NPFVGA fertilizer optimization report 2020

1. PROJECT DETAILS:

a. **Name of the Project**: Optimizing Fertilizer Recommendations for Ontario Peaches

b. **Investigators:** Kathryn Carter, Fruit Specialist (OMAFRA), Christoph Kessel, former Soil Fertility Specialist (OMAFRA); Dr. Tejendra Chapagain, Soil Fertility Specialist (OMAFRA), Sarah Marshall, Manager (Ontario Tender Fruit Growers), Larissa Osborne, Marketing and Production Analyst (Ontario Tender Fruit Growers)

c. **Total Duration of the project**: 3 years (commencing in 2018)

d. **Reporting Period**: April 2020 to February 2021

e. **Short Summary** (200 words)

The productivity of fruit trees is influenced by tree nutrition. Lack of Nitrogen can result in reduction in tree growth, and reduced yields. Excess Nitrogen can result in excessive vigour, pest issues (brown rot and Oriental fruit moth) delay maturity and decrease fruit colouration.

Currently few tender fruit growers conduct soil or leaf analysis on a regular basis. Fertilizers are applied based on the grower's previous experience at the site. However, increased interest in high density tree plantings (closer tree spacings), may affect fruit tree nutritional requirements. As a result, there is a need to evaluate OMAFRA's nutrient recommendations for peaches based on changes in production practices. Optimizing fertilizer applications can help to reduce fertilizer costs and reduce environmental impact.

The goal of this project was to:

- To better understanding of current fertilizer practices, and soil and tissue test results orchards
- To use this information to optimize the timing and rates of fertilizer programs.
- To investigate and assess surface and subsurface nitrogen and phosphorus losses within current orchard soil and fertilizer management practices.

2. **PROGRESS MADE DURING THE REPORTING PERIOD**:

- Soil sampling (spring and July, Fall) and Leaf sampling (July) have been completed and samples have been analyzed by the lab (see Appendix). This is the final year of the project and all field work has been completed.

- Nitrogen Index has been used to evaluate potential sub-surface nitrogen loss in each orchard for each year of the project (2018, 2019 and 2020) March/April 2021
- PLATO was used to evaluate potential surface and sub-surface phosphorous loss in each orchard for each year of the project (2018, 2019 and 2020) March/April 2021

3. **PLAN OF ACTION FOR THE NEXT PERIOD**:
   - Although the project is completed, OMAFRA is in the process of conducting statistical analysis on the data. This analysis will be provided in newsletter articles.
   - Participating growers will receive the final report summarizing their soil and petiole analysis, and for each trial sites an N-Index, PLATO, and estimated N & P budgets in May 2021.
   - A short article about the project will be circulated in the Ontario Tender Fruit Growers newsletter in May 2021.
   - The results of the project will be reviewed and used to amend OMAFRA's fertilizer recommendations and develop future research projects.

4. **PROBLEMS/ ISSUES FACED AND REMEDIAL MEASURES TAKEN**:

This project originally planned on taking water samples directly form tiles to evaluate nutrient leachate, but since tiles could not be isolated to the specific trial site or orchard, it was too difficult to tell if the N & P management in the trial areas were directly affecting the tile drain water. As a result, OMAFRA attempted to use a "buried bottle" method of collecting surface water run off to evaluate phosphorous loss. Unfortunately, this method was not effective in collecting water samples, so we were unable to analyze nutrient levels in surface water run off. However, the use of incremental soil depth analysis, water extractable phosphorous (WEP) & nutrient models (N Index & Phosphorous Loss Assessment tool Ontario -PLATO) provided a good understanding of subsurface N & P losses as well as surface P losses. This models information will provide a better understanding of how much of the nutrients are being used as opposed to how much have leached. This information will d help to optimize fertilizer recommendations.

Although COVID-19 had minimal impact on field work, it did affect the projects knowledge tech transfer (spring meetings with growers and newsletter articles).

OMAFRA has hired a new fertility specialist Dr Tejendra Chapagain and he is assisting in analyzing the data and incorporating the results of the project into OMAFRA's production guidelines. To assist in analyzing the results of this trial we have hired Christoph Kessel to provide some assistance with the transition.

5. **CONFERENCE PRESENTATIONS/OUTREACH ACTIVITIES/ MEDIA COVERAGE PERTINENT TO THE PROJECT:**

A presentation summarizing the results of this research was presented in March on the OFVC online educational sessions and will be posted on the OFVC website. In Spring/Summer 2020, OMAFRA will have a conference call with grower co-operators to discuss the results of the project.

A newsletter article summarizing the results of the research project will be posted on the ON fruit blog in May/June 2021.

6. **Preliminary Results**

Nitrogen

Nitrogen (N) plays an important role in peach production and is applied annually. Nitrogen is involved in vegetative growth, and the production of proteins, amino acids and chlorophyll. Nitrogen deficiency can reduce tree growth and decrease yields. While excess Nitrogen can delay fruit maturity, decreased colouration of fruit, cause shading out of lower fruit wood, and increase pest pressure (Brown rot and peach twig borers and OFM).

In the soils, N is present as Nitrates (NO3) or Ammonium (NH4), with Nitrates being the nutrients that the tree is able to uptake. Our research showed that Nitrate levels were higher in top levels of the soil (0-15 and 15-30cm) during summer (July-August) compared to (November). This was to be expected as the growers applied N in the late spring. Soil N levels (0 to 15 cm) varied between the sites from 4 to 90 ppm. We hope to collect yield data from growers to get a better understanding of the impacts of these N levels on the crops. In general, soil nitrate level increased over years across sites in both the top and sub- soils with the highest level in 2020.

Tissue samples are often the best method of evaluating nutrient uptake by trees. Drought and other environmental conditions can impact the trees uptake of nutrients which may result in deficiency even when nutrients are present at adequate levels in the soil. N levels in tissues met OMAFRA recommendations

(OMAFRA recommendations are 3.4-4.1% N) with the exception of one site in 2018 and 2019 which was slightly low in N Tissue, but not deficient. Nitrogen levels in soils and tissue were generally correlated with soil N levels. In general tissue N aligned well with soil N in 2020, with the exception of 2018 and 2019 at site 3. Tissue Nitrogen levels were above OMAFRA recommended levels at all of the sites (>3.4 to 4.1% N). It is interesting to note that tissue levels were above tissue recommendations set in other areas (California) where they recommend % N in tissue to be 2.6- 2.8% N for optimum colour and storage quality. Research has shown that trees with tissue N levels are above 3% (Johnson and Uriu, 1989) have excess vigour and issues with fruit quality. Tree growth and weather conditions in Ontario differ from California, and this may have an impact on N needs, vigour and yields (which we did not study in this trial). However, we did see that despite the considerable variability in N fertilizer applications applied in orchards, N levels in tissues were all above the OMAFRA recommended levels. Although further work needs to be done to evaluate yields, and tree growth under lower N applications, our research suggests that there may be opportunities to reduce N applications.

Potassium (K)

Potassium (K) plays an important role in cell turgor and opening and closing of the stomata. K levels in fruit are relatively large, and as a result there is a fair amount of K removed at harvest. Generally K deficiency isn't an issue in tender fruit and K only needs to be applied. Excess K can result in deficiency of other nutrients (Mg).

All of the sites fell within the optimum soil K recommendations for 0 to 15 cm from Pennsylvania State University (150 to 300 ppm). Soil K level was gradually increased over years in 0-15 cm depth across four orchards. There exists a positive (and moderately strong) association between soil and tissue K (r = 0.77, r2 = 0.6). Tissue K levels were slightly low (but not deficient) at site 1 and site 2 which we would not have known without a tissue analysis. However, all other sites met OMAFRA recommendations (2.3-3.5% K). Tissue K levels were not considered to be excess at any of the sites, however levels at site 4 indicate that it might be beneficial for the grower to hold off on applying a K application in 2021.

Phosphorous

Phosphorous (P) is used to store, transfer and utilize energy in plants. Phosphorous deficiency is not common in peaches and phosphorous in Ontario. Phosphorous is generally only applied at planting in peaches, however, phosphorous is present in manure and other organic amendments. Phosphorous runoff has created concerns with algal blooms in the Great Lakes Watershed. Excess phosphorous can cause fruit to ripen earlier and result in poor quality fruit.

The results of our trial found that in general, soil P was higher in the upper 0-5cm compared to 0-15cm as was expected. Soil P and WEP were higher in 0-5 and 0-15 cm depths in 2018 across four sites compared to 2019 and 2020, probably due to application manure, we are investigating further. Soil P and WEP levels are consistently higher in site 4 over the course of the project. Site 4 applies more organic matter-mushroom substrate etc. this may be the reason for the high levels. Phosphorous levels in soils and tissues met the OMAFRA recommended levels (0.15 to 0.4 % P in tissues, and 13 to 15 ppm for soils).

Research has shown that soil Phosphorous levels (0 to 15 cm) above 50 ppm P have an increased risk of leaching P (Wang et al, 2010), however, we did not see P levels in soil reach this level in our trial. In addition soil (0-5 cm) Water extractable Phosphorous (WEP levels) greater than 12 ppm are considered to be at higher risk of phosphorous leaching, and we did see increased risk of leaching at one site based on this threshold.

Soil phosphorous levels (0 to 15 cm) over 20 ppm indicate an increased risk of dissolved reactive phosphorous (DRP) surface runoff (Wang et al, 2010). A few of the sites tested did have an increased risk of DRP runoff and as a result OMAFRA conducted some modelling to determine the phosphorous loss potential (see below)

Our research showed that there were not any specific trends or strong associations between soil and tissue P (except for 2018) indicating that tissue P does not appear to have a strong correlation with soil P.

Summary of fertilizer analysis

The results of this trial support the value of using tissue analysis in determining fertilizer recommendations in orchards as nutrient levels in soils and tissues may not always coincide. The results also suggest that based on research conducted in other areas (California) there may be some opportunities to reduce N applications, which could result in economic benefits to growers and environmental benefits. However, further research needs to be done, to ensure that lower N applications would not impact yields or tree growth.

Overall K levels and P levels in tissue met the OMAFRA recommendations. At site 4 were slightly high in 2020 indicating that the grower may benefit from refraining from applying K until 2022.

Soil phosphorous tests results indicate that there is a low risk of Phosphorous leaching. However, some of the sites may have an increased risk of dissolved phosphorous runoff. All sites considered in this study were also assessed for some indicators related to soil health and water quality. Those indicators involved phosphorus loss potential, soil erosion risk and nitrogen index scores.

Soil Health Modelling

Phosphorus Loss Potential

Since soil analysis indicated that there may be a risk of phosphorous run off in some of the orchards, we decided to determine the potential of phosphorous loss at each site, to determine the potential risk. Phosphorus loss potential was calculated by PLATO which refers to the Phosphorus Loss Assessment Tool for Ontario (PLATO). This tool is used to estimate the risk of phosphorus loss on any given farm and it uses specific soil, crop and nutrient application information to provide a risk rating.

PLATO calculates a Field Characteristic Index which represents the risk of phosphorus loss - through two different steps: the first step offers to input county and geotownship, along with soil series, soil texture and a soil test phosphorus value (0-15 cm) while the second step guides to select a crop type, fertilizers applied, tile drainage system and spacing details, along with an estimate of erosion. An estimate of erosion can be calculated by PLATO by providing additional information on the slope and tillage details.

PLATO Score generally ranges between 0 to as high as 150 or 200 which depends on the hydrologic soil group, timing and application method of fertilizers and organic manures, P-Soil test, estimated soil erosion, tile drainage system, their spacing and distance to buffer zone, etc. When the score is less than 30, it is considered to be very low – that means potential phosphorus loading into surface water is minimal from this site. And when this score is greater than 140 – that means the potential P-contribution into surface water from that site is very high.

Table 2: Total Phosphorus Index calculated by PLATO for all sites from 2018-2020.

Years	**Total Phosphorus Index**			
	Site 1:	**Site 2:**	**Site 3:**	**Site 4:**
2018	12.7	5.2	14.2	22.3
2019	18.9	8.0	16.7	20.7
2020	13.8	6.8	10.2	11.3

Average	**15.1**	**6.7**	**13.7**	**18.1**

Table 2 shows total phosphorus index (TPI) across four sites considered in this study from 2018-2020. The average TPI was 15.1 for site 1, 6.7 for site 2, 13.7 for site 3, and 18.1 for site 4. Above all, all four sites considered in this study gave **very low P-Index (<30)**: that means P loading into surface water is minimal from these sites.

The relatively higher values in 2019 in Site 1 and 3, as well as in 2018 and 2019 in Site 4, were primarily due to higher soil P test values combined with the application of manure and phosphate fertilizers. As mentioned earlier, these values are also affected by hydrologic soil group, timing and application method of fertilizers and organic manures, estimated soil erosion, tile drainage system, their spacing and distance to buffer zone, etc.

As a result, even though the results of the soil analysis indicated that there was a risk of phosphorous loss at some orchards, phosphorous models developed in Ontario indicate that orchard floor management and lack of slopes in the orchards, minimize the risk of phosphorous run off.

Soil Erosion Risk Potential

Research has shown that soil health can have a significant impact on production and packouts in orchards (Prengaman, 2021). Estimation of soil erosion risk is important to determine the amount of soil (particularly the top-soil) lost from the system which greatly impacts soil fertility and health, water quality, microbial diversity and ecosystem functions, and productivity of the orchard. Estimation of soil erosion potential involved two different steps:

1. Estimation of the Management Practice Factor which represents the management practices used in the orchards: using **RUSLE2 for Ontario**. RUSLE2 refers to version **2** of the **R**evised **U**niversal **S**oil **L**oss **E**quation. This is a computer program that estimates long-term average soil loss caused by rainfall and related overland flow from cropland, pastureland, forestland, construction sites, mined land, and reclaimed land. This program is used in the United States to guide conservation planning, and predict soil and sediment loads from upland areas. RUSLE2 for Ontario is the same computer program used in the United States but includes only the datasets specifically developed to represent the Ontario environment.

2. Using this factor as input to the **Water Erosion Potential Mapping tool in AgMaps**. AgMaps is a GIS-based agricultural mapping website and its Water Erosion Calculator tool can be used to estimate average annual soil loss from the field.

We calculated management practice factors for four different orchard management scenarios in Ontario as follows:

- the first scenario is when the orchard has continuous sod/vegetative cover covering all soil (that means there is no bare soil and no herbicide strip within the tree rows). The management practice factor for this scenario was **0.03**: none of the sites involved in this study have fallen in this category.
- the second scenario is when the orchard has no-till permanent sod cover between tree rows but there is a herbicide strip or bare soil within the tree rows which is never cultivated. The management practice factor for this scenario was **0.08** – Sites 2, 3 and 4 involved in this study have been following this practice.
- The third scenario is when cover crops are established between the tree rows annually that means the site is disced and planted with cover crops every year. The management practice factor for this scenario was **0.13**. One of the four sites (e.g. Site 1) involved in this study has been following this practice.
- And the fourth scenario is when the soil is disturbed or cultivated between rows and within the tree row - that means there is a bare soil under mature orchard trees. The management practice factor for this scenario was **0.34** - none of the sites involved in this study have fallen in this category.

Table 1: Estimated Soil Erosion Risk (ton/ac/yr) for different management scenarios.

Management Practice	**Soil Erosion Risk (ton/acre/year)**			
	Site 1:	**Site 2:**	**Site 3:**	**Site 4:**
Permanent Cover	0.1 (0.2 mT/ha/yr)	0.1 (0.1 mT/ha/yr)	0.1 (0.3 mT/ha/yr)	0.1 (0.1 mT/ha/yr)
No-till	0.2 (0.5 mT/ha/yr)	0.2 (0.4 mT/ha/yr)	0.4 (0.8 mT/ha/yr)	0.2 (0.4 mT/ha/yr)
Annual CC	0.4 (0.8 mT/ha/yr)	0.3 (0.6 mT/ha/yr)	0.6 (1.3 mT/ha/yr)	0.3 (0.6 mT/ha/yr)
Cultivated	0.9 (2.0 mT/ha/yr)	0.7 (1.5 mT/ha/yr)	1.5 (3.4 mT/ha/yr)	0.7 (1.5 mT/ha/yr)
Inherent	2.7 (6 mT/ha/yr)	2 (4.4 mT/ha/yr)	4.5 (10.1 mT/ha/yr)	2 (4.5 mT/ha/yr)

Table 1 summarizes soil erosion risk potential for all sites for abovementioned management scenarios (e.g., permanent cover, no-till, annual cover crops, cultivated and inherent conditions). These values ranged between 0.1 to 2.7 ton/ac/yr for site 1, 0.1 to 2 ton/ac/yr for site 2, 0.1 to 4.5 ton/ac/yr for site 3 and 0.1 to 2 ton/ac/yr for site 4. The actual loss (i.e., risk associated with existing management practices) was 0.4, 0.2, 0.4 and 0.2 ton/ac/yr for site 1, 2, 3, and 4, respectively. That means all sites considered in this study gave relatively low erosion risk scores (<5 ton/ac/yr) perhaps because 1) these sites were all relatively flat except for the site 3 which has a steeper slope on the east side, and 2) adoption of no-till permanent sod cover between the tree rows.

As a result, RUSLE2 erosion modelling indicates that all of the sites had low risk of erosion, which is good for soil health.

Nitrogen Index Calculation

Nitrogen Index tells whether the existing N management strategy is reasonable in terms of potential loss of N into watersheds. Peaches are grown on sandy soils, and require annual applications of Nitrogen. As part of this project we wanted to determine how much of the N applied was used by the crop and estimate potential Nitrogen loss, as this might provide an indication of sites where N levels could be reduced. We did calculate N-Index using a traditional approach/manual method which involved a five-step process as follows:

1. Determine Hydrologic Soil Group (HSG) and the Maximum Allowable N-Index value for each soil group – that were derived from AgMaps as well as from OMAFRA website.
2. Determine Value A which was calculated from Crop Removal Balance for Nitrogen (e.g., N applied minus crop N removal).
3. Determine Value B which was calculated from Nitrogen Available for Potential Loss during the non-growing season (i.e., fall/winter) from applications of manure or nitrogen fertilizers following crop harvest.
4. Add Value A and Value B together to determine the Calculated N-Index Value.
5. Compare the calculated N-Index value to a maximum allowable N-Index value for the dominant soil type (as characterized by HSG). The calculated N-Index value must not exceed the maximum allowable N-Index value.

Table 3: Nitrogen Index values calculated by traditional approach for all sites.

Management Practice	Sites			
	Site 1:	Site 2:	Site 3:	Site 4:

Hydrologic Soil Group	Tavistock (C)	Vineland (B)	Vineland (B)	Chinguacousy (C)
Leaching Risk	Low	Medium	Medium	Low
Maximum Allowable N-Index	**6**	**4**	**4**	**6**
N-Index from Previous Crop Balance (Value A)	1	3	1	1
N-Index for Available N for Potential Loss (Value B)	0-1	0-1	0-1	0-1
Total N-Index (A+B)	**2**	**4**	**2**	**2**

Table 3 summarizes Hydrologic Soil Group (HSG) and the Maximum Allowable N-Index value for each soil group, Value A and Value B, as well as total N-Index Value for all four sites considered in this study. The maximum N-Index value allowable for Site 1 and 4 was 6 (i.e., low risk category based on the hydrologic soil group) while this value was 4 (i.e., medium risk category) for Site 2 and 3 – that means the higher the values, the lower would be the risk.

Similarly, N-Index values determined from previous crop removal balance (Value A) ranged between 1 and 3 for all sites. This value was higher in Site 2 due to application of higher chemical N fertilizer (average of 100 lb N per acre per year) compared to other sites (average of 60-65 lb N per acre per year). However, Value B for all sites ranged between 0 and 1 as they did not receive chemical N fertilizers in the fall/winter. Therefore, calculated total N index value (e.g., by adding value A and B together) did not exceed the maximum N-Index value allowable for each site. But there is a potential to lower this value by reducing application rate in Site 2. In general, N-Index value can be lowered by reducing application rates or changing application timing to spring pre-plant or side-dress or by including a cover crop.

As result, N loss was not a major concern at any of these sites, however the N-index values at site 2 could be lowered by reducing the application rates, or by amending fertilizer timings and orchard floor cover.

OVERALL CONCLUSION:

The indicators associated with soil health and water quality (e.g., erosion risk potential, phosphorus loss potential, and N-Index) showed that the orchards considered in this study provide reasonably good erosion protection as they have a tree canopy and often grass cover in the areas that are not covered with trees. Also, P-loading and Nitrate leaching potential from these sites are reasonably lower. The overall conclusion from this study involved:

- N, P and K **were not deficient**: it is recommended that soils be tested every three years while tissue testing be done every year.
- There may be potential to reduce N applications at some of the sites which could reduce grower costs, however more research needs to be done to ensure there is no impact on yields or fruit quality.
- All sites considered in this study gave relatively **low soil erosion risk** scores perhaps because the sites are all relatively flat.
- Field Characteristics Indices as generated by PLATO fall under **VERY LOW** category: P loading into surface water is minimal from these sites.
- Calculated N-Index value **did not exceed** the maximum N-Index value allowable for each site: Growers N management strategy seems working well in all sites.
- There is potential to reduce the N-Index value (e.g. in site 2) by reducing N application rates. N-Index values can also be reduced by changing application timing to spring or side-dress or by including a cover crop.

Appendix 1:

Table.1 Leaf analysis summary, sampled August 2-3, 2018, and July, 2019, 2020

	%					ppm				
	N	P	K	Ca	Mg	B	Cu	Fe	Mn	Zn
OMAFRA	3.4-4.1	0.15-0.4	2.23-3.5	1.0-2.5	0.35-0.6	20-60		25-200	20-200	15-100
2018 Average	3.6	0.2	2.3	1.7	0.5	28.7	8.8	88.8	24.0	35.2
2018 Max	3.8	0.3	2.9	1.9	0.6	32.4	10.3	119.9	35.6	50.7
2018 Min	3.4	0.2	1.7	1.5	0.5	26.0	7.4	69.0	8.4	25.0
2019 Average	3.54	0.25	2.36	1.36	0.41	0.17	25.73	68.17	26.19	7.07
2019 Max	3.88	0.29	2.78	1.5	0.46	0.18	28.56	84.68	36.74	7.43
2019 Min	3.17	0.22	1.84	1.18	0.39	0.16	23.32	55.88	14.85	6.88
2020 Average	3.76	.2225	2.475	1.35	.4375	31.82	9.7475	84.4525	25.6675	30.3575
2020 Max	3.93	.23	3.09	1.4	.48	34.38	11.04	91.58	29.98	35.74
2020 Minimum	3.64	.21	1.82	1.28	.38	26	8.53	78.43	14.92	22.27

Highlighted areas indicate significant differences between 2018 and 2019 which need to be clarified with the lab.

Table 2. Soil analysis summary (August 17 & 27, 2018 and July, 2019 and July 2020)

				%	Ppm				
Year	**Sampling depth**		**pH**	**OM**	**P (Olsen)**	**P (WEP)***	**K**	**Mg**	**Ca**
2018	0-5 cm	Average	6.2	2.2	30	5.9	249	112	878
		Max	7.3	2.5	49	9.1	290	160	1337
		Min	5.7	1.9	22	3.3	198	71	673
2018	0-15	Average	6.8	2.0	18	n/a	181	119	1073
		Max	7.4	2.4	35	n/a	263	172	1472
		Min	6.5	1.7	9	n/a	153	88	876
2018	30-60	Average	7.4	0.9	6	n/a	44	144	2361
		Max	7.8	1.5	8	n/a	69	163	3826
		Min	7.1	0.6	3	n/a	31	107	1272
2019	0-5 cm	Average	6.72	2.13	24.54	4.47	279.75	110.99	1059.19
		Max	7.13	3.1	36.64	7.93	459.77	148.76	1456.87
		Min	6.3	1.6	18.95	2.51	154.95	83.24	898.42
2019	0-15	Average	6.86	2.03	18.31	n/a	217.11	113.75	850.74
		Max	7.16	2.9	25.6	n/a	295.68	154.4	1664.71
		Min	6.5	1.6	13.38	n/a	116.36	86.2	1225.56
2019	0 to 30	Average	7.33	0.85	6.46	n/a	53.14	147.77	1945.07
		Max	7.48	1.1	9.92	n/a	95.09	179.1	2807.61
		Min	7.23	0.7	4.15	n/a	31.93	100.68	1218.92
2020	0 - 5	Average	n/a	n/a	18.3775	3.815	n/a 7.93 2.51 3.815	n/a	n/a
		Max	n/a	n/a	25.65	7.93	n/a	n/a	n/a

		Min	n/a	n/a	17.27	2.51	n/a	n/a	n/a
	0 to 15	Average	6.9	3.05	13.1075	n/a	269.345	1303.883	1303.883
2020		Max	7.16	3.4	17.59	n/a	308.03	1437.85	1437.85
		Min	6.5	1.6	9.84	n/a	215.96	1152.45	1152.45
2020	0 to 30	Average	n/a	n/a	5.5	n/a	n/a	n/a	n/a
		Max	n/a	n/a	8	n/a	n/a	n/a	n/a
		Min	n/a	n/a	4	n/a	n/a	n/a	n/a

* Water extractable phosphorus

Table 3. Soil nitrate-nitrogen summary

		Nitrate Ppm					
Year	**Sampling depth**	**0-15 cm**		**15-30 cm**		**30-60 cm**	
		Aug	Nov	Aug	Nov	Aug	Nov
2018	Average	14.6	4.4	12.3	5.1	3.7	7.3
2018	Max	20.7	6.4	29.3	7.8	7.4	11.3
2018	Min	4.2	1.9	1.2	1.3	0.2	1.9
2019	Average	16.56	5.5	7.35	2.6	4.04	1.175
2019	Max	29.92	8.4	14.97	4.2	6.32	2.4
2019	Min	4.24	3	1.23	0.5	0.9	0.1
2020	Average	**47.15**	9.667	**22.45**	17.28	**17.9**	5.966
2020	Max	**90.9**	12.5	38.6	40.7	22.1	10.1

Citations

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