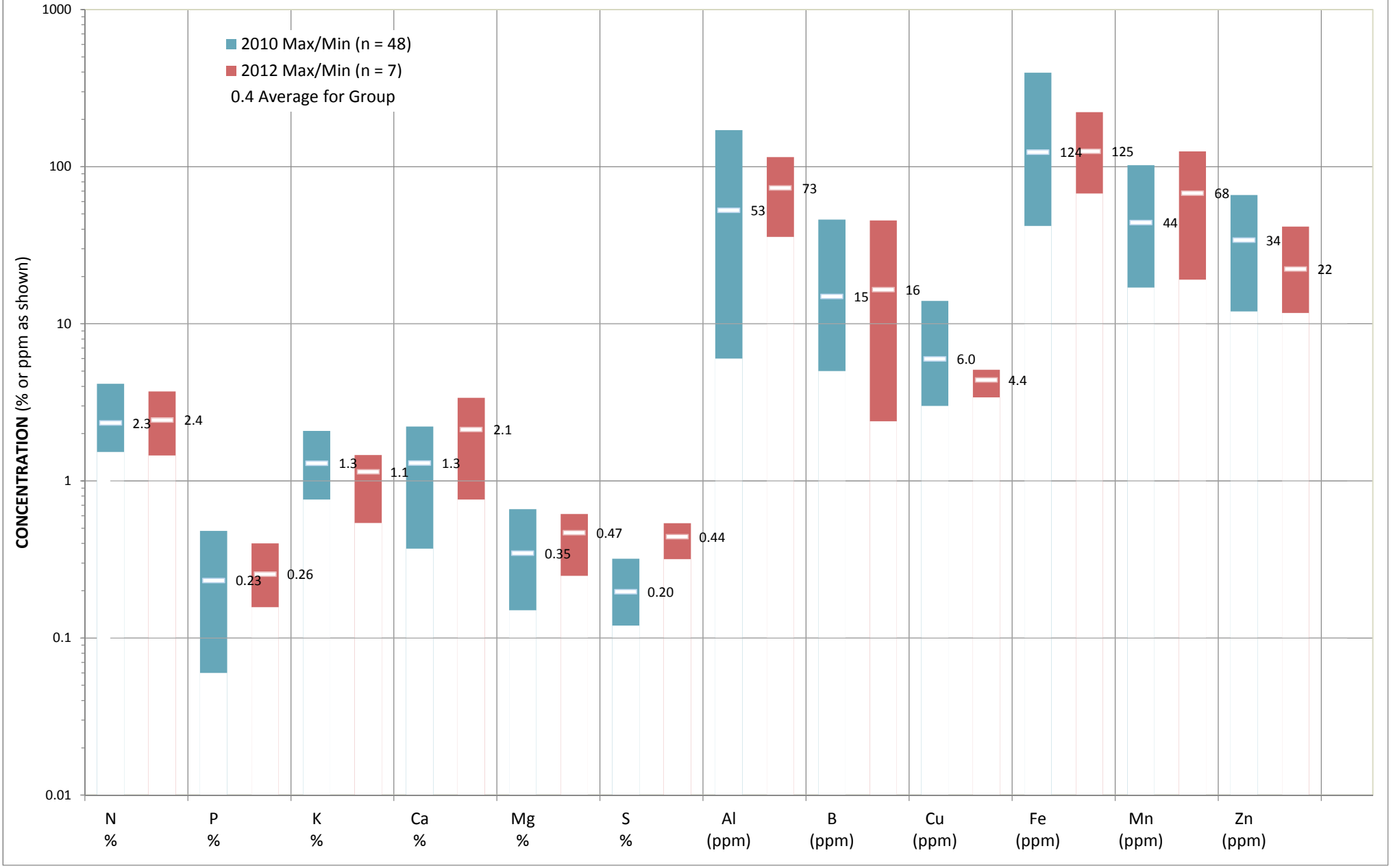
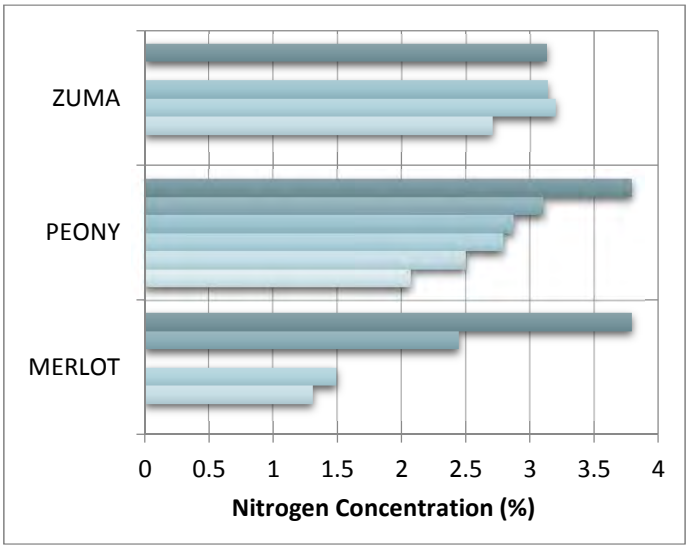
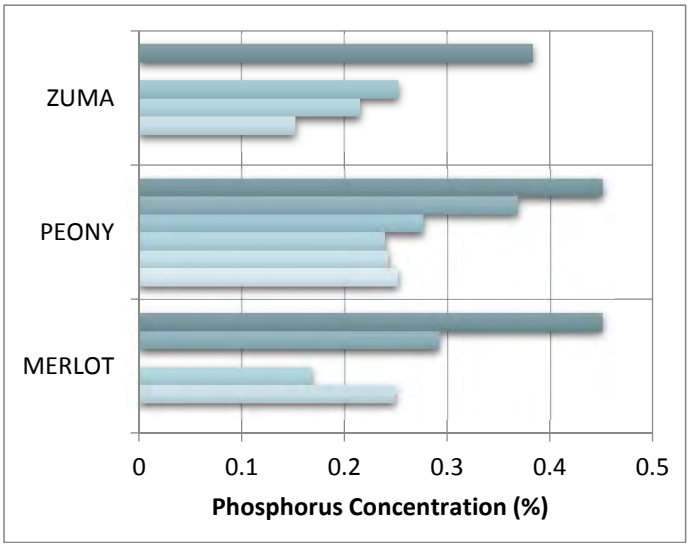
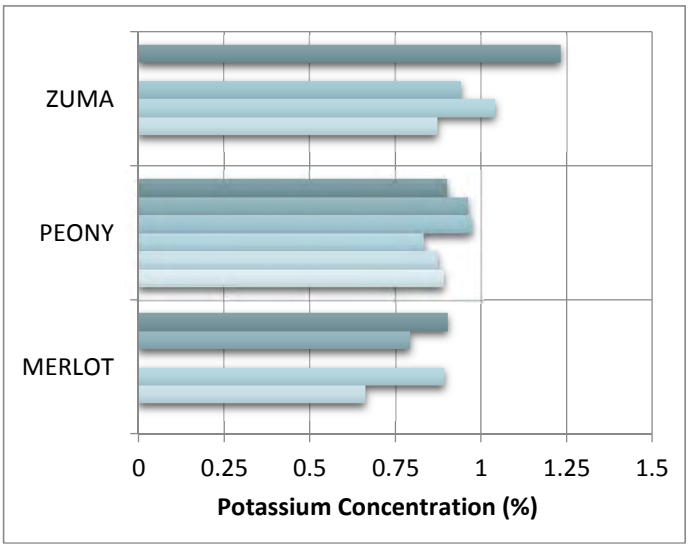
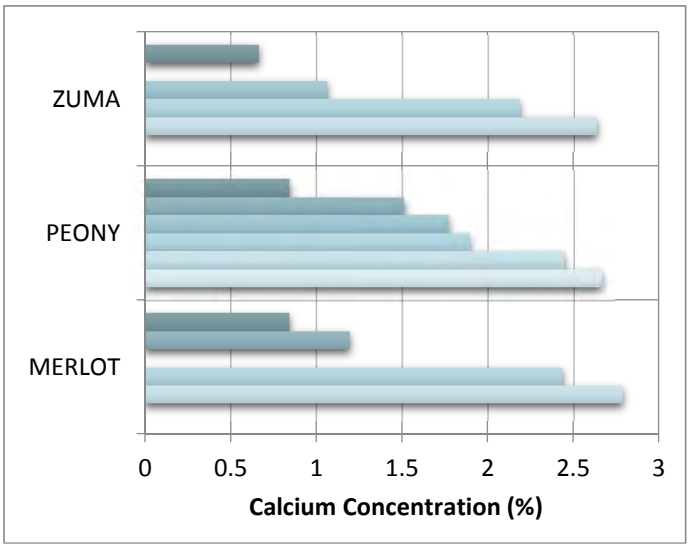


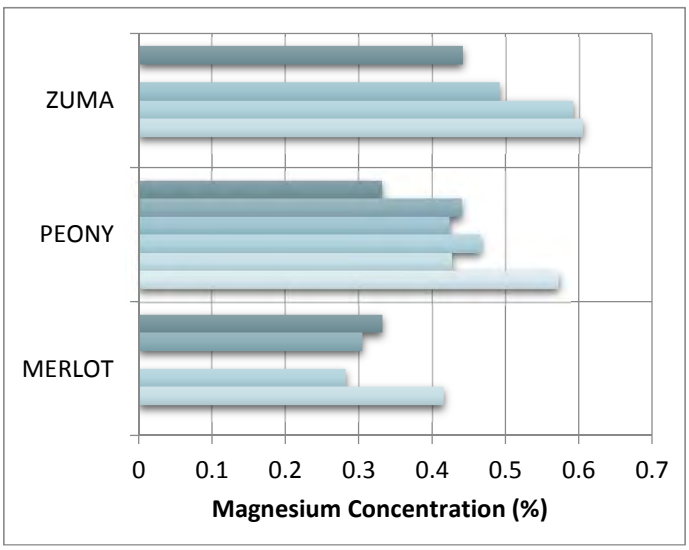
Chart 3. Upper Leaf Analyses from Three Farms, Week 0 to Week 10, 2012

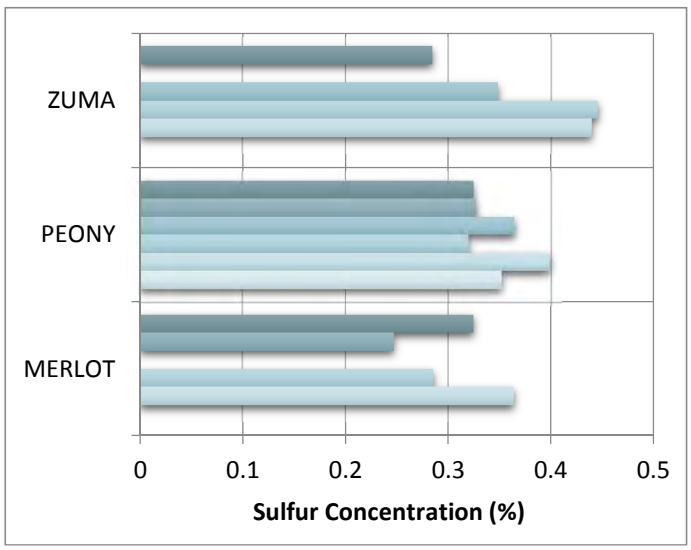






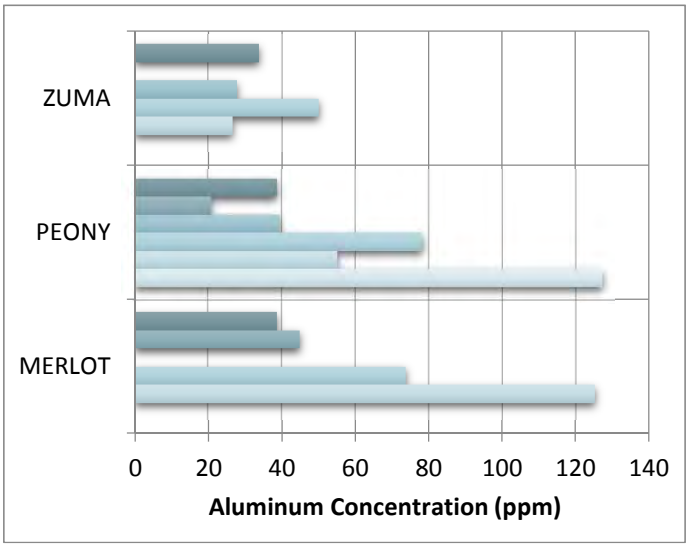


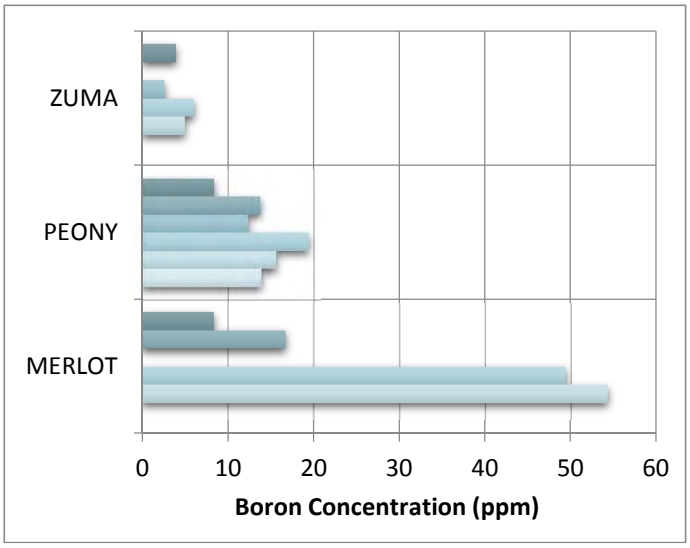


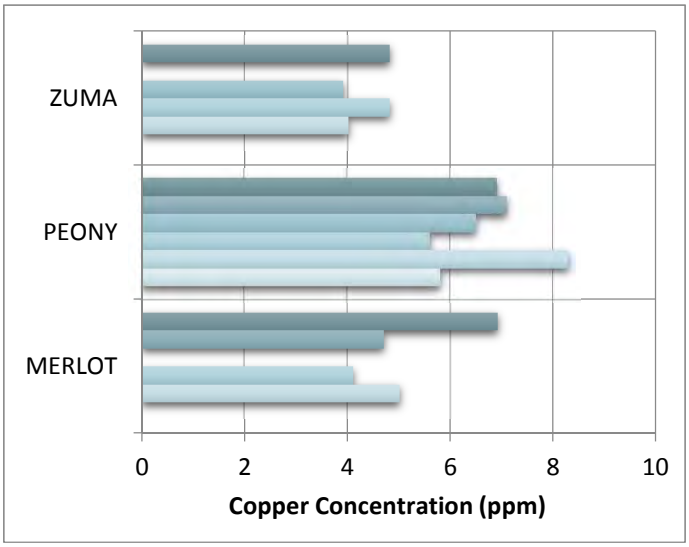


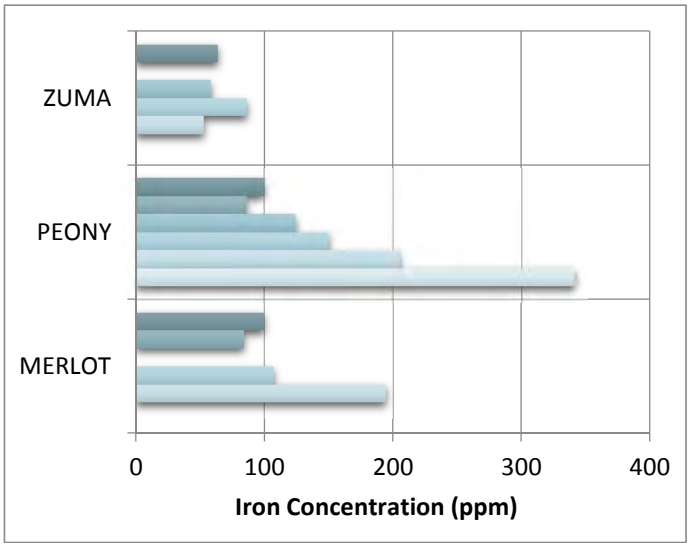
WEEK 0 WEEK 2 WEEK 4 WEEK 6 WEEK 8 WEEK 10

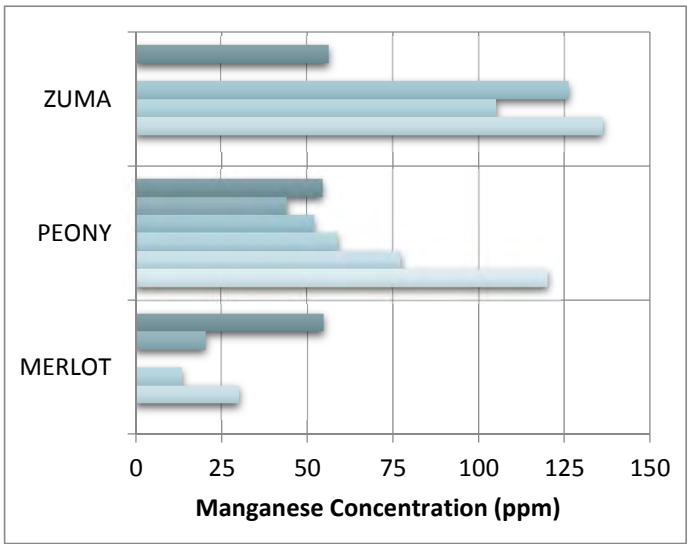
Chart 3 (cont'd). Upper Leaf Analyses from Three Farms, Week 0 to Week 10, 2012











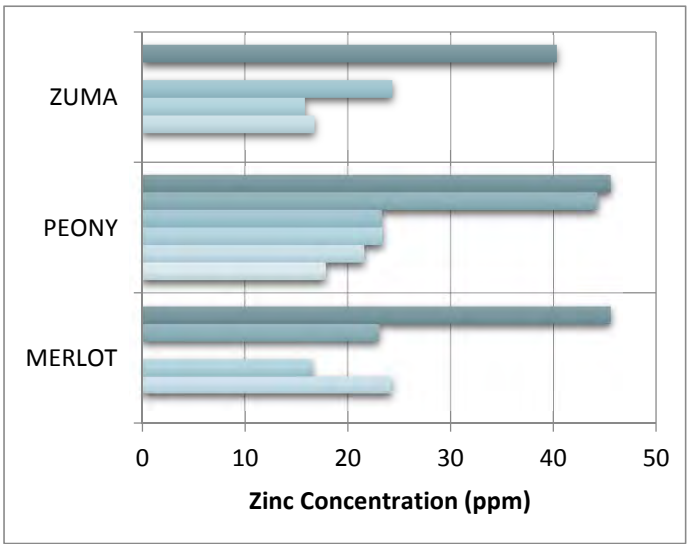


Chart 4. 2012 Upper Leaf, Lower Leaf, and Soil Analyses from ZUMA Duchesse Field

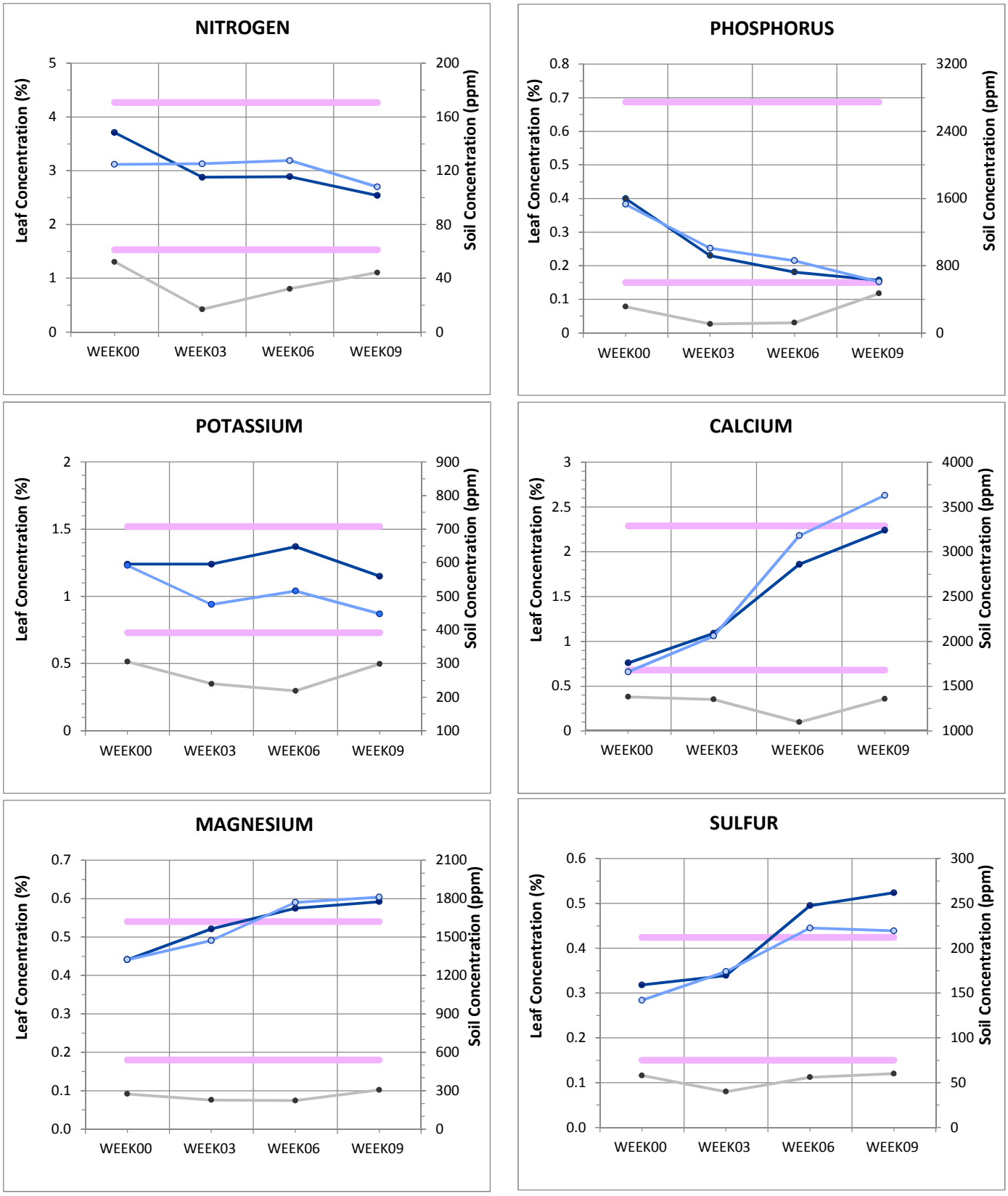


Chart 4 (cont'd). 2012 Upper Leaf, Lower Leaf, and Soil Analyses from ZUMA Duchesse Field

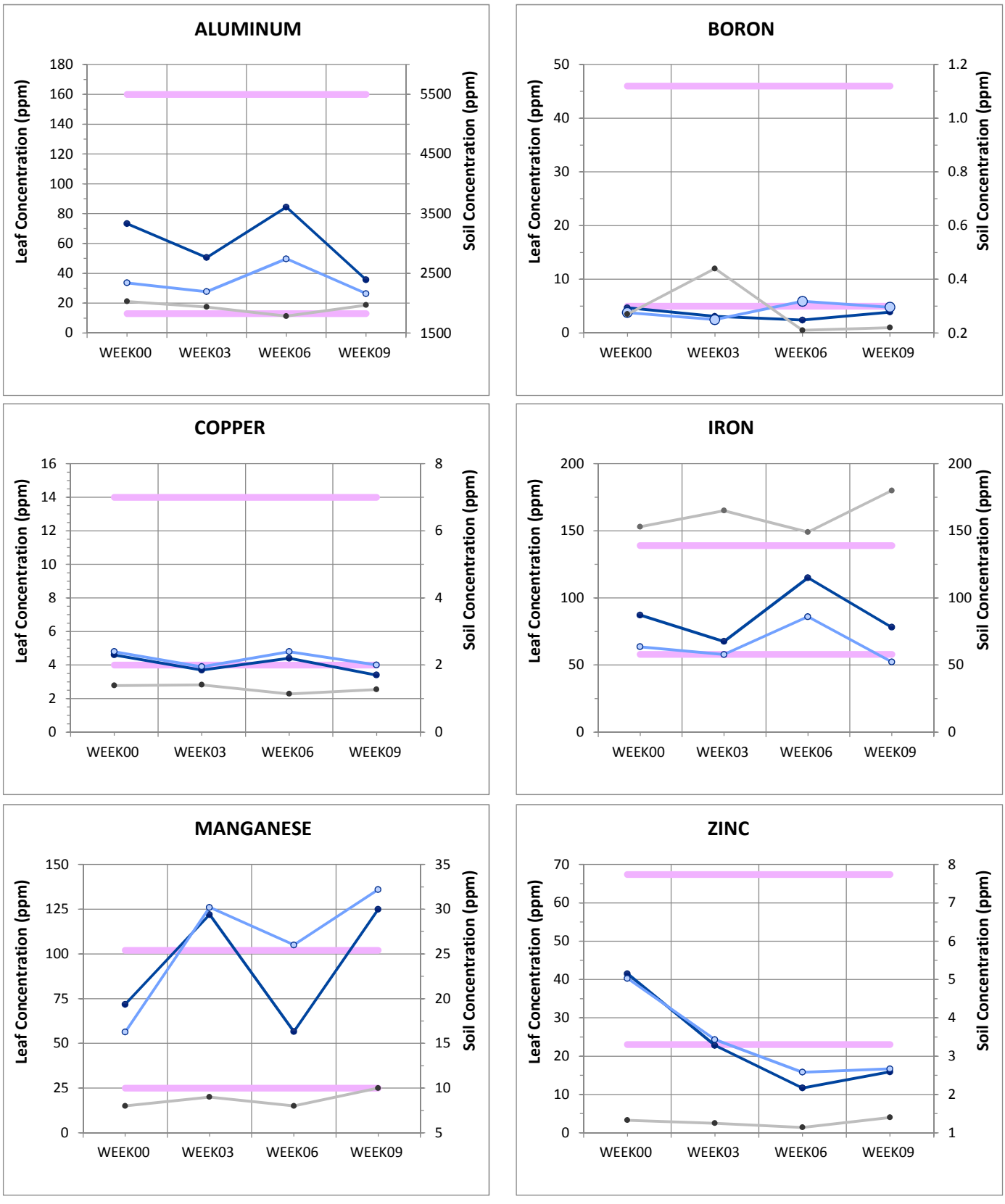


Chart 5. 2014 Nutrient Concentrations in 'Good' & 'Poor' Duchesse deNemour Peony Leaves - Major Nutrients

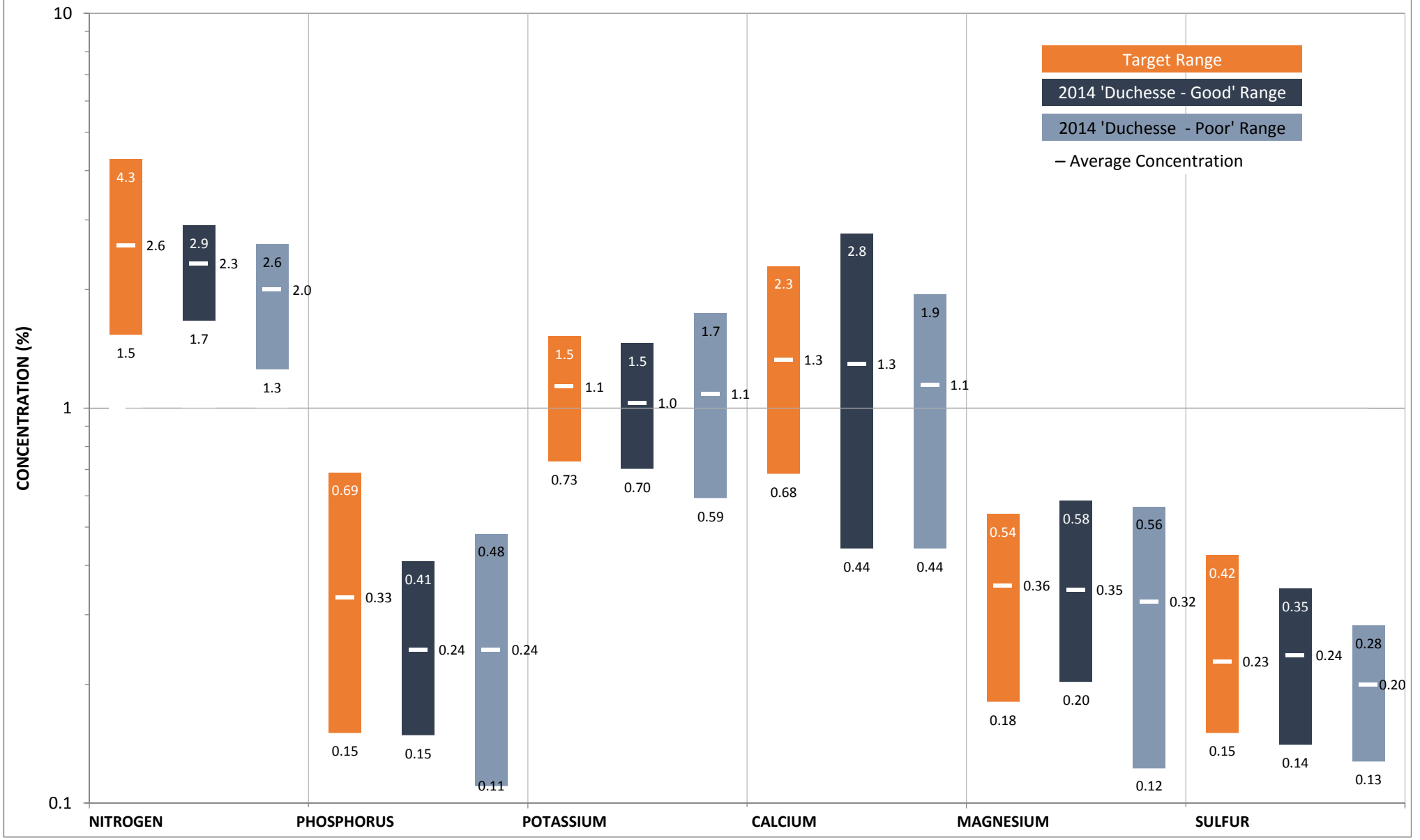


Chart 5. 2014 Nutrient Concentrations in 'Good' & 'Poor' Duchesse deNemour Peony Leaves - Minor Nutrients

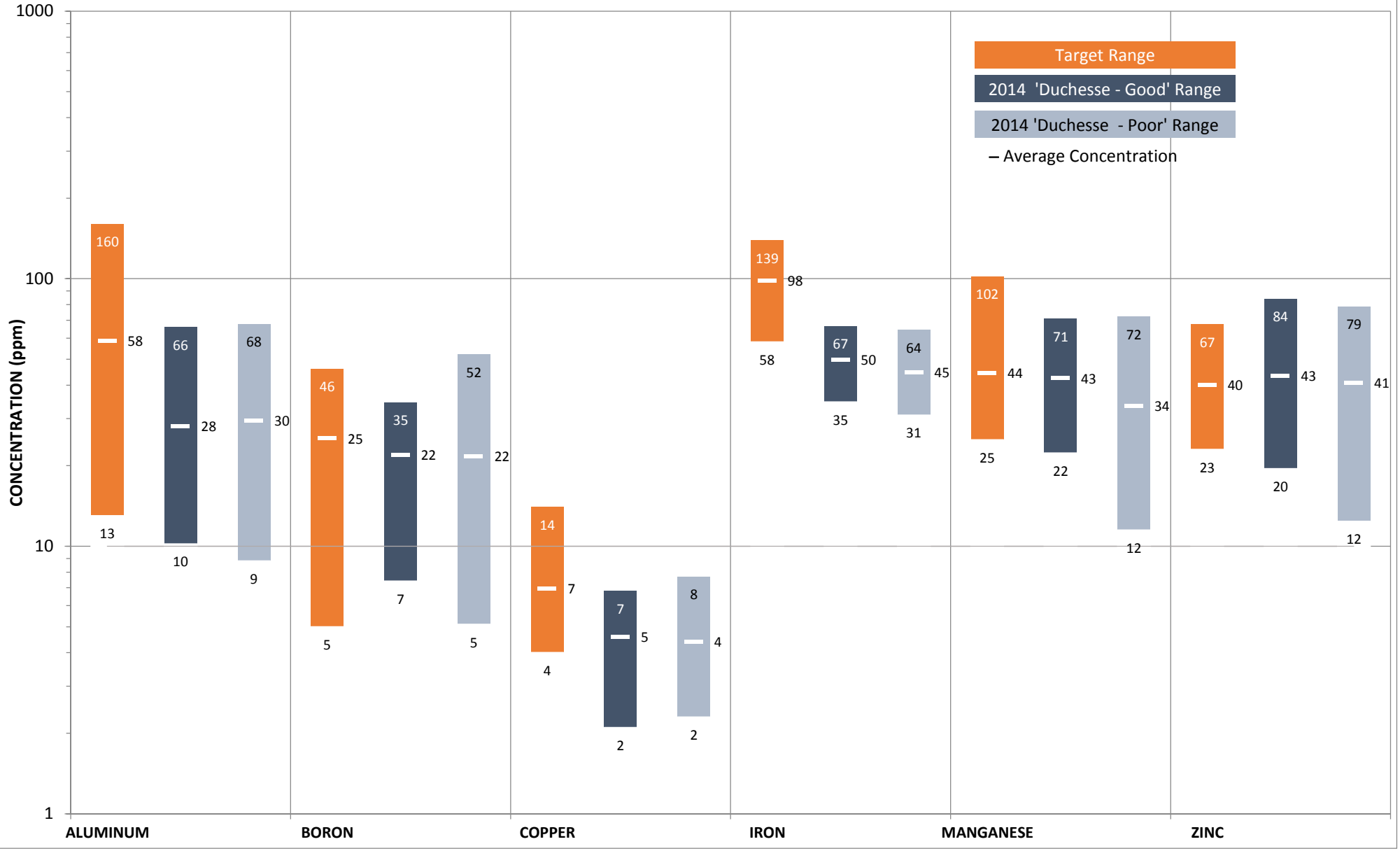


Chart 6. 2014 Nutrient Concentrations in 'Good' & 'Poor' Sarah Bernhardt Peony Leaves - Major Nutrients

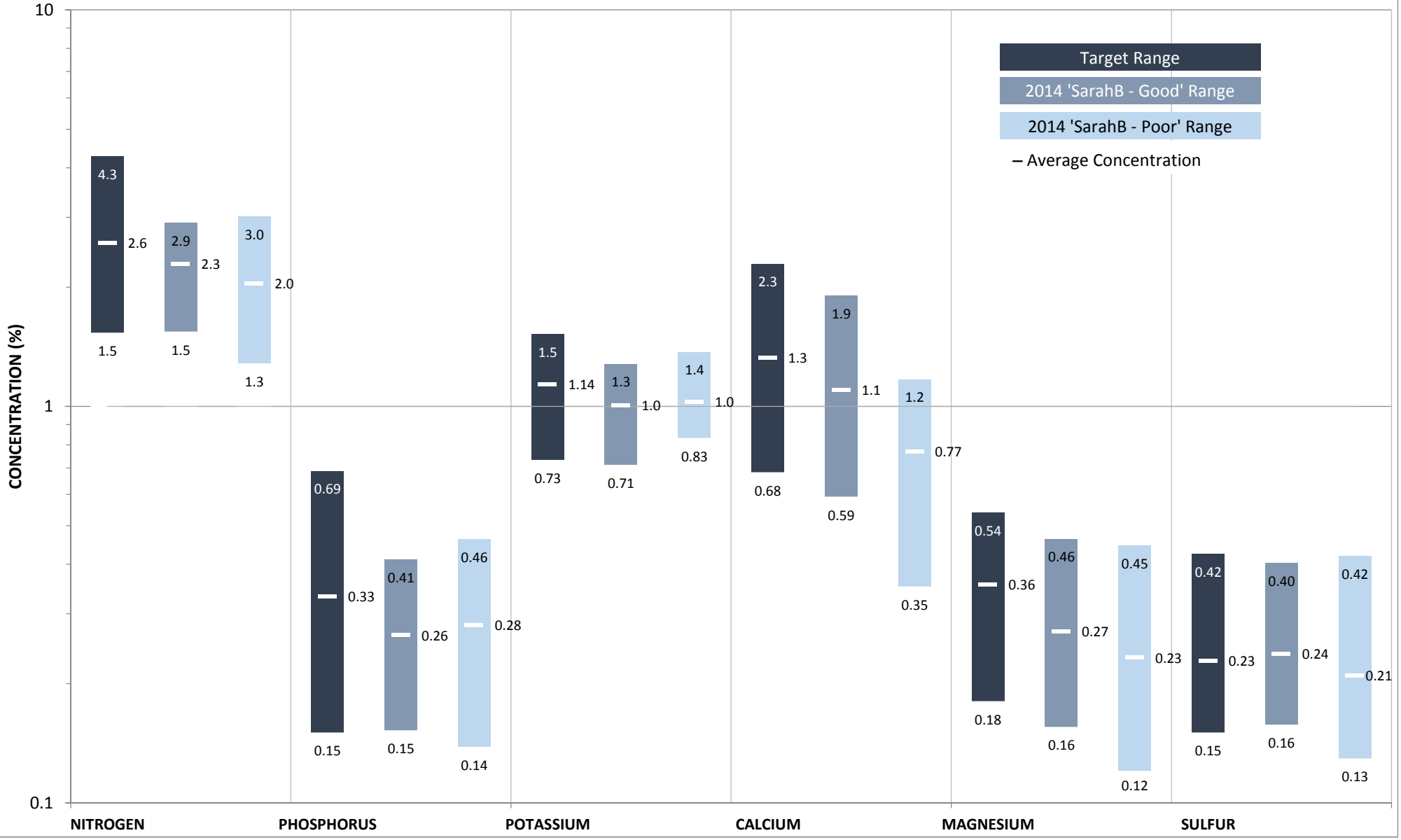
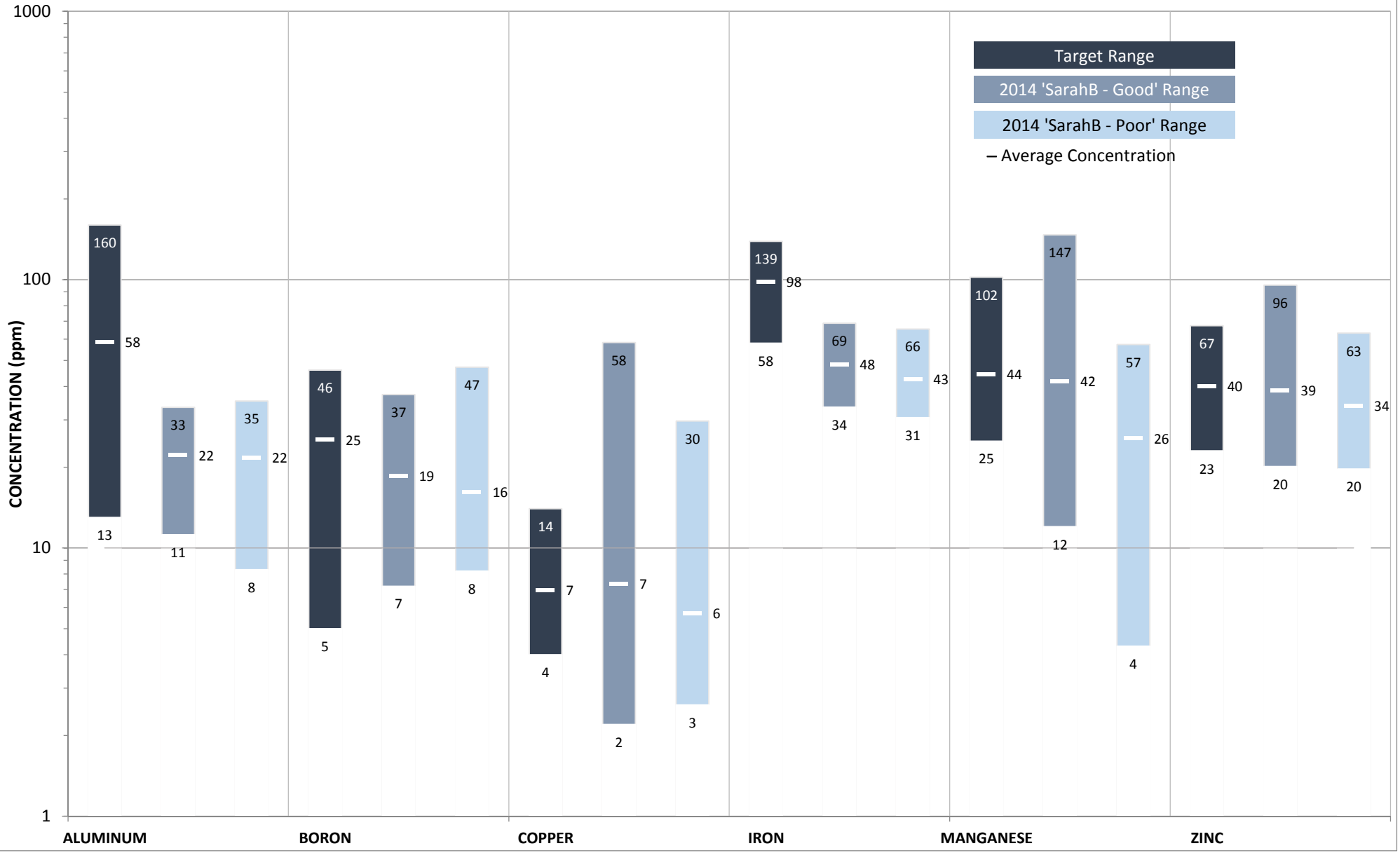


Chart 6. 2014 Nutrient Concentrations in 'Good' & 'Poor' Sarah Bernhardt Peony Leaves - Minor Nutrients



2010-2014 TISSUEDATA.XLS/SARAHB GOOD-POOR

Chart 7. 2014 Tissue Histograms

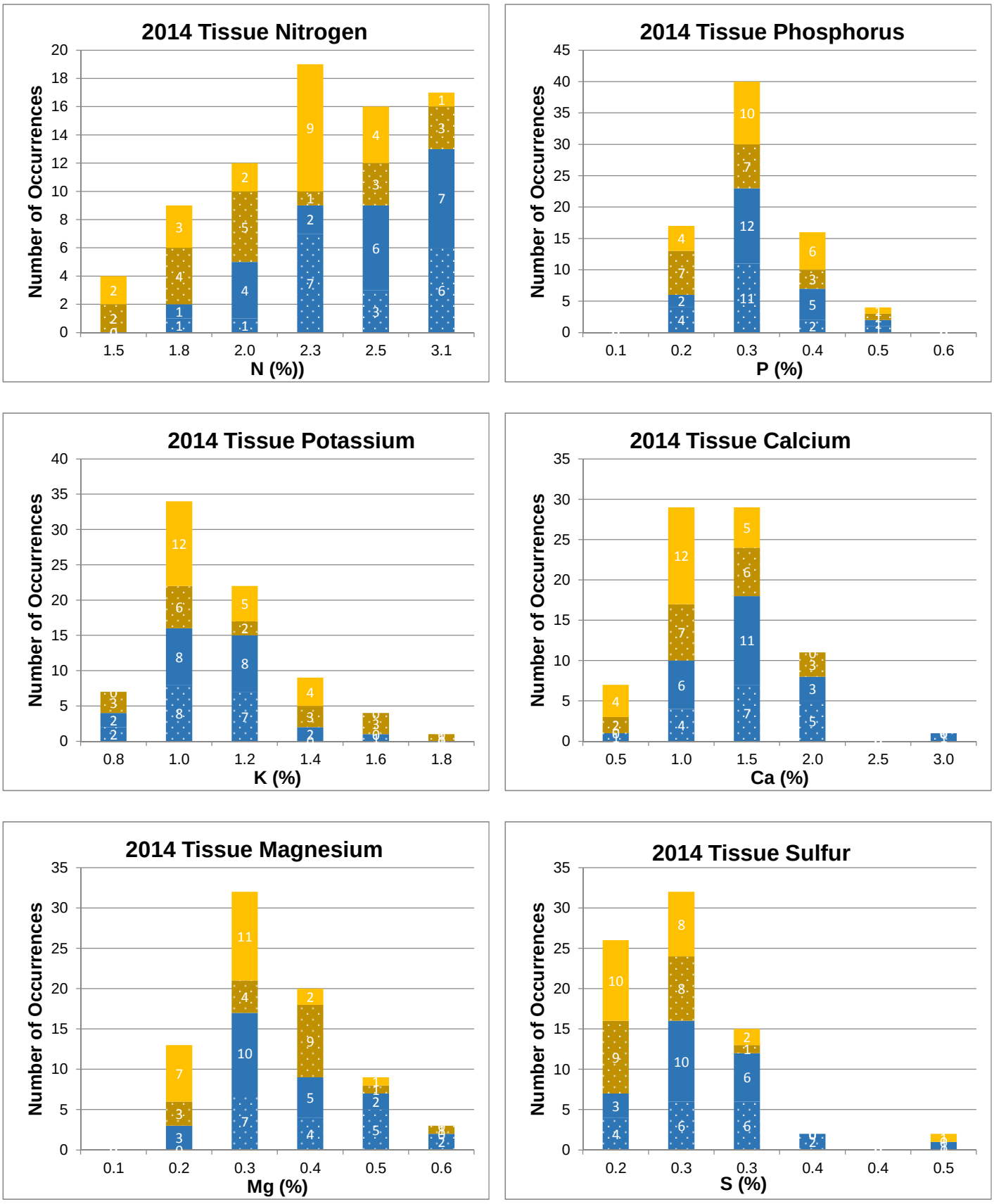
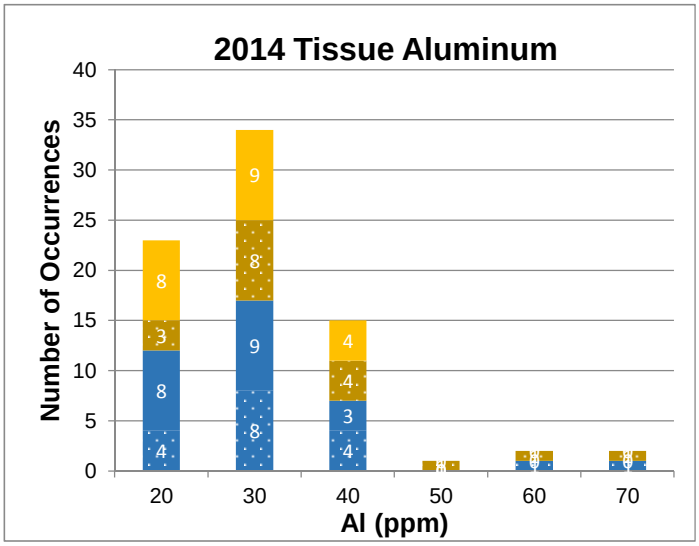
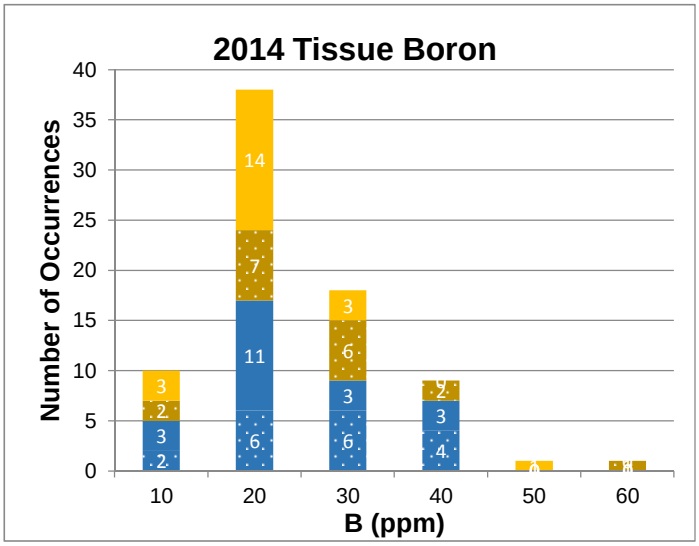
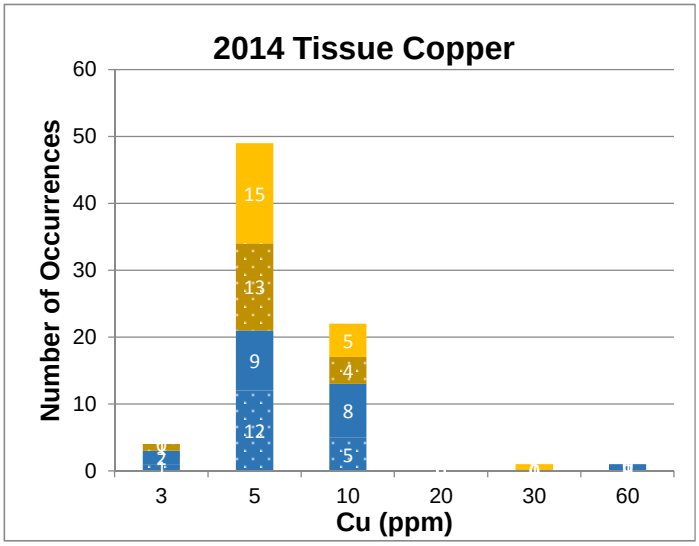
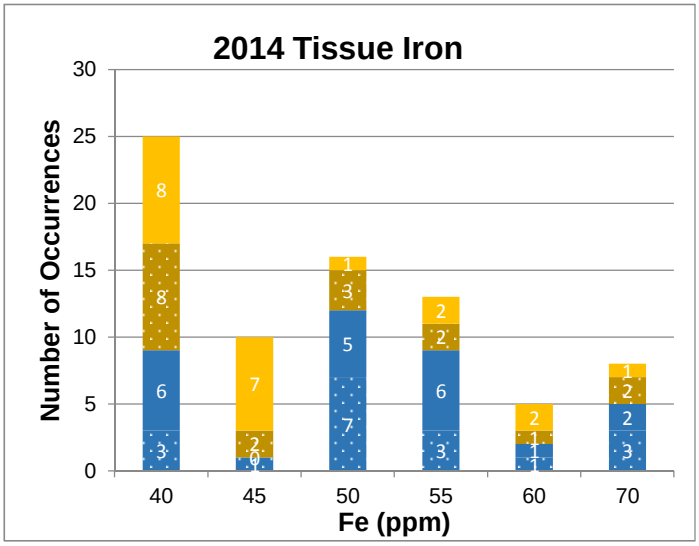


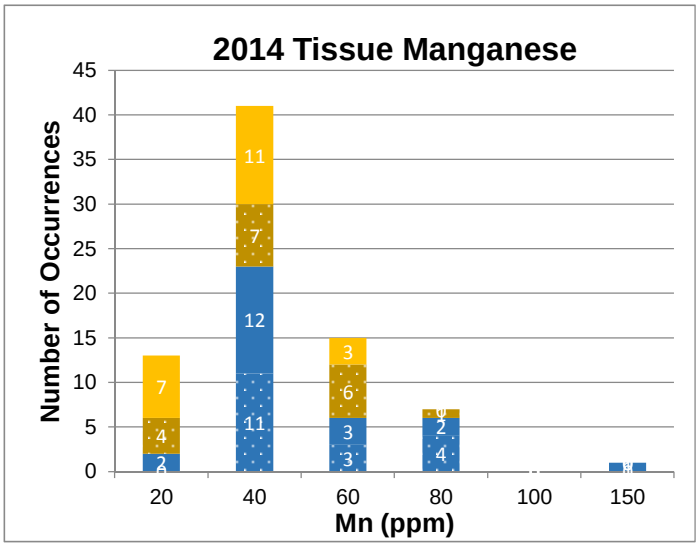
Chart 7 (cont'd). 2014 Tissue Histograms

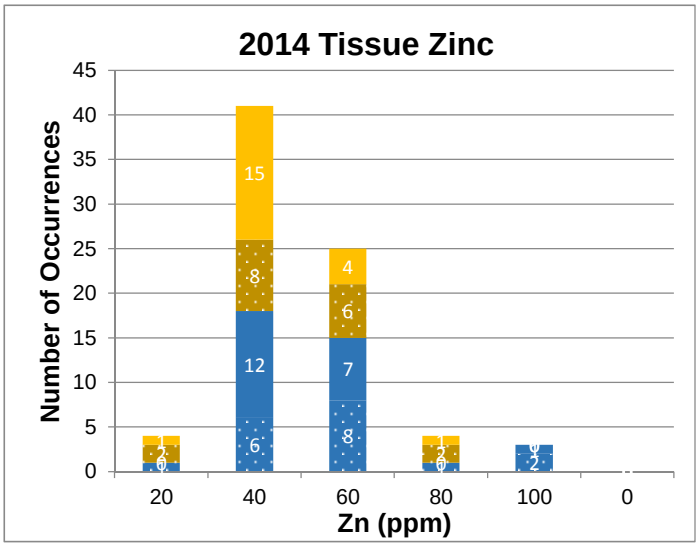












Duchesse - Good Sarah - Good Duchesse - Poor Sarah - Poor

Chart 8. Correlation Charts between 2014 Co-Sampled Soil pH and Leaf Analyses

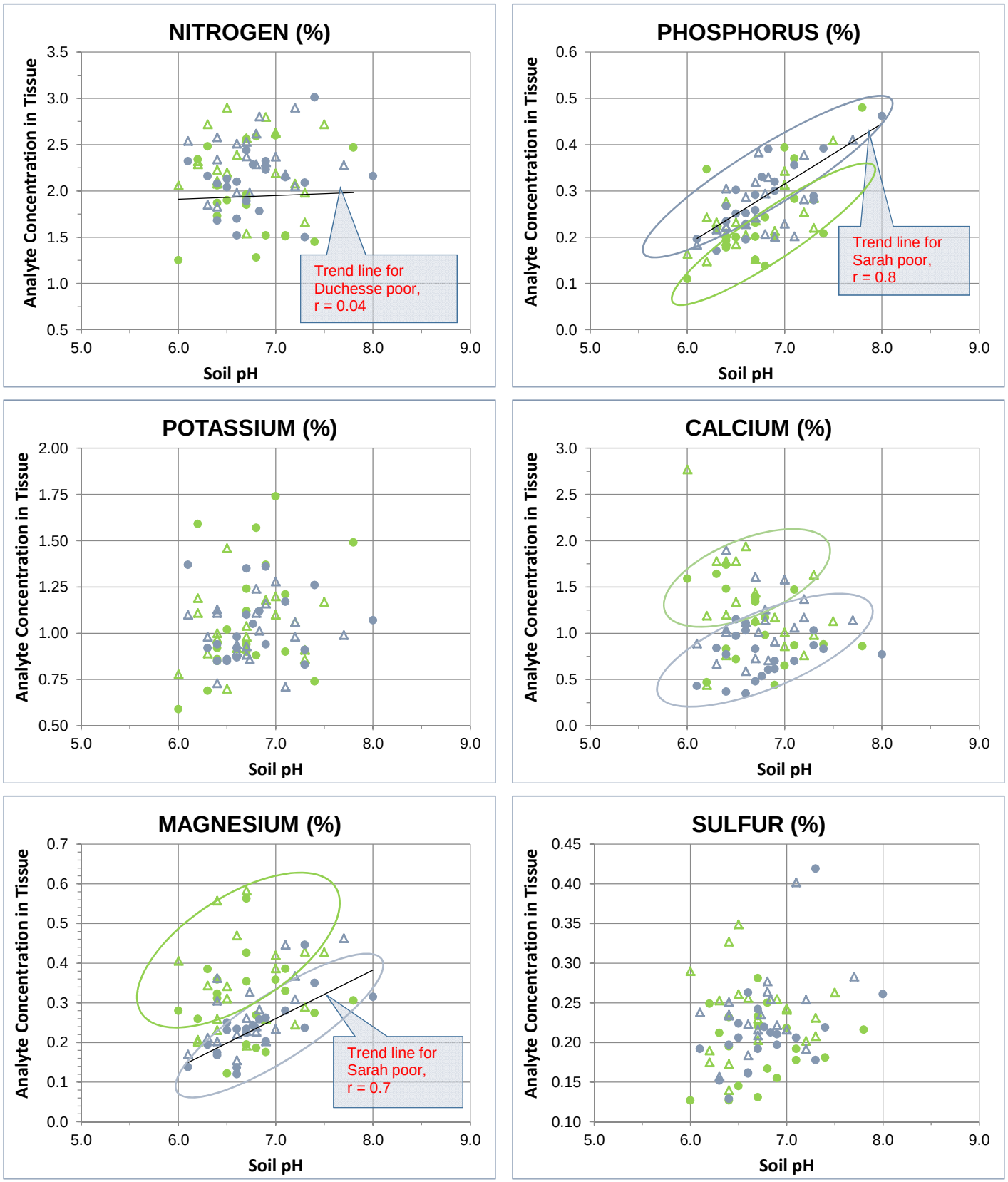
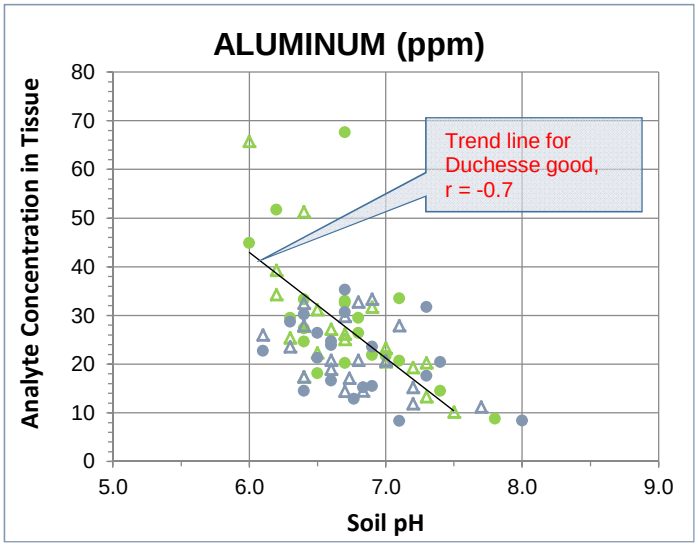
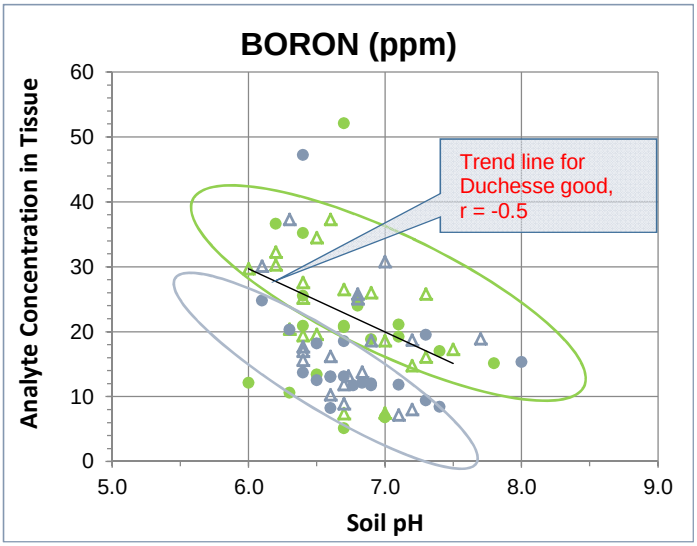
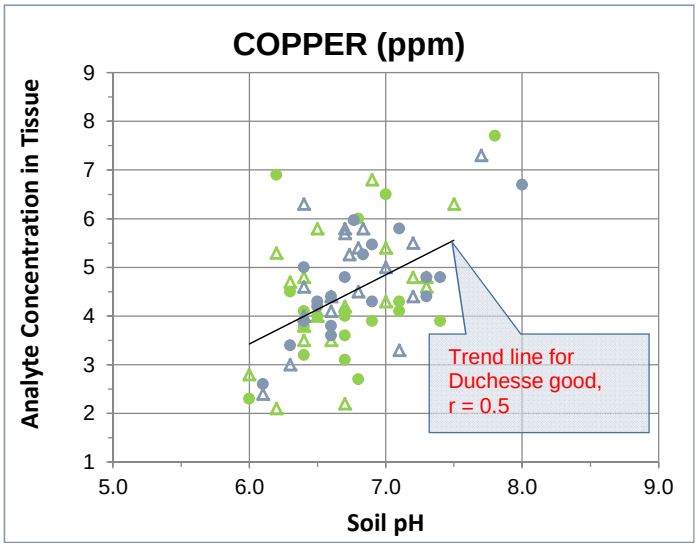
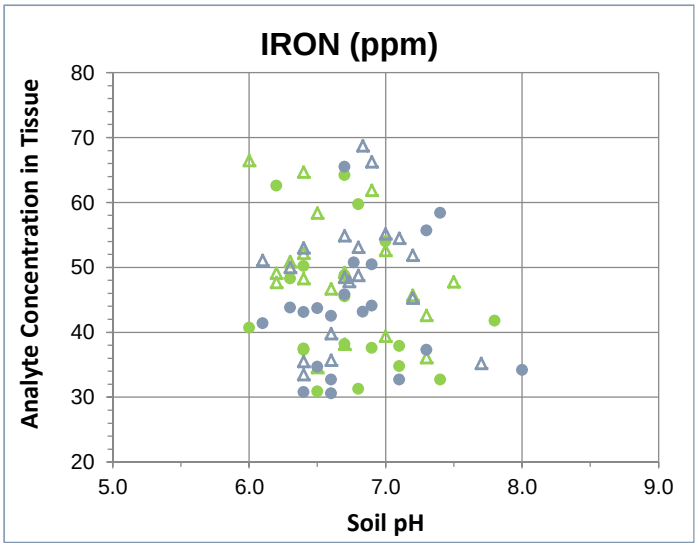


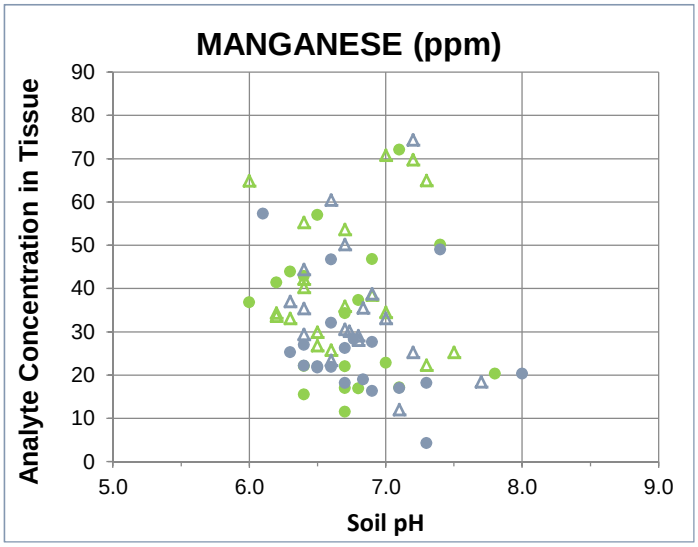
Chart 8 (cont'd). Correlation Charts between 2014 Co-Sampled Soil pH and Leaf Analyses

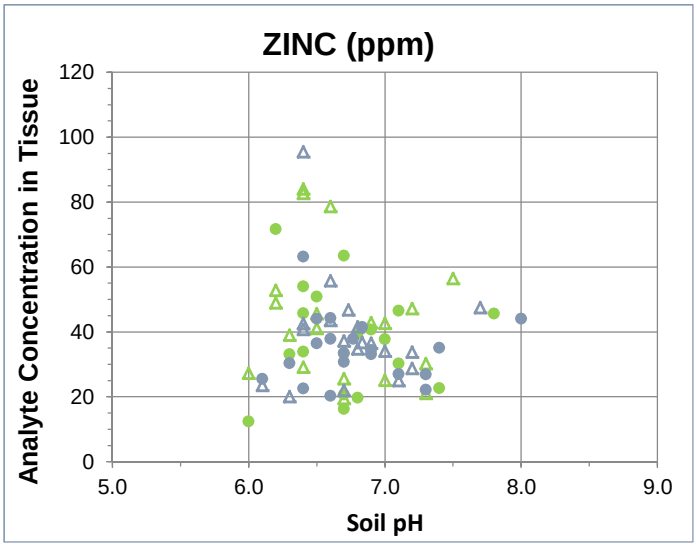










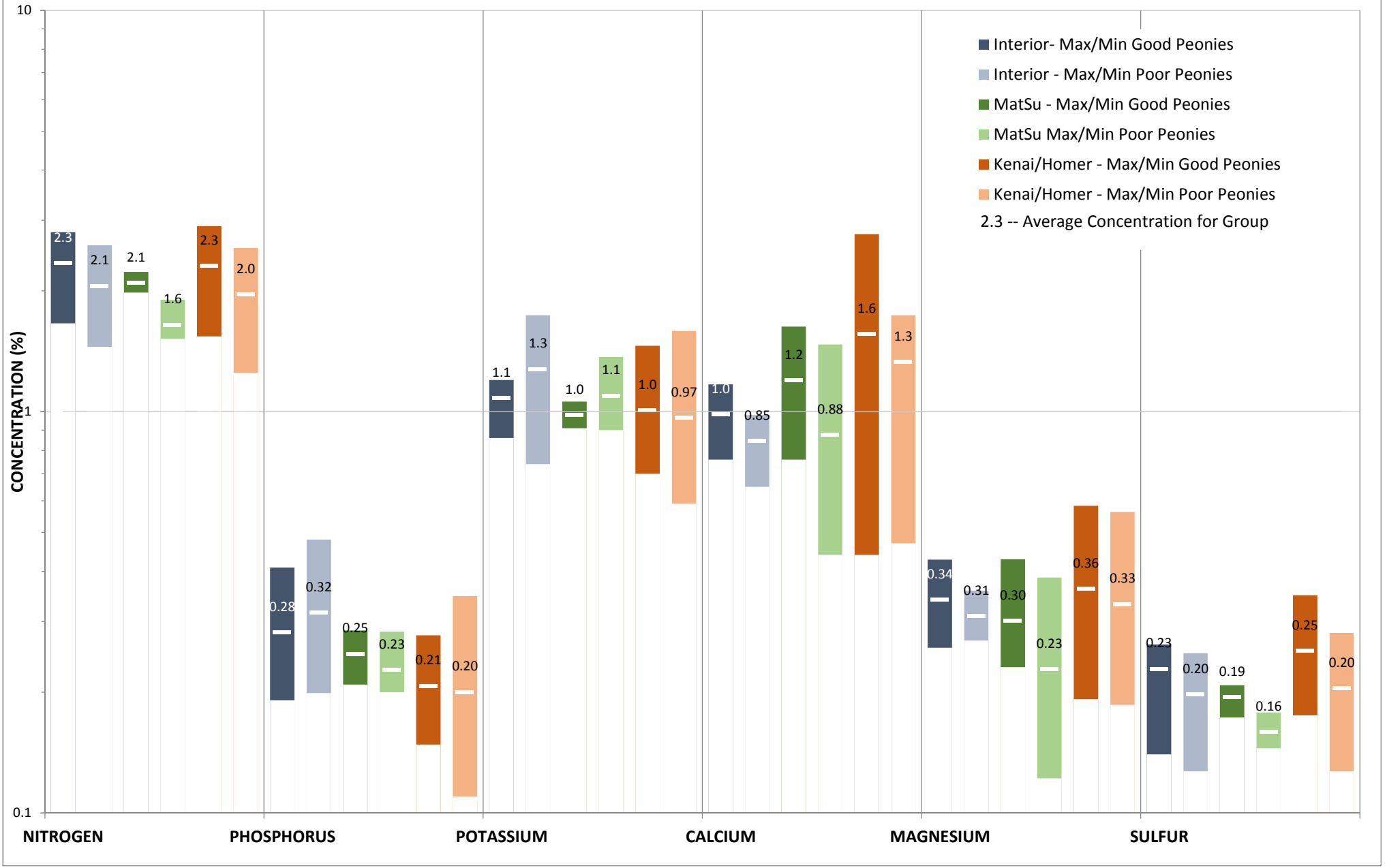


△2014 Duchesse Good ●2014 Duchesse Poor △2014 Sarah Good ●2014 Sarah Poor

Area where majority of the data points are for Duchesse plants

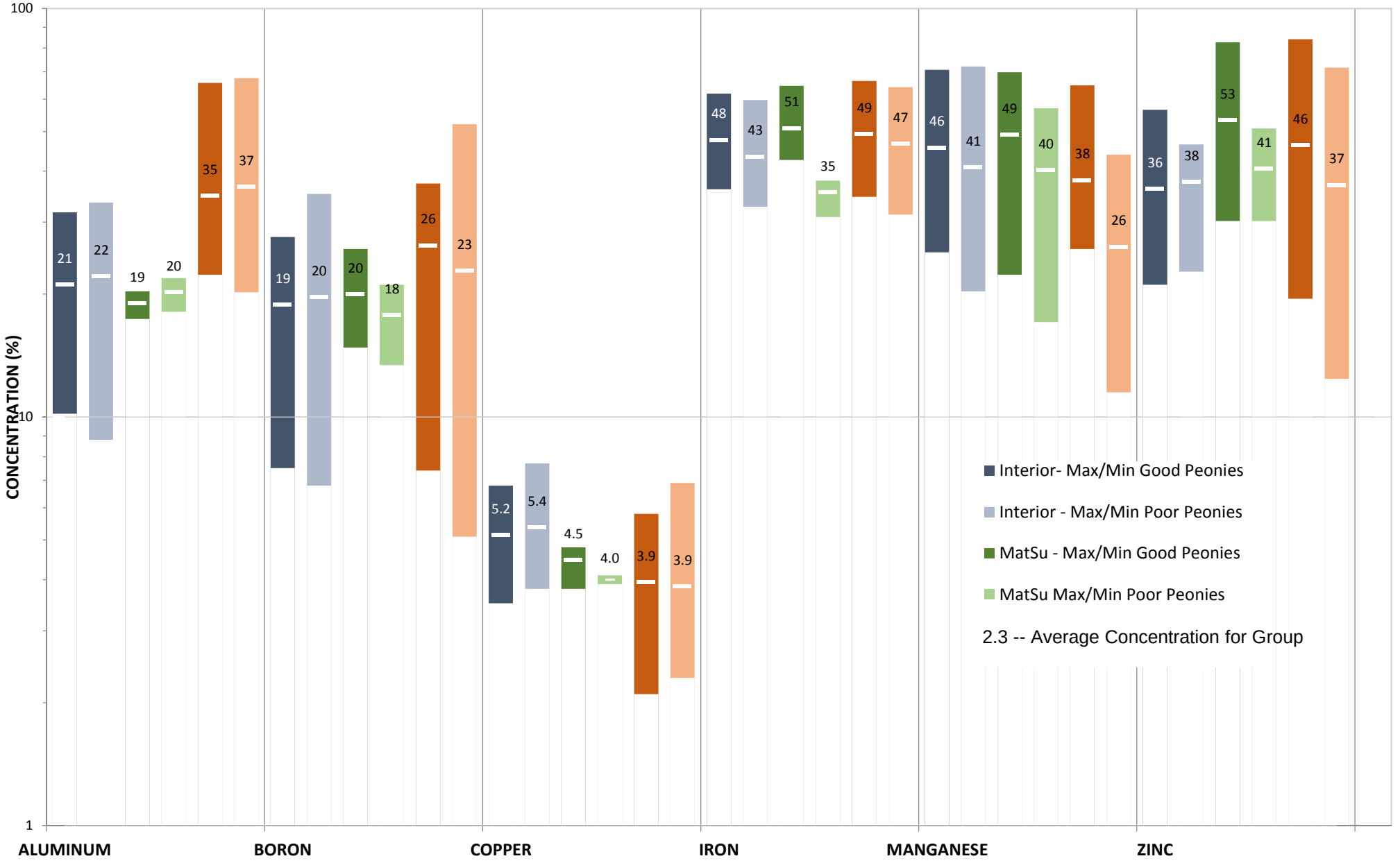
Area where majority of the data points are for Sarah plants

Chart 9. Regional Differences in Duchesse deNemour Peony Tissue Samples - Major Nutrients



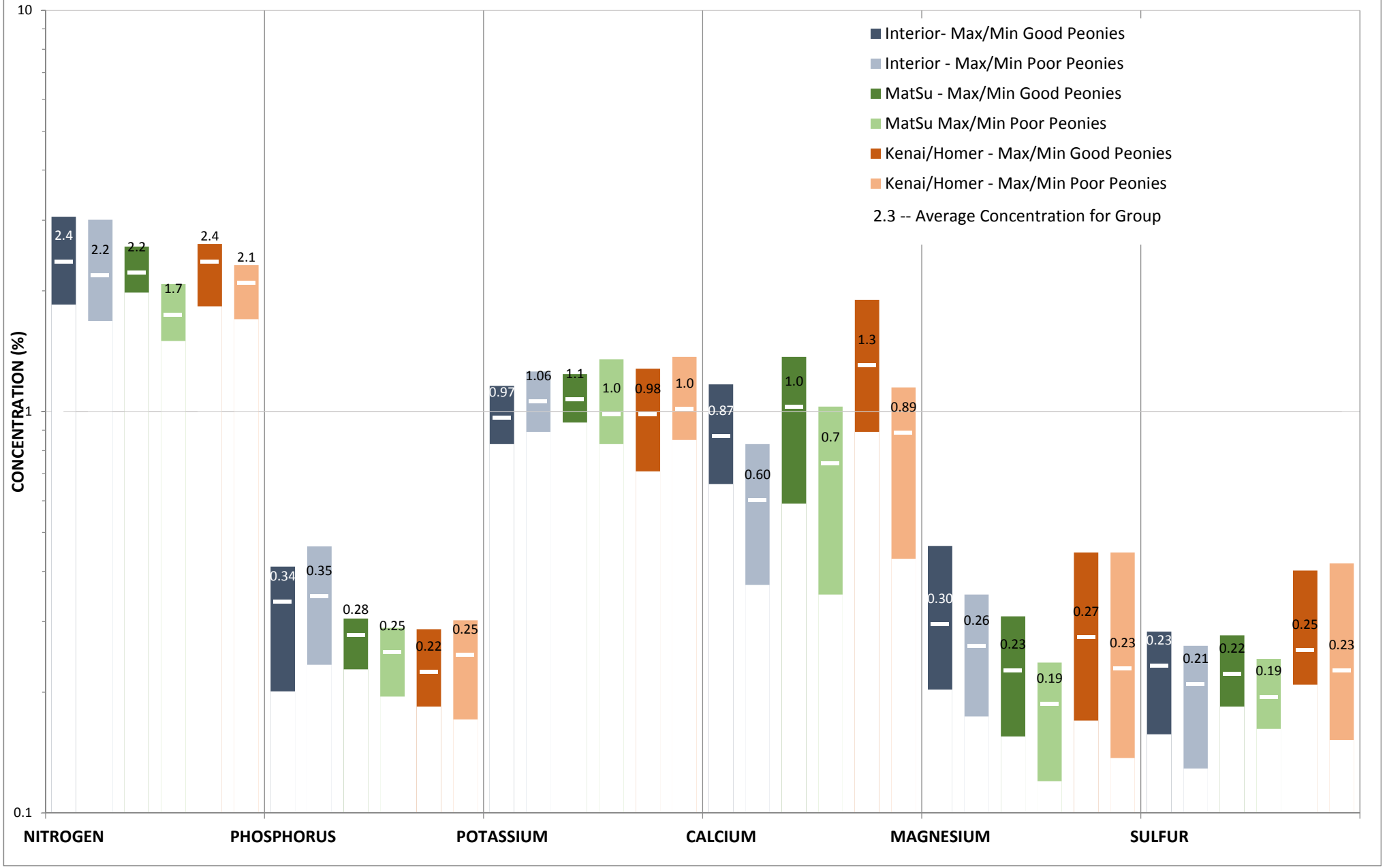
2014 REGIONALTISSUE.XLSX/SARAHB

Chart 9. Regional Differences in Duchesse deNemour Peony Tissue Samples - Minor Nutrients



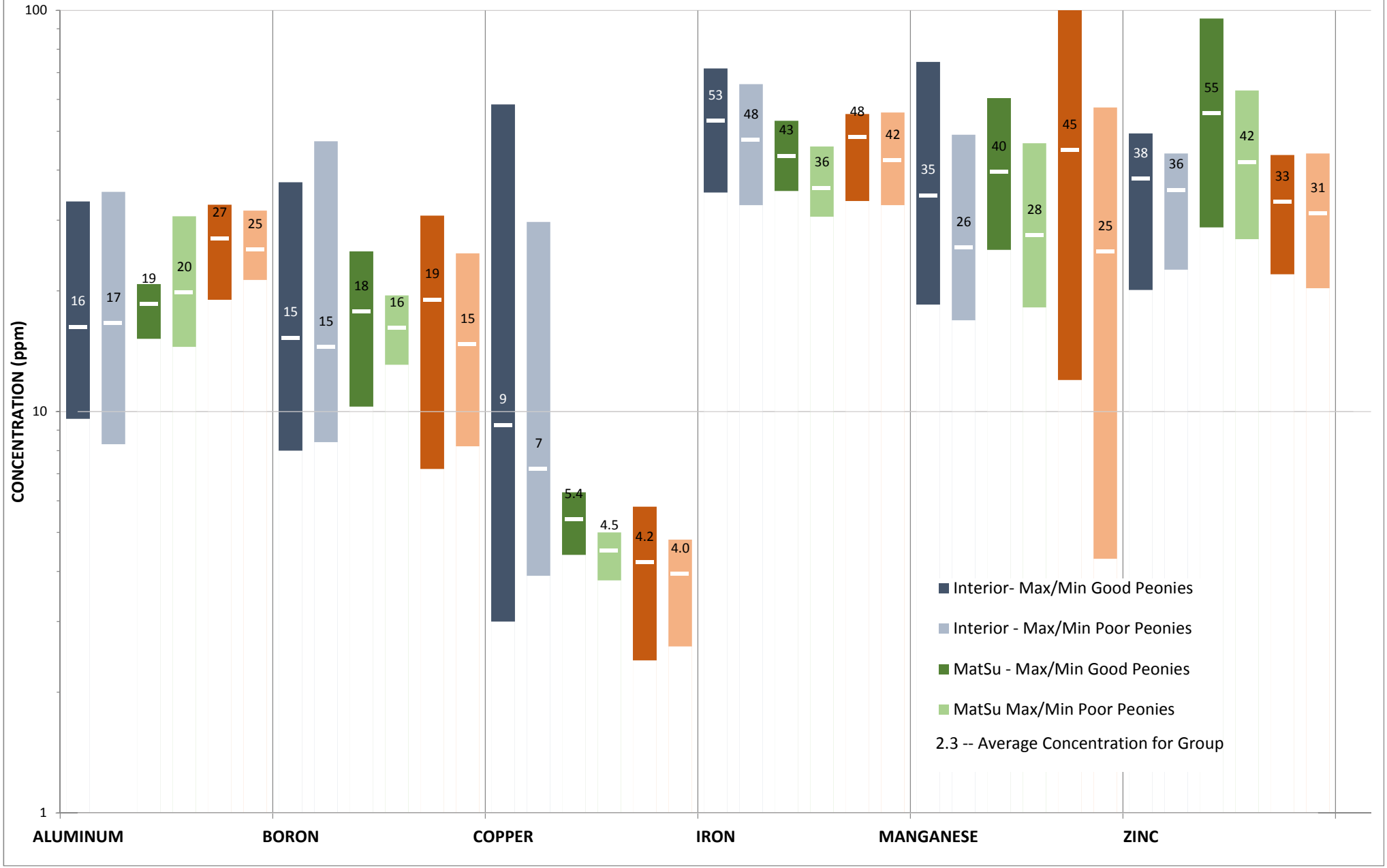
2014 REGIONALTISSUE.XLSX/SARAHB

Chart 10. Regional Differences in Sarah Bernhardt Peony Tissue Samples - Major Nutrients



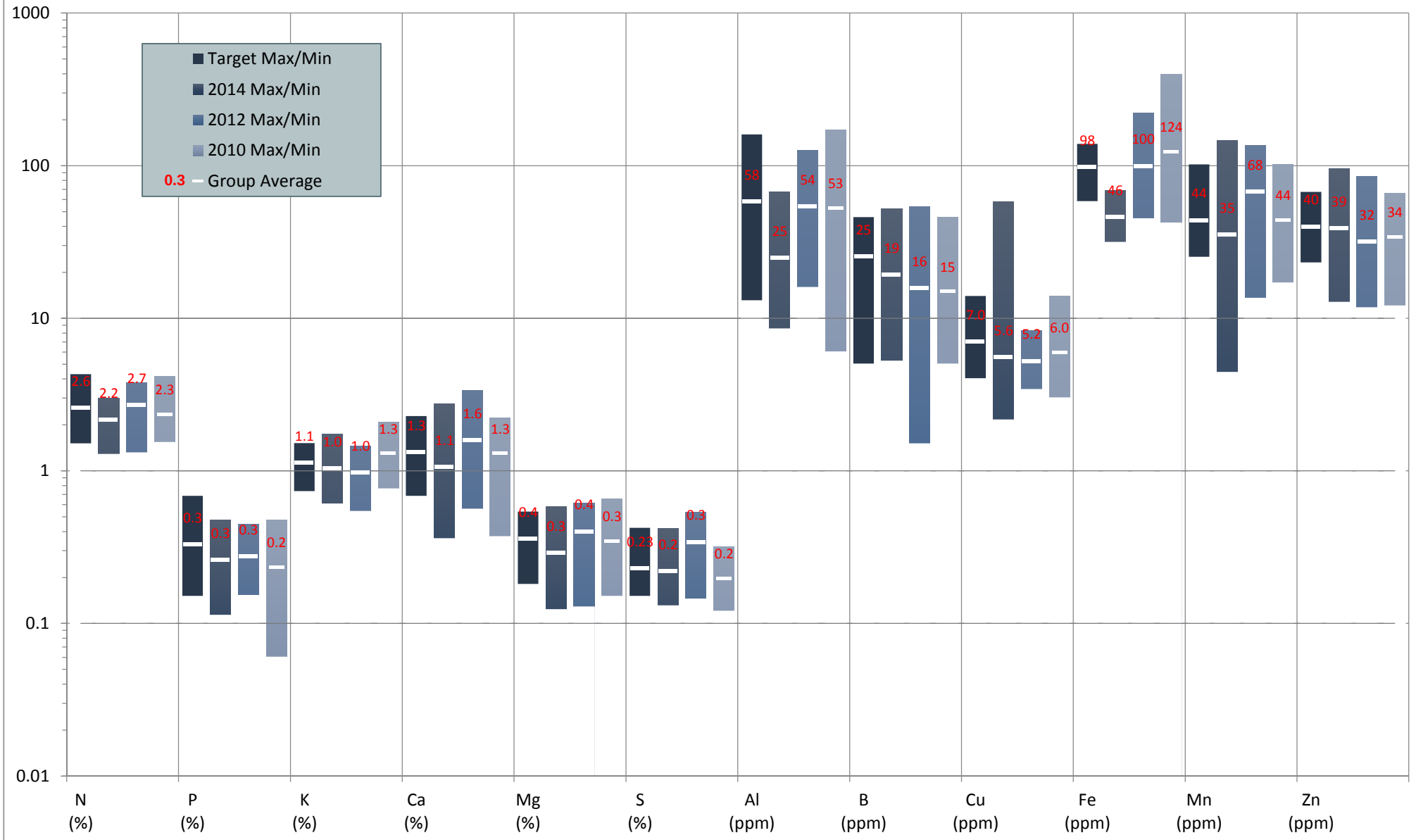
2014 REGIONALTISSUE.XLSX/SARAHB

Chart 10. Regional Differences in Sarah Bernhardt Peony Tissue Samples - Minor Nutrients



2014 REGIONALTISSUE.XLSX/SARAHB

Chart 11. Summary Data for 2010-2012-2014 Participants



APPENDIX A

ANALYTICAL DATA SUMMARY

2010 Soil Data

Farm ID	Location	Matrix/ Round	Variety	Sample Date	Organic Matter (% Rating)	Organic Matter (lbs/A)	P - weak Bray (ppm)	P - Olsen (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	Na (ppm)	pH (soil)	pH (buffered)	H (meq/100g)	CEC (meq/100g)	N (NO3-N, ppm)	S (SO4-S, ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	B (ppm)	Soluble Salts (mmhos/cm)
17	KENAI PEN	Soil 1	Lactiflora	07/22/10	19.1	411	19	20	297	196	2279	36	5.5	5.5	4.9	18.8	103	34	1.4	2	136	0.7	0.4	0.7
17	KENAI PEN	Soil 2	Lactiflora	9//27/10	19	410	15	47	232	135	2135	26	5.7	5.8	3.3	15.8	67	22	0.3	1	124	0.2	0.9	0.7
4	KENAI PEN	Soil 1	Lactiflora	07/09/10	20.4	438	9	36	202	334	1614	22	5.8	5.6	2.7	14.1	24	14	1.8	2	123	0.4	0.3	0.2
4	KENAI PEN	Soil 2	Lactiflora	08/17/10	19.6	423	5	15	232	271	1259	25	5.8	5.7	2.2	11.4	22	12	2.6	2	134	0.5	0.4	0.3
12	INTERIOR	Soil 1	Lactiflora	06/22/10	15	330	35	34	189	831	3531	38	6.4	6.4	2.5	27.6	63	10	2.8	11	160	1.2	0.3	0.7
12	INTERIOR	Soil 2	Lactiflora	08/02/10	16.6	363	25	31	99	779	4018	31	6	6.3	4.7	31.6	76	6	1.4	5	124	0.8	0.2	1
12	INTERIOR	Soil 1	Lactiflora	06/22/10	6.8	166	63	68	213	765	2691	52	6.4	6.8	2	22.5	46	8	1.6	6	167	1.6	0.1	0.8
12	INTERIOR	Soil 2	Lactiflora	08/02/10	17	370	115	88	231	426	2149	57	5.7	5.9	4	19.1	18	17	4.1	8	149	1.2	0.5	0.4
3	KENAI PEN	Soil 1	Lactiflora+hybrid m	06/25/10	18.6	403	86	118	415	247	2210	54	6.4	5.9	1.4	15.8	26	18	19.8	2	122	0.3	0.5	0.6
3	KENAI PEN	Soil 2	Lactiflora+hybrid m	09/21/10	21.7	464	61	202	646	266	277	129	5.7	5.8	4.8	23.1	42	24	4	2	190	0.8	1	0.7
10	KENAI PEN	Soil 1	Lactiflora	06/25/10	7.1	172	137	66	520	412	1456	22	5.7	6.2	3.2	15.3	18	5	2.1	2	144	1.7	0.3	0.2
10	KENAI PEN	Soil 2	Lactiflora	08/13/10	7.3	176	13	41	928	499	1772	30	6.1	6.5	2.5	18	42	12	2.6	4	137	1.5	0.9	0.8
11	INTERIOR	Soil 2	Lactiflora	08/17/10	8.1	193	276	228	675	406	3513	30	6.3	6.7	2.7	25.4	166	75	5.4	14	51	2.2	1.3	2.2
18	KENAI PEN	Soil 1	Lactiflora	06/22/10	8.3	196	263	155	415	418	2087	42	5.3	6.2	6.8	21.9	42	22	8.3	20	173	1.8	0.3	0.5
18	KENAI PEN	Soil 2	Lactiflora	08/02/10	13.1	291	74	35	161	901	2993	52	6	6.5	4.1	27	126	15	1	5	126	1	0.3	1.2
33	KENAI PEN	Soil 1	Hybrid	06/18/10	7.7	184	9	29	307	69	2467	26	6.2	5.9	1.9	15.7	51	59	0.6	2	77	0.6	0.1	0.5
33	KENAI PEN	Soil 2	Hybrid	08/17/10	7.3	176	40	34	170	51	2033	79	6.4	6.3	1.1	12.5	27	20	0.6	5	125	0.5	0.2	0.4
34	KENAI PEN	Soil 1	Hybrid	06/18/10	13.1	291	30	36	366	65	2576	22	5.8	5.8	3.4	17.8	80	82	0.5	2	101	0.4	0.1	1
34	KENAI PEN	Soil 2	Hybrid	08/17/10	7.6	181	37	30	360	49	1945	33	5.9	6	2.3	13.5	84	55	1	5	159	0.6	0.3	0.7
35	KENAI PEN	Soil 1	Lactiflora	06/18/10	13.1	292	38	39	295	50	2220	20	5.4	5.6	4.9	17.2	107	46	0.2	3	105	0.3	0.1	0.9
35	KENAI PEN	Soil 2	Lactiflora	08/17/10	12.9	287	34	37	357	48	1970	41	5.6	5.8	3.5	14.8	129	32	0.5	4	158	0.3	0.2	0.7
32	OUTSIDE	Soil 1	Lactiflora	05/05/10	2.9	87	54	92	478	258	1642	27	5.6	6.3	3.6	15.2	29	25	17.8	9	52	4.8	0.3	0.4
19	OUTSIDE	Soil 1	Hybrid	04/28/10	3.9	107	15	18	188	317	2392	24	6.4	6.4	1.5	16.6	10	7	10	4	47	1.8	0.2	0.2
19	OUTSIDE	SoIL 2	Hybrid	06/02/10	3.3	97	60	65	252	399	2119	40	6.5	6.5	1.2	15.9	9	8	3.4	3	35	1.6	0.5	0.1

2010 Tissue Data

Farm ID	Location	Matrix/Roun	Analysis Date	Variety	N (%)	S (%)	P (%)	K (%)	Mg (%)	Ca (%)%	Na (%)	Fe (ppm)	Al (ppm)	Mn (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)
17	KENAI PEN	Tissue 1	07/22/10	Lactiflora	2.37	0.2	0.27	1.49	0.39	1.02	0.01	78	33	33	9	5	35
17	KENAI PEN	Tissue 2	08/09/10	Lactiflora	2.44	0.22	0.14	0.98	0.28	1.37	0.01	85	34	33	12	6	19
17	KENAI PEN	Tissue 3	09/07/10	Lactiflora	1.98	0.18	0.09	0.86	0.36	1.98	0.02	127	40	35	19	3	44
4	KENAI PEN	Tissue 1	07/09/10	Lactiflora	2.54	0.17	0.37	1.48	0.3	0.56	0.04	128	91	24	19	6	30
4	KENAI PEN	Tissue 2	07/23/10	Lactiflora	2.19	0.14	0.29	1.27	0.39	0.73	0.01	126	84	31	8	5	32
4	KENAI PEN	Tissue 3	08/03/10	Lactiflora	2.17	0.15	0.22	1.24	0.29	0.69	0.01	242	145	29	19	4	26
4	KENAI PEN	Tissue 4	08/17/10	Lactiflora	2.04	0.12	0.17	0.93	0.34	1.08	0.01	153	107	28	10	6	28
37	INTERIOR	Tissue 1	06/22/10	Lactiflora	3.13	0.2	0.31	1.02	0.28	0.95	0.01	158	57	37	7	6	38
37	INTERIOR	Tissue 2	07/02/10	Lactiflora	2.55	0.25	0.25	0.99	0.43	1.29	0.01	86	38	69	13	6	30
37	INTERIOR	Tissue 3	07/20/10	Lactiflora	1.99	0.15	0.2	0.97	0.66	1.75	0.01	93	21	50	6	5	22
37	INTERIOR	Tissue 4	08/02/10	Lactiflora	2.18	0.16	0.16	0.76	0.46	1.88	0.01	95	27	44	9	4	22
39	INTERIOR	Tissue 1	06/22/10	Lactiflora	2.48	0.15	0.33	1.26	0.24	0.37	0.01	159	55	18	6	6	41
39	INTERIOR	Tissue 2	07/02/10	Lactiflora	2.07	0.15	0.25	1.22	0.34	0.61	0.01	188	86	29	7	5	31
39	INTERIOR	Tissue 3	07/20/10	Lactiflora	2.15	0.14	0.21	1.07	0.64	1.26	0.01	159	46	36	5	6	26
39	INTERIOR	Tissue 4	08/02/10	Lactiflora	2.25	0.19	0.17	0.94	0.56	1.79	0.01	225	73	51	9	4	22
3	KENAI PEN	Tissue 1	06/25/10	Lactiflora+hybrid mi›	2.42	0.15	0.11	1.25	0.6	2.09	0.01	212	66	72	30	7	52
3	KENAI PEN	Tissue 2	07/27/10	Lactiflora+hybrid mi›	1.88	0.19	0.18	1.47	0.28	1.35	0.01	84	24	41	19	6	46
3	KENAI PEN	Tissue 3	08/17/10	Lactiflora+hybrid mi›	1.77	0.17	0.15	1.29	0.21	1.58	0.02	76	53	22	15	5	35
3	KENAI PEN	Tissue 4	09/21/10	Lactiflora+hybrid mi›	1.78	0.26	0.06	1.59	0.22	2.07	0.01	65	6	34	36	7	66
10	KENAI PEN	Tissue 1	06/25/10	Lactiflora	2.93	0.19	0.35	1.62	0.22	0.91	0.01	88	31	37	16	6	64
10	KENAI PEN	Tissue 2	07/09/10	Lactiflora	2.94	0.24	0.23	1.59	0.45	0.87	0.01	83	28	43	23	7	55
10	KENAI PEN	Tissue 3	07/22/10	Lactiflora	2.4	0.26	0.22	1.15	0.57	1.32	0.01	64	13	30	18	8	45
10	KENAI PEN	Tissue 4	08/13/10	Lactiflora	2.23	0.26	0.22	1.34	0.32	1.18	0.01	86	24	25	24	6	42
11	INTERIOR	Tissue 4	08/17/10	Lactiflora	1.93	0.21	0.16	0.92	0.23	1.84	0.02	82	46	17	23	4	20
18	KENAI PEN	Tissue 1	06/22/10	Lactiflora	2.36	0.17	0.29	0.96	0.28	0.68	0.01	111	29	29	5	6	33
18	KENAI PEN	Tissue 2	07/02/10	Lactiflora	2.39	0.21	0.26	1.44	0.35	0.85	0.01	190	52	44	11	6	29
18	KENAI PEN	Tissue 3	07/20/10	Lactiflora	1.53	0.21	0.26	1.44	0.58	1.95	0.02	94	25	74	17	7	40
18	KENAI PEN	Tissue 4	08/02/10	Lactiflora	1.98	0.18	0.18	0.89	0.54	1.9	0.01	140	44	55	14	4	28
9	INTERIOR	Tissue 4	08/03/10	Lactiflora	1.41	0.13	0.15	0.98	0.23	1.07	0.01	49	21	16	58	3	11
33	KENAI PEN	Tissue 1	06/18/10	Hybrid	2.82	0.25	0.38	1.39	0.29	0.94	0.01	396	171	30	9	7	28
33	KENAI PEN	Tissue 2	06/30/10	Hybrid	2.21	0.18	0.2	1.33	0.21	1.29	0.02	84	70	36	8	6	18
33	KENAI PEN	Tissue 3	07/15/10	Hybrid	2.09	0.19	0.21	1.5	0.24	1.36	0.01	76	28	70	11	9	20
33	KENAI PEN	Tissue 4	08/17/10	Hybrid	1.84	0.18	0.14	1.52	0.19	1.46	0.03	104	63	24	8	5	12
34	KENAI PEN	Tissue 1	06/18/10	Hybrid	3.23	0.3	0.36	2.08	0.32	1.29	0.01	254	97	51	11	5	31
34	KENAI PEN	Tissue 2	06/30/10	Hybrid	2.22	0.21	0.17	1.48	0.21	1.28	0.02	81	38	53	8	4	18
34	KENAI PEN	Tissue 3	07/15/10	Hybrid	1.79	0.15	0.12	1.36	0.19	1.1	0.01	42	23	58	6	6	14
34	KENAI PEN	Tissue 4	07/27/10	Hybrid	2.06	0.19	0.15	1.54	0.28	1.45	0.01	93	44	61	16	8	21
35	KENAI PEN	Tissue 1	06/18/10	Lactiflora	4.15	0.32	0.48	1.99	0.22	1.19	0.01	284	102	76	11	8	65
35	KENAI PEN	Tissue 2	06/30/10	Lactiflora	3.3	0.25	0.23	1.55	0.16	1.3	0.02	85	57	72	8	4	36
35	KENAI PEN	Tissue 3	07/15/10	Lactiflora	2.1	0.16	0.16	1.46	0.15	1.13	0.01	46	26	84	6	5	24
35	KENAI PEN	Tissue 4	08/17/10	Lactiflora	1.97	0.15	0.12	1.36	0.15	2.22	0.01	73	33	46	9	5	18
32	OUTSIDE	Tissue 1	05/05/10	Lactiflora	3.4	0.26	0.36	1.06	0.31	1.11	0.01	112	61	102	26	8	50
32	OUTSIDE	Tissue 4	06/30/10	Lactiflora	1.58	0.16	0.15	0.9	0.18	1.5	0.02	71	43	40	46	5	29
19	OUTSIDE	Tissue 1	04/28/10	Hybrid	2.57	0.22	0.45	1.37	0.39	1.16	0.01	114	51	33	22	7	39
19	OUTSIDE	Tissue 2	05/05/10	Hybrid	2.22	0.19	0.33	1.15	0.38	1.12	0.01	64	33	31	26	6	27
19	OUTSIDE	Tissue 3	05/17/10	Hybrid	1.96	0.18	0.32	1.52	0.44	1.46	0.02	139	160	40	34	14	47
19	OUTSIDE	Tissue 4	06/02/10	Hybrid	1.9	0.15	0.28	1.08	0.37	1.28	0.01	58	21	25	25	6	23

2012 Soil Data

Farm ID	Location	Matrix/Round	Analysis Date	Total Exchange Capacity (ME/100g)	pH (buffered)	pH (soil)	Organic Matter (% Rating)	Sulfur (SO4-S, ppm)	P (Mehlich III, ppm)	P (weak Bray, ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Al (ppm)	Al (KCl Ext) (ppm)	Mo (ppm)	N (NO3-N, ppm)	N (NO4-N, ppm)	Total Acidity (ME/100g)
3	KENAI PEN	2012-01	07/13/12	18.61	6.7	5.9	14.49	43	305	378	2225	233	736	58	2.1	328	42	4.58	19.56	1622	5	0.05	108.8	156.1	2.894
3	KENAI PEN	2012-02	10/19/12	16.34	6.7	6.4	14.9	20	318	306	2442	130	539	42	0.89	525	16	1.34	8.25	1526	<1	0.15	20.1	7.3	2.894
4	KENAI PEN	2012-01	07/20/12	11.46	6.7	6.5	15.91	26	47	45	1770	155	104	34	0.47	210	18	1.25	3.9	1778	4	<0.05	5.6	0.7	2.894
5	KENAI PEN	2012-01	07/25/12	18.41	6.6	6.7	12.76	14	50	86	2395	576	221	52	0.64	475	30	3.33	8.25	580	1	0.14	8.6	2.5	4.112
5	KENAI PEN	2012-02	10/19/12	20.79	6.5	6.3	12.19	9	67	132	2613	577	235	31	0.61	528	35	3.48	7.08	542	<1	<0.05	6.4	4.1	5.33
8	KENAI PEN	2012-01	07/20/12	9.53	5.9	5.1	7.53	37	103	464	630	36	533	30	0.66	224	14	2.65	1.59	2077	52	<0.05	44.1	4.2	12.638
8	KENAI PEN	2012-02	09/13/12	6.23	6.4	5.3	8.13	16	19	53	668	28	49	28	<0.2	175	7	1.05	1.08	1742	15	0.25	20.2	<0.5	6.548
9	INTERIOR	2012-01	06/29/12	11.55	6.6	5.8	4.05	10	92	143	1395	180	125	27	0.29	355	41	2.33	18.42	845	19	<0.05	14.1	4.2	4.112
9	INTERIOR	2012-02	08/31/12	12.52	6.8	5.7	4.12	11	72	127	1509	181	101	28	0.34	321	32	1.98	3.55	724	7	0.15	5.2	1.6	1.676
10	KENAI PEN	2012-01	07/09/12	14.29	6.7	6.1	7.85	18	58	125	1629	353	417	40	0.65	384	32	2.56	5.35	684	3	0.14	7.1	3.5	2.894
10	KENAI PEN	2012-02	10/05/12	13.45	6.6	6.1	7.19	10	46	131	1419	362	486	53	0.52	389	19	2.21	2.84	725	4	0.21	<0.5	2	4.112
11	INTERIOR	2012 SOIL00	06/27/12	27.16	7.3	6.7	7.83	37	375	393	4259	444	276	49	0.79	426	36	8.07	15.2	545	2	0.29	17.8	0.6	0
11	INTERIOR	2012 SOIL02	07/17/12	23.88	7.5	6.9	7.72	34	193	261	3897	400	187	43	0.88	460	49	8.15	10.86	501	3	<0.05	<0.5	0.7	0
11	INTERIOR	2012 SOIL06	09/12/12	20.38	--	7.8	8.16	63	348	507	3110	472	238	52	0.77	436	40	5.51	13.98	427	5	0.25	<0.5	1.4	0
11	INTERIOR	2012 SOIL08	09/26/12	17.86	--	7.8	7.31	56	255	325	2692	427	203	56	0.75	434	40	4.84	9.49	413	7	0.22	0.6	<0.5	0
12	INTERIOR	2012-01	07/13/12	24.39	6.9	5.8	11.18	10	74	60	2830	558	84	48	0.43	432	11	1.99	1.67	880	4	0.11	16.7	0.5	0.458
12	INTERIOR	2012-02	09/27/12	18.38	7	6	8.92	12	60	53	2311	439	86	41	0.36	398	11	2.38	1.59	735	1	0.25	13.5	2.9	0
14	CENTRAL	2012-01	07/11/12	15.53	6.1	5.5	13.18	16	7	<1	1956	80	60	16	0.39	365	19	2.36	1.78	2307	18	0.12	5.2	7.4	10.202
14	CENTRAL	2012-02	09/11/12	8.45	6.1	5.7	11.73	16	10	16	1086	70	72	24	0.46	379	7	1.31	2.02	2146	11	<0.05	2.3	5.2	10.202
17	KENAI PEN	2012-01	07/30/12	15.23	6.4	6.2	17.3	25	77	122	2415	101	124	31	0.45	482	6	1.28	2.09	1552	3	0.16	<0.5	4.8	6.548
17	KENAI PEN	2012-02	10/23/12	19.23	6.7	6.6	15.06	23	49	172	3306	121	133	25	0.38	448	5	1.39	1.92	1371	8	0.2	6.5	5	2.894
18	INTERIOR	2012 SOIL00	06/26/12	24.82	6.5	5.4	11.35	13	663	208	2245	301	966	83	0.69	468	30	2.76	17.82	776	5	<0.05	51.2	33.5	5.33
18	KENAI PEN	2012-01	07/16/12	7.62	6.4	6.4	13.1	24	40	51	1145	73	94	26	0.37	351	8	0.82	1.84	2083	22	0.11	10.2	1.8	6.548
18	INTERIOR	2012 SOIL02	07/24/12	23.14	6.9	6.5	10.3	15	514	269	2821	522	1003	79	0.93	541	25	3.75	20.12	490	3	0.06	33.2	5.1	0.458
18	INTERIOR	2012 SOIL04	08/01/12	19.89	6.7	5.9	11.29	25	517	514	2140	381	803	79	0.78	478	28	2.65	14.41	580	3	0.19	67.6	12.1	2.894
18	INTERIOR	2012 SOIL06	08/08/12	16.79	6.5	6	10.83	30	401	550	2034	305	464	74	0.45	404	27	2.69	8.7	634	4	0.12	20.4	2.3	5.33
18	INTERIOR	2012 SOIL08	08/22/12	25.61	6.3	5.4	17.04	20	501	114	2417	342	740	57	0.7	418	25	2.82	16.65	598	7	0.2	38.5	2.5	7.766
18	INTERIOR	2012 SOIL10	09/18/12	18.85	6.6	6.3	11.21	19	499	290	2278	372	817	54	0.83	456	27	2.54	14.79	507	5	0.05	54.4	2.4	4.112
18	KENAI PEN	2012-02	10/12/12	11.88	6.6	6.3	12.73	22	59	135	1908	80	89	33	0.35	343	6	1.07	1.72	1822	5	0.35	12.9	1.8	4.112
19	OUTSIDE	2012-01	05/11/12	9.71	7.2	6.1	2.6	9	100	106	1328	169	82	24	0.33	219	16	1.25	13.37	785	3	0.07	2.9	<0.5	0
20	OUTSIDE	2012-01	05/18/12	15.4	7.4	7	3.42	8	24		2243	351	200	17	0.73	97	59	2	2.8	670	--	0.07	4.9	1.7	--
23	OUTSIDE	2012-01	05/08/12	16.99	7.3	6.8	3.3	11	305	197	2434	370	445	19	0.8	384	38	3.51	23.6	417	<1	0.09	5.3	2	0
25	CENTRAL	2012-01	06/29/12	13.36	6.5	5.2	6.45	20	244	373	1244	98	356	25	0.56	594	33	3.03	4.12	912	8	0.2	31.5	3.8	5.33
25	CENTRAL	2012-02	10/09/12	11.29	6.7	5.9	5.65	17	227	419	1448	118	337	26	0.53	514	27	3.81	4.1	881	5	0.2	2	2	2.894
41	KENAI PEN	2012-01	07/02/12	13.2	6.6	6	8.93	52	86	248	1906	59	356	47	0.32	178	8	1.15	1.53	1972	--	--	4	1.5	4.11
41	KENAI PEN	2012 SOIL00	07/02/12	12.5	6.4	5.9	8.91	58	73	313	1381	274	306	41	0.27	153	8	1.39	1.33	2030	9	0.1	48.7	3.6	6.55
41	KENAI PEN	2012 SOIL03	07/20/12	10.38	6.6	6.4	8.96	40	67	107	1352	227	240	31	0.44	165	9	1.41	1.25	1937	4	0.1	11.7	5.2	4.112
41	KENAI PEN	2012 SOIL06	08/17/12	9.24	6.8	6.2	8.38	56	63	121	1099	223	219	34	0.21	149	8	1.14	1.14	1782	6	<0.05	30.1	2.1	1.676
41	KENAI PEN	2012 SOIL08	09/04/12	13.24	6.4	5.8	7.83	60	53	470	1358	306	299	53	0.22	180	10	1.27	1.4	1968	11	0.2	41.5	2.8	6.548
41	KENAI PEN	2012 SOIL15	10/16/12	11	7.5	6.7	8.39	24	65	329	1494	262	250	30	<0.2	146	6	1.32	1.18	1753	7	0.19	1.9	<0.5	0

2012 Tissue Data

Farm ID	Location	Analysis Date	Matrix/Round	Plant Part	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)%	Magnesium (%)	Sulfur (%)	Boron (ppm)	Iron (ppm)	Manganese (ppm)	Copper (ppm)	Zinc (ppm)	Aluminum (ppm)	Molybdenum (ppm)
5	KENAI PEN	07/23/12	2012 LEAF		2.69	0.231	0.68	1.14	0.465	0.276	27.5	44.8	53.7	4.8	43.5	15.9	<0.2
9	INTERIOR	06/28/12	2012 LEAF		2.41	0.19	0.83	0.83	0.259	0.235	6.4	76.2	35.4	4.8	22.7	52.7	<0.2
10	KENAI PEN	07/06/12	2012 LEAF		3.69	0.402	1.19	1.19	0.523	0.337	15.9	70.1	51.3	6.3	84.9	19	0.2 U
11	INTERIOR	06/26/12	WEEK00	TOP	3.79	0.45	0.9	0.84	0.331	0.324	8.3	99.2	54.4	6.9	45.5	38.6	<0.2
11	INTERIOR	07/16/12	WEEK02	TOP	2.44	0.291	0.79	1.19	0.304	0.247	16.7	83.7	20.2	4.7	23	44.7	--
11	INTERIOR	09/10/12	WEEK06	TOP	1.49	0.167	0.89	2.43	0.281	0.285	49.3	107	13.5	4.1	16.5	73.6	--
11	INTERIOR	09/10/12	WEEK06	BOTTOM	1.65	0.279	1.46	2.56	0.249	0.522	43.8	222	19.1	4.5	13.4	115	--
11	INTERIOR	09/24/12	WEEK08	TOP	1.31	0.249	0.66	2.78	0.414	0.363	54.2	194	30	5	24.2	125	--
11	INTERIOR	09/24/12	WEEK08	BOTTOM	1.45	0.313	1	2.98	0.276	0.538	45.5	199	30.1	5.1	28.5	109	--
12	INTERIOR	07/11/12	2012 LEAF		2.24	0.261	0.71	0.74	0.347	0.144	1.5	70.7	104	4.9	28	29.5	--
14	CENTRAL	07/10/12	2012 LEAF		2.17	0.201	0.94	0.56	0.128	0.145	10.4	58.4	65.3	4.2	35.6	55	<0.2
17	KENAI PEN	07/30/12	2012 LEAF		2.73	0.266	0.81	1.13	0.304	0.274	11.3	104	75.2	6	45.3	48	1.9
18	INTERIOR	06/26/12	WEEK00		3.79	0.45	0.9	0.84	0.331	0.324	8.3	99.2	54.4	6.9	45.5	38.6	<0.2
18	INTERIOR	07/13/12	2012 LEAF		2.93	0.301	1.02	0.93	0.248	0.278	16.4	49.2	95.4	4.9	52.5	19.9	<0.2
18	INTERIOR	07/24/12	WEEK02	TOP	3.1	0.368	0.96	1.51	0.439	0.327	13.7	86.1	43.9	7.1	44.3	20.8	--
18	INTERIOR	07/30/12	WEEK04	TOP	2.87	0.276	0.97	1.77	0.423	0.364	12.3	124	51.8	6.5	23.3	39.3	--
18	INTERIOR	08/06/12	WEEK06	TOP	2.79	0.239	0.83	1.89	0.465	0.319	19.3	150	58.7	5.6	23.4	78.2	--
18	INTERIOR	08/20/12	WEEK08	TOP	2.5	0.242	0.87	2.44	0.426	0.398	15.6	205	77.1	8.3	21.6	55	--
18	INTERIOR	09/18/12	WEEK10	TOP	2.07	0.251	0.89	2.66	0.571	0.351	13.8	341	120	5.8	17.8	127	--
18	INTERIOR	09/18/12	WEEK10	BOTTOM	1.97	0.226	0.54	3.38	0.615	0.356	12	109	49.9	5	22.5	45.3	--
19	OUTSIDE	05/09/12	2012 Leaf		4.11	0.615	1	1.18	0.279	0.316	24.6	86.4	64.1	7.7	67.4	40.8	<0.2
20	OUTSIDE	05/17/12	2012 Leaf		2.42	0.193	0.73	2.29	0.462	0.213	41.2	130	37.6	5.6	33.5	127	<0.2
23	OUTSIDE	05/07/12	2012-Leaf		2.89	0.366	0.89	1.36	0.31	0.241	25.3	129	35.7	6.4	37.3	106	0.3
25	CENTRAL	06/28/12	2012 LEAF		3.59	0.326	1.17	0.8	0.237	0.306	16.7	113	91.4	7.3	58.5	71.8	<0.2
26	KENAI PEN	07/13/12	2012 LEAF		3.54	0.276	1.38	1.17	0.326	0.427	22.1	61.5	61.1	6	32.7	29.3	0.2
27	KENAI PEN	07/18/12	2012 LEAF		2.74	0.322	0.92	0.96	0.249	0.266	15.4	54.1	38.4	4.4	40.2	36.2	0.8
41	KENAI PEN	06/29/12	2012 LEAF	TOP	3.44	0.365	1.02	1.02	0.277	0.394	9	59.9	106	5.2	29.7	30.4	<0.2
41	KENAI PEN	06/29/12	2012 LEAF	BOTTOM	3.36	0.311	1.09	0.97	0.255	0.367	6.6	56.2	88.7	4.4	24.2	31	<0.2
41	KENAI PEN	06/29/12	WEEK00	BOTTOM	3.71	0.4	1.24	0.76	0.441	0.318	4.7	87.2	71.8	4.6	41.5	73.3	<0.2
41	KENAI PEN	06/29/12	WEEK00	TOP	3.12	0.383	1.23	0.66	0.441	0.284	3.8	63.6	56.3	4.8	40.3	33.6	<0.2
41	KENAI PEN	07/18/12	WEEK03	BOTTOM	2.88	0.23	1.24	1.09	0.521	0.339	3.1	67.6	122	3.7	22.8	50.6	--
41	KENAI PEN	07/18/12	WEEK03	TOP	3.13	0.252	0.94	1.06	0.491	0.348	2.5	57.8	126	3.9	24.3	27.7	--
41	KENAI PEN	08/15/12	WEEK06	TOP	3.19	0.215	1.04	2.18	0.59	0.445	5.9	86	105	4.8	15.8	49.7	--
41	KENAI PEN	08/15/12	WEEK06	BOTTOM	2.89	0.181	1.37	1.86	0.575	0.495	2.4	115	56.6	4.4	11.7	84.4	--
41	KENAI PEN	08/30/12	WEEK09	TOP	2.7	0.152	0.87	2.63	0.604	0.439	4.8	52.3	136	4	16.7	26.4	--
41	KENAI PEN	08/30/12	WEEK09	BOTTOM	2.54	0.157	1.15	2.24	0.592	0.524	3.9	78.1	125	3.4	15.9	35.7	--

2014 Soil Data

Farm ID	Location	Variety	Condition	Sampling Date	APGA Sample ID	Lab ID	CEC (meq/ 100g)	Active pH (1:1)	H (% of CEC)	Buffer pH (SMP)	KCl Al (ppm)	KCl Al (lbs/ a)	KCl Al (% of CEC)	Mehlich III Al (ppm)	Total Acidity (meq/100g)	SOM (%)	KCL Avail-able NH_4^+ (ppm)	KCL Avail-able NO_3^- (ppm)	Bray II P (ppm)	Bray II P (lbs/a P_2O_5)	Mehlich III P (ppm)	Mehlich III P (lbs/a P_2O_5)	Mehlich III K (ppm)	Mehlich III K (lbs/a)	Mehlich III K (% of CEC)
3	KENAI PEN	Duchess	Good	07/09/14	87	MZD87	22.85	5.5	30.00	6.5	1	0	0.00	1657	5.33	16.65	6.1	76.5	564	2583	208	953	535	1070	6.00
3	KENAI PEN	Duchess	Poor	07/09/14	88	MZD88	27.91	5.7	24.00	6.7	1	2	0.04	1537	2.89	16.82	6.1	84.0	767	3513	241	1104	537	1074	4.93
3	KENAI PEN	Sarah Bernhardt	Good	07/09/14	85	MZS85	16.60	6.4	9.00	7.0	1	2	0.07	1392	0.00	16.07	6.2	22.8	346	1585	190	870	451	902	6.97
3	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	86	MZS86	17.93	6.5	7.50	6.9	1	2	0.06	1420	0.46	15.58	4.9	8.4	466	2134	171	783	429	858	6.13
5	KENAI PEN	Sarah Bernhardt	Good	07/09/14	83	MZS83	20.60	7.1	0.00	0.0	1	0	0.00	375	0.00	8.27	2.7	4.7	119	545	42	192	166	332	2.07
5	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	84	MZS84	22.73	6.9	1.50	7.3	1	0	0.00	401	0.00	9.81	4.5	4.1	106	485	25	115	157	314	1.77
7	KENAI PEN	Duchess	Good	07/09/14	71	MZD71	14.29	6.0	15.00	6.4	2	4	0.16	1968	6.55	12.52	4.4	1.5	157	719	39	179	99	198	1.78
7	KENAI PEN	Duchess	Poor	07/09/14	72	MZD72	16.61	6.2	12.00	6.7	2	4	0.13	1723	2.89	12.34	3.7	0.9	250	1145	43	197	76	152	1.17
7	KENAI PEN	Duchess (new)	Good	07/09/14	73	MZD73	12.78	5.8	21.00	6.6	2	4	0.17	1612	4.11	14.16	5.8	11.9	71	325	37	169	103	206	2.07
7	KENAI PEN	Duchess (new)	Poor	07/09/14	74	MZD74	12.09	5.8	21.00	6.4	1	0	0.00	2015	6.55	11.87	3.9	10.5	46	211	17	78	59	118	1.25
7	KENAI PEN	Sarah Bernhardt	Good	07/09/14	69	MZS69	14.89	6.0	15.00	6.4	1	2	0.07	1926	6.55	12.46	4.5	1.8	242	1108	48	220	103	206	1.77
7	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	70	MZS70	23.40	6.2	12.00	6.6	3	6	0.14	1773	4.11	12.58	4.0	2.7	204	934	40	183	97	194	1.06
9	INTERIOR	Duchess	Good	06/24/14	21	MZD21	12.90	7.5	0.00	0.0	1	0	0.00	554	0.00	2.41	3.8	2.6	359	1644	160	733	259	518	5.15
9	INTERIOR	Duchess	Poor	06/24/14	22	MZD22	15.17	7.8	0.00	0.0	1	0	0.00	522	0.00	2.50	4.1	4.4	350	1603	145	664	313	626	5.29
9	INTERIOR	Sarah Bernhardt	Good	06/24/14	19	MZS19	13.70	7.2	0.00	0.0	1	0	0.00	531	0.00	2.85	4.0	3.4	711	3256	186	852	309	618	5.78
9	INTERIOR	Sarah Bernhardt	Poor	06/24/14	20	MZS20	10.65	7.1	0.00	0.0	1	0	0.00	5.39	0.00	2.84	4.7	4.2	477	2185	161	737	19	38	6.07
11	INTERIOR	Sarah Bernhardt	Good	06/25/14	25	MZS25	22.49	7.7	0.00	0.0	1	2	0.05	465	0.00	6.16	5.0	1.5	48	220	353	1617	306	612	3.49
11	INTERIOR	Sarah Bernhardt	Poor	06/25/14	26	MZS26	14.32	8.0	0.00	0.0	1	0	0.00	306	0.00	3.67	3.7	1.2	279	1278	136	623	127	254	2.27
12	INTERIOR	Duchess	Good	07/07/14	47	MZD47	15.48	6.3	10.50	7.0	1	0	0.00	780	0.00	5.86	4.6	11.3	236	1081	129	591	156	312	2.58
12	INTERIOR	Duchess	Poor	07/07/14	48	MZD48	17.21	5.9	12.00	7.0	1	0	0.00	801	0.00	5.94	8.7	10.8	187	856	118	540	153	306	2.28
12	INTERIOR	Sarah Bernhardt	Good	07/07/14	45	MZS45	20.33	6.6	6.00	7.2	1	0	0.00	723	0.00	5.81	6.4	13.8	182	834	93	426	135	270	1.70
12	INTERIOR	Sarah Bernhardt	Poor	07/07/14	46	MZS46	14.69	7.0	0.00	7.4	1	2	0.08	645	0.00	4.25	5.1	2.2	261	1195	102	467	33	66	1.50
17	KENAI PEN	Duchess	Good	07/09/14	77	MZD77	10.87	5.4	33.00	6.3	11	22	1.12	1362	7.77	17.11	8.6	12.8	118	540	61	279	97	194	2.29
17	KENAI PEN	Duchess	Poor	07/09/14	78	MZD78	11.36	5.6	27.00	6.3	5	10	0.49	1638	7.77	17.54	5.8	6.2	151	692	69	316	96	192	2.17
17	KENAI PEN	Sarah Bernhardt	Good	07/09/14	75	MZS75	13.40	5.8	21.00	6.4	7	14	0.58	1774	6.55	12.34	51.4	8.4	193	884	78	357	112	224	2.14
17	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	76	MZS76	10.33	5.8	21.00	6.5	4	8	0.43	1331	5.33	14.22	13.4	2.9	159	728	63	289	70	140	1.74
18	INTERIOR	Sarah Bernhardt	Good-Compost -1	06/23/14	7	MZS07	20.48	5.9	18.00	6.9	2	4	0.11	533	0.46	10.51	22.9	39.8	768	3517	429	1965	734	1468	9.19
18	INTERIOR	Sarah Bernhardt	Good-Compost -2	06/23/14	8	MZS08	21.33	5.7	24.00	6.8	3	6	0.16	487	1.68	10.78	42.3	49.6	512	2345	415	1901	927	1854	11.14
18	INTERIOR	Sarah Bernhardt	Good-Compost -3	06/23/14	9	MZS09	22.03	5.7	24.00	6.8	1	0	0.00	591	1.68	9.92	49.8	22.7	654	2995	481	2203	889	1778	10.35
18	INTERIOR	Sarah Bernhardt	Good-Compost -Avg	06/23/14		Avg	21.28	5.8	22.00	6.8	2	3	0.09	537	1.27	10.40	38.3	37.4	645	2952	442	2023	850	1700	10.23
18	INTERIOR	Sarah Bernhardt	Good-Peat -1	06/23/14	1	MZS01	23.03	5.2	39.00	6.5	1	2	0.05	590	5.33	12.16	23.6	13.2	404	1850	264	1209	379	758	4.22
18	INTERIOR	Sarah Bernhardt	Good-Peat -2	06/23/14	2	MZS02	20.00	5.3	36.00	7.0	1	0	0.00	702	0.00	5.52	26.3	13.1	434	1988	294	1347	348	696	4.46
18	INTERIOR	Sarah Bernhardt	Good-Peat -3	06/23/14	3	MZS03	17.68	5.4	33.00	6.7	1	2	0.06	577	2.89	9.33	15.1	5.8	311	1424	212	971	196	392	2.84
18	INTERIOR	Sarah Bernhardt	Good-Peat -Avg	06/23/14		Avg	20.24	5.3	36.00	6.7	1	1	0.04	623	2.74	9.00	21.7	10.7	383	1754	257	1176	308	615	3.84
18	INTERIOR	Sarah Bernhardt	Good-Soil -1	06/23/14	13	MZS13	22.26	5.2	39.00	6.7	2	4	0.10	819	2.89	6.66	58.5	19.3	717	3284	506	2317	716	1432	8.25
18	INTERIOR	Sarah Bernhardt	Good-Soil -2	06/23/14	14	MZS14	20.32	5.2	39.00	6.8	1	2	0.05	770	1.68	6.57	34.1	14.0	714	3270	427	1956	512	1024	6.46
18	INTERIOR	Sarah Bernhardt	Good-Soil -3	06/23/14	15	MZS15	20.44	5.2	39.00	6.6	2	4	0.11	744	4.11	6.72	47.9	23.5	562	2574	416	1905	564	1128	7.08
18	INTERIOR	Sarah Bernhardt	Good-Soil -Avg	06/23/14		Avg	21.01	5.2	39.00	6.7	2	3	0.09	778	2.89	6.65	46.8	18.9	664	3043	450	2059	597	1195	7.26
18	INTERIOR	Sarah Bernhardt	Poor-Compost -1	06/23/14	10	MZS10	20.99	5.8	21.00	7.0	2	4	0.11	593	0.00	9.99	49.2	30.3	587	2688	452	2070	837	1674	10.22
18	INTERIOR	Sarah Bernhardt	Poor-Compost -2	06/23/14	11	MZS11	20.07	5.8	21.00	6.8	1	0	0.00	596	1.68	8.10	30.3	23.3	478	2189	426	1951	688	1376	8.79
18	INTERIOR	Sarah Bernhardt	Poor-Compost -3	06/23/14	12	MZS12	22.96	5.7	24.00	6.9	1	2	0.05	538	0.46	11.20	75.4	39.1	565	2588	556	2546	985	1970	11.00
18	INTERIOR	Sarah Bernhardt	Poor-Compost -Avg	06/23/14		Avg	21.34	5.8	22.00	6.9	1	2	0.05	576	0.71	9.76	51.6	30.9	543	2488	478	2189	837	1673	10.00
18	INTERIOR	Sarah Bernhardt	Poor-Peat -1	06/23/14	4	MZS04	18.89	5.5	30.00	6.8	1	2	0.06	560	1.68	8.55	34.0	10.8	719	3293	396	1814	580	1160	7.87
18	INTERIOR	Sarah Bernhardt	Poor-Peat -2	06/23/14	5	MZS05	19.69	5.5	30.00	6.9	3	6	0.17	644	0.49	6.19	18.4	18.6	428	1960	323	1479	355	710	4.62

2014 Soil Data

Farm ID	Location	Variety	Condition	Sampling Date	APGA Sample ID	Lab ID	CEC (meq/ 100g)	Active pH (1:1)	H (% of CEC)	Buffer pH (SMP)	KCl Al (ppm)	KCl Al (lbs/ a)	KCl Al (% of CEC)	Mehlich III Al (ppm)	Total Acidity (meq/100g)	SOM (%)	KCL Avail-able NH_4^+	KCL Avail-able NO_3^-	Bray II P (ppm)	Bray II P (lbs/a P_2O_5)	Mehlich III P (ppm)	Mehlich III P (lbs/a P_2O_5)	Mehlich III K (ppm)	Mehlich III K (lbs/a)	Mehlich III K (% of CEC)
18	INTERIOR	Sarah Bernhardt	Poor-Peat -3	06/23/14	6	MZS06	19.07	5.4	33.00	6.8	2	4	0.12	616	1.68	6.80	27.7	10.0	376	1722	229	1049	270	540	3.63
18	INTERIOR	Sarah Bernhardt	Poor-Peat -Avg	06/23/14		Avg	19.22	5.5	31.00	6.8	2	4	0.12	607	1.28	7.18	26.7	13.1	508	2325	316	1447	402	803	5.37
18	INTERIOR	Sarah Bernhardt	Poor-Soil -1	06/23/14	16	MZS16	18.51	5.7	24.00	6.9	1	0	0.00	696	0.46	5.40	6.6	9.2	295	1351	206	943	234	468	3.24
18	INTERIOR	Sarah Bernhardt	Poor-Soil -2	06/23/14	17	MZS17	18.70	5.3	36.00	6.6	1	0	0.00	709	4.11	5.10	13.3	14.4	457	2093	282	1292	368	736	5.05
18	INTERIOR	Sarah Bernhardt	Poor-Soil -3	06/23/14	18	MZS18	19.90	5.5	30.00	6.8	2	4	0.11	697	1.68	5.27	6.5	11.4	395	1809	262	1200	256	512	3.30
18	INTERIOR	Sarah Bernhardt	Poor-Soil -Avg	06/23/14		Avg	19.04	5.5	30.00	6.8	1	1	0.04	701	2.08	5.26	8.8	11.7	382	1751	250	1145	286	572	3.86
41	KENAI PEN	Duchess	Good	07/08/14	55	MZD55	11.45	6.2	12.00	6.7	3	6	0.29	1722	2.89	9.94	5.8	2.5	188	861	43	197	183	366	4.10
41	KENAI PEN	Duchess	Poor	07/08/14	56	MZD56	9.69	6.2	12.00	6.6	3	6	0.34	1691	4.11	9.51	5.6	2.7	151	692	40	183	147	294	3.89
41	KENAI PEN	Sarah Bernhardt	Good	07/08/14	53	MZS53	12.30	6.0	15.00	6.7	4	8	0.36	1774	2.89	7.85	4.5	6.2	98	449	22	101	94	188	1.96
41	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	54	MZS54	11.92	6.2	12.00	6.7	8	16	0.75	1730	2.89	9.45	4.3	4.6	88	403	24	110	120	240	2.58
42	INTERIOR	Duchess	Good	06/24/14	23	MZD23	12.85	6.4	9.00	7.3	1	0	0.00	566	0.00	2.02	3.4	3.9	137	627	57	261	60	120	1.20
42	INTERIOR	Duchess	Poor	06/24/14	24	MZD24	12.25	6.7	4.50	7.4	1	0	0.00	548	0.00	2.34	5.1	0.1	229	1049	80	366	51	102	1.07
43	INTERIOR	Duchess	Good	06/26/14	29	MZD29	9.65	4.9	47.00	6.4	55	110	6.33	1642	6.55	5.03	9.1	18.6	220	1008	85	389	170	340	4.52
43	INTERIOR	Duchess	Poor	06/26/14	30	MZD30	7.66	5.0	45.00	6.4	52	104	7.54	1572	6.55	5.01	49.1	29.9	248	1136	97	444	245	508	8.50
43	INTERIOR	Sarah Bernhardt	Good	06/26/14	27	MZS27	9.98	4.8	49.00	6.3	75	150	8.35	1728	7.77	6.33	25.3	30.2	314	1438	130	595	230	460	5.91
43	INTERIOR	Sarah Bernhardt	Poor	06/26/14	28	MZS28	9.11	4.8	19.00	6.4	64	128	7.81	1667	6.55	5.45	19.9	24.1	249	1140	93	426	190	380	5.35
44	INTERIOR	Duchess	Good	06/30/14	31	MZD31	6.13	6.0	15.00	7.0	1	0	0.00	1736	0.00	2.16	3.8	0.7	236	1081	68	311	146	292	6.11
44	INTERIOR	Duchess	Poor	06/30/14	32	MZD32	8.66	6.3	10.50	7.1	1	0	0.00	1479	0.00	1.93	6.9	0.5	360	1649	133	609	222	444	6.57
45	CENTRAL	Duchess	Good	06/30/14	35	MZD35	6.79	5.6	27.00	6.4	6	12	0.98	1781	6.55	11.01	6.8	6.7	257	1177	57	261	184	368	6.95
45	CENTRAL	Duchess	Poor	06/30/14	36	MZD36	9.50	5.8	21.00	6.5	4	8	0.47	1793	5.33	10.74	7.8	14.6	444	2034	116	531	254	508	6.86
45	CENTRAL	Sarah Bernhardt	Good	06/30/14	33	MZS33	8.83	5.6	27.00	6.4	4	8	0.50	1672	6.55	11.66	7.3	7.0	421	1928	126	577	117	234	3.40
45	CENTRAL	Sarah Bernhardt	Poor	06/30/14	34	MZS34	7.98	5.6	27.00	6.4	8	16	1.11	1641	6.55	11.21	5.9	6.3	467	2139	113	518	119	238	3.82
46	CENTRAL	Duchess	Good	06/30/14	39	MZD39	5.21	5.9	18.00	7.2	3	6	0.64	642	0.00	1.75	5.0	0.8	343	1571	81	371	184	368	9.06
46	CENTRAL	Duchess	Poor	06/30/14	40	MZD40	4.76	5.6	27.00	6.9	17	34	3.97	764	0.46	2.07	4.1	0.6	291	1333	67	307	223	446	12.01
46	CENTRAL	Sarah Bernhardt	Good	06/30/14	37	MZS37	5.42	5.3	36.00	6.6	27	54	5.54	896	4.11	3.37	3.7	1.2	244	1118	52	238	105	210	4.97
46	CENTRAL	Sarah Bernhardt	Poor	06/30/14	38	MZS38	5.92	5.3	36.00	6.6	32	64	6.01	919	4.11	3.98	4.7	1.1	257	1177	59	270	145	290	6.28
47	CENTRAL	Duchess	Good	07/01/14	43	MZD43	12.63	7.0	0.00	7.3	1	0	0.00	873	0.00	4.23	3.9	1.7	397	1818	234	1072	332	664	6.74
47	CENTRAL	Duchess	Poor	07/01/14	44	MZD44	12.64	7.1	0.00	0.0	3	6	0.26	953	0.00	3.71	4.1	1.7	357	1635	207	948	398	769	8.07
47	CENTRAL	Sarah Bernhardt	Good	07/01/14	41	MZS41	12.58	7.2	0.00	0.0	2	4	0.18	872	0.00	3.49	3.3	2.7	224	1026	114	522	292	584	5.95
47	CENTRAL	Sarah Bernhardt	Poor	07/01/14	42	MZS42	11.73	7.0	0.00	7.3	1	2	0.09	952	0.00	3.81	4.8	1.9	225	1031	102	467	247	494	5.40
48	INTERIOR	Duchess	Good	07/07/14	51	MZD51	16.39	6.1	13.50	6.9	1	2	0.07	1021	0.46	5.51	4.5	5.3	368	1685	176	806	247	494	3.86
48	INTERIOR	Duchess	Poor	07/07/14	52	MZD52	12.20	5.5	30.00	6.8	4	8	0.36	1157	1.68	6.11	3.6	12.0	262	1200	148	678	264	528	5.55
48	INTERIOR	Sarah Bernhardt	Good	07/07/14	49	MZS49	19.03	5.8	21.00	6.9	2	4	0.12	943	0.46	6.01	31.8	56.3	295	1351	194	889	436	872	5.87
48	INTERIOR	Sarah Bernhardt	Poor	07/07/14	50	MZS50	12.63	5.8	21.00	6.7	5	10	0.44	1010	2.89	7.72	4.1	11.5	170	779	99	453	140	280	2.84
49	KENAI PEN	Duchess	Good	07/08/14	59	MZD59	13.26	5.3	36.00	6.2	18	36	1.51	2122	8.98	11.53	5.1	18.0	49	224	14	64	136	272	2.63
49	KENAI PEN	Duchess	Poor	07/08/14	60	MZD60	9.14	6.2	12.00	6.7	1	2	0.12	1999	2.89	8.75	3.9	8.3	44	202	13	60	138	276	3.87
49	KENAI PEN	Sarah Bernhardt	Good	07/08/14	57	MZS57	16.33	6.5	7.50	6.8	1	0	0.00	1619	1.68	13.34	5.1	10.1	426	1951	154	705	356	712	5.59
49	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	58	MZS58	11.92	5.8	21.00	6.3	1	0	0.00	2043	7.77	12.78	5.4	10.5	72	330	22	101	147	294	3.16
50	KENAI PEN	Duchess	Good	07/08/14	63	MZD63	10.76	5.4	33.00	6.2	17	34	1.76	1832	8.98	12.58	7.0	10.0	14	64	14	64	50	100	1.19
50	KENAI PEN	Duchess	Poor	07/08/14	64	MZD64	9.76	5.5	30.00	6.2	11	22	1.25	2233	8.98	12.86	5.3	12.4	10	45	8	37	54	108	1.42
50	KENAI PEN	Sarah Bernhardt	Good	07/08/14	61	MZS61	16.25	5.2	39.00	6.1	25	50	1.71	2304	10.20	13.72	3.4	28.6	87	398	21	96	214	428	3.38
50	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	62	MZS62	15.17	5.2	39.00	6.1	26	52	1.90	2226	10.20	14.89	3.0	22.9	107	490	28	128	198	396	3.35
51	KENAI PEN	Duchess	Good	07/08/14	67	MZD67	9.85	5.7	24.00	6.5	1	0	0.00	1842	5.33	15.29	15.7	13.8	130	595	47	215	62	124	1.61
51	KENAI PEN	Duchess	Poor	07/08/14	68	MZD68	12.39	5.6	27.00	6.4	4	8	0.36	1844	6.55	13.88	12.3	16.8	233	1067	64	293	76	152	1.57

2014 Soil Data

Farm ID	Location	Variety	Condition	Sampling Date	APGA Sample ID	Lab ID	CEC (meq/ 100g)	Active pH (1:1)	H (% of CEC)	Buffer pH (SMP)	KCl Al (ppm)	KCl Al (lbs/ a)	KCl Al (% of CEC)	Mehlich III Al (ppm)	Total Acidity (meq/100g)	SOM (%)	KCL Available NH_4^+ (ppm)	NO_3^- (ppm)	Bray II P (ppm)	Bray II P (lbs/a P_2O_5)	Mehlich III P (ppm)	Mehlich III P (lbs/a P_2O_5)	Mehlich III K (ppm)	Mehlich III K (lbs/a)	Mehlich III K (% of CEC)
51	KENAI PEN	Sarah Bernhardt	Good	07/08/14	65	MZS65	11.57	5.8	21.00	6.6	3	6	0.29	1669	4.11	13.04	9.8	17.1	574	2629	187	856	81	162	1.80
51	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	66	MZS66	10.94	5.9	18.00	6.5	1	0	0.00	1733	5.33	12.89	11.4	6.7	441	2020	129	591	68	136	1.59
52	KENAI PEN	Duchess	Good	07/09/14	79	MZD79*	6.13	5.1	42.00	6.0	43	86	7.79	1852	11.42	13.94	10.6	2.0	16	73	10	46	47	94	1.97
52	KENAI PEN	Duchess	Poor	07/09/14	80	MZD80*	6.71	5.2	39.00	6.0	41	82	6.79	1847	11.42	13.70	10.5	2.3	13	60	10	46	55	110	2.10
52	KENAI PEN	Festiva	Good	07/09/14	81	MZF81	14.87	6.1	13.50	6.7	1	0	0.00	1201	2.89	4.29	3.5	1.3	332	1521	83	380	151	302	2.60
52	KENAI PEN	Festiva	Poor	07/09/14	82	MZF82	14.85	6.1	13.50	6.8	1	2	0.07	1173	1.68	3.31	4.2	1.4	153	701	92	421	192	384	3.32
53	CENTRAL	Sarah Bernhardt	Good	07/10/14	89	MZS89	12.37	6.5	7.50	6.8	1	2	0.09	1645	1.68	11.41	3.1	1.5	265	1214	116	531	286	572	5.93
53	CENTRAL	Sarah Bernhardt	Poor	07/10/14	90	MZS90	10.06	6.3	10.50	6.7	1	2	0.11	1634	2.89	10.58	3.1	1.1	222	1017	92	421	254	508	6.47

2014 Soil Data

Farm ID	Location	Variety	Condition	Sampling Date	Mehlich III Ca (ppm)	Ca (lbs/a)	Ca (% of CEC)	Mehlich III Mg (ppm)	Mg (lbs/a)	Mg (% of CEC)	S (ppm)	Mehlich III Na (ppm)	Na (lbs/a)	Na (% of CEC)	Mehlich III B (ppm)	Mehlich III Fe (ppm)	Mehlich III Mn (ppm)	Mehlich III Cu (ppm)	Mehlich III Zn (ppm)
3	KENAI PEN	Duchess	Good	07/09/14	2696	5392	58.99	116	232	4.23	24	41	82	0.78	0.88	446	12	1.30	5.92
3	KENAI PEN	Duchess	Poor	07/09/14	3746	7492	67.11	110	220	3.28	23	40	80	0.62	0.91	445	10	1.40	4.47
3	KENAI PEN	Sarah Bernhardt	Good	07/09/14	2413	4826	72.68	201	402	10.09	28	45	90	1.18	0.61	311	17	2.65	8.32
3	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	2734	5468	76.24	195	390	9.06	27	41	82	0.99	0.64	339	11	1.24	9.15
5	KENAI PEN	Sarah Bernhardt	Good	07/09/14	2934	5834	71.21	643	1286	26.01	17	33	66	0.70	0.76	409	14	4.61	7.09
5	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	3229	6458	71.03	683	1366	25.04	12	34	68	0.65	0.61	395	14	4.79	7.06
7	KENAI PEN	Duchess	Good	07/09/14	2184	4368	76.42	100	200	5.83	20	26	52	0.79	0.25	301	10	0.96	3.30
7	KENAI PEN	Duchess	Poor	07/09/14	2734	5468	82.30	76	152	3.81	17	23	46	0.60	0.28	245	8	0.81	2.23
7	KENAI PEN	Duchess (new)	Good	07/09/14	1584	3168	61.97	213	426	13.89	17	26	52	0.88	0.30	312	9	1.01	5.76
7	KENAI PEN	Duchess (new)	Poor	07/09/14	1619	3238	66.96	142	284	9.79	16	28	56	1.01	0.27	296	4	0.96	3.40
7	KENAI PEN	Sarah Bernhardt	Good	07/09/14	2295	4590	77.07	92	184	5.15	22	33	66	0.96	0.22	280	6	1.18	2.17
7	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	3906	7812	83.46	81	162	2.88	20	24	48	0.45	0.20	250	6	1.06	1.83
9	INTERIOR	Duchess	Good	06/24/14	1904	3808	73.80	313	626	20.22	10	25	50	0.84	0.60	287	32	3.64	7.88
9	INTERIOR	Duchess	Poor	06/24/14	2255	4510	74.32	358	716	19.67	9	26	52	0.75	0.64	263	38	3.12	11.09
9	INTERIOR	Sarah Bernhardt	Good	06/24/14	2104	4208	76.79	275	550	16.73	10	23	46	0.73	0.83	296	28	2.74	8.93
9	INTERIOR	Sarah Bernhardt	Poor	06/24/14	1646	3292	77.28	203	406	15.88	8	19	38	0.78	0.76	308	29	2.75	6.42
11	INTERIOR	Sarah Bernhardt	Good	06/25/14	3155	6310	70.14	668	1336	24.75	106	82	164	1.59	0.78	374	43	5.63	9.71
11	INTERIOR	Sarah Bernhardt	Poor	06/25/14	2021	4042	70.57	450	900	26.19	51	33	66	1.00	0.84	408	52	6.07	4.77
12	INTERIOR	Duchess	Good	07/07/14	1904	3808	61.50	439	878	23.63	12	64	128	1.80	0.20	395	5	2.24	2.45
12	INTERIOR	Duchess	Poor	07/07/14	2058	4116	59.79	497	994	24.07	15	74	148	1.87	0.23	377	8	3.07	3.54
12	INTERIOR	Sarah Bernhardt	Good	07/07/14	2951	5902	72.58	448	896	18.36	12	64	128	1.37	0.52	372	11	2.45	2.79
12	INTERIOR	Sarah Bernhardt	Poor	07/07/14	2193	4393	74.64	402	804	22.80	7	33	66	0.98	0.41	364	12	3.13	3.98
17	KENAI PEN	Duchess	Good	07/09/14	1216	2432	55.93	88	176	6.75	23	23	46	0.92	0.21	396	8	1.44	2.46
17	KENAI PEN	Duchess	Poor	07/09/14	1391	2782	61.22	113	226	8.29	24	21	42	0.80	0.38	423	10	1.42	2.33
17	KENAI PEN	Sarah Bernhardt	Good	07/09/14	1861	3722	69.44	94	188	5.85	33	31	62	1.01	0.35	463	6	1.05	1.50
17	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	1418	2836	68.64	90	180	7.26	22	23	46	0.97	0.29	437	8	1.24	1.61
18	INTERIOR	Sarah Bernhardt	Good-Compost -1	06/23/14	2238	4476	57.64	404	808	16.44	31	76	152	1.61	0.62	411	24	2.47	13.67
18	INTERIOR	Sarah Bernhardt	Good-Compost -2	06/23/14	2068	4136	48.48	379	758	14.81	31	69	138	1.41	0.69	381	25	2.31	14.23
18	INTERIOR	Sarah Bernhardt	Good-Compost -3	06/23/14	2171	4342	49.27	403	806	15.24	34	58	116	1.14	0.84	400	26	2.50	15.53
18	INTERIOR	Sarah Bernhardt	Good-Compost -Avg	06/23/14	2159	4318	51.80	395	791	15.50	32	68	135	1.39	0.72	397	25	2.43	14.48
18	INTERIOR	Sarah Bernhardt	Good-Peat -1	06/23/14	1946	3892	42.25	355	710	12.85	28	87	174	1.64	0.65	353	26	1.90	10.71
18	INTERIOR	Sarah Bernhardt	Good-Peat -2	06/23/14	1813	3626	45.33	308	616	12.83	27	64	128	1.39	0.60	330	27	2.00	7.74
18	INTERIOR	Sarah Bernhardt	Good-Peat -3	06/23/14	1684	3368	47.62	309	618	14.56	19	77	154	1.89	0.48	319	27	1.72	6.50
18	INTERIOR	Sarah Bernhardt	Good-Peat -Avg	06/23/14	1814	3629	45.07	324	648	13.41	25	76	152	1.64	0.58	334	27	1.87	8.32
18	INTERIOR	Sarah Bernhardt	Good-Soil -1	06/23/14	1764	3528	39.62	306	612	11.46	30	80	160	1.56	0.65	404	44	2.19	14.27
18	INTERIOR	Sarah Bernhardt	Good-Soil -2	06/23/14	1672	3344	41.14	297	594	12.18	21	54	108	1.16	0.65	387	37	1.87	10.11
18	INTERIOR	Sarah Bernhardt	Good-Soil -3	06/23/14	1662	3324	40.66	283	566	11.54	26	76	152	1.62	0.61	371	36	2.20	29.39
18	INTERIOR	Sarah Bernhardt	Good-Soil -Avg	06/23/14	1699	3399	40.47	295	591	11.73	26	70	140	1.45	0.64	387	39	2.09	17.92
18	INTERIOR	Sarah Bernhardt	Poor-Compost -1	06/23/14	2173	4346	51.76	395	790	15.68	30	59	118	1.22	0.63	375	23	2.56	18.44
18	INTERIOR	Sarah Bernhardt	Poor-Compost -2	06/23/14	2162	4324	53.86	366	732	15.20	22	53	106	1.15	0.70	394	23	2.51	14.20
18	INTERIOR	Sarah Bernhardt	Poor-Compost -3	06/23/14	2277	4554	49.59	379	758	13.76	39	85	170	1.61	0.79	403	25	2.24	14.81
18	INTERIOR	Sarah Bernhardt	Poor-Compost -Avg	06/23/14	2204	4408	51.74	380	760	14.88	30	66	131	1.33	0.71	391	24	2.44	15.82
18	INTERIOR	Sarah Bernhardt	Poor-Peat -1	06/23/14	1771	3542	46.88	305	610	13.46	28	75	150	1.73	0.84	345	27	2.01	14.96
18	INTERIOR	Sarah Bernhardt	Poor-Peat -2	06/23/14	1912	3824	48.55	352	704	14.90	21	80	160	1.77	0.66	320	26	2.00	11.74

2014 Soil Data

Farm ID	Location	Variety	Condition	Sampling Date	Mehlich III Ca (ppm)	Ca (lbs/a)	Ca (% of CEC)	Mehlich III Mg (ppm)	Mg (lbs/a)	Mg (% of CEC)	S (ppm)	Mehlich III Na (ppm)	Na (lbs/a)	Na (% of CEC)	Mehlich III B (ppm)	Mehlich III Fe (ppm)	Mehlich III Mn (ppm)	Mehlich III Cu (ppm)	Mehlich III Zn (ppm)
18	INTERIOR	Sarah Bernhardt	Poor-Peat -3	06/23/14	1770	3540	46.41	344	688	15.03	25	80	160	1.82	0.47	308	27	2.08	8.79
18	INTERIOR	Sarah Bernhardt	Poor-Peat -Avg	06/23/14	1818	3635	47.28	334	667	14.46	25	78	157	1.77	0.66	324	27	2.03	11.83
18	INTERIOR	Sarah Bernhardt	Poor-Soil -1	06/23/14	1984	3968	53.59	389	778	17.51	15	71	142	1.67	0.68	311	29	2.16	9.87
18	INTERIOR	Sarah Bernhardt	Poor-Soil -2	06/23/14	1624	3248	43.42	316	632	14.08	18	62	124	1.44	0.45	332	32	2.22	8.18
18	INTERIOR	Sarah Bernhardt	Poor-Soil -3	06/23/14	2002	4004	50.30	349	698	14.61	16	76	152	1.66	0.53	332	28	2.55	11.46
18	INTERIOR	Sarah Bernhardt	Poor-Soil -Avg	06/23/14	1870	3740	49.10	351	703	15.40	16	70	139	1.59	0.55	325	30	2.31	9.84
41	KENAI PEN	Duchess	Good	07/08/14	1546	3092	67.51	210	420	15.28	24	21	42	0.80	0.20	133	10	1.24	1.36
41	KENAI PEN	Duchess	Poor	07/08/14	1189	2378	61.35	250	500	21.50	24	21	42	0.94	0.20	145	9	1.05	1.03
41	KENAI PEN	Sarah Bernhardt	Good	07/08/14	1917	3834	77.93	56	112	3.79	13	28	56	0.99	0.22	138	5	1.22	0.74
41	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	1914	3828	80.29	50	100	3.50	13	25	50	0.91	0.20	153	7	1.26	1.03
42	INTERIOR	Duchess	Good	06/24/14	1696	3392	65.99	343	686	22.24	56	47	94	1.59	0.50	220	44	2.90	6.82
42	INTERIOR	Duchess	Poor	06/24/14	1780	2560	72.65	299	598	20.34	32	40	80	1.42	0.53	216	51	2.41	7.46
43	INTERIOR	Duchess	Good	06/26/14	694	1388	35.96	61	122	5.27	25	21	42	0.95	0.65	258	6	1.25	2.58
43	INTERIOR	Duchess	Poor	06/26/14	460	920	30.03	69	138	7.51	25	25	50	1.42	1.30	299	5	1.22	1.88
43	INTERIOR	Sarah Bernhardt	Good	06/26/14	637	1274	31.91	47	94	3.92	27	21	32	0.91	1.24	374	5	1.41	1.50
43	INTERIOR	Sarah Bernhardt	Poor	06/26/14	596	1192	32.71	46	92	4.21	30	19	38	0.91	1.16	316	4	1.23	1.52
44	INTERIOR	Duchess	Good	06/30/14	774	1578	63.13	106	212	14.41	37	20	40	1.42	0.56	101	10	1.21	4.33
44	INTERIOR	Duchess	Poor	06/30/14	1225	2450	70.73	118	236	11.35	34	16	32	0.80	0.63	131	22	1.98	6.05
45	CENTRAL	Duchess	Good	06/30/14	772	1544	56.85	59	118	7.24	13	15	30	0.96	0.56	178	14	1.38	9.24
45	CENTRAL	Duchess	Poor	06/30/14	1221	2442	64.26	74	148	6.49	14	20	40	0.92	0.71	190	18	1.49	10.62
45	CENTRAL	Sarah Bernhardt	Good	06/30/14	1136	2272	64.33	41	82	3.87	14	19	38	0.94	0.59	245	18	1.35	10.61
45	CENTRAL	Sarah Bernhardt	Poor	06/30/14	1019	2038	62.85	32	64	3.34	14	16	32	0.87	0.49	246	17	1.55	20.61
46	CENTRAL	Duchess	Good	06/30/14	662	1324	63.53	47	94	7.52	7	15	30	1.25	0.46	531	28	2.33	4.51
46	CENTRAL	Duchess	Poor	06/30/14	450	900	47.27	47	94	8.23	9	16	32	1.46	0.47	723	19	1.69	3.63
46	CENTRAL	Sarah Bernhardt	Good	06/30/14	496	992	45.76	42	84	6.46	9	16	32	1.28	0.21	545	18	1.56	5.55
46	CENTRAL	Sarah Bernhardt	Poor	06/30/14	533	1066	45.02	38	76	5.35	11	18	36	1.32	0.31	606	18	1.37	5.33
47	CENTRAL	Duchess	Good	07/01/14	1949	3898	77.16	224	448	14.78	13	38	76	1.31	0.61	481	17	3.81	6.14
47	CENTRAL	Duchess	Poor	07/01/14	1898	3796	75.08	234	468	15.43	13	33	66	1.14	0.79	455	19	4.37	4.89
47	CENTRAL	Sarah Bernhardt	Good	07/01/14	1984	3968	78.86	205	410	13.58	13	41	82	1.42	0.64	502	15	4.13	2.48
47	CENTRAL	Sarah Bernhardt	Poor	07/01/14	1859	3718	79.24	200	400	14.21	11	29	58	1.07	0.77	475	16	4.87	2.61
48	INTERIOR	Duchess	Good	07/07/14	2513	5026	76.66	105	210	5.34	31	21	42	0.56	0.23	388	8	2.58	4.88
48	INTERIOR	Duchess	Poor	07/07/14	1399	2798	57.34	88	176	6.01	37	20	40	0.71	0.27	422	7	2.37	3.10
48	INTERIOR	Sarah Bernhardt	Good	07/07/14	2631	5262	69.13	78	156	3.42	30	20	40	0.46	0.25	363	10	2.67	4.91
48	INTERIOR	Sarah Bernhardt	Poor	07/07/14	1606	3212	63.58	168	336	11.08	30	30	60	1.03	0.30	410	11	2.64	3.05
49	KENAI PEN	Duchess	Good	07/08/14	1469	2938	55.39	60	120	3.77	19	21	42	0.69	0.43	203	5	1.43	2.14
49	KENAI PEN	Duchess	Poor	07/08/14	1420	2840	77.68	60	120	5.47	17	18	36	0.86	0.49	118	2	1.84	3.43
49	KENAI PEN	Sarah Bernhardt	Good	07/08/14	2442	4884	74.77	213	426	10.87	18	47	94	1.25	0.84	330	32	2.32	11.23
49	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	1646	3292	69.04	86	172	6.01	16	22	44	0.80	0.38	232	3	1.52	3.35
50	KENAI PEN	Duchess	Good	07/08/14	1250	2500	58.09	66	132	5.11	25	21	42	0.85	0.20	216	6	0.82	2.49
50	KENAI PEN	Duchess	Poor	07/08/14	1152	2304	59.02	84	168	7.17	23	26	52	1.16	0.20	253	6	1.10	2.38
50	KENAI PEN	Sarah Bernhardt	Good	07/08/14	1715	3430	52.77	49	98	2.51	26	24	48	0.64	0.33	275	15	0.99	2.12
50	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	1600	3200	52.74	42	84	2.31	27	25	50	0.72	0.30	303	15	0.89	2.53
51	KENAI PEN	Duchess	Good	07/08/14	1288	2576	65.38	92	184	7.78	25	27	54	1.19	0.27	223	9	1.56	4.63
51	KENAI PEN	Duchess	Poor	07/08/14	1544	3088	62.31	113	226	7.60	25	33	66	1.16	0.27	230	10	1.38	4.63

2014 Soil Data

Farm ID	Location	Variety	Condition	Sampling Date	Mehlich III Ca (ppm)	Ca (lbs/a)	Ca (% of CEC)	Mehlich III Mg (ppm)	Mg (lbs/a)	Mg (% of CEC)	S (ppm)	Mehlich III Na (ppm)	Na (lbs/a)	Na (% of CEC)	Mehlich III B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
51	KENAI PEN	Sarah Bernhardt	Good	07/08/14	1610	3220	69.58	76	152	5.47	30	49	98	1.84	0.29	251	17	1.08	3.91
51	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	1546	3092	70.66	103	206	7.85	26	47	94	1.87	0.28	256	14	1.26	4.16
52	KENAI PEN	Duchess	Good	07/09/14	438	876	35.73	71	142	9.65	17	40	80	1.97	0.43	234	20	1.41	4.74
52	KENAI PEN	Duchess	Poor	07/09/14	534	1068	39.79	76	152	9.44	18	45	90	2.92	0.38	232	21	1.41	5.01
52	KENAI PEN	Festiva	Good	07/09/14	1955	3910	65.74	287	574	16.08	9	71	142	2.08	0.37	256	18	2.40	2.92
52	KENAI PEN	Festiva	Poor	07/09/14	1961	3922	66.03	271	542	15.21	8	64	128	1.87	0.20	263	15	2.89	3.15
53	CENTRAL	Sarah Bernhardt	Good	07/10/14	1852	3704	74.86	160	320	10.78	9	24	48	0.84	0.46	337	9	1.55	4.09
53	CENTRAL	Sarah Bernhardt	Poor	07/10/14	1454	2908	72.27	117	234	9.69	10	23	46	0.99	0.52	344	9	1.52	2.78

2014 Tissue Data

Farm ID	Location	Variety	Condition	Sampling Date	APGA Sample ID	Lab ID	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Al (ppm)
3	KENAI PEN	Duchess	Good	07/09/14	87	MZP87	2.90	0.232	1.46	1.34	0.342	0.349	34.5	58.4	29.9	5.8	41.1	31.2
3	KENAI PEN	Duchess	Poor	07/09/14	88	MZP88	1.92	0.201	1.24	1.34	0.354	0.233	52.1	48.8	17.0	4.0	33.3	32.6
3	KENAI PEN	Sarah Bernhardt	Good	07/09/14	85	MZP85	2.37	0.229	1.28	1.58	0.234	0.216	30.8	55.2	33.1	5.0	34.1	20.7
3	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	86	MZP86	2.23	0.300	1.36	0.70	0.203	0.197	11.7	44.1	16.3	4.3	33.1	23.6
5	KENAI PEN	Sarah Bernhardt	Good	07/09/14	83	MZP83	2.18	0.202	0.71	1.06	0.446	0.402	7.2	54.5	12.0	3.3	25.0	27.9
5	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	84	MZP84	2.09	0.280	0.91	0.87	0.446	0.419	9.4	55.7	4.3	4.8	22.2	31.7
7	KENAI PEN	Duchess	Good	07/09/14	71	MZP71	2.11	0.277	1.00	1.78	0.558	0.327	25.2	52.2	42.2	4.8	84.1	51.3
7	KENAI PEN	Duchess	Poor	07/09/14	72	MZP72	1.85	0.234	0.90	1.40	0.426	0.281	20.9	64.2	22.0	4.1	63.5	67.6
7	KENAI PEN	Duchess (new)	Good	07/09/14	73	MZP73	2.39	0.205	0.92	1.94	0.470	0.256	37.3	46.7	25.8	3.5	78.7	27.2
7	KENAI PEN	Duchess (new)	Poor	07/09/14	74	MZP74	1.87	0.178	0.86	1.74	0.359	0.195	25.5	50.2	15.5	3.2	54.0	33.3
7	KENAI PEN	Sarah Bernhardt	Good	07/09/14	69	MZP69	1.83	0.224	1.11	1.04	0.305	0.251	17.7	33.5	29.4	4.0	40.8	27.9
7	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	70	MZP70	1.70	0.252	0.98	1.11	0.234	0.263	13.0	32.7	21.9	3.6	37.8	24.7
9	INTERIOR	Duchess	Good	06/24/14	21	MZP21	2.72	0.409	1.17	1.13	0.428	0.263	17.3	47.8	25.3	6.3	56.5	10.2
9	INTERIOR	Duchess	Poor	06/24/14	22	MZP22	2.47	0.480	1.49	0.86	0.306	0.216	15.1	41.8	20.3	7.7	45.6	8.8
9	INTERIOR	Sarah Bernhardt	Good	06/24/14	19	MZP19	2.39	0.398	1.07	0.92	0.271	0.222	14.9	44.2	27.2	6.5	32.9	9.6
9	INTERIOR	Sarah Bernhardt	Poor	06/24/14	20	MZP20	2.15	0.356	1.17	0.70	0.280	0.206	11.8	32.7	17.0	5.8	27.0	8.3
11	INTERIOR	Sarah Bernhardt	Good	06/25/14	25	MZP25	2.28	0.411	0.99	1.14	0.463	0.283	18.9	35.2	18.5	7.3	47.5	11.2
11	INTERIOR	Sarah Bernhardt	Poor	06/25/14	26	MZP26	2.16	0.462	1.07	0.77	0.315	0.261	15.3	34.2	20.3	6.7	44.0	8.4
12	INTERIOR	Duchess	Good	07/07/14	47	MZP47	2.63	0.313	1.20	0.86	0.420	0.241	7.5	52.6	34.5	4.3	25.1	23.3
12	INTERIOR	Duchess	Poor	07/07/14	48	MZP48	2.60	0.394	1.74	0.65	0.358	0.218	6.8	54.0	22.8	6.5	37.7	21.7
12	INTERIOR	Sarah Bernhardt	Good	07/07/14	45	MZP45	2.90	0.378	1.06	1.17	0.368	0.254	8.0	51.9	74.4	4.4	33.8	11.9
12	INTERIOR	Sarah Bernhardt	Poor	07/07/14	46	MZP46	3.01	0.392	1.26	0.83	0.350	0.219	8.4	58.4	49.0	4.8	35.1	20.4
17	KENAI PEN	Duchess	Good	07/09/14	77	MZP77	2.72	0.232	0.89	1.78	0.344	0.253	20.4	50.9	33.1	4.7	39.0	25.4
17	KENAI PEN	Duchess	Poor	07/09/14	78	MZP78	2.48	0.219	0.69	1.64	0.385	0.212	10.6	48.3	43.9	4.5	33.1	29.5
17	KENAI PEN	Sarah Bernhardt	Good	07/09/14	75	MZP75	2.34	0.222	0.73	1.90	0.362	0.234	15.6	53.0	35.4	4.6	42.6	32.5
17	KENAI PEN	Sarah Bernhardt	Poor	07/09/14	76	MZP76	2.04	0.251	0.85	1.15	0.250	0.206	12.5	43.7	21.7	4.3	36.5	26.4
18	INTERIOR	Sarah Bernhardt	Good-Compost -1	06/23/14	7	MZP07	3.06	0.337	1.08	0.66	0.287	0.254	13.5	70.5	34.6	5.8	36.5	16.0
18	INTERIOR	Sarah Bernhardt	Good-Compost -2	06/23/14	8	MZP08	2.51	0.318	0.90	0.66	0.267	0.235	9.8	64.1	27.7	5.8	34.3	13.5
18	INTERIOR	Sarah Bernhardt	Good-Compost -3	06/23/14	9	MZP09	2.84	0.335	1.06	0.80	0.294	0.275	18.1	71.7	44.4	5.8	39.4	14.1
18	INTERIOR	Sarah Bernhardt	Good-Compost -Avg	06/23/14		Avg	2.80	0.330	1.01	0.71	0.283	0.255	13.8	68.8	35.6	5.8	36.7	14.5
18	INTERIOR	Sarah Bernhardt	Good-Peat -1	06/23/14	1	MZP01	2.17	0.383	0.89	0.76	0.257	0.219	12.0	45.1	23.0	5.9	41.9	17.9
18	INTERIOR	Sarah Bernhardt	Good-Peat -2	06/23/14	2	MZP02	1.88	0.390	0.83	1.12	0.353	0.232	13.4	47.5	30.9	5.1	49.1	15.4
18	INTERIOR	Sarah Bernhardt	Good-Peat -3	06/23/14	3	MZP03	1.89	0.377	0.86	1.15	0.372	0.254	14.2	50.9	36.5	4.8	49.4	18.1
18	INTERIOR	Sarah Bernhardt	Good-Peat -Avg	06/23/14		Avg	1.98	0.383	0.86	1.01	0.327	0.235	13.2	47.8	30.1	5.3	46.8	17.1
18	INTERIOR	Sarah Bernhardt	Good-Soil -1	06/23/14	13	MZP13	2.57	0.315	0.85	0.73	0.283	0.217	11.6	51.4	37.8	5.7	36.5	13.8
18	INTERIOR	Sarah Bernhardt	Good-Soil -2	06/23/14	14	MZP14	2.25	0.318	0.91	0.78	0.263	0.215	10.2	47.5	26.0	5.6	38.2	15.6
18	INTERIOR	Sarah Bernhardt	Good-Soil -3	06/23/14	15	MZP15	2.30	0.324	0.89	0.68	0.239	0.216	13.8	46.5	28.0	5.8	37.1	13.9
18	INTERIOR	Sarah Bernhardt	Good-Soil -Avg	06/23/14		Avg	2.37	0.319	0.88	0.73	0.262	0.216	11.9	48.5	30.6	5.7	37.3	14.4
18	INTERIOR	Sarah Bernhardt	Poor-Compost -1	06/23/14	10	MZP10	2.54	0.304	1.00	0.54	0.256	0.219	13.4	56.7	29.8	5.4	32.9	13.7
18	INTERIOR	Sarah Bernhardt	Poor-Compost -2	06/23/14	11	MZP11	2.14	0.323	0.89	0.56	0.253	0.209	10.8	47.2	25.4	5.3	36.2	17.0
18	INTERIOR	Sarah Bernhardt	Poor-Compost -3	06/23/14	12	MZP12	2.28	0.332	0.93	0.74	0.277	0.203	11.8	47.4	27.8	5.7	34.2	15.8
18	INTERIOR	Sarah Bernhardt	Poor-Compost -Avg	06/23/14		Avg	2.32	0.320	0.94	0.61	0.262	0.210	12.0	50.4	27.7	5.5	34.4	15.5
18	INTERIOR	Sarah Bernhardt	Poor-Peat -1	06/23/14	4	MZP04	1.72	0.382	0.99	0.71	0.279	0.211	12.6	41.6	22.5	5.0	43.2	13.8

2014 Tissue Data

Farm ID	Location	Variety	Condition	Sampling Date	APGA Sample ID	Lab ID	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Al (ppm)
18	INTERIOR	Sarah Bernhardt	Poor-Peat -2	06/23/14	5	MZP05	1.91	0.408	1.12	0.59	0.242	0.223	12.3	47.4	17.6	5.3	41.3	17.9
18	INTERIOR	Sarah Bernhardt	Poor-Peat -3	06/23/14	6	MZP06	1.71	0.381	1.25	0.52	0.254	0.204	11.4	40.4	16.9	5.5	39.9	14.0
18	INTERIOR	Sarah Bernhardt	Poor-Peat -Avg	06/23/14		Avg	1.78	0.390	1.12	0.61	0.258	0.213	12.1	43.1	19.0	5.3	41.5	15.2
18	INTERIOR	Sarah Bernhardt	Poor-Soil -1	06/23/14	16	MZP16	2.31	0.338	1.12	0.50	0.231	0.222	14.9	59.4	33.6	6.2	42.7	14.7
18	INTERIOR	Sarah Bernhardt	Poor-Soil -2	06/23/14	17	MZP17	2.23	0.329	0.97	0.51	0.247	0.227	10.5	47.7	26.7	5.7	36.6	13.8
18	INTERIOR	Sarah Bernhardt	Poor-Soil -3	06/23/14	18	MZP18	2.31	0.323	1.06	0.60	0.254	0.210	9.8	45.2	24.6	6.0	34.1	10.0
18	INTERIOR	Sarah Bernhardt	Poor-Soil -Avg	06/23/14		Avg	2.28	0.330	1.05	0.54	0.244	0.220	11.7	50.8	28.3	6.0	37.8	12.8
41	KENAI PEN	Duchess	Good	07/08/14	55	MZP55	2.57	0.236	0.98	1.44	0.583	0.230	7.4	49.2	35.9	4.2	19.5	25.1
41	KENAI PEN	Duchess	Poor	07/08/14	56	MZP56	2.56	0.231	1.12	1.12	0.563	0.221	5.1	45.5	34.3	3.6	20.7	20.2
41	KENAI PEN	Sarah Bernhardt	Good	07/08/14	53	MZP53	2.53	0.242	0.93	1.61	0.229	0.209	8.9	54.9	50.2	5.8	22.0	29.8
41	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	54	MZP54	2.10	0.228	0.87	1.03	0.137	0.161	8.2	42.5	32.1	4.4	20.3	23.9
42	INTERIOR	Duchess	Good	06/24/14	23	MZP23	1.66	0.220	0.86	0.98	0.289	0.231	16.1	36.1	65.0	4.6	21.1	13.3
42	INTERIOR	Duchess	Poor	06/24/14	24	MZP24	1.45	0.208	0.74	0.88	0.274	0.181	17.0	32.7	50.1	3.9	22.7	14.5
43	INTERIOR	Duchess	Good	06/26/14	29	MZP29	2.08	0.191	0.97	0.76	0.259	0.140	27.6	48.3	40.3	3.5	29.2	27.8
43	INTERIOR	Duchess	Poor	06/26/14	30	MZP30	1.73	0.199	0.92	0.83	0.323	0.127	35.2	37.5	42.9	3.8	33.9	24.6
43	INTERIOR	Sarah Bernhardt	Good	06/26/14	27	MZP27	1.85	0.217	0.98	0.67	0.212	0.157	37.3	50.0	37.0	3.0	20.1	23.6
43	INTERIOR	Sarah Bernhardt	Poor	06/26/14	28	MZP28	1.68	0.234	0.94	0.37	0.174	0.129	47.2	43.1	22.2	3.9	22.6	30.2
44	INTERIOR	Duchess	Good	06/30/14	31	MZP31	2.19	0.343	1.10	1.01	0.387	0.243	18.6	39.4	70.8	5.4	42.7	20.5
44	INTERIOR	Duchess	Poor	06/30/14	32	MZP32	1.51	0.370	1.21	0.87	0.330	0.192	19.2	34.8	72.1	4.3	46.5	33.5
45	CENTRAL	Duchess	Good	06/30/14	35	MZP35	2.23	0.209	0.97	1.20	0.231	0.173	19.4	64.7	55.3	3.8	82.7	17.4
45	CENTRAL	Duchess	Poor	06/30/14	36	MZP36	1.90	0.200	1.02	0.72	0.122	0.145	13.4	30.9	57.0	4.0	50.9	18.1
45	CENTRAL	Sarah Bernhardt	Good	06/30/14	33	MZP33	2.58	0.305	1.13	1.01	0.203	0.235	17.0	35.5	44.4	6.3	95.5	17.4
45	CENTRAL	Sarah Bernhardt	Poor	06/30/14	34	MZP34	2.08	0.267	0.85	0.77	0.168	0.197	13.7	30.8	27.0	5.0	63.2	14.5
46	CENTRAL	Duchess	Good	06/30/14	39	MZP39	2.08	0.254	1.06	0.76	0.245	0.202	14.8	45.7	69.8	4.8	47.2	19.3
46	CENTRAL	Duchess	Poor	06/30/14	40	MZP40	1.52	0.200	1.37	0.44	0.176	0.155	18.8	37.6	46.8	3.9	40.7	21.9
46	CENTRAL	Sarah Bernhardt	Good	06/30/14	37	MZP37	1.98	0.228	0.94	0.59	0.155	0.184	10.3	39.8	60.5	4.4	55.8	20.8
46	CENTRAL	Sarah Bernhardt	Poor	06/30/14	38	MZP38	1.52	0.195	0.92	0.35	0.120	0.162	13.1	30.6	46.7	3.8	44.2	16.6
47	CENTRAL	Duchess	Good	07/01/14	43	MZP43	1.98	0.285	0.91	1.63	0.429	0.208	25.8	42.6	22.3	4.8	30.2	20.3
47	CENTRAL	Duchess	Poor	07/01/14	44	MZP44	1.52	0.283	0.90	1.47	0.386	0.178	21.1	37.9	17.1	4.1	30.2	20.7
47	CENTRAL	Sarah Bernhardt	Good	07/01/14	41	MZP41	2.05	0.282	0.98	1.37	0.309	0.192	18.7	45.3	25.3	5.5	28.8	15.2
47	CENTRAL	Sarah Bernhardt	Poor	07/01/14	42	MZP42	1.50	0.289	0.83	1.03	0.237	0.178	19.5	37.3	18.2	4.4	26.9	17.6
48	INTERIOR	Duchess	Good	07/07/14	51	MZP51	2.80	0.214	1.18	1.17	0.258	0.255	26.0	61.9	38.5	6.8	42.9	31.7
48	INTERIOR	Duchess	Poor	07/07/14	52	MZP52	2.59	0.243	1.57	0.98	0.269	0.250	24.7	59.7	37.3	6.0	39.4	29.5
48	INTERIOR	Sarah Bernhardt	Good	07/07/14	49	MZP49	2.31	0.201	1.16	0.91	0.203	0.222	18.6	66.3	38.8	58.3	36.6	33.4
48	INTERIOR	Sarah Bernhardt	Poor	07/07/14	50	MZP50	2.44	0.291	1.10	0.48	0.234	0.192	13.1	65.5	26.2	29.7	30.7	35.3
49	KENAI PEN	Duchess	Good	07/08/14	59	MZP59	2.32	0.148	1.11	1.19	0.202	0.175	32.3	47.7	34.4	2.1	49.0	34.3
49	KENAI PEN	Duchess	Poor	07/08/14	60	MZP60	1.96	0.151	0.94	1.38	0.195	0.131	20.7	38.2	11.5	3.1	16.2	33.0
49	KENAI PEN	Sarah Bernhardt	Good	07/08/14	57	MZP57	2.62	0.207	1.11	1.26	0.227	0.264	25.8	48.8	29.1	4.5	34.8	32.8
49	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	58	MZP58	2.16	0.171	0.92	0.84	0.194	0.152	20.3	43.8	25.3	3.4	30.3	28.7
50	KENAI PEN	Duchess	Good	07/08/14	63	MZP63	2.29	0.243	1.19	0.44	0.207	0.190	30.3	49.1	33.6	5.3	52.8	39.3
50	KENAI PEN	Duchess	Poor	07/08/14	64	MZP64	2.34	0.347	1.59	0.47	0.259	0.249	36.6	62.6	41.4	6.9	71.7	51.7
50	KENAI PEN	Sarah Bernhardt	Good	07/08/14	61	MZP61	2.54	0.184	1.10	0.89	0.170	0.238	30.1	51.1	147.0	2.4	23.5	26.0
50	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	62	MZP62	2.32	0.196	1.37	0.43	0.138	0.192	24.8	41.4	57.3	2.6	25.5	22.7

2014 Tissue Data

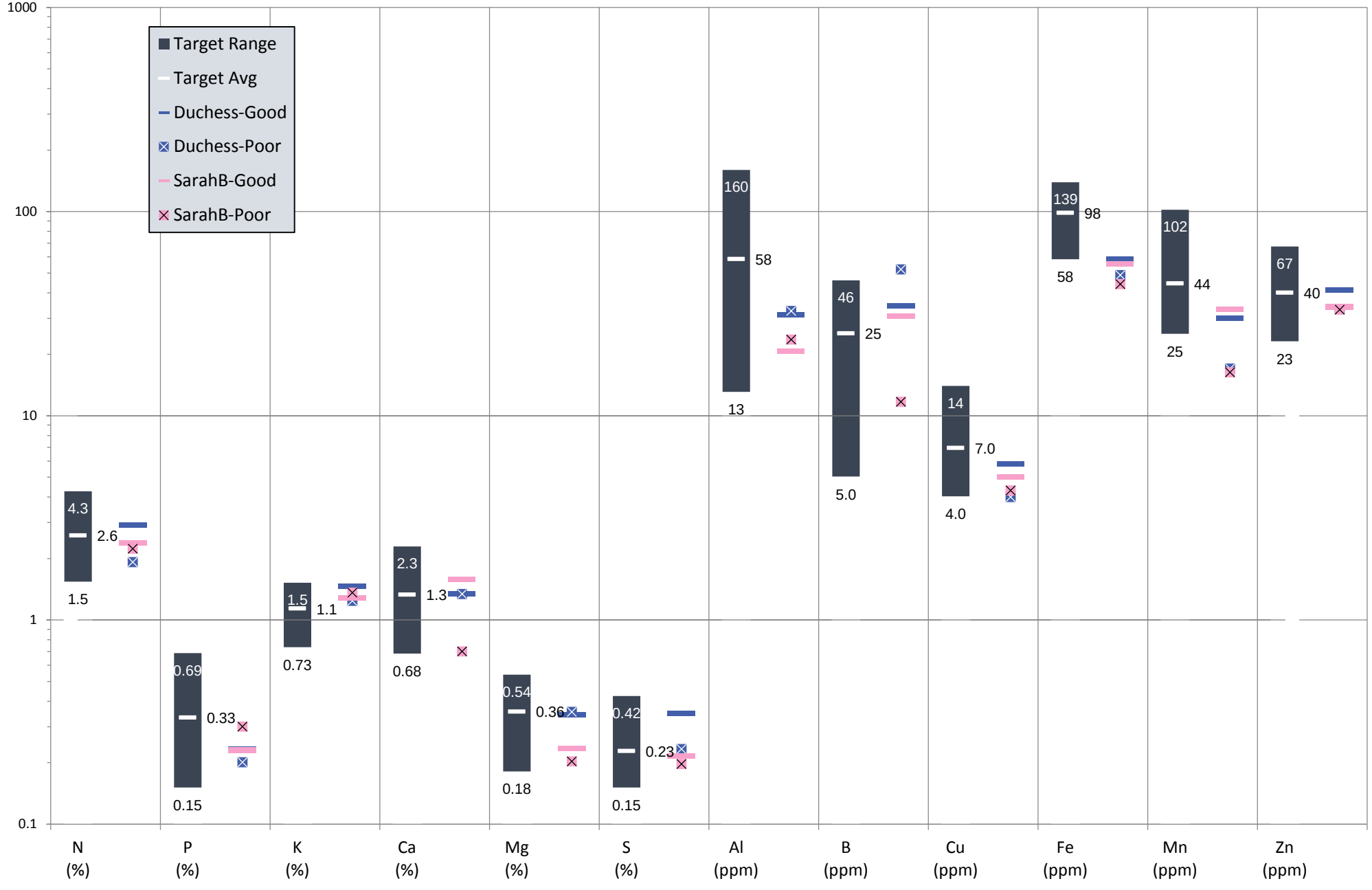
Farm ID	Location	Variety	Condition	Sampling Date	APGA Sample ID	Lab ID	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Al (ppm)
51	KENAI PEN	Duchess	Good	07/08/14	67	MZP67	2.20	0.185	0.70	1.78	0.311	0.261	19.6	34.6	26.8	4.0	45.6	22.3
51	KENAI PEN	Duchess	Poor	07/08/14	68	MZP68	2.06	0.193	0.85	1.48	0.311	0.232	20.9	37.3	22.1	4.1	45.7	27.3
51	KENAI PEN	Sarah Bernhardt	Good	07/08/14	65	MZP65	2.51	0.287	0.90	1.12	0.220	0.223	16.2	35.7	23.4	4.1	43.6	19.0
51	KENAI PEN	Sarah Bernhardt	Poor	07/08/14	66	MZP66	2.13	0.302	0.86	0.97	0.231	0.224	18.2	34.7	22.0	4.2	44.0	21.3
52	KENAI PEN	Duchess	Good	07/09/14	79	MZP79	2.06	0.164	0.78	2.77	0.406	0.290	29.7	66.5	64.9	2.8	27.3	65.8
52	KENAI PEN	Duchess	Poor	07/09/14	80	MZP80	1.25	0.110	0.59	1.59	0.280	0.127	12.1	40.7	36.8	2.3	12.4	44.9
52	KENAI PEN	Festiva	Good	07/09/14	81	MZP81	1.54	0.152	1.04	1.14	0.192	0.203	26.5	38.2	53.7	2.2	25.6	26.2
52	KENAI PEN	Festiva	Poor	07/09/14	82	MZP82	1.28	0.138	0.88	1.17	0.186	0.167	24.0	31.3	16.9	2.7	19.7	26.4
53	CENTRAL	Sarah Bernhardt	Good	07/10/14	89	MZP89	2.29	0.294	1.24	1.14	0.241	0.277	25.1	53.1	28.1	5.4	41.6	20.8
53	CENTRAL	Sarah Bernhardt	Poor	07/10/14	90	MZP90	1.89	0.258	1.35	0.83	0.224	0.242	18.5	45.8	18.2	4.8	33.5	30.7

APPENDIX B

INDIVIDUAL GROWER CHARTS FOR 2014 SAMPLES

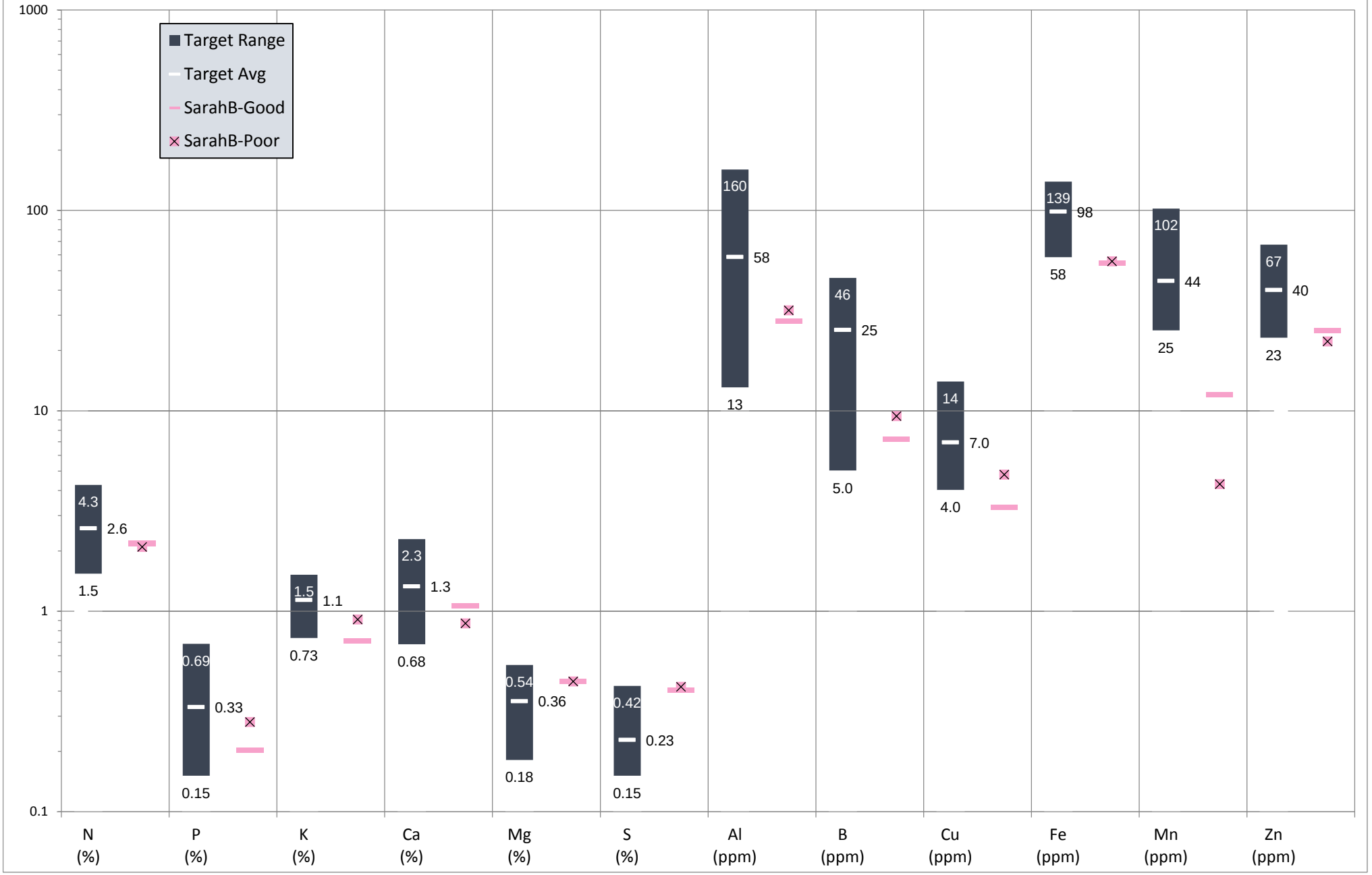
2014 Tissue Data Compared to Target Ranges

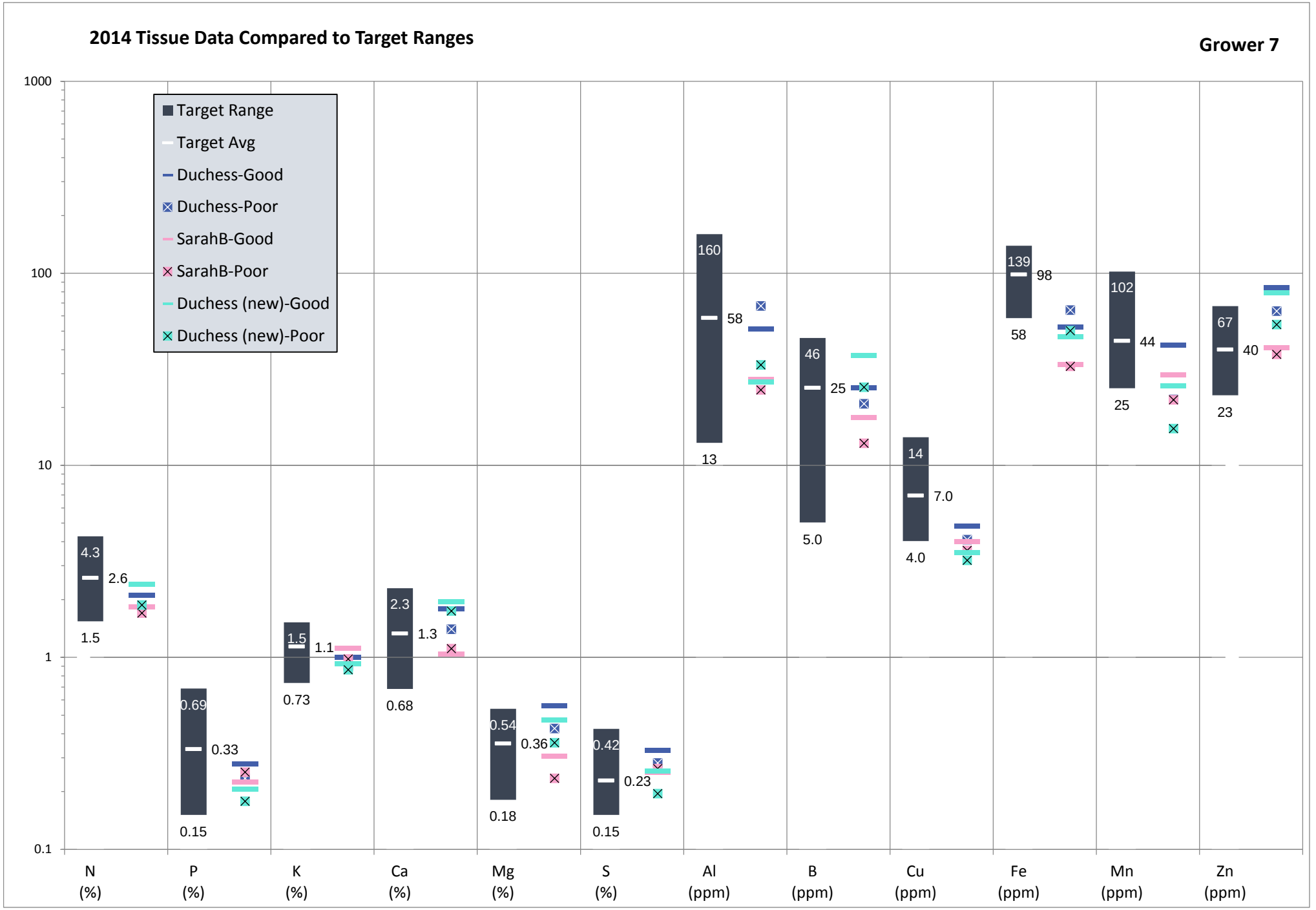
Grower 3

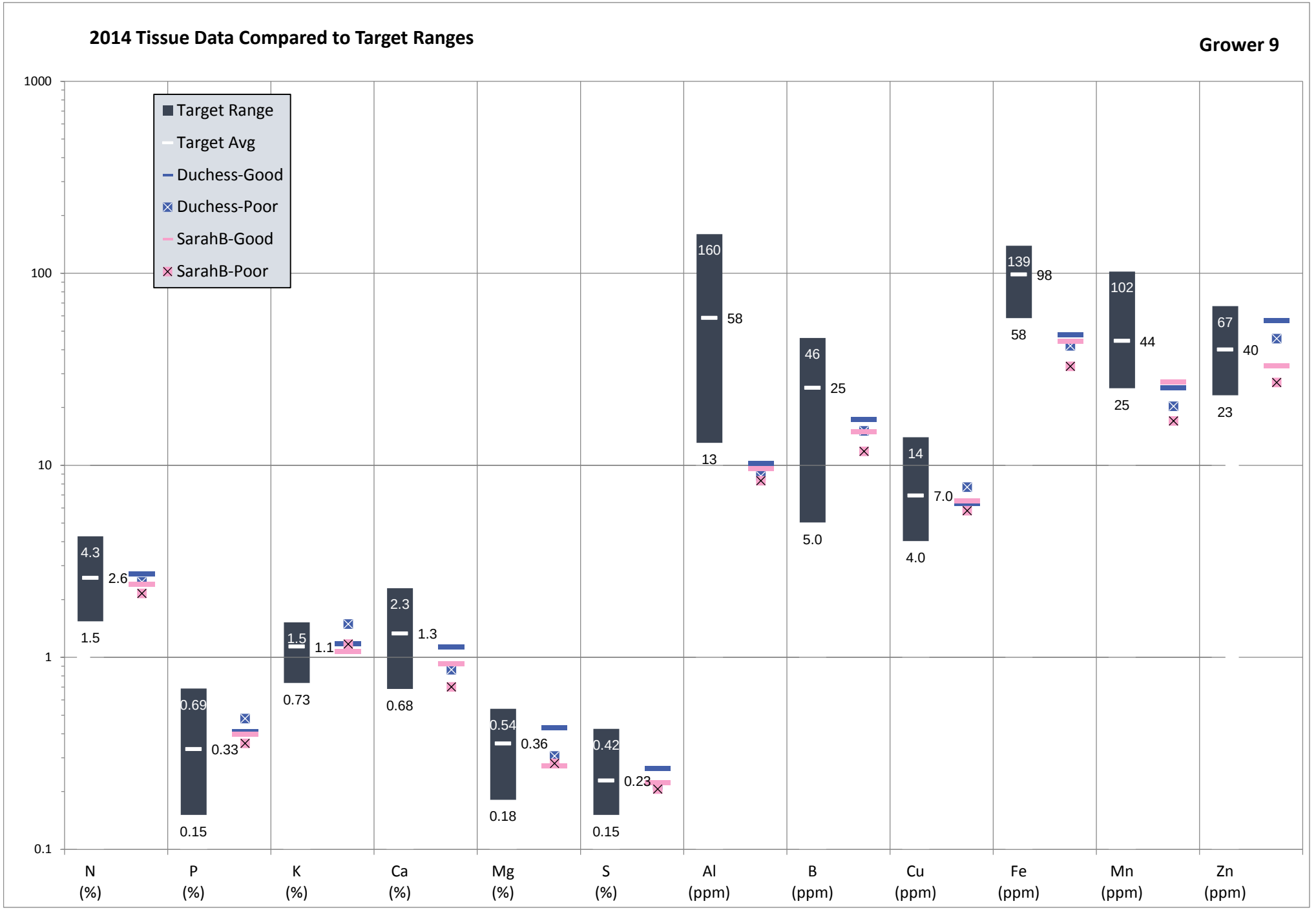


2014 Tissue Data Compared to Target Ranges

Grower 5

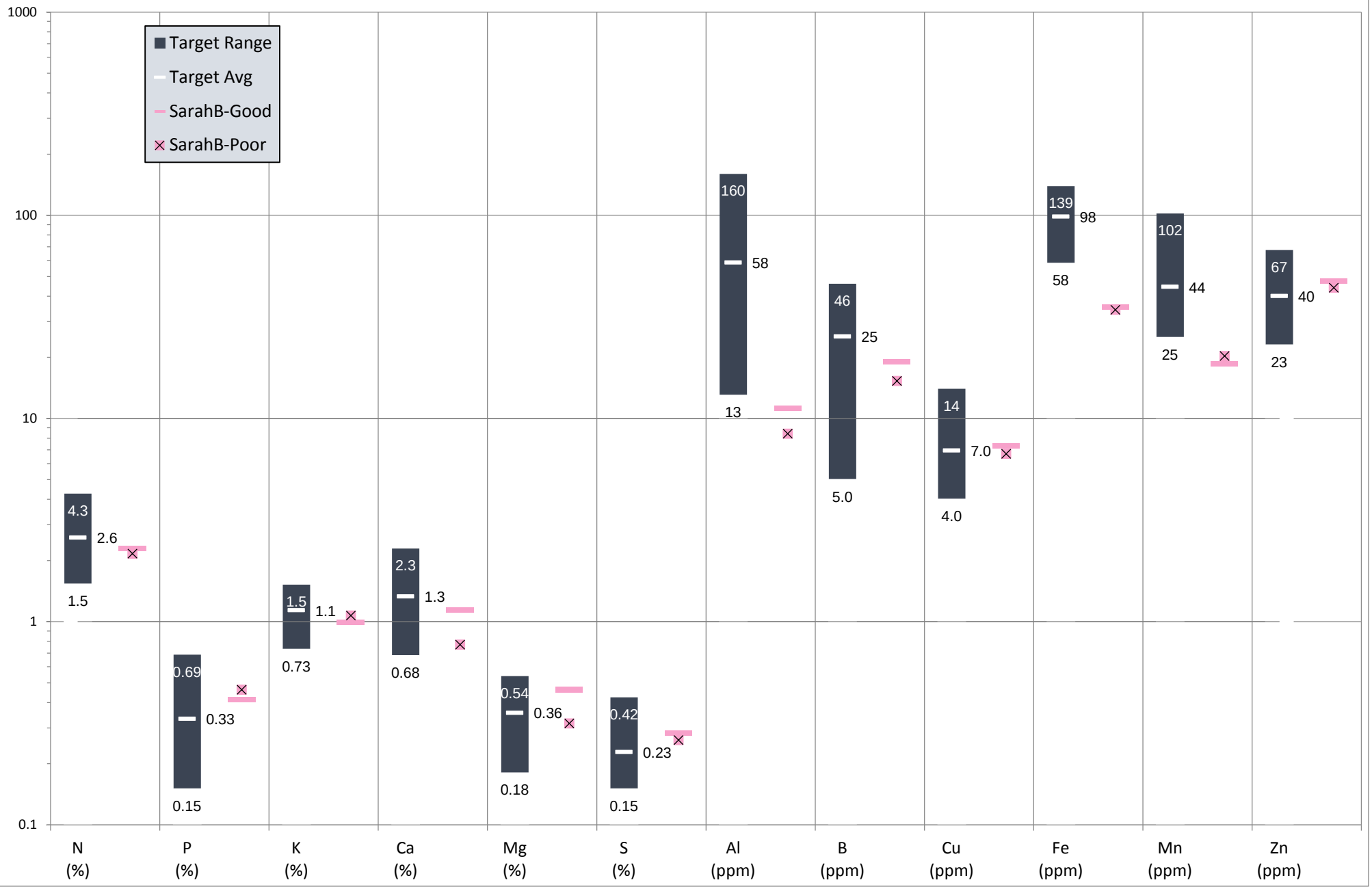



2014 Tissue Data Compared to Target Ranges
Grower 7
Target Range
Target Avg
Duchess-Good
Duchess-Poor
SarahB-Good
SarahB-Poor
Duchess (new)-Good
Duchess (new)-Poor
1000
100
10
1
0.1
4.3
2.6
1.5
0.69
0.33
0.15
1.5
1.1
0.73
2.3
1.3
0.68
0.54
0.36
0.18
0.42
0.23
0.15
160
58
13
46
25
5.0
14
7.0
4.0
139
98
58
102
44
25
67
40
23
N (%)
P (%)
K (%)
Ca (%)
Mg (%)
S (%)
Al (ppm)
B (ppm)
Cu (ppm)
Fe (ppm)
Mn (ppm)
Zn (ppm)


2014 Tissue Data Compared to Target Ranges
Grower 9
Target Range
Target Avg
Duchess-Good
Duchess-Poor
SarahB-Good
SarahB-Poor
1000
100
10
1
0.1
4.3
2.6
1.5
0.69
0.33
0.15
1.5
1.1
0.73
2.3
1.3
0.68
0.54
0.36
0.18
0.42
0.23
0.15
160
58
13
46
25
5.0
14
7.0
4.0
139
98
58
102
44
25
67
40
23
N (%)
P (%)
K (%)
Ca (%)
Mg (%)
S (%)
Al (ppm)
B (ppm)
Cu (ppm)
Fe (ppm)
Mn (ppm)
Zn (ppm)

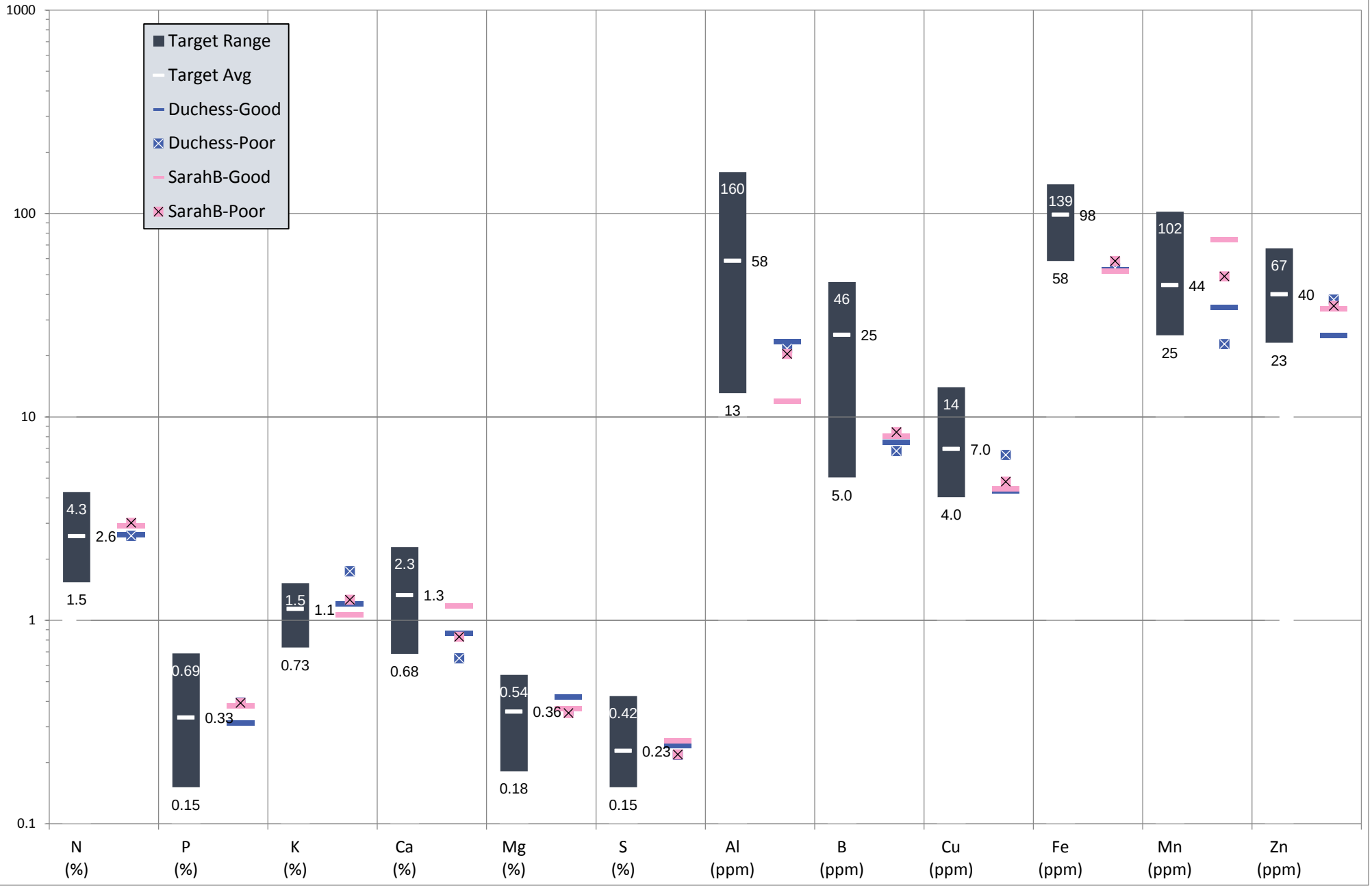
2014 Tissue Data Compared to Target Ranges

Grower 11



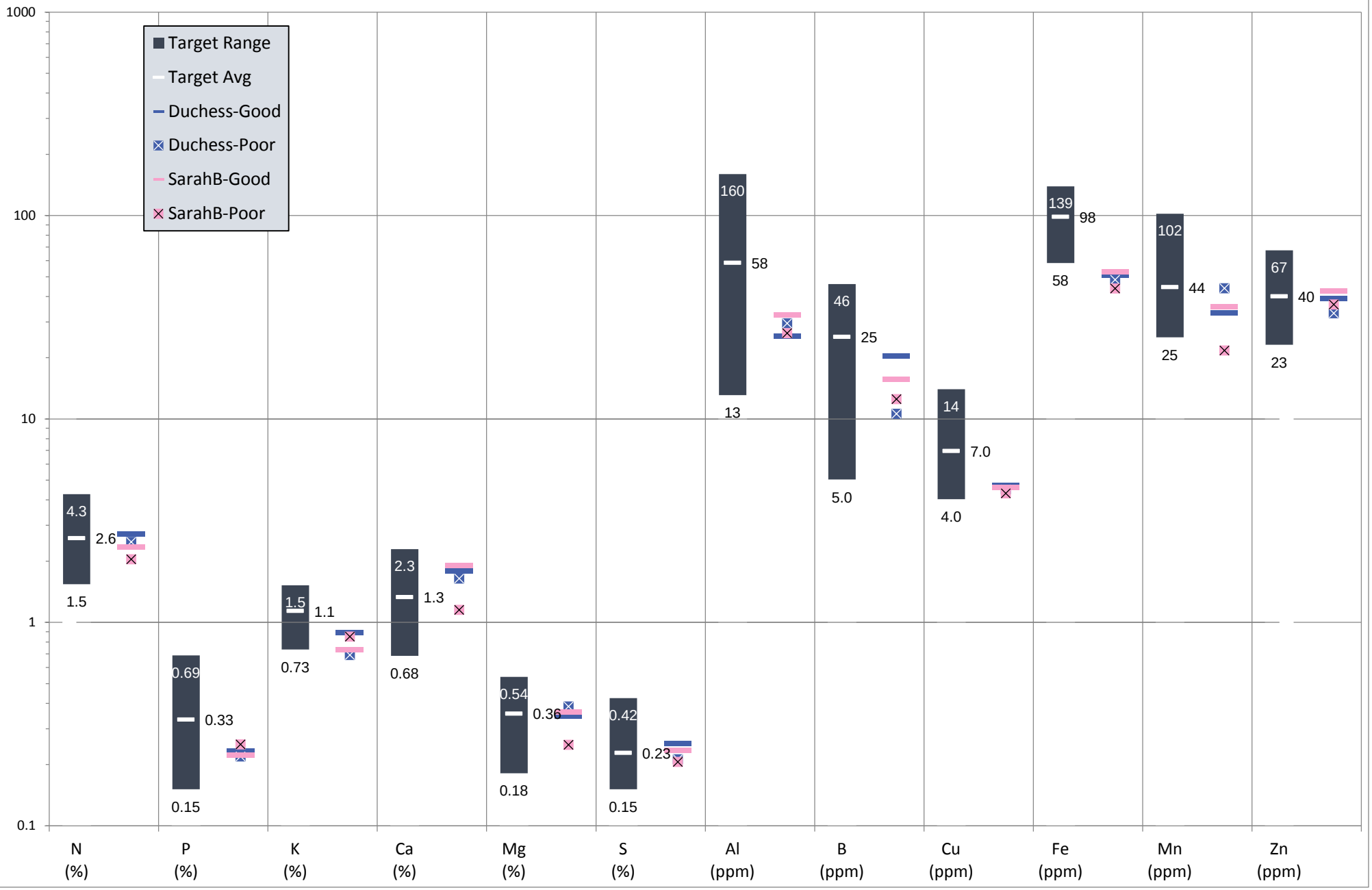
2014 Tissue Data Compared to Target Ranges

Grower 12



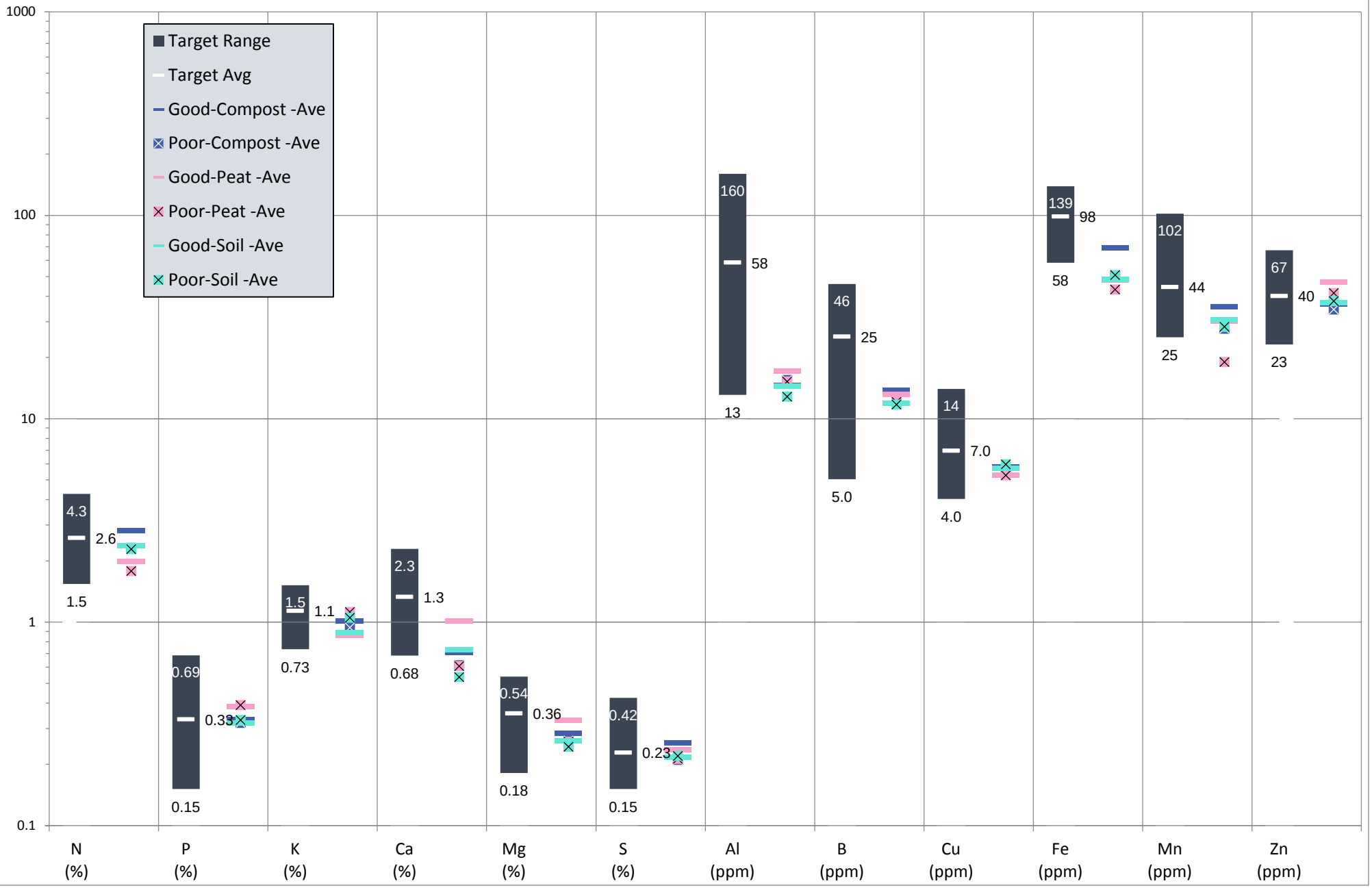
2014 Tissue Data Compared to Target Ranges

Grower 17



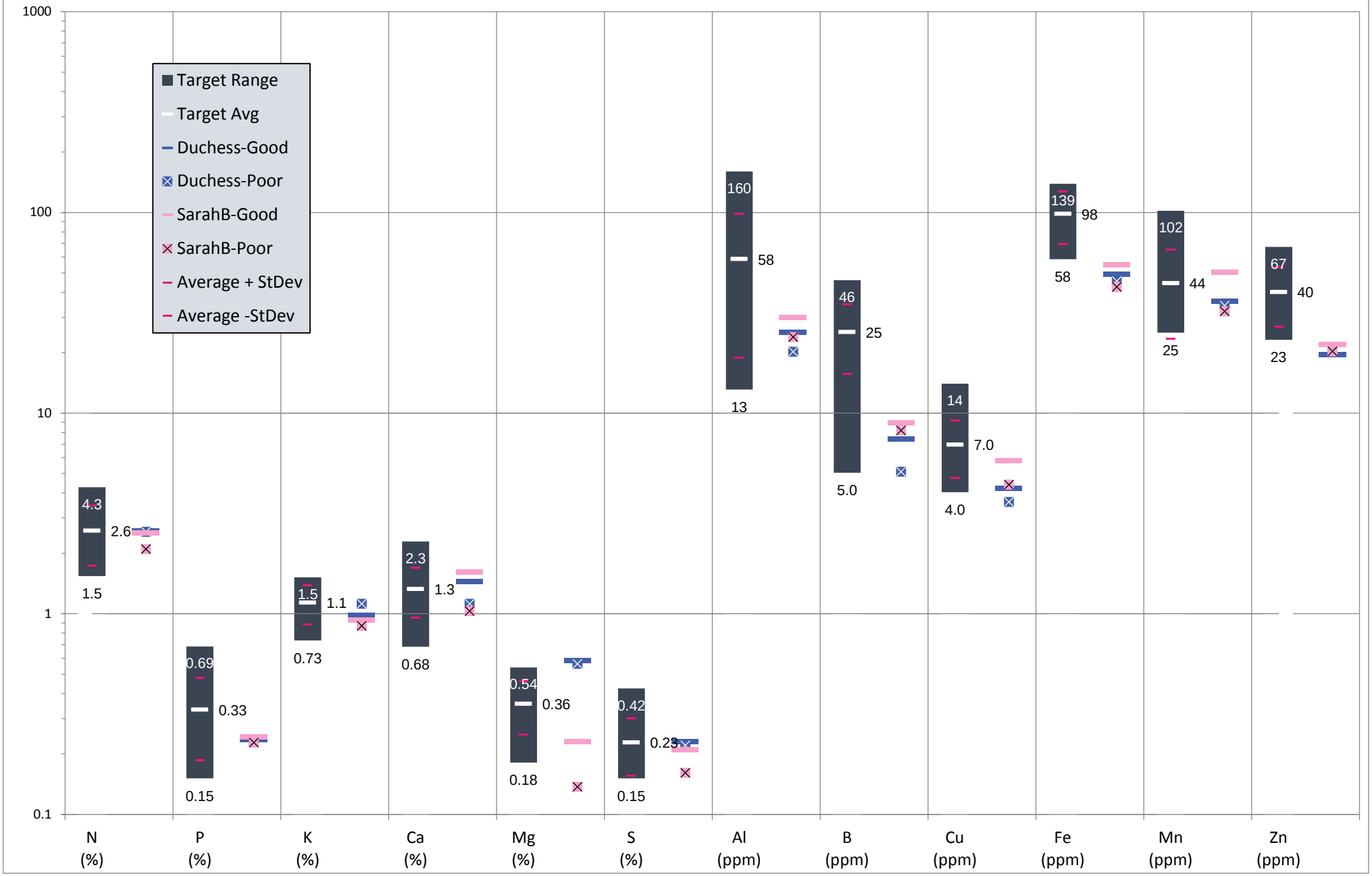
2014 Tissue Data Compared to Target Ranges

Grower 18



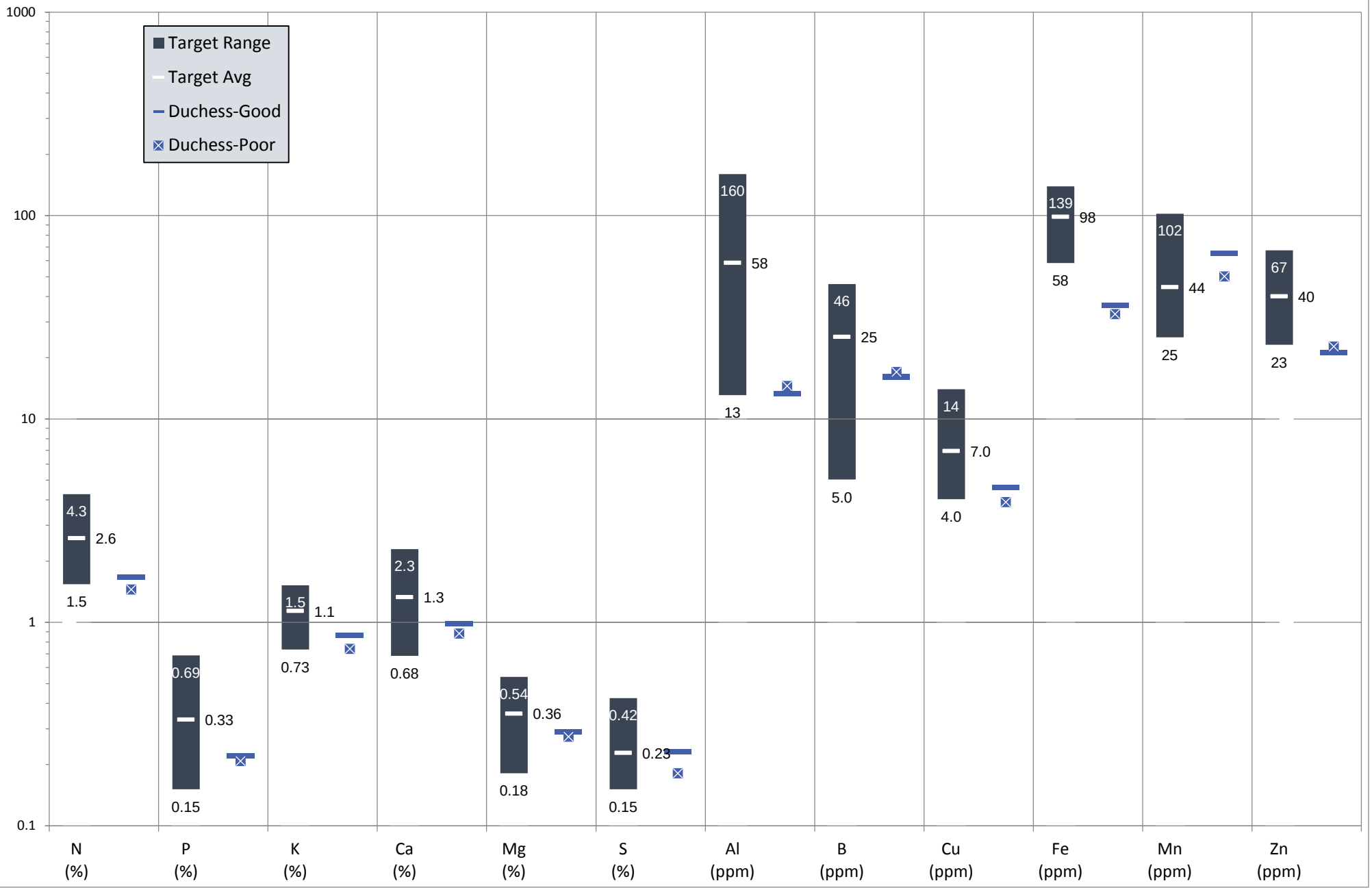
2014 Tissue Data Compared to Target Ranges

Grower 41



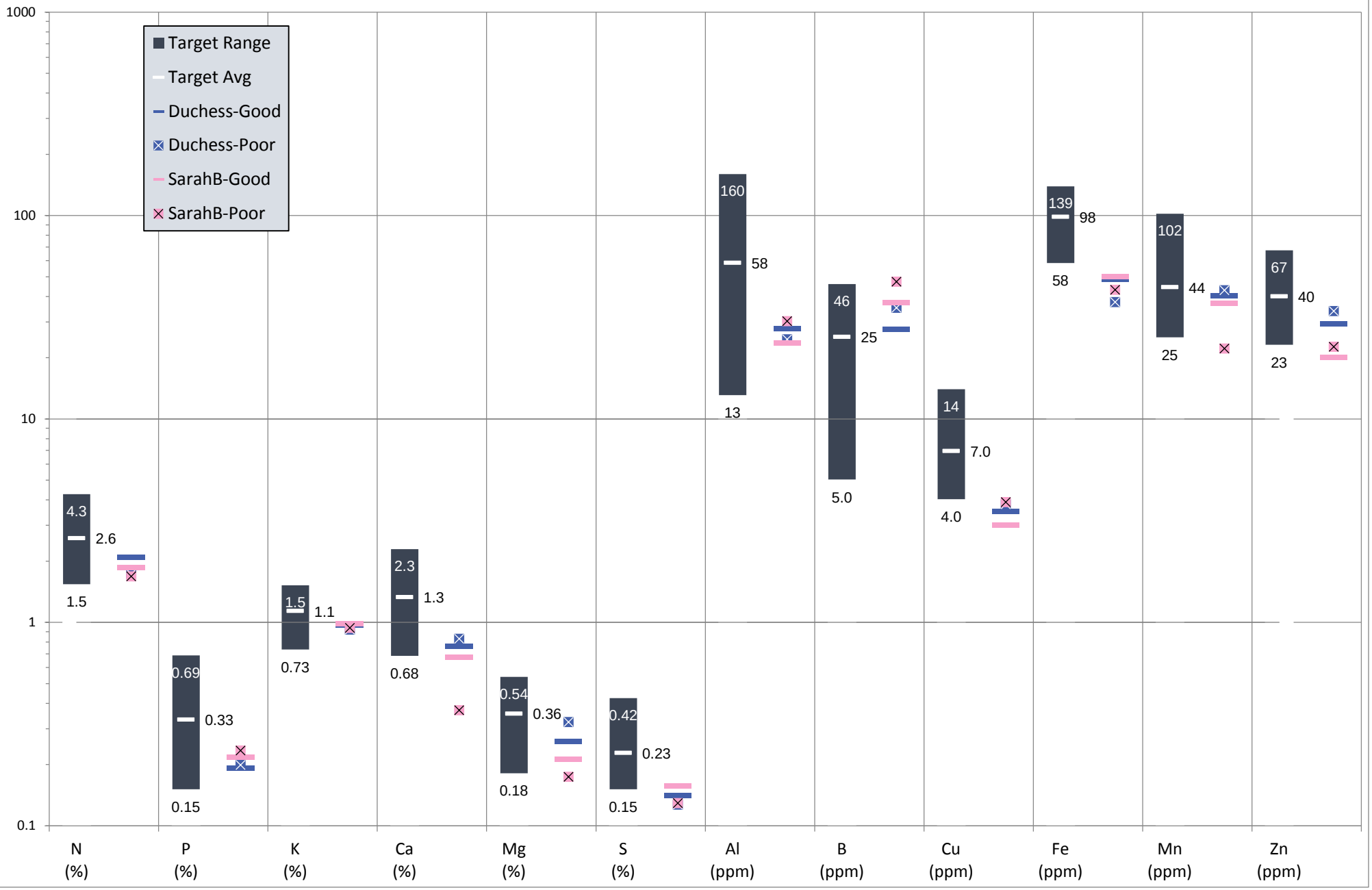
2014 Tissue Data Compared to Target Ranges

Grower 42



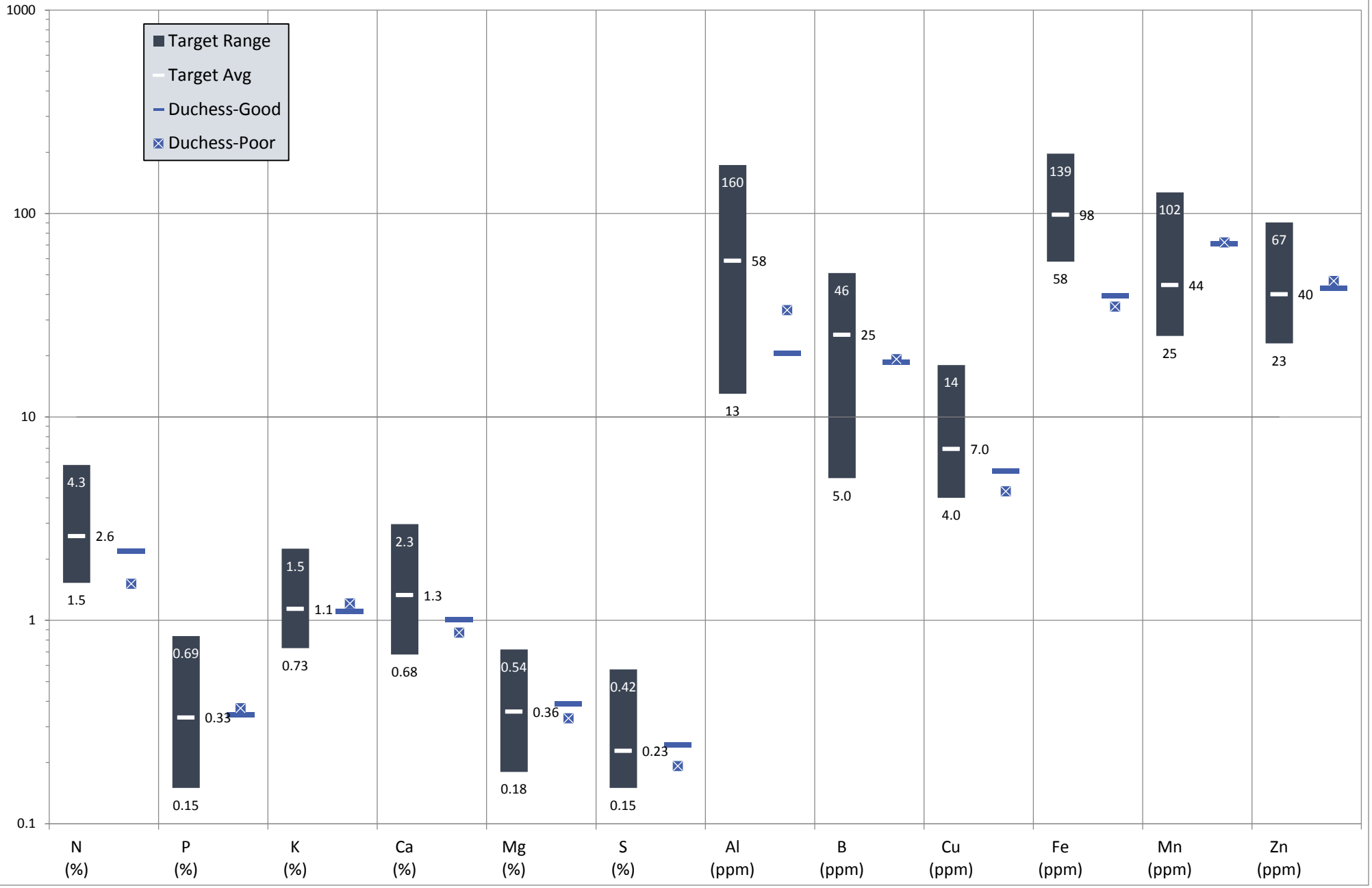
2014 Tissue Data Compared to Target Ranges

Grower 43



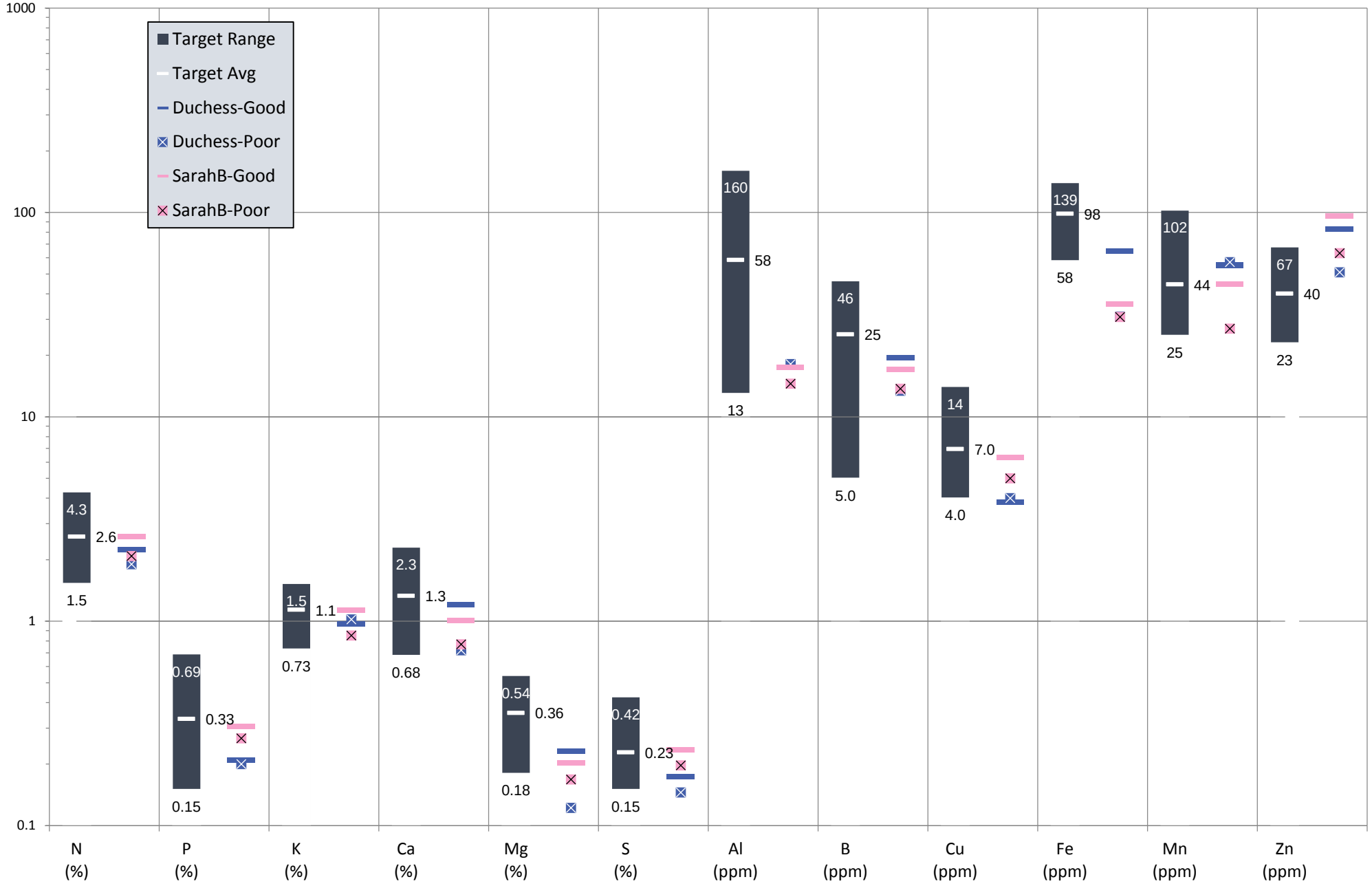
2014 Tissue Data Compared to Target Ranges

Grower 44



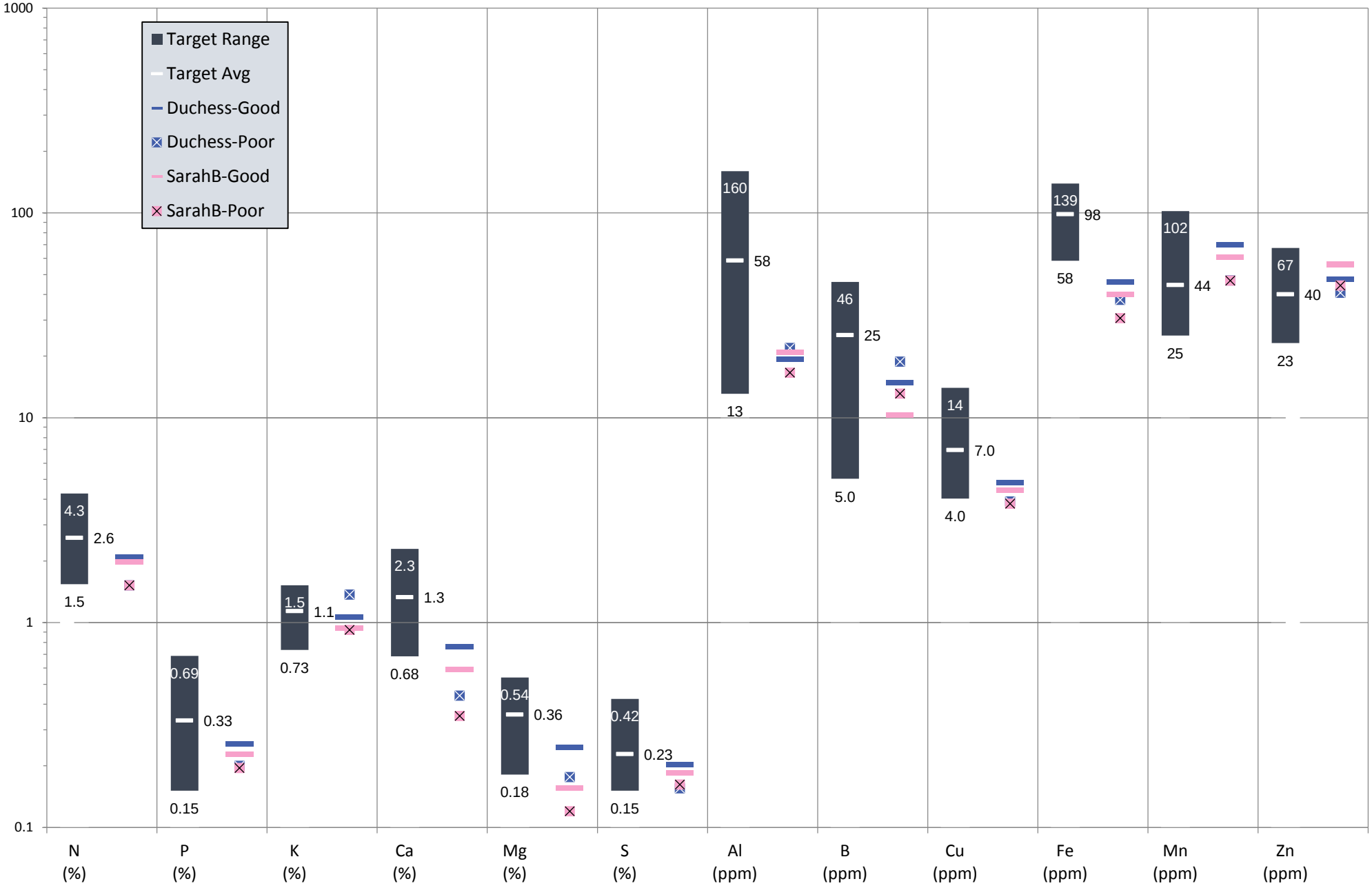
2014 Tissue Data Compared to Target Ranges

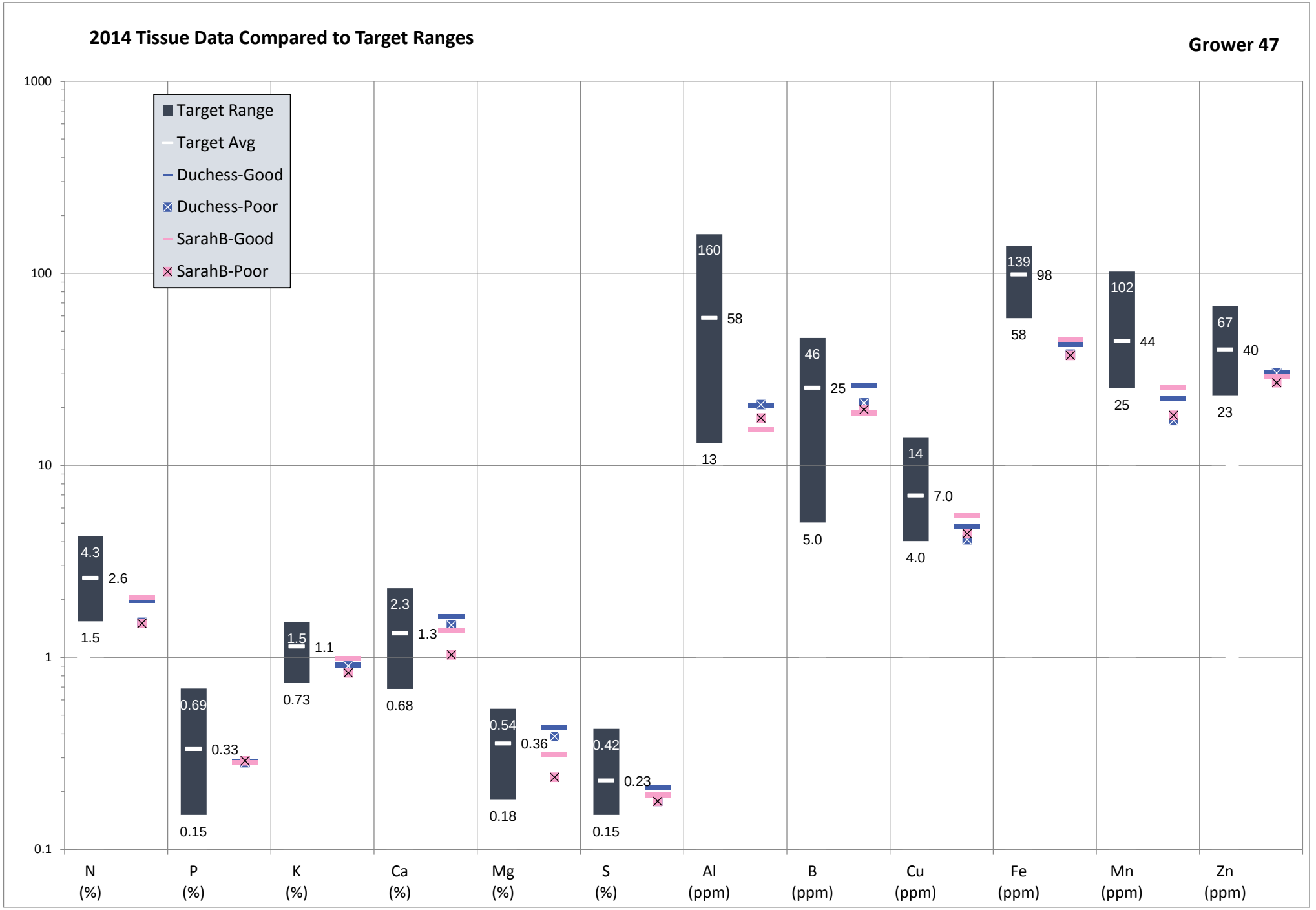
Grower 45



2014 Tissue Data Compared to Target Ranges

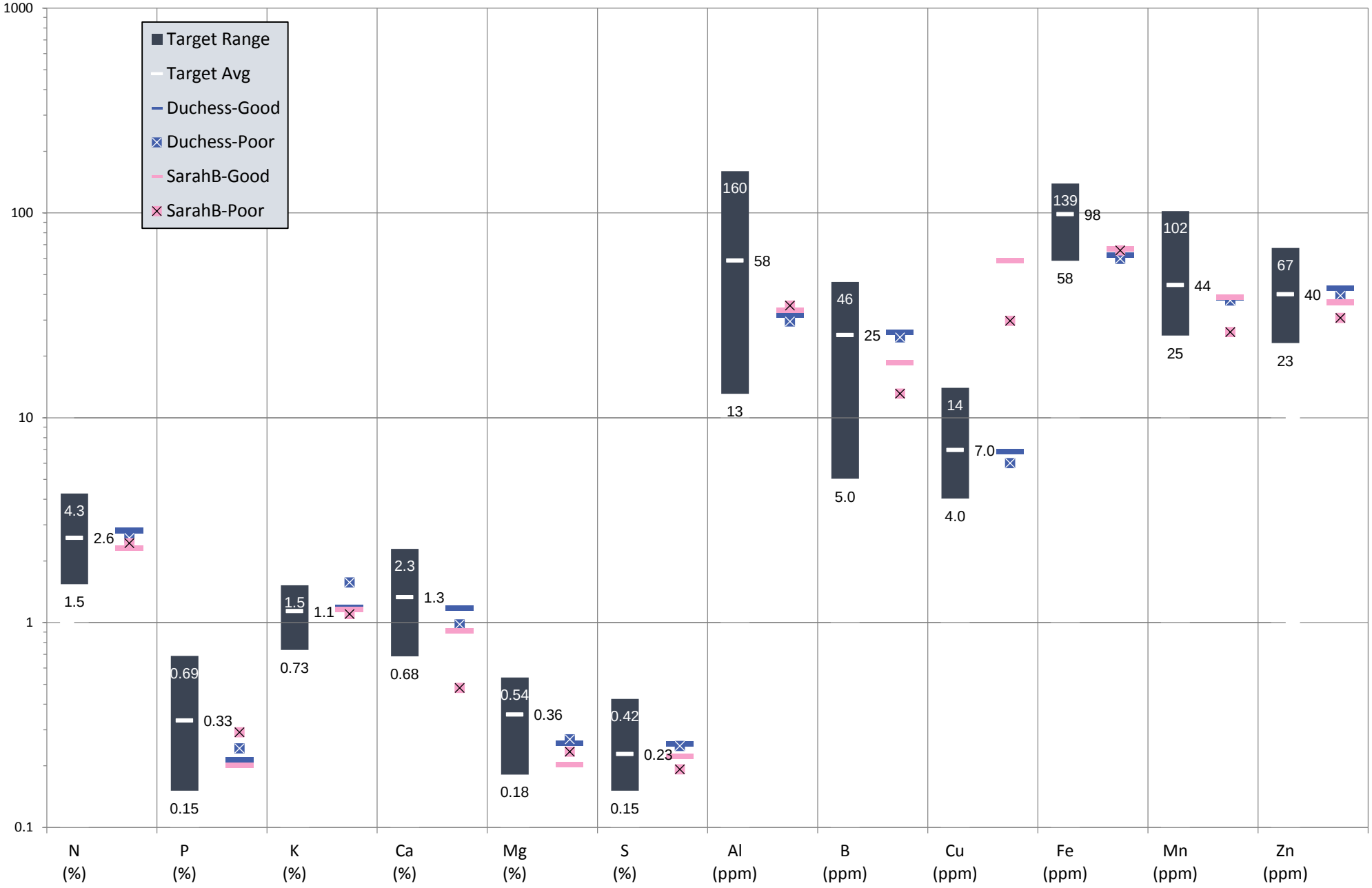
Grower 46

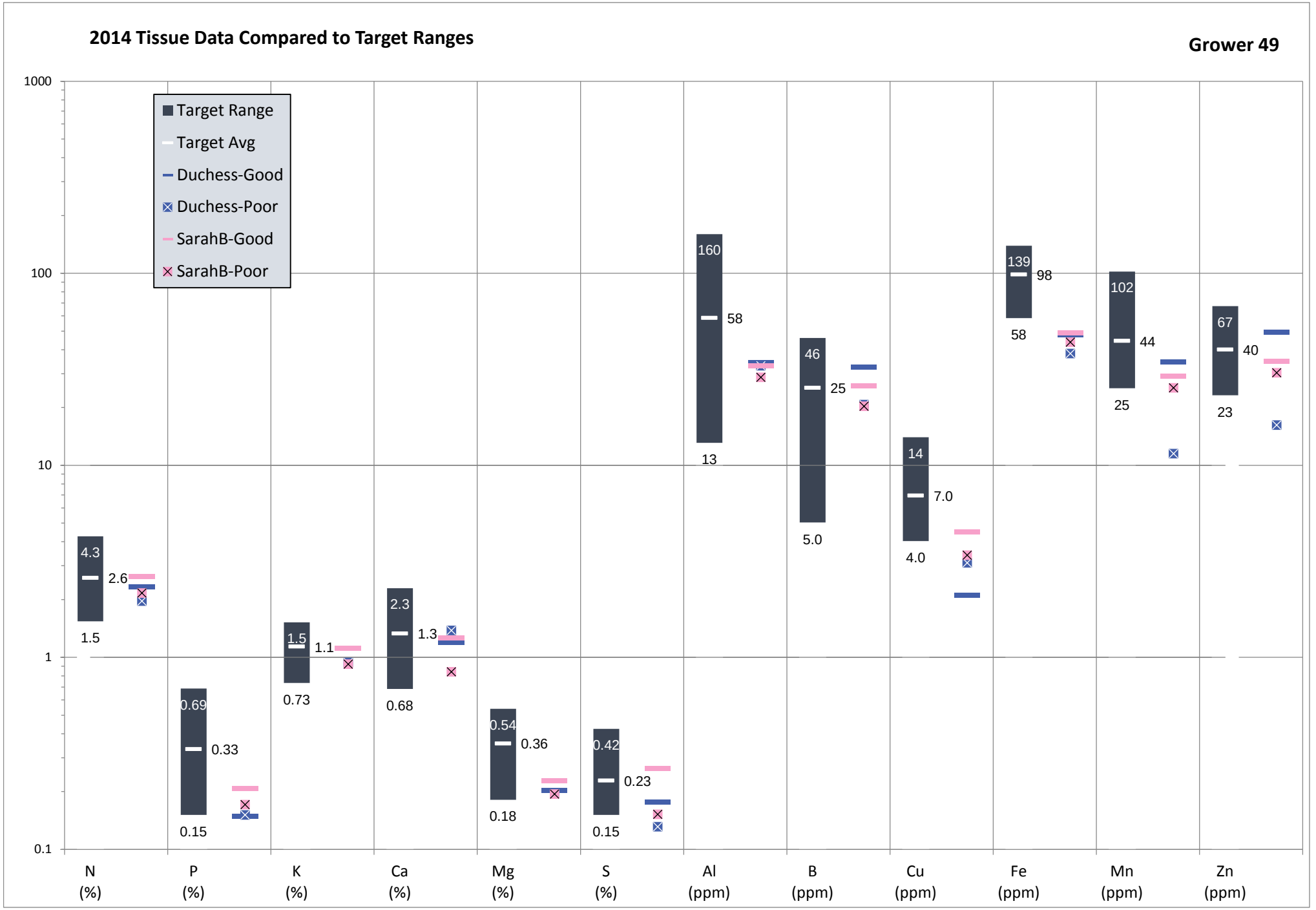



2014 Tissue Data Compared to Target Ranges
Grower 47
Target Range
Target Avg
Duchess-Good
Duchess-Poor
SarahB-Good
SarahB-Poor
1000
100
10
1
0.1
4.3
2.6
1.5
0.69
0.33
0.15
1.5
1.1
0.73
2.3
1.3
0.68
0.54
0.36
0.18
0.42
0.23
0.15
160
58
13
46
25
5.0
14
7.0
4.0
139
98
58
102
44
25
67
40
23
N (%)
P (%)
K (%)
Ca (%)
Mg (%)
S (%)
Al (ppm)
B (ppm)
Cu (ppm)
Fe (ppm)
Mn (ppm)
Zn (ppm)

2014 Tissue Data Compared to Target Ranges

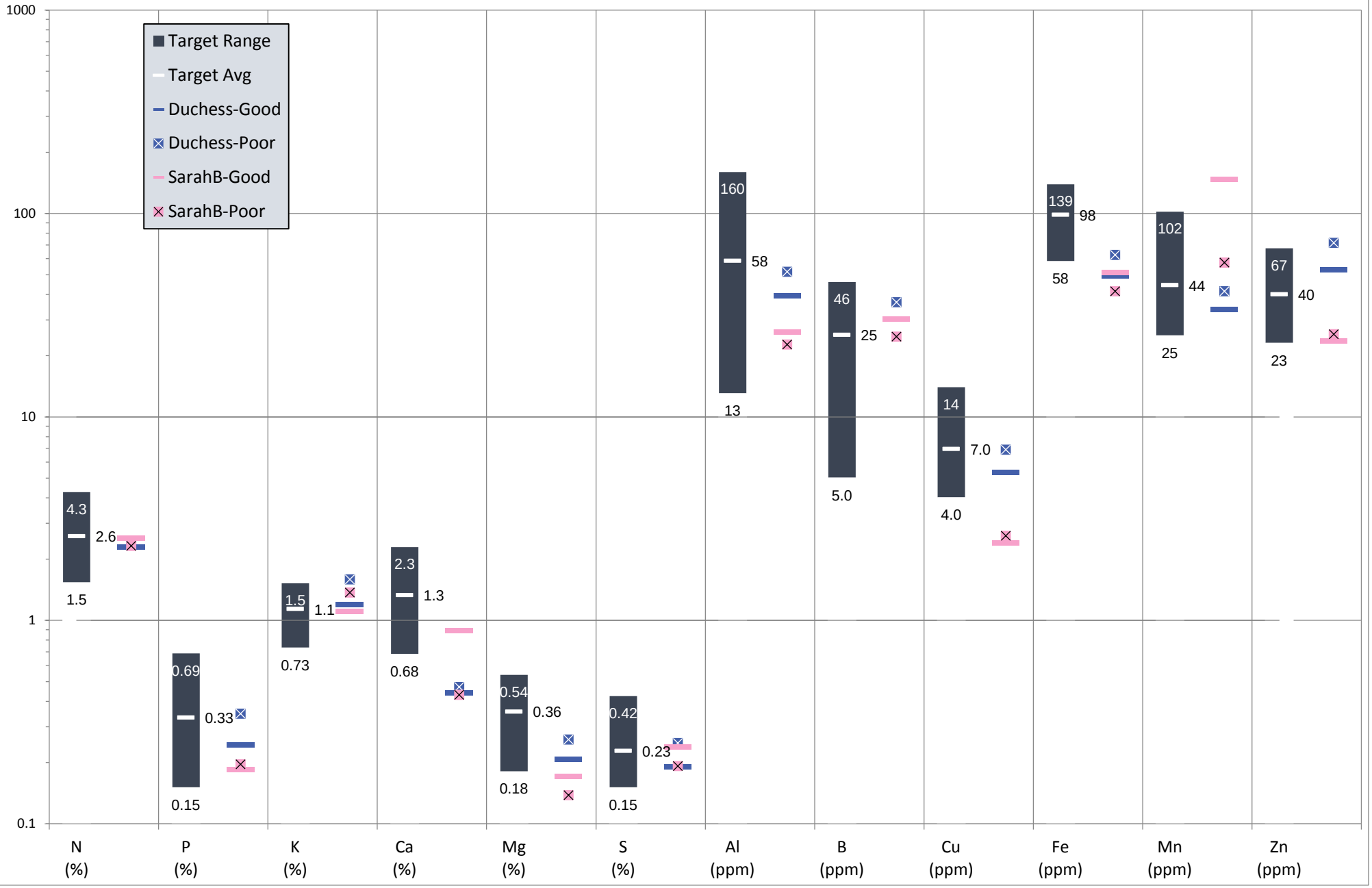
Grower 48




2014 Tissue Data Compared to Target Ranges
Grower 49
Target Range
Target Avg
Duchess-Good
Duchess-Poor
SarahB-Good
SarahB-Poor
1000
100
10
1
0.1
4.3
2.6
1.5
0.69
0.33
0.15
1.5
1.1
0.73
2.3
1.3
0.68
0.54
0.36
0.18
0.42
0.23
0.15
160
58
13
46
25
5.0
14
7.0
4.0
139
98
58
102
44
25
67
40
23
N (%)
P (%)
K (%)
Ca (%)
Mg (%)
S (%)
Al (ppm)
B (ppm)
Cu (ppm)
Fe (ppm)
Mn (ppm)
Zn (ppm)

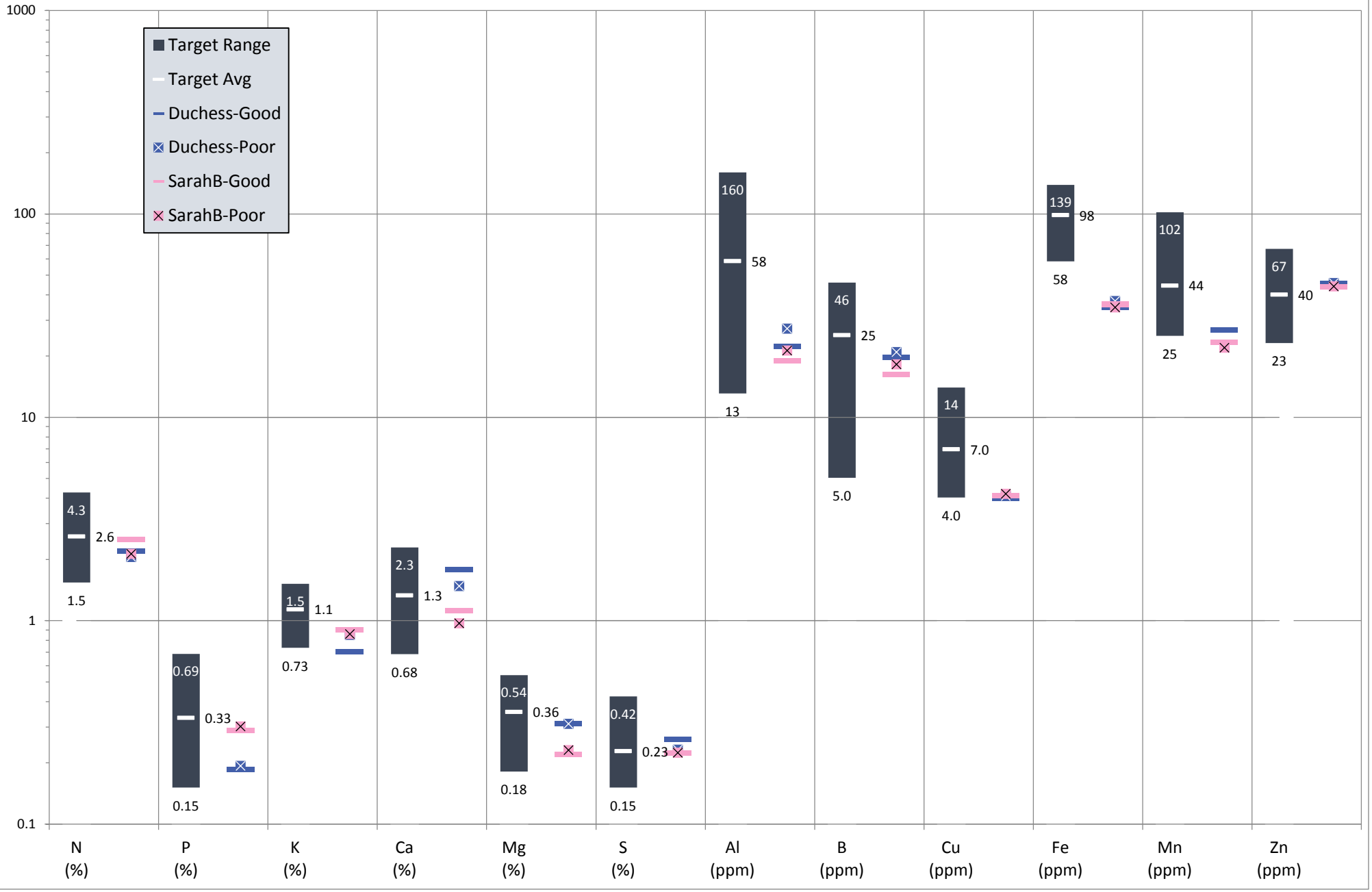
2014 Tissue Data Compared to Target Ranges

Grower 50



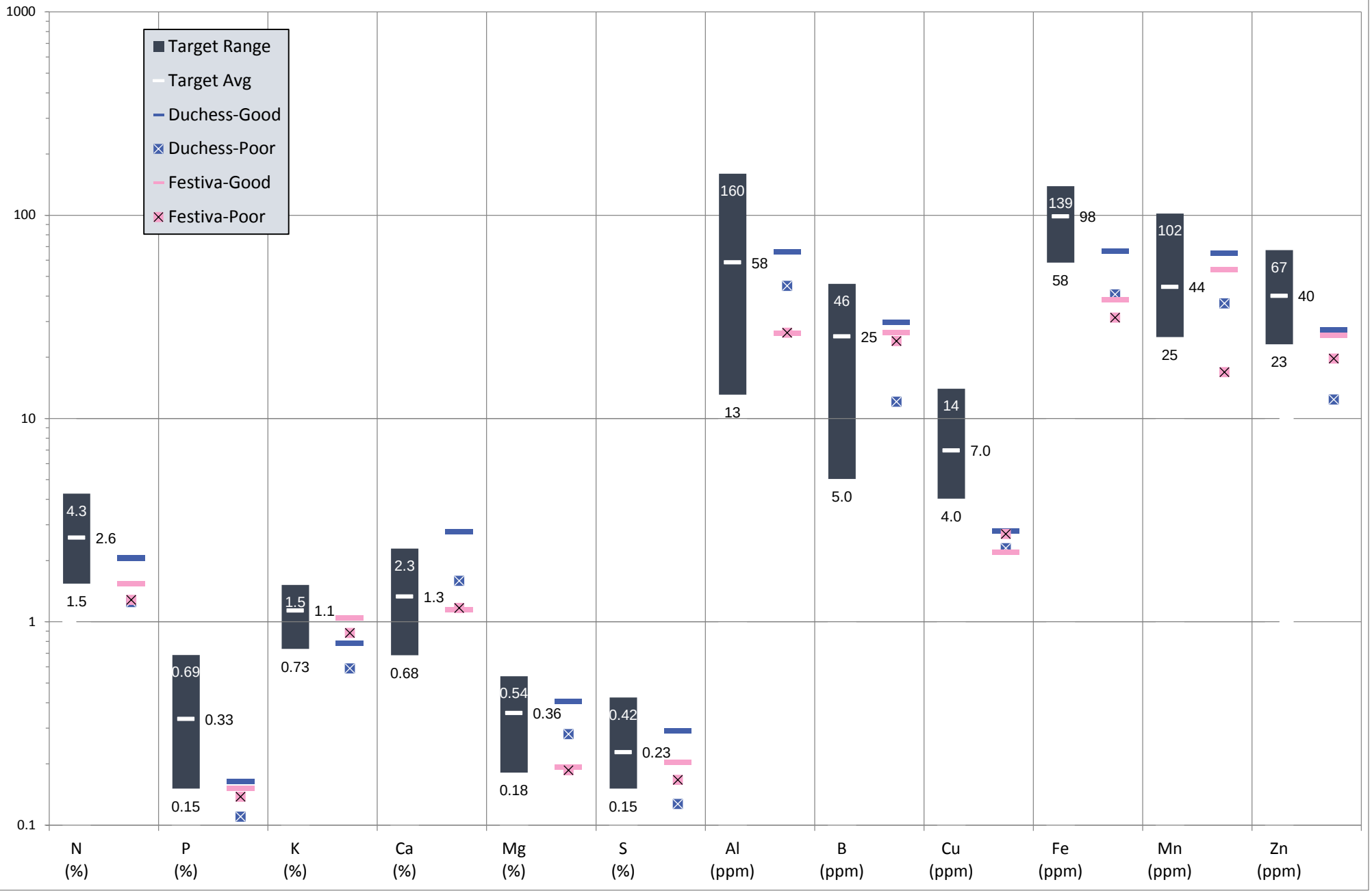
2014 Tissue Data Compared to Target Ranges

Grower 51



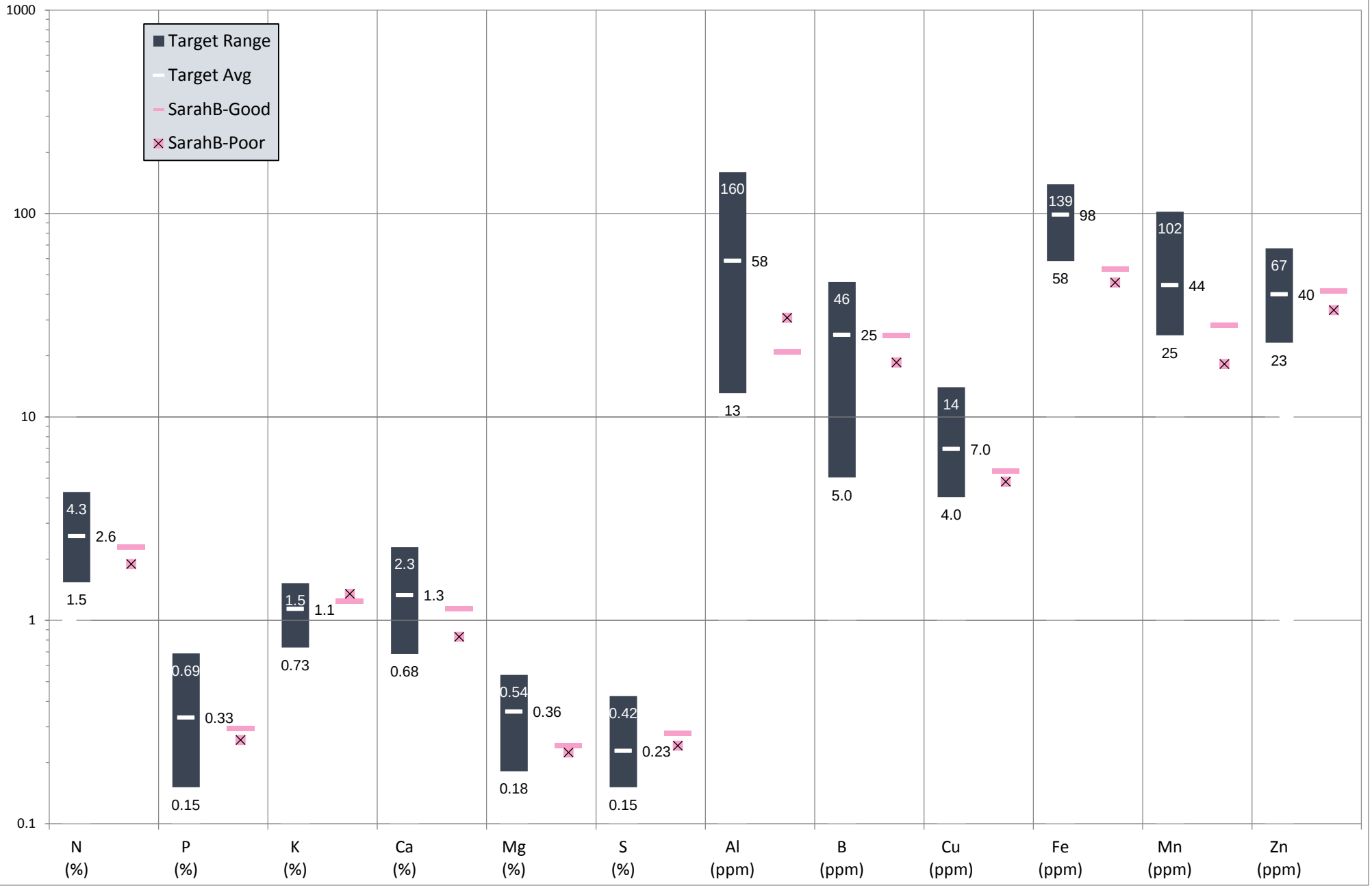
2014 Tissue Data Compared to Target Ranges

Grower 52



2014 Tissue Data Compared to Target Ranges

Grower 53

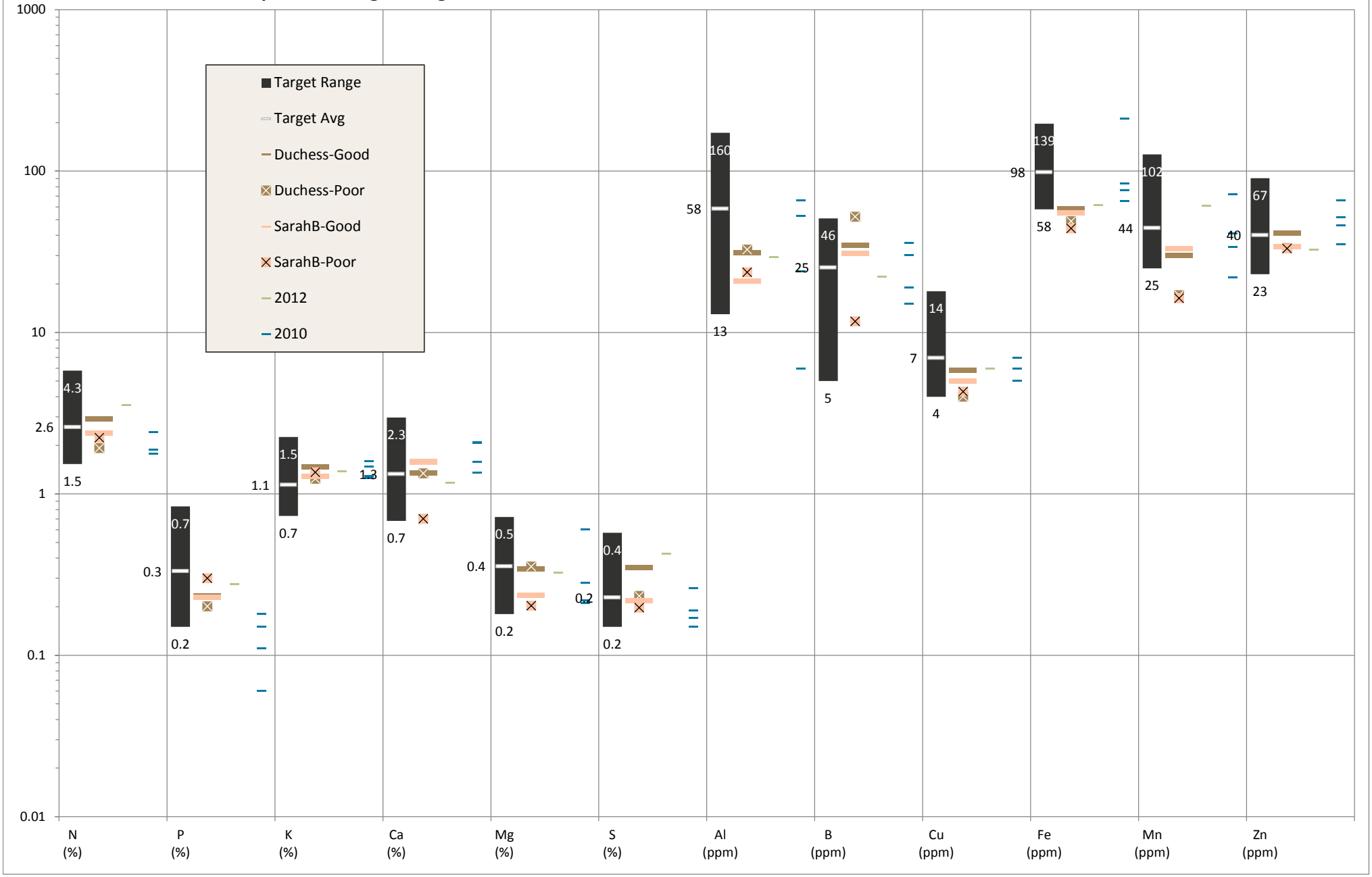


APPENDIX C

COMPILED DATA CHARTS FOR
2010-2012-2014 PARTICIPATING GROWERS

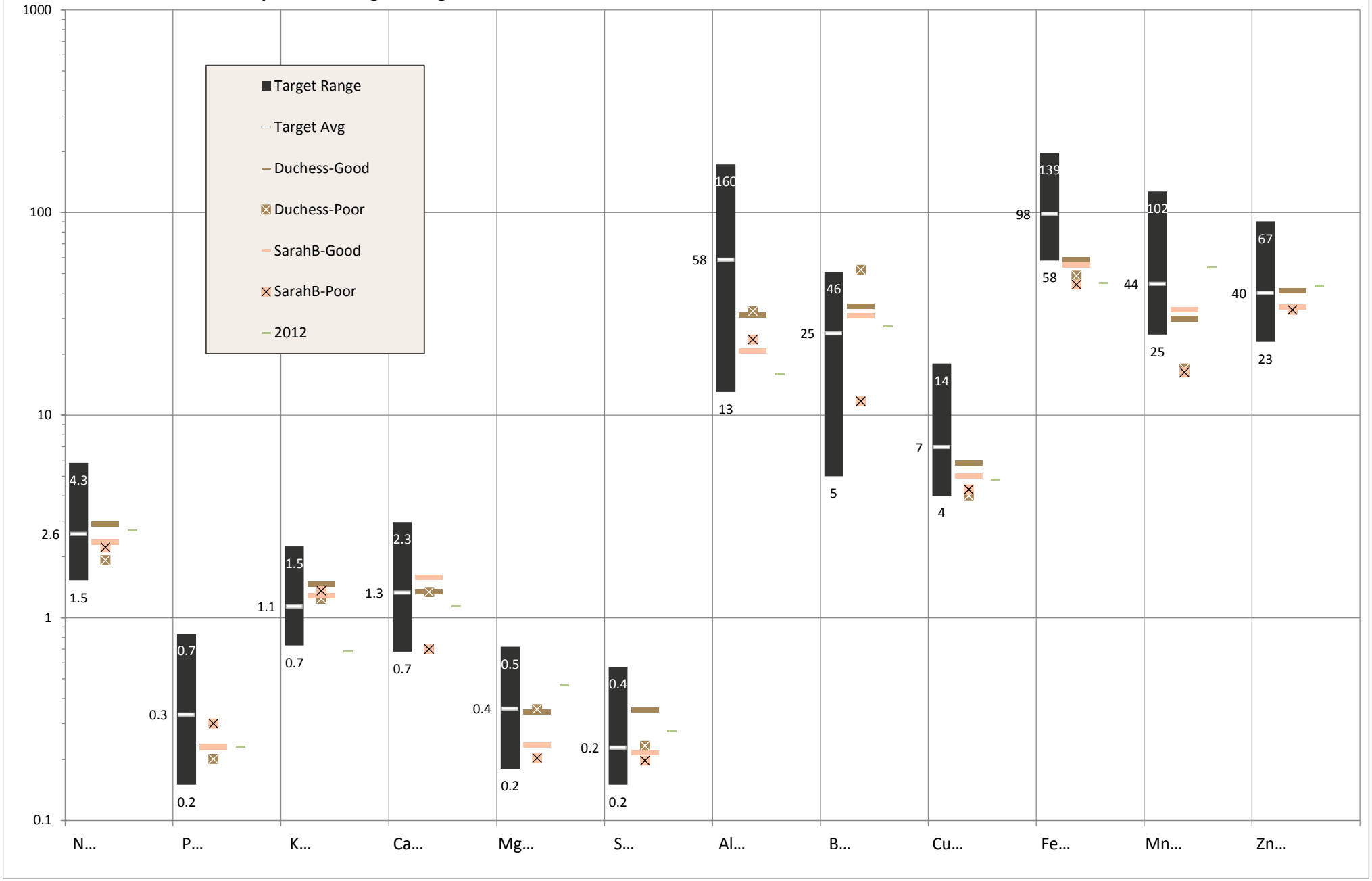
2014 Tissue Data Compared to Target Ranges

Grower 3



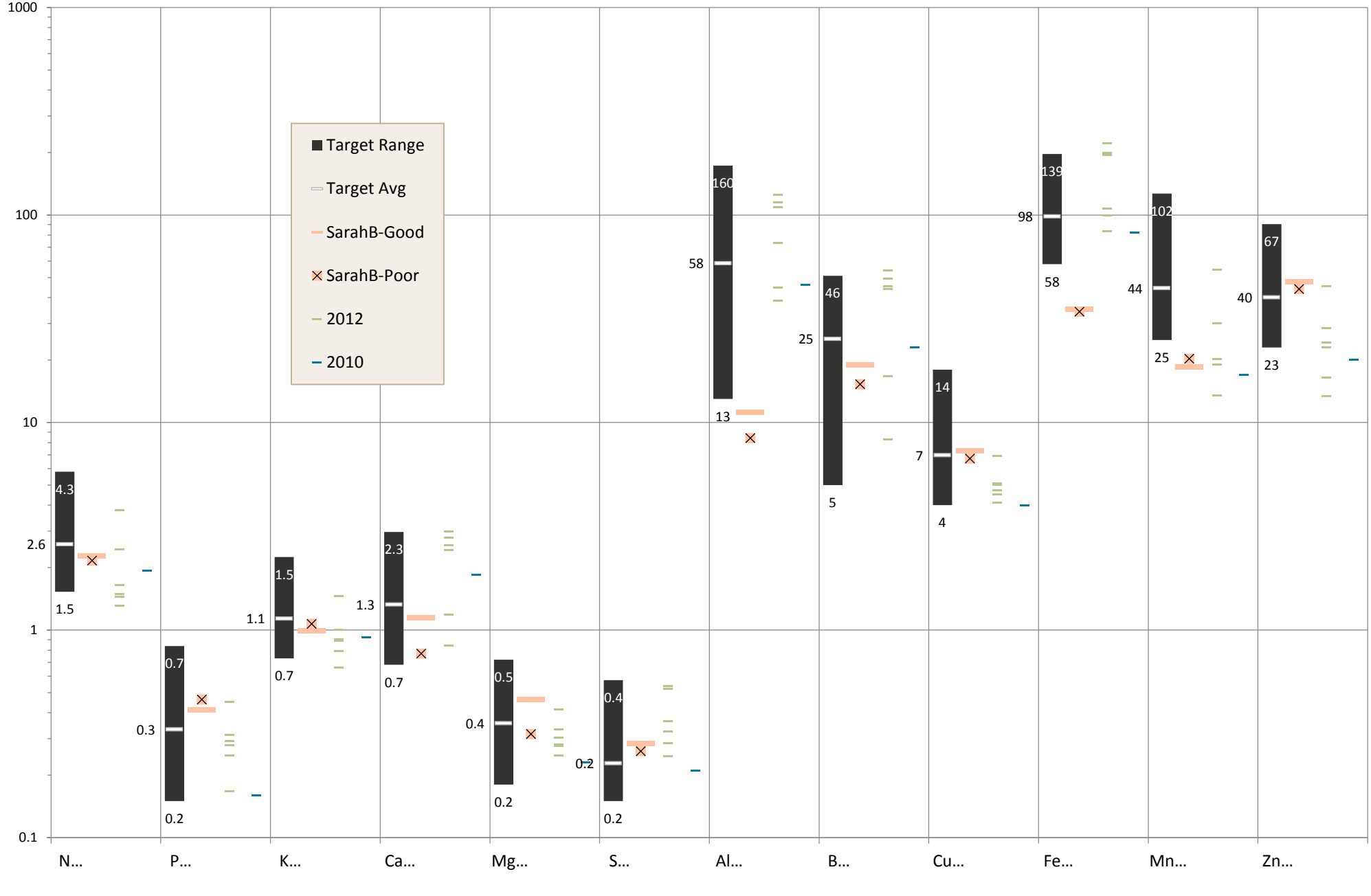
2014 Tissue Data Compared to Target Ranges

Grower 5



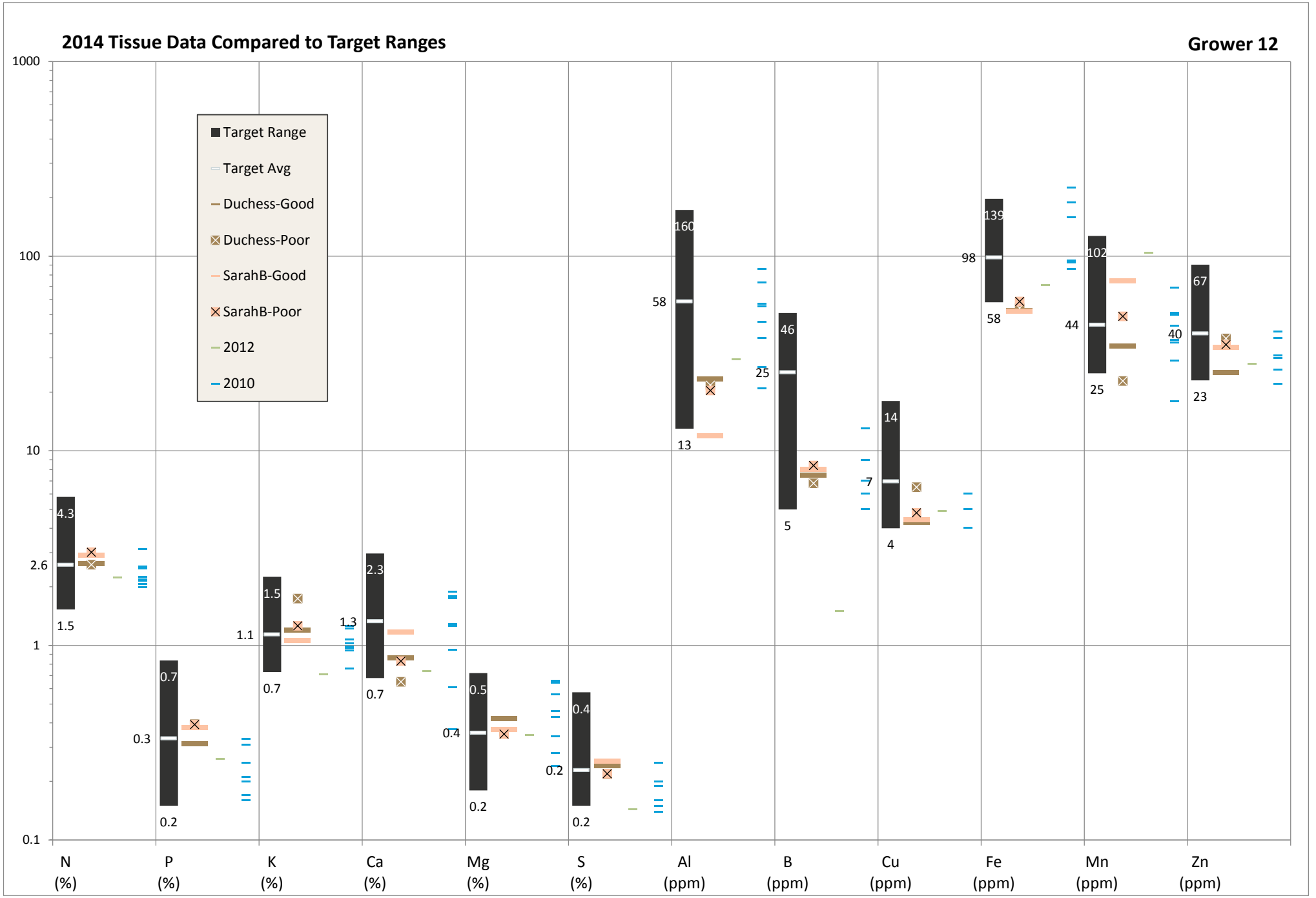
2014 Tissue Data Compared to Target Ranges

Grower 11



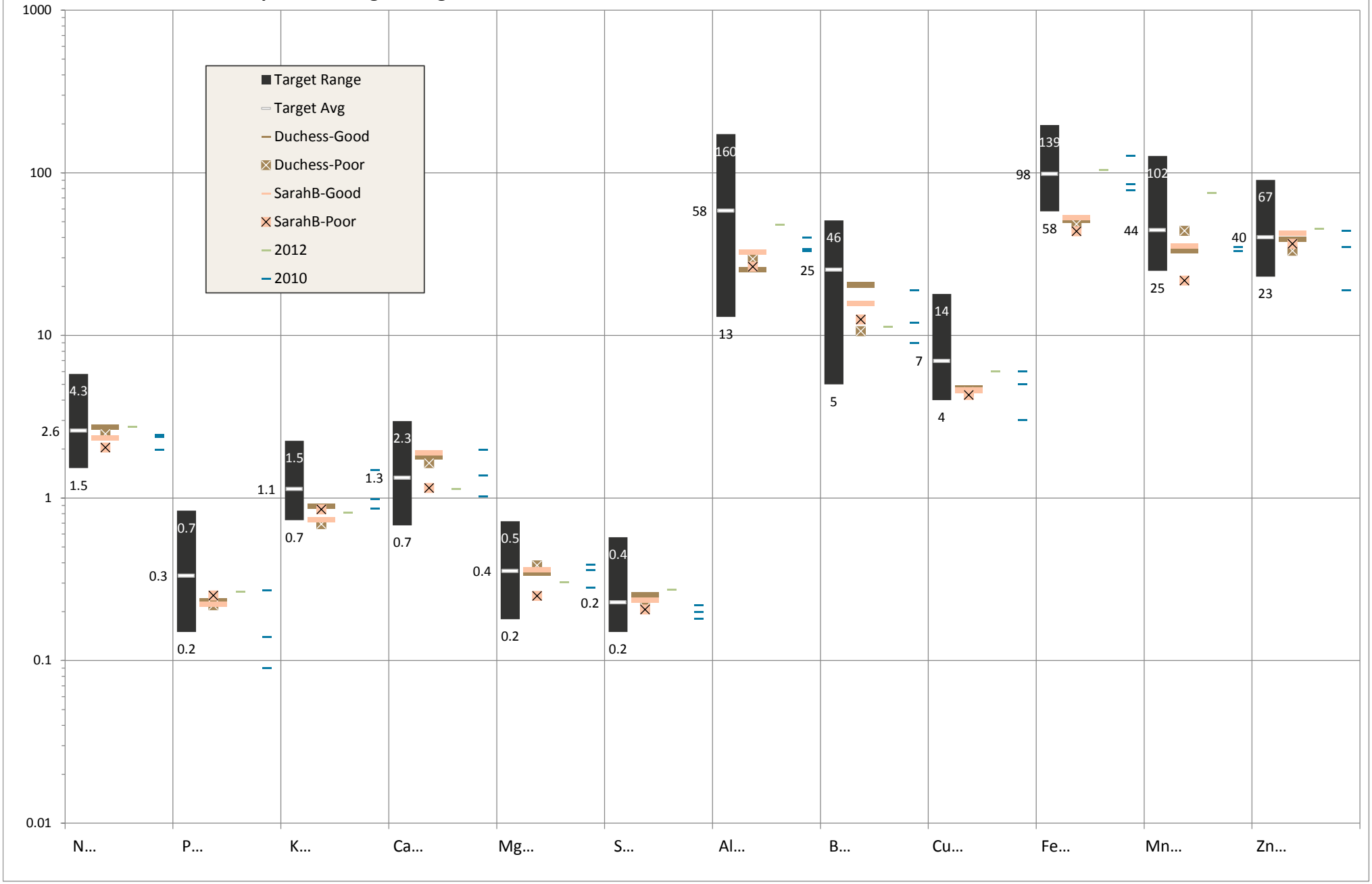
2014 Tissue Data Compared to Target Ranges

Grower 12



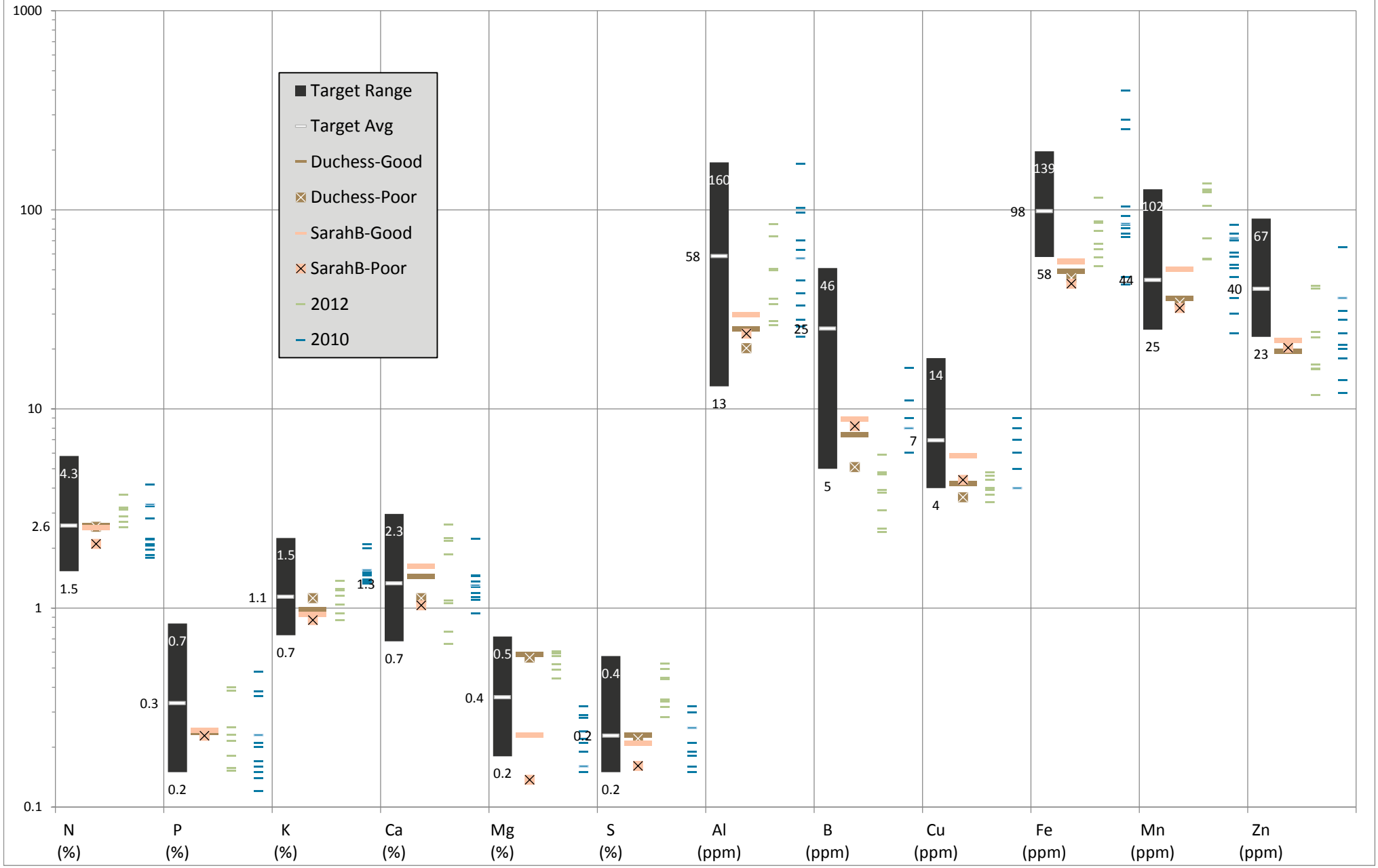
2014 Tissue Data Compared to Target Ranges

Grower 17



2014 Tissue Data Compared to Target Ranges

Grower 41



APPENDIX D

SUMMARY REPORT FOR PEONY NUTRIENT STUDY IN ALASKA IN 2014

Summary report for peony nutrient study in Alaska in 2014

Mingchu Zhang[1], Sue Kent[2], and Robert Van Veldhuizen[1]

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[2]Alaska Peony Growers' Association

Background

The Alaska peony industry has grown rapidly in recent years. The number of peony growers continues to increase. The industry is pretty new in the state and past soil and nutrient research are mostly for small grains and hay crops. Therefore, there is no current soil or nutrient test standard in the state that can be used to guide growers to apply nutrients to soils for peonies. A study was initiated in 2012 to survey growers' fields for soil and tissue nutrient concentrations. The results of that survey indicated that future survey studies for peonies in the state should include a soil and tissue test for well grown peonies along with a soil and tissue test for poorly grown peonies. Based on this, a diagnostic standard from soil or tissue testing can be established. Therefore, in the summer of 2014, a survey of growers' fields for soil and tissue samples from both well and poorly grown peonies were conducted. The objective of this survey was to determine the range of nutrient concentrations in good and poor peony tissue and soil.

Approach

The soil and plant samples were taken from growers' fields prior to flower cutting. Tissue samples were taken randomly from the first leaf from the top, replicated in five plants. The stage for both tissue and soil sampling was at hard bud stage (2.5 maturity index). Soil samples were taken from the depth (0-6 inches or 15 cm) around the peony plant roots. The soil samples were taken from the same peony plants where the tissue samples were taken. There were five soil samples, each of the samples were composited and mixed thoroughly. Samples were taken in three regions: Interior (Fairbanks, Two Rivers, North Pole, and Delta Junction areas), South Central (Trapper Creek, Wasilla, and Palmer areas), and the Kenai Peninsula (Nikiski, Kenai, Soldotna, and Homer areas). The peony cultivars, 'Sarah Bernhardt' and 'Duchess' were used as the standard cultivars for testing because these two cultivars are the most popular in the state. The age of the peony plants at sampling was equal or greater than three-years old, with the exception one or two growers from which two-year old peonies were sampled. Soil samples were air dried, passed through 2-mm sieve, and then placed in a plastic bag

and labeled. Tissue samples were dried at 65°C and then placed in paper bags and labeled. All the samples were sent to Brookside Laboratories Inc. of New Bremen, Ohio for nutrient concentration analysis. In addition to soil and tissue sampling, a survey was also taken from growers regarding fertilization rate, types of fertilizes, and how and when the fertilizers were applied. Upon receiving the analytical results from Brookside Laboratories, the data were analyzed for regional averages.

Results

We surveyed 21 growers in the summer of 2014, eight from the interior, four from south central and nine from the Kenai Peninsula. As for types of nutrients the various growers used, there were many different varieties, such as home compost, fish based organic fertilizers, municipal and local compost, peony blend, urea, and triple super phosphate. In essence, growers used a wide variation of both organic and inorganic nutrient sources. Some growers used organic nutrient sources exclusively, whereas others used inorganic sources. Many used a combination of both. For the rate of fertilizer application, it varied greatly from grower to grower. However, the general impression was that most growers over applied nutrients for peonies, especially at the time of planting.

For the basic soil properties of soil organic matter content (SOM), pH, and cation exchange capacity (CEC), the differences between good and poor sites within the same cultivars was narrow. The exception was for the soil organic matter content from the Sarah Bernhardt cultivar in the interior where it was 1% higher in the good site compared to the poor site (Table 1). For all three regions, the

Table 1. Average values (and ranges) of soil organic matter (SOM), pH, cation exchange capacity (CEC) from the interior, south central, and the Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
SOM (%)	7.52 (2.85 – 12.16)[1]	6.47 (2.84 – 11.20)	3.83 (2.02 – 5.86)	3.97 (1.93 – 6.11)
pH	5.8 (4.8 – 7.7)	5.9 (4.8 – 7.1)	6.2 (6.1 – 7.5)	6.2 (5.0 – 7.8)
CEC (meq/100g)	19.51 (9.98 – 23.03)	17.16 (9.11 – 22.96)	12.23 (6.13 – 16.39)	12.19 (7.66 – 17.21)
South Central				
SOM (%)	7.48 (3.37 – 11.66)	7.40 (3.81 – 11.21)	5.66 (1.75 – 11.01)	5.51 (2.07 – 10.74)
pH	6.2 (5.3 – 7.2)	6.1 (5.3 – 7.0)	6.2 (5.6 – 7.0)	6.2 (5.6 – 7.1)
CEC (meq/100g)	9.80 (5.42 – 12.58)	8.92 (5.92 – 11.73)	8.21 (5.21 – 12.63)	8.97 (4.76 – 12.64)
Kenai Peninsula				
SOM (%)	12.14 (7.85 – 16.07)	12.78 (9.45 – 15.58)	12.67 (4.29 – 17.11)	11.88 (3.31 – 17.54)
pH	6.1 (5.2 – 7.1)	6.1 (5.2 – 6.9)	5.7 (5.3 – 6.2)	5.9 (5.5 – 6.2)
CEC (meq/100g)	15.24 (11.57 – 20.60)	15.54 (10.33 – 23.40)	13.44 (9.85 – 22.85)	13.76 (9.14 – 27.91)

[1]Numbers in the parenthesis = range of the tested item in the samples.

soil organic matter content and soil CEC were higher from the Sarah Bernhardt cultivar as compared to the Duchess (Table 1). The Sarah Bernhardt cultivar is most likely the first and most popular peony grown in all three regions. As such, the soil from around the Sarah Bernhardt cultivar might have a longer history of cultivation and receiving inputs (i.e. organic sources of nutrients) than the soil around the more newly planted Duchess cultivar. Compared amongst all three regions, soils from the Kenai Peninsula seemed to have higher organic matter content. However, the CEC in the interior for the Sarah Bernhardt cultivar was slightly greater than the ones from the Kenai Peninsula (Table 1). Since both soil organic matter and clay minerals contribute soil CEC, in the interior the ability of the soil to hold nutrients was mainly due to clay minerals, whereas, that ability was mostly due to soil organic matter in the Kenai Peninsula. For both soil organic matter content and CEC, the south central region appeared to be lower than the other two regions (Table 1).

The soil macronutrient concentrations of soil mineral nitrogen (N), Mehlich 3 phosphorus (P), and exchangeable potassium (K) were all higher in the interior from the soils around the Sarah Bernhardt cultivar compared to the other two regions (Table 2). For the Duchess cultivar, that difference was not as pronounced as the Sarah Bernhardt (Table 2). The soil mineral N is the nitrogen in the soil that is in a readily available form for plant nutrient uptake. For example, a value of nearly 50 ppm N from the good site of the Sarah Bernhardt cultivar in the interior, is equal to about 100 lbs N/acre (i.e. 217.4 lbs of urea).

Table 2. Average values (and ranges) of soil mineral N (NH_4-N + NO_3-N), Mehlich 3 phosphorus, and exchangeable potassium concentration from the interior, south central, and the Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Mineral N (ppm)	49.9 (6.5 – 88.1) [1]	36.4 (4.9 – 114.5)	11.9 (4.5 – 27.7)	22.5 (5.2 – 79.0)
Mehlich 3 P (ppm)	314 (93 – 506)	266 (93 – 556)	113 (68 – 176)	120 (80 – 148)
Exchange K (ppm)	477 (135 – 927)	363 (19 – 985)	173 (60 – 259)	208 (51 – 313)
South Central				
Mineral N (ppm)	7.5 (4.6 – 14.3)	7.2 (4.2 – 12.2)	8.3 (5.6 – 13.5)	11.0 (4.7 – 22.4)
Mehlich 3 P (ppm)	102 (52 – 126)	92 (59 – 113)	124 (57 – 234)	130 (67 – 207)
Exchange K (ppm)	200 (105 – 292)	191 (119 – 254)	233 (184 – 332)	292 (223 – 398)
Kenai Peninsula				
Mineral N (ppm)	23.4 (6.3 – 59.8)	14.2 (6.7 – 25.9)	23.4 (4.8 – 82.6)	21.6 (4.6 – 90.1)
Mehlich 3 P (ppm)	93 (21 – 190)	63 (22 – 171)	61 (14 – 208)	65 (8 – 241)
Exchange K (ppm)	197 (81 – 451)	161 (70 – 429)	157 (50 – 535)	153 (54 – 537)

[1]Numbers in the parenthesis = range of the tested item in the samples.

That is a significant amount of nitrogen in soil, especially at the flower cutting time later in the growing season. For the Duchess cultivar, the poor site in the interior had a higher soil mineral N and exchangeable K level in the soil, indicating that the impediment for growth was not from nutrients but some other variable such as weed management (Table 2). The difference among all three regions for the Duchess cultivar was not that obvious as compared to the Sarah Bernhardt cultivar (Table 2).

The difference between good and poor sites of the micronutrient concentrations in the soil, was narrow for both the Sarah Bernhardt and Duchess cultivars (Table 3). However, compared among regions, the calcium (Ca) concentration in soil in the interior was a couple hundred parts per million higher than the one in south central (Table 3). Even though both concentrations were high with no deficiency of Ca, the difference might be attributed to the parent geological materials from which soil was formed and also to the management practice such as use of organic sources of nutrients (bone meal, compost, etc.). Also, higher Ca concentration was observed in the Sarah Bernhardt cultivar as compared to the Duchess. As suggested earlier, the Sarah Bernhardt cultivar might have received more

Table 3. Average values (and ranges) of key soil micronutrient concentrations from the interior, south central and the Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Ca (ppm)	2035 (637 – 3155) [1]	1838 (596 – 2277)	1581 (774 – 2513)	1530 (460 – 2255)
Mg (ppm)	326 (47 – 668)	319 (46 – 450)	228 (61 – 439)	238 (69 – 497)
Zn (ppm)	10.71 (1.50 – 29.39)	9.44 (1.52 – 18.44)	4.82 (2.45 – 7.88)	5.52 (1.88 – 11.09)
Cu (ppm)	2.43 (1.41 – 5.63)	2.58 (1.23 – 6.07)	2.30 (1.21 – 3.64)	2.36 (1.22 – 3.12)
B (ppm)	0.67 (0.25 – 1.24)	0.66 (0.30 – 1.16)	0.46 (0.20 – 0.65)	0.60 (0.23 – 1.30)
Mn (ppm)	26 (5 – 44)	25 (4 – 52)	18 (5 – 44)	22 (5 – 51)
South Central				
Ca (ppm)	1367 (496 – 1984)	1216 (533 – 1859)	1128 (662 – 1949)	1190 (450 – 1898)
Mg (ppm)	112 (41 – 205)	97 (32 – 200)	110 (47 – 224)	118 (47 – 234)
Zn (ppm)	5.68 (2.48 – 10.61)	7.83 (2.61 – 20.61)	6.63 (4.51 – 9.24)	6.38 (3.63 – 10.62)
Cu (ppm)	2.15 (1.35 – 4.13)	2.33 (1.37 – 4.87)	2.51 (1.38 – 3.81)	2.52 (1.49 – 4.37)
B (ppm)	0.48 (0.21 – 0.64)	0.52 (0.31 – 0.77)	0.54 (0.46 – 0.61)	0.66 (0.47 – 0.79)
Mn (ppm)	15 (9 – 18)	15 (9 – 18)	20 (17 – 28)	19 (18 – 19)
Kenai Peninsula				
Ca (ppm)	2148 (1610 – 2934)	2249 (1418 – 3906)	1688 (1216 – 2696)	1862 (1152 – 3746)
Mg (ppm)	178 (49 – 643)	166 (42 – 683)	137 (60 – 287)	135 (60 – 271)
Zn (ppm)	4.64 (0.74 – 11.23)	3.84 (1.03 – 4.16)	3.44 (1.36 – 5.76)	3.01 (1.03 – 4.63)
Cu (ppm)	1.89 (0.99 – 4.61)	1.66 (0.89 – 4.79)	1.35 (0.82 – 2.40)	1.43 (0.81 – 2.89)
B (ppm)	0.45 (0.22 – 0.84)	0.36 (0.20 – 0.64)	0.35 (0.20 – 0.88)	0.36 (0.20 – 0.91)
Mn (ppm)	14 (6 – 32)	10 (3 – 15)	10 (5 – 18)	8 (2 – 15)

[1]Numbers in the parenthesis = range of the tested item in the samples.

nutrients over time as compared to the Duchess cultivar due to having a longer history of production. Calcium concentration in the soils from Kenai Peninsula was in the same range as the interior. However, the magnesium (Mg) concentration in the peninsula was apparently lower than the interior (Table 3). Little difference was found among the three regions for copper (Cu) and boron (B). But the zinc (Zn) was apparently higher for the Sarah Bernhardt cultivar in the interior than the in the other two regions, and manganese (Mn) was higher in both the Sarah Bernhardt and Duchess cultivars for the interior compared to the other two regions (Table 3). During the survey, we have not seen any deficiencies for these micronutrients. The variation here served as a status quo of micronutrient concentrations for peonies grown in soils in each of the three regions.

The nutrient concentrations in peony tissue, especially for nitrogen, demonstrated a fairly even range for both good and poor sites for both the Sarah Bernhardt and Duchess cultivars (Table 4). For example, in south central, the good site had a tissue N concentration of 2.23% for the Sarah Bernhardt cultivar, and 2.10% for the Duchess cultivar. In contrast, the poor site only had a nitrogen concentration of 1.75% for the Sarah Bernhardt cultivar and 1.65% for the Duchess cultivar. For the interior and Kenai Peninsula, the difference between good and poor sites in terms of nitrogen concentration was narrow. However, that was most likely due to a higher supply of nutrients from the soil in the interior and Kenai Peninsula (Table 2). For the potassium concentration, it appeared to be negatively related to the nitrogen concentration in peony tissue. That meant a high nitrogen concentration was accompanied by a low potassium concentration in the peony tissue (Table 4). For phosphorus, there was no clear trend (Table 4).

Table 4. Average values (and ranges) of nitrogen, phosphorus, and potassium concentrations in peony tissue from the interior, south central and Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Nitrogen (%)	2.37 (1.85 – 3.06) [1]	2.18 (1.68 – 3.01)	2.35 (1.66 – 2.80)	2.06 (1.45 – 2.60)
Phosphorus (%)	0.336 (0.201 – 0.411)	0.347 (0.234 – 0.462)	0.282 (0.191 – 0.409)	0.316 (0.199 – 0.480)
Potassium (%)	0.97 (0.83 – 1.16)	1.06 (0.89 – 1.26)	1.08 (0.86 – 1.20)	1.28 (0.74 – 1.74)
South Central				
Nitrogen (%)	2.23 (1.98 – 2.58)	1.75 (1.50 – 2.08)	2.10 (1.98 – 2.23)	1.65 (1.52 – 1.90)
Phosphorus (%)	0.277 (0.228 – 0.305)	0.252 (0.195 – 0.287)	0.249 (0.209 – 0.285)	0.228 (0.200 – 0.283)
Potassium (%)	1.07 (0.94 – 1.24)	0.99 (0.83 – 1.35)	0.98 (0.91 – 1.06)	1.10 (0.90 – 1.37)
Kenai Peninsula				
Nitrogen (%)	2.37 (1.83 – 2.62)	2.10 (1.70 – 2.32)	2.40 (2.06 – 2.90)	2.03 (1.25 – 2.56)
Phosphorus (%)	0.225 (0.184 – 0.287)	0.248 (0.171 – 0.302)	0.214 (0.148 – 0.277)	0.207 (0.110 – 0.347)
Potassium (%)	0.98 (0.71 – 1.28)	1.02 (0.85 – 1.37)	1.00 (0.70 – 1.46)	0.98 (0.59 – 1.59)

[1]Numbers in the parenthesis = range of the tested item in the samples.

For the micronutrient concentrations in the peony tissue, a high calcium (Ca) concentration was associated with the good site in all three regions for both cultivars (Table 5). Since calcium can enhance the cell wall strength, the high nitrogen in the peony tissue corresponding with the high calcium concentration was good for plant growth for all growers in all regions. The magnesium (Mg) and boron (B) concentrations also corresponded with the good and poor sites, meaning the good site had higher apparent magnesium and boron concentrations in tissues than did the poor sites (Table 5). For zinc and copper, the gap between the good and poor sites was not as large as for the other micronutrients. However, for the iron (Fe) concentration, there was a large gap between the good and poor sites, especially for the Sarah Bernhardt cultivar (Table 5). Iron is an essential element for chlorophyll production. The high iron concentration in tissue helps the photosynthesis process of the peony plants.

Table 5. Average values (and ranges) of key micronutrient concentrations in peony tissue from the interior, south central and Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Ca (%)	0.87 (0.66 – 1.17) [1]	0.60 (0.37 – 0.83)	0.99 (0.86 – 1.17)	0.85 (0.65 – 0.98)
Mg (%)	0.295 (0.203 – 0.463)	0.260 (0.174 – 0.350)	0.340 (0.258 – 0.428)	0.310 (0.269 – 0.358)
Zn (ppm)	38.1 (20.1 – 49.4)	35.8 (22.6 – 44.0)	36.3 (21.1 – 56.5)	37.6 (22.7 – 46.5)
Cu (ppm)	9.3 (3.0 – 58.3)	7.2 (3.9 – 29.7)	5.2 (3.5 – 6.8)	5.4 (3.9 – 7.7)
Fe (ppm)	53.1 (35.2 – 70.5)	47.6 (32.7 – 65.5)	47.7 (36.1 – 61.9)	43.4 (32.7 – 59.7)
B (ppm)	15.3 (8.0 – 37.3)	14.5 (8.4 – 47.2)	18.9 (7.5 – 27.6)	19.7 (6.8 – 35.2)
South Central				
Ca (%)	1.03 (0.59 – 1.37)	0.75 (0.35 – 1.03)	1.20 (0.76 – 1.63)	0.88 (0.44 – 1.47)
Mg (%)	0.227 (0.155 – 0.309)	0.187 (0.120 – 0.237)	0.302 (0.231 – 0.429)	0.228 (0.122 – 0.386)
Zn (ppm)	55.4 (28.8 – 95.5)	42.0 (26.9 – 63.2)	53.4 (30.2 – 82.7)	40.6 (30.2 – 50.9)
Cu (ppm)	5.4 (4.4 – 6.3)	4.5 (3.8 – 5.0)	4.5 (3.8 – 4.8)	4.0 (3.9 – 4.1)
Fe (ppm)	43.4 (35.5 – 53.1)	36.1 (30.6 – 45.8)	51.0 (42.6 – 64.7)	35.5 (30.9 – 37.9)
B (ppm)	17.8 (10.3 – 25.1)	16.2 (13.1 (19.5)	20.0 (14.8 – 25.8)	17.8 (13.4 – 21.1)
Kenai Peninsula				
Ca (%)	1.31 (0.89 – 1.90)	0.89 (0.43 – 1.15)	1.61 (0.44 – 2.77)	1.35 (0.47 – 1.74)
Mg (%)	0.274 (0.170 – 0.446)	0.229 (0.138 – 0.446)	0.380 (0.202 – 0.583)	0.209 (0.127 – 0.281)
Zn (ppm)	33.3 (22.0 – 42.6)	31.2 (22.2 – 44.0)	48.6 (19.5 – 84.1)	39.0 (12.4 – 71.7)
Cu (ppm)	4.2 (2.4 – 5.8)	4.0 (2.6 – 4.8)	4.1 (2.1 – 5.8)	4.0 (2.3 – 6.9)
Fe (ppm)	48.3 (33.5 – 55.2)	42.3 (32.7 – 55.7)	50.6 (34.6 – 66.5)	48.4 (37.3 – 64.2)
B (ppm)	19.0 (7.2 – 30.8)	14.8 (9.4 – 24.8)	26.3 (7.4 – 34.5)	22.7 (5.1 – 52.1)

[1]Numbers in the parenthesis = range of the tested item in the samples.

As shown in the results, some nutrients were available in the soil but were not reflected in the tissue nutrient concentrations (nitrogen in Duchess in the interior). This indicated that nutrients even though in sufficient quantities in the soil were not utilized by the plants during the growing season. Therefore, there must have been other factors that affected the uptake of soil nutrients by peony roots. These may include soil physical properties such as the soil might have been too compacted for roots to penetrate, or management practices such as weed competition, or physical accessibility of roots to access the nutrient sources such as surface applied nutrients don't always make it down to the peony roots. Peony roots expand every year, as such, the plant roots increase their contact area with soil resulting in more chances to obtain soil nutrients. If the peony plant is too young (two to three years), the nutrient use efficiency is low simply because there are not enough roots to take up nutrients from soil. This suggests that nutrient application especially the inorganic nutrient sources, should be applied in relative low rate when the peony is planted.

Also, the soil mineral nitrogen concentration varies with time due to microbial consumption, or leaching/runoff. The soil mineral nitrogen concentration only serves as an index to indicate the status of available nitrogen at the time of sampling. Given the fact that there are quite a large number of growers who are using organic nutrients, a soil incubation experiment is currently being conducted for assessing the nitrogen mineralization from organic matter in the soil over the growing season. The soil samples from the incubation experiment are under laboratory analysis at this time, but the results will be reported at the annual peony growers' meeting this winter.

Conclusions

The survey results showed the regional differences in soil nutrient concentrations for peony production. For some of the major nutrient concentrations in soil such as phosphorus, the difference among regions was large. The study also showed the nutrient differences in soil and peony tissue between good and poor sites. However, the poor nutrient concentrations in the plant tissues did not always correspond to the low nutrient concentrations in the soil. There were other factors that may affect nutrient uptake by peonies such as weeds competing with peony plants in using available nutrients in the soil. Soil nitrogen levels appeared to be high in the interior late in the growing season. But it was not clear what will be the impact of the high nitrogen in the soil to the cut flower quality.