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New Brunswick Forage 4R Nutrient Stewardship C2021-0033-Y4

Objective

The objectives of this project are to examine the sulfur status of New Brunswick alfalfa stands through tissue testing and to engage producers to use a 4R nutrient stewardship approach to forage production and determine the cost to grow a tonne of high-quality forage on NB livestock farms.

Summary

Forages play a vital role on all NB livestock operations. For the sector to continue to be a driving force in the NB economy and for individual producers to remain competitive under new global trading agreements, it is critical for the NB livestock industry to produce high quality forages in quantities that meet their requirements.

One major component of any good fertility plan is to identify plant nutrients that may be limiting production. In years past, sulfur (S) deficiencies were uncommon in alfalfa, as atmospheric S deposition supplied a portion of the crop's needs. However, S received from atmospheric sulfur dioxide emissions (acid rain) has steadily declined in the last 30-yrs. Sulfur deficiency in New Brunswick alfalfa stands has not been examined.

A second major component of a good fertility plan is to use the right nutrient source, rate, time and placement (4R approach) to optimize agronomic crop yield and quality, economics of production, environmental sustainability and social good on a site-specific basis. From the many discussions over the last few years at various producer meetings throughout the regions of the province, it is evident that farmers in NB rarely measure forage yields. Yield measurement would provide vital information on when to rotate or renew the crop and assist with making on-farm management decisions to help decrease waste or economic losses. Knowing yields also allows the farmer to monitor the nutrient removal from the soil and to make informed decisions on fertilizer, manure, and lime application rates. With tighter margins farms are being forced to look at COP more closely and make management decisions that align with higher profitability.

The data collected in the NB alfalfa tissue study indicates that sufficient sulfur is available to NB alfalfa crops. A history of livestock manure on most fields sampled is believed to be the reason as it could supply much of an alfalfa crops S needs. If producers start to push their alfalfa crops for increased yields, they should continually monitor that S does not become limiting. Producers should also monitor Potassium, Boron and Magnesium as they were frequently low to deficient in the samples collected and correct deficiencies with a good fertilizer program.

A 4R forage fertility program can increase forage yield, but it is not statistically better than the practices being used on the 6 cooperating farms. Forage quality did not differ between a 4R program and a farm's standard program, but it is thought that harvests past peak quality growth stage may have negated differences that would have been seen if harvest had occurred at the appropriate growth stage for peak quality. A 4R forage fertility program did show a slight ROI compared to a farm's standard practice, but detailed cost of production information should be figured for individual farms and not simply provide an average value that would not be useful in farm financial planning and budgeting.

Conclusion

The data collected in the NB alfalfa tissue study indicates that sufficient sulfur is available to NB alfalfa crops. A history of livestock manure on most fields sampled is believed to supply enough S to the crop. If producers start to push their alfalfa crops for increased yields, they should continually monitor that S does not become limiting. Producers need to monitor Potassium, Boron and Magnesium as they were frequently low to deficient in the samples collected and correct deficiencies with a good fertilizer program.

A 4R forage fertility program can increase forage yield, but it is not statistically better than the practices being used on the 6 cooperating farms. This program did not improve on the forage quality that the 6 cooperating farms were able to obtain with their standard practices. However, a 4R forage fertility program did show a slight ROI compared to a farms standard practice. A 4R program should be constantly evaluated an adjusted to ensure soil mining of nutrients doesn't occur and that it is meeting the goals of individual farm operations.

Cost of production information should be figured for individual farms and not simply provide an average value that would not be useful in farm financial planning and budgeting. Templates already exist to help producers determine their COP (OMAFRA Publication 60).

Programme de gestion des éléments nutritifs pour le fourrage 4R du Nouveau-Brunswick C2021-0033-Y4

Objectifs

Les objectifs de ce projet sont d'examiner la teneur en soufre des peuplements de luzerne du Nouveau-Brunswick au moyen d'analyses de tissus et d'inciter les producteurs à utiliser une approche de gestion des éléments nutritifs 4R pour la production de fourrage et de déterminer le coût de production d'une tonne de fourrage de haute qualité dans les fermes d'élevage du Nouveau-Brunswick.

Résumé

Les fourrages jouent un rôle essentiel dans toutes les exploitations d'élevage au Nouveau-Brunswick. Pour que le secteur continue d'être une force motrice dans l'économie du Nouveau-Brunswick et pour que les producteurs individuels restent compétitifs dans le cadre des nouveaux accords commerciaux mondiaux, il est essentiel que l'industrie de l'élevage du Nouveau-Brunswick produise des fourrages de haute qualité dans des quantités qui répondent à leurs besoins.

Un élément important de tout bon plan de fertilité consiste à identifier les éléments nutritifs des plantes qui peuvent limiter la production. Par le passé, les carences en soufre (étaient rares dans la luzerne, car les dépôts atmosphériques de soufre répondaient à une partie des besoins de la culture. Cependant, le soufre provenant des émissions atmosphériques de dioxyde de soufre (pluies acides) a régulièrement diminué au cours des 30 dernières années. La carence en soufre dans les peuplements de luzerne du Nouveau-Brunswick n'a pas été examinée.

Un deuxième élément important d'un bon plan de nutrition consiste à utiliser la bonne source d'éléments nutritifs, le bon taux, le bon moment et le bon emplacement (approche 4R) pour optimiser le rendement et la qualité agronomiques des cultures, l'économie de la production, la durabilité environnementale et le bien-être social sur une base spécifique au site. D'après les nombreuses discussions qui ont eu lieu au cours des dernières années lors de diverses réunions de producteurs dans toutes les régions de la province, il est évident que les agriculteurs du Nouveau-Brunswick mesurent rarement les rendements des cultures fourragères. La mesure du rendement fournirait des renseignements essentiels sur le moment de la rotation ou du renouvellement de la culture et aiderait à prendre des décisions de gestion à la ferme pour aider à réduire le gaspillage ou les pertes économiques. Connaître les rendements permet également à l'agriculteur de surveiller l'élimination des éléments nutritifs du sol et de prendre des décisions éclairées sur les taux d'application des engrais, du fumier et de la chaux. Avec des marges plus serrées, les exploitations agricoles sont obligées d'examiner de plus près les coûts de production et de prendre des décisions de gestion qui vont dans le sens d'une plus grande rentabilité.

Les données recueillies dans le cadre de l'étude sur les tissus de la luzerne du Nouveau-Brunswick indiquent que les cultures de luzerne du Nouveau-Brunswick disposent d'une quantité suffisante de soufre. Les antécédents de fumier de bétail dans la plupart des champs échantillonnés seraient à l'origine de cette situation, car il pourrait répondre à une grande partie des besoins en soufre des cultures de luzerne. Si les producteurs commencent à pousser leurs cultures de luzerne pour augmenter les rendements, ils devraient continuellement surveiller que le soufre ne devienne pas limitatif. Les producteurs devraient également surveiller le potassium, le bore et le magnésium, car ils étaient souvent faibles ou déficients dans les échantillons prélevés, et corriger les carences avec un bon programme d'engrais.

Un programme de fertilisation des fourrages 4R peut augmenter le rendement des fourrages, mais il n'est pas statistiquement meilleur que les pratiques utilisées dans les 6 fermes coopérantes. La qualité du fourrage ne diffère pas entre un programme 4R et le programme standard d'une exploitation, mais on pense que les récoltes effectuées après le stade de croissance de la qualité maximale peuvent avoir annulé les différences qui auraient été observées si la récolte avait eu lieu au stade de croissance approprié pour une qualité maximale. Un programme de fertilité des fourrages 4R a montré un léger retour sur investissement par rapport à la pratique standard d'une ferme, mais des informations détaillées sur les coûts de production devraient être calculées pour les fermes individuelles et ne pas simplement fournir une valeur moyenne qui ne serait pas utile pour la planification financière et la budgétisation de la ferme.

Conclusion

Les données recueillies dans le cadre de l'étude sur les tissus de la luzerne du Nouveau-Brunswick indiquent que les cultures de luzerne du Nouveau-Brunswick disposent d'une quantité suffisante de soufre. On pense que les antécédents de fumier de bétail dans la plupart des champs échantillonnés fournissent suffisamment de soufre à la culture. Si les producteurs commencent à pousser leurs cultures de luzerne pour augmenter les rendements, ils doivent continuellement surveiller que le soufre ne devienne pas limitant. Les producteurs doivent surveiller le potassium, le bore et le magnésium, car ils étaient souvent faibles ou déficients dans les échantillons prélevés, et corriger les carences avec un bon programme d'engrais.

Un programme de fertilisation des fourrages 4R peut augmenter le rendement des fourrages, mais il n'est pas statistiquement meilleur que les pratiques utilisées dans les 6 fermes coopérantes. Ce programme n'a pas amélioré la qualité du fourrage que les 6 fermes coopérantes ont pu obtenir avec leurs pratiques standard. Cependant, un programme de fertilité des fourrages 4R a montré un léger retour sur investissement par rapport aux pratiques standard des exploitations. Un programme 4R doit être constamment évalué et ajusté pour s'assurer qu'il n'y a pas d'extraction d'éléments nutritifs du sol et qu'il répond aux objectifs des exploitations agricoles individuelles.

Les informations sur les coûts de production doivent être calculées pour chaque exploitation et ne pas se contenter de fournir une valeur moyenne qui ne serait pas utile pour la planification financière et la budgétisation de l'exploitation. Il existe déjà des modèles pour aider les producteurs à déterminer leurs coûts de production (publication 60 du MAAARO).

Enabling Agricultural Research and Innovation

C2021-0033

New Brunswick Forage 4R Nutrient Stewardship

Final Report
2020-2023

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A second major component of a good fertility plan is to use the right nutrient source, rate, time and placement (4R approach) to optimize agronomic crop yield and quality, economics of production, environmental sustainability and social good on a site-specific basis. From the many discussions over the last few years at various producer meetings throughout the regions of the province, it is evident that farmers in NB rarely measure forage yields. Yield measurement would provide vital information on when to rotate or renew the crop and assist with making on-farm management decisions to help decrease waste or economic losses. Knowing yields also allows the farmer to monitor the nutrient removal from the soil and to make informed decisions on fertilizer, manure, and lime application rates. With tighter margins farms are being forced to look at COP more closely and make management decisions that align with higher profitability.

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Introduction:

Forages play a vital role on all NB livestock operations. For the sector to continue to be a driving force in the NB economy and for individual producers to remain competitive under new global trading agreements, it is critical for the NB livestock industry to produce high quality forages in quantities that meet their requirements.

High quality forage production relies on many controllable factors such as species selection, establishment, fertility, harvest and post-harvest management and storage. Producers need to optimize the factors that they can control so that they can improve their bottom line and remain viable. In project EARI15-042 "Improved Forage Quality and Quantity through the use of New Mixtures", the controllable factor of species selection was examined. Forage dry matter yield ranged from a low of 2.5 t/ac to yields of 4.5-5.0 t/ac. This spread in yields lead the research team to question the current provincial fertilizer recommendations, which are based on yields of 2.5 t/ac and on-farm forage fertilizer management practices. It is proposed that an investigation into 4R nutrient stewardship on NB forage crops be conducted.

One major component of any good fertility plan is to identify plant nutrients that may be limiting production. In years past, sulfur (S) deficiencies were uncommon in alfalfa, as atmospheric S deposition supplied a portion of the crop's needs. However, S received from atmospheric sulfur dioxide emissions (acid rain) has steadily declined in the last 30-yrs. This has resulted in S-deficiencies showing up in alfalfa stands in the US and Ontario. Producers in these regions are now having to add S through fertilizer to achieve high yields from their alfalfa stands.

Sulfur is an essential element for alfalfa yield, quality, regrowth and stand durability. Sulfur-deficient alfalfa fields will be lower yielding and show stunted, yellow plants that lack vigor. Producers are more likely to see sulfur deficiencies under the following conditions:

- Mature stands of alfalfa (with no sulfur application).
- Sandy, coarse-textured soils where sulfur will readily leach.
- Low organic matter soils.
- High yielding environments (with no sulfur application).
- Non-manured fields.

Sulfur deficiency in New Brunswick alfalfa stands has not been examined. With reduced atmospheric S deposition and the fact that alfalfa has the highest S requirements of any of the field crops, with a 5 ton/ac crop of alfalfa removing about 25 lbs/ac of sulfur, it is probably that the productivity of New Brunswick alfalfa stands is limited by a sulfur deficiency.

If a sulfur deficiency is suspected, a tissue test confirmation followed by a good sulfur fertility program can solve the problem. Tissue testing of alfalfa (at late-bud stage) is considered a suitable diagnostic approach for determining sulfur deficiencies. Tissue sampling is not a replacement for sound soil sampling practices but should be used in conjunction with soil reports to accurately assess nutrient deficiencies.

The critical level below which alfalfa is considered S deficient and may benefit from applying sulfur is 0.25%. A 2012 field survey of Ontario alfalfa stands indicated that 21% of fields had S- tissue analysis below this level. With atmospheric S-deposition continuing to decline, the number of fields showing S-deficiencies would continue to increase unless otherwise corrected through the addition of sulfur to a farm's fertilizer program. It is also noteworthy that 37% of these fields tested below the critical K value of 1.7%. A similar situation could exist in New Brunswick and is worth examination. Addressing any deficiencies in a crop has the potential to increase yields and make farms more profitable.

A second major component of a good fertility plan is to use the right nutrient source, rate, time and placement (4R approach) to optimize agronomic crop yield and quality, economics of production, environmental sustainability and social good on a site-specific basis.

The Maritimes has long been identified as having an advantage in the production of high yielding, quality forage. However, according to The Bootstraps Report (Russell, 2013), NB dairy farms have not capitalized on this advantage. The report states that NB dairy farms have higher forage costs due to low yields and low quality, which in turn contributes to a high percentage of NB dairy farms not being profitable. NB dairy operations generally apply greater amounts of crop nutrients (fertilizer, lime, manure, etc.) compared to other NB livestock operations, so it is felt that low yielding, low quality forage is similarly produced on many of the other NB livestock operations.

From the many discussions over the last few years at various producer meetings throughout the regions of the province, it is evident that farmers in NB rarely measure forage yields. Yield measurement would provide vital information on when to rotate or renew the crop and assist with making on-farm management decisions to help decrease waste or economic losses. Knowing yields also allows the farmer to monitor the nutrient removal from the soil and to make informed decisions on fertilizer, manure, and lime application rates. With tighter margins farms are being forced to look at COP more closely and make management decisions that align with higher profitability.

Results of this proposed work will not only benefit NB livestock farms, but anyone producing forage in New Brunswick. If enough forage can be grown on a reduced number of acres utilizing a 4R Nutrient Stewardship BMP, it would free up acres for producers to grow other cash crops. This would provide an addition revenue stream or reduce purchased feed expenses; either way contributing to increased profitability.

***Project Objectives(s)*:**

- to examine the sulfur status of New Brunswick alfalfa stands through tissue testing.
- to engage producers to use a 4R nutrient stewardship approach to forage production and determine the cost to grow a tonne of high-quality forage on NB livestock farms.

***Project Deliverable(s)*:**

- sulfur status of New Brunswick alfalfa stands
- identification of other nutrient deficiencies in New Brunswick Alfalfa stands.
- compare forage yields using a farms standard practice to a 4R approach
- compare forage quality using a farms standard practice to a 4R approach
- compare the COP of a farms standard practice to a 4R approach
- determine an average COP for a tonne of high-quality forage on NB livestock farms.

Materials and Methods:

<u>New Brunswick Alfalfa Tissue Study</u>

This was a multi-year on-farm project. First cut data was collected from 27 farms in 2020, 28 farms in 2021 and 26 farms in 2022. Second cut data was collected from 26 farms in 2020, 27 farms in 2021 and 25 farms in 2022

NBSCIA co-ordinators identified up to 3 potential co-operators from their region(s) to participate in this project. A co-operator needed to have >60% alfalfa in their stand. Allowances were made in the event of winter kill and co-operator availability in each region.

The top 6 inches or upper third of the alfalfa plant from approximately 35 random plants within a field were collect at tenth bloom stage just prior to producers harvesting first cut and then again prior to second cut. The exact location of sample collection using a handheld GPS, cell phone or other suitable device, was pinned so that the second cut sample could be taken from the same spot as the first. The tissue samples were couriered to A&L labs shortly after they were collected for plant tissue analysis.

Soil samples were collected at the same time and from the same location as the tissue samples. These were sent to PEI Analytical Labs for a detailed soil chemical analysis.

A detailed fertilization history was collected from each co-operating farm to help interpret the results.

The data was tabulated and examined for trends.

<u>New Brunswick Forage 4R Nutrient Stewardship</u>

This is a multi-year on-farm project.

Solicitation and selection of producers was done so that there is geographic distribution around the province, providing both dairy and beef producers and a variety of soil types.

The on-farm agronomy plots (2x1 acre per farm) were established in the spring of 2021 on existing perennial forage stands (preferably 1st production year). The treatments were as follows:

- Farms Standard Fertilizer and Lime (farm treatment)

- 4R Fertilizer and Lime (4R treatment)

For the first year, fertility recommendations for the 4R treatment were provided by NBDAAF livestock feed specialist and were based on soil test and book values for crop removal. In year two, these were finetuned based on the prior year's yield and actual crop removal.

Farmers were provided with the 4R prescription in the spring of each year. They ordered the fertilizer along with their regular spring order and applied it to the appropriate strip prior to first cut and again after first cut.

Forage samples were collected within 3-days of the farm harvesting the field containing the trial. Eight random ¼ m^2 quadrates were hand harvested from each treatment. All samples were weighed green, and weights recorded. Two composite samples were then taken from each treatment and retained frozen until they were shipped to A&L labs for a detailed forage quality analysis

Details on the farm treatment and the cost of all fertilizer was collected at the end of the season.

All data was tabulated and interpreted to meet the deliverables.

***Results and Discussion*:**

New Brunswick Alfalfa Tissue Study

The percent of alfalfa tissue samples falling into one of four nutrient sufficiency ratings for sulfur is graphically presented in Figures 1 and 2. Of the New Brunswick alfalfa fields sampled, most have tissue sulfur levels that are sufficient for proper crop growth and development. Only 2 samples out of 159 collected over the 2-yrs showed deficient levels. This occurred in the second cut of 2020. 2020 was a an extremely dry growing season, so it is suspected that limited water availability likely restricted the uptake of the nutrient or restricted the mineralization of sulfur into a plant available form. It is suspected that since most stands sampled come are from livestock operations where manure is used at some point in the life of the stand that there is ample organic sulfur applied. With proper weather conditions this can become available to the crop in an amount that is not limiting.

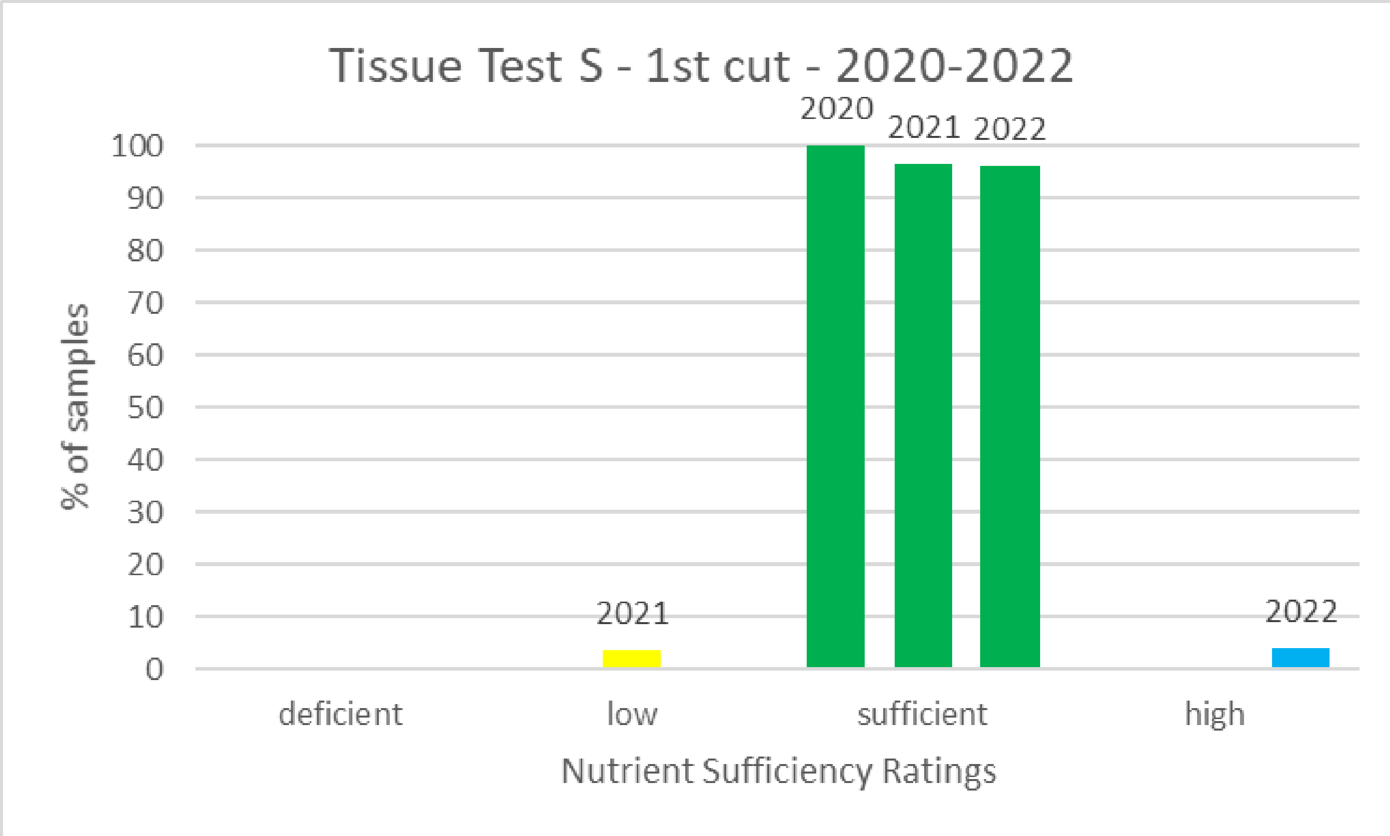


Figure 1. Tissue Test Sulfur from 1st cut

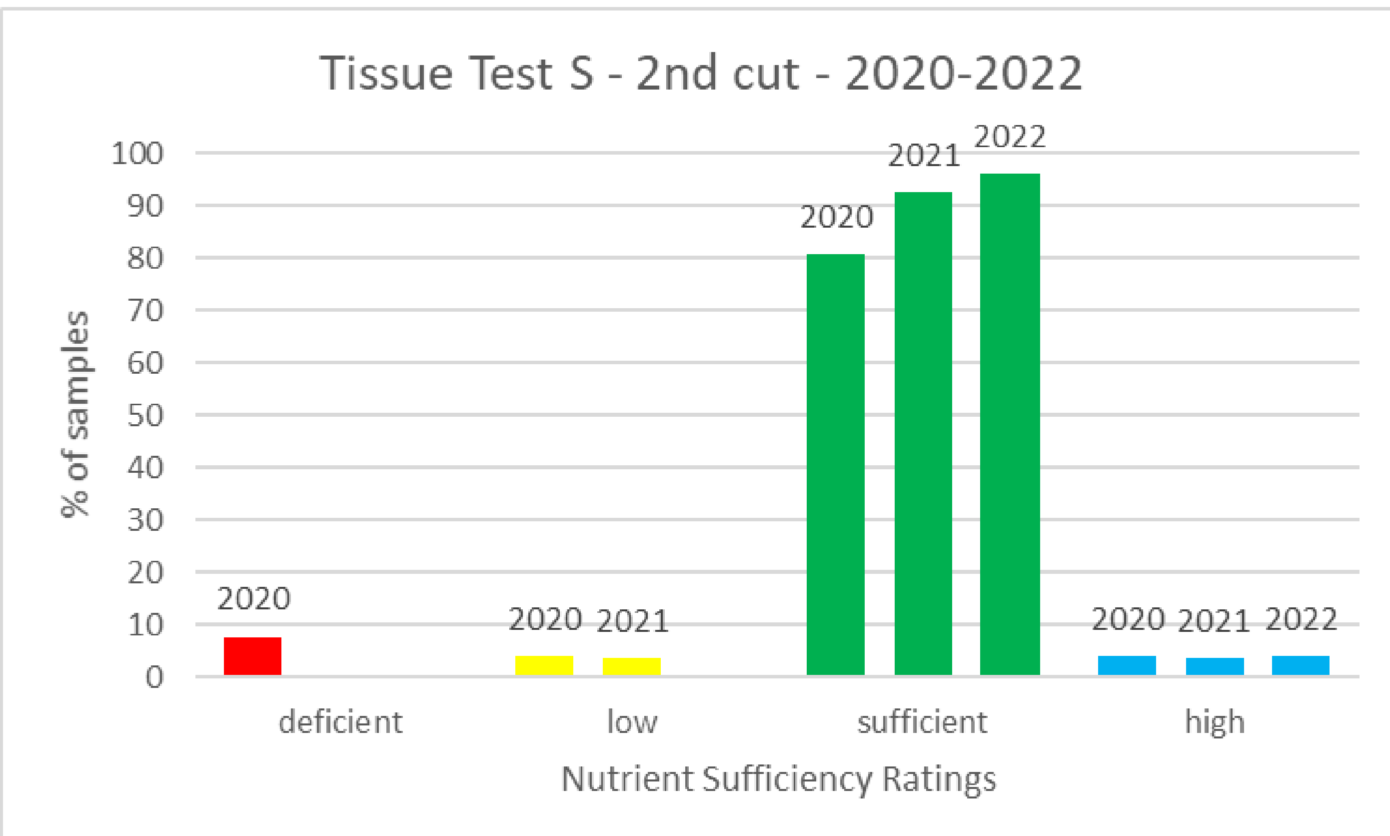


Figure 2. Tissue Test Sulfur from 2nd cut

Similar graphs were generated for Potassium (K), Boron (B) and Magnesium (Mg) and are shown in Appendix A. These three nutrients showed the greatest frequency of being low or deficient of the other nutrients analyzed for.

Slightly less than 10% of samples showed K deficiency in all years and at both cuttings. Samples that exhibited a deficiency in K were most often from fields that showed medium soil test levels (data not shown). Alfalfa is a heavy user of K and can draw down soil potassium levels over time if adequate K is not applied. The decrease in samples in 2022 showing sufficient K is most likely due to increased fertilizer costs and reduced fertilizer usage in this year.

Numerous samples appeared as low or deficient in B in all years of the trial. Close to 40% of samples in 2020 showed deficient levels of B. 2020 was an extremely dry growing season and B availability has been shown to be reduced under low soil water conditions. Even with increased precipitation in 2021 and 2022, still 20% of samples were deficient for B in cut 2 of 2021 and close to 30% of samples from both cuts in 2022. Survey data showed minimal usage of Boron in fertilizer. In some cases, producers were fertilizing with only manure and the odd application of wood ash. Even though these products contain small amounts of B, it appears it isn't enough to prevent B deficiency. It has been long known that 1 to 2 kg/ha of boron should be broadcast annually to ensure this nutrient isn't limiting as it is linked to yield, quality and winterhardiness of the alfalfa crop. It is worth noting that all stands examined were a mixture of alfalfa and grass. Having mixtures does cause challenges with crop management and fertilization. Combine this with the fact that certain crops have a low tolerance to excess boron and growers may be warry of applying to much.

Magnesium (Mg) appeared as low in 70% or more of samples in all years at the first sampling date and close to 50% of all samples in all years at the second sampling data. In 2020 low Mg levels was thought to be related to the droughty growing season; like B, Mg availability is greatly reduced under low soil water conditions. When the trend continued in the other 2-years, the project team began looking at different causes. Soil Mg levels appeared sufficient for being able to provide adequate Mg to the crop, but it is evident from the tissue samples that something was preventing it from getting into the plant. Spring nitrogen and potassium fertilization of pasture has been shown to result in low magnesium levels in plant tissue. Since we are dealing with mixed stands, and some producers are fertilizing them more like a grass crop than alfalfa, it is possible that current management is inducing the low tissue Mg levels. Soil nutrient interactions are extremely complexed, and this observation could very well be the result of something completely different, and it remains undiscernible at this time.

New Brunswick Forage 4R Nutrient Stewardship

Dry matter yields for the individual sites varied from year-to-year (Figures 3 and 4). Part of the yield variation may have been weather related, while some can be explained by site specific management. A yield decline at the Moncton site in 2022 is thought to be related to the site not receiving the second fertilizer application that had been prescribed. This farm had an oversupply of forage from two tremendous growing seasons, so they decided not to fertilize for additional yield for second cut in 2022. This decision was also related to fertilizer having doubled in cost from one year to the next. The yield increase at the Central site in 2022 over what was observed for that site in 2021 could be related to a liming amendment that had occurred in the spring of 2022. The lime used was a waste product from a local pulp mill that is known to reacted and adjust soil pH quickly. The pH adjustment along with the added Calcium may have resulted in increased fertilizer efficiency resulting in increased yield. The decline in yield at the Kings site was related to only a single harvest being taken at that site in 2022 due to the farm having an oversupply of forage.

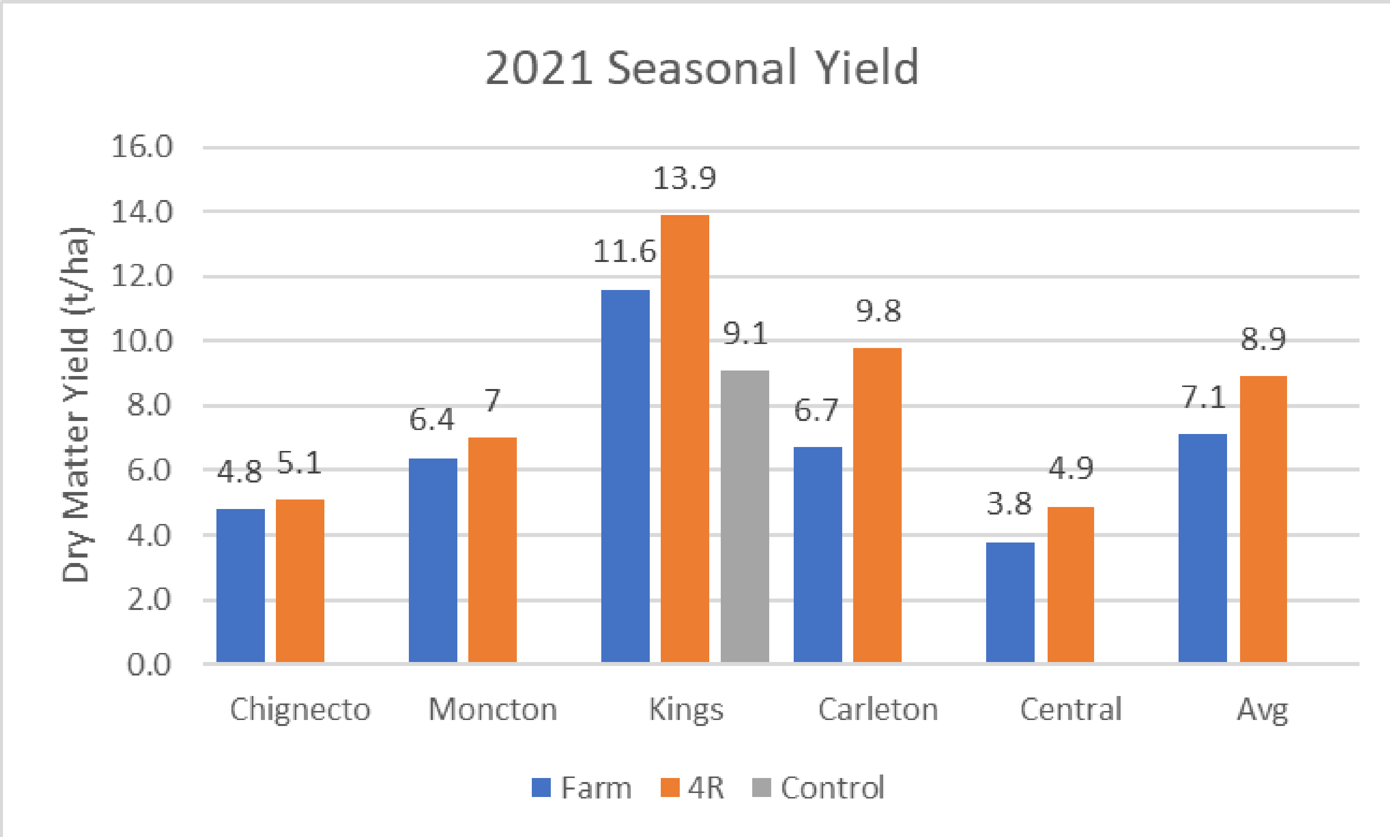


Figure 3. 2021 Dry Matter Yields

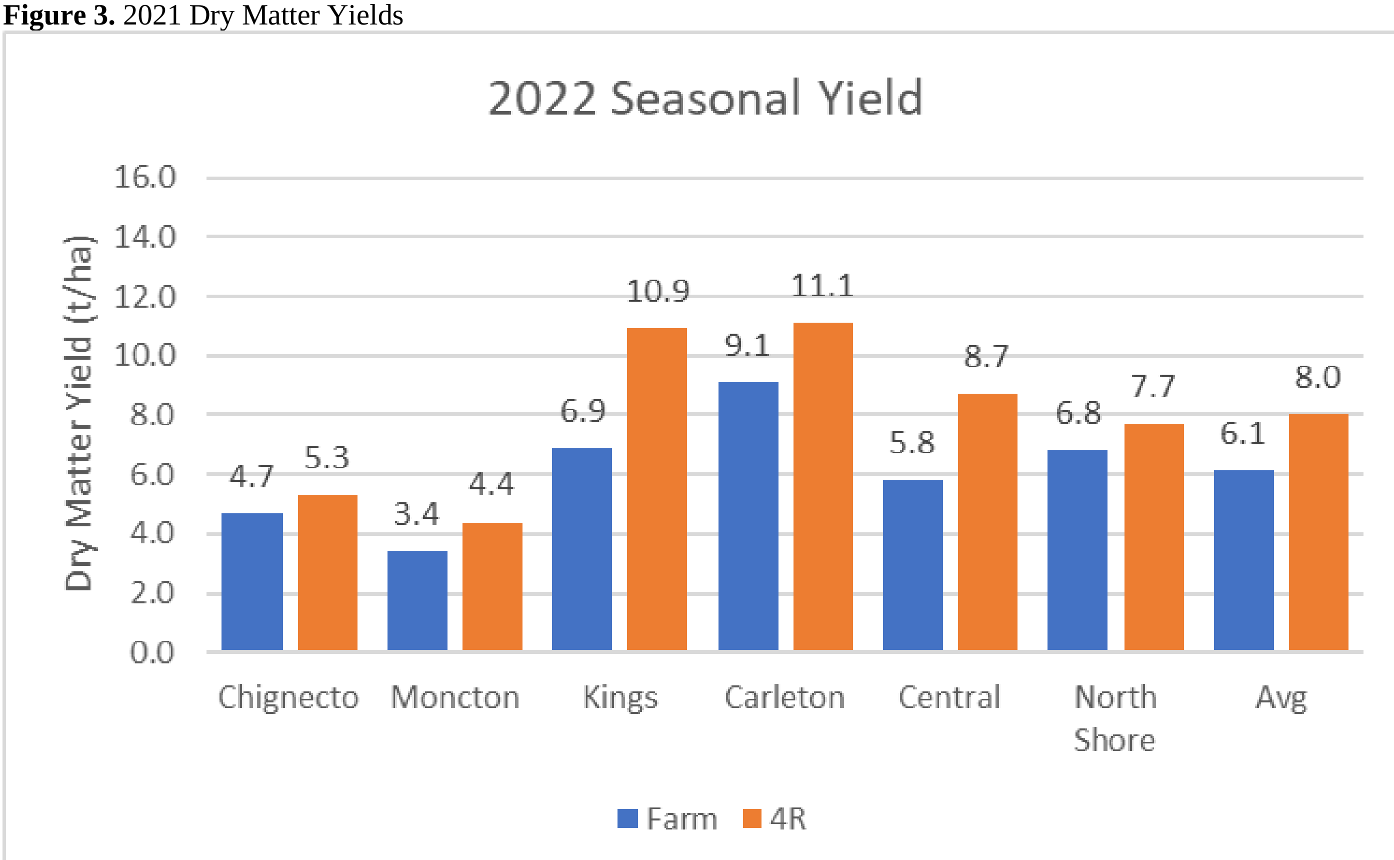


Figure 4. 2022 Dry Matter Yields

Yield variation between sites is thought to be related to stand age, species present and background soil chemical makeup (Appendix B). It is important to keep in mind that more than soil chemical makeup should be looked at when examining the productivity of a site. Biological and physical properties should also be taken into consideration. If this project was to be done again, the project team would consider conducting soil heath assessments at each site. The Kings site showed the highest potassium levels of all sites, and it is felt that this contributed to the high yields at this site. Soil pH, another important soil parameter, approached 6.0 for most sites except Chignecto. Chignecto's average soil pH was 7.5 and had an extreme imbalance of calcium and magnesium. It is possible that this created soil nutrient interactions that resulted in yield limiting nutrients to not be obtained by the crop. Further evaluation outside the scope of this project would need to be done to confirm the findings at this site.

When averaged across sites, there was 1.8 t/ha of dry matter advantage with the 4R program in 2021 and a 1.9 t/ha advantage in 2022. Even though the 4R treatment resulted in higher yields in both years and at all sites, it was not significantly different at a p-value of 0.05 (stats not shown). It is important to keep in mind that a good 4R program not only optimizes agronomic crop yield, but also quality, economics of production, environmental sustainability and social good on a site-specific basis.

From the standpoint of environment sustainability, although not a specific deliverable, the project team looked at nutrient uptake and removal of Phosphorus (P) and potassium (K) under the two programs. The data for P is not shown as application rates under the 4R program matched closely with what the crop removed. The data for K is shown in Figure 5. Neither the 4R treatment nor the farm treatment supplied enough K over the 2-yrs of the trial to replace all the K that was removed in the crop. Only once, at the Chignecto site, did the 4R treatment supply more K than the crop used and was due to a manure application that had occurred outside of the original fertilizer prescription. As a rule, for every 14.8 kg K/ha removed beyond what was supplied, soil test could drop by 1ppm. Regardless of what program a farm continues to follow, this drawn down of K would need to be addressed so as not to mine the soil of K.

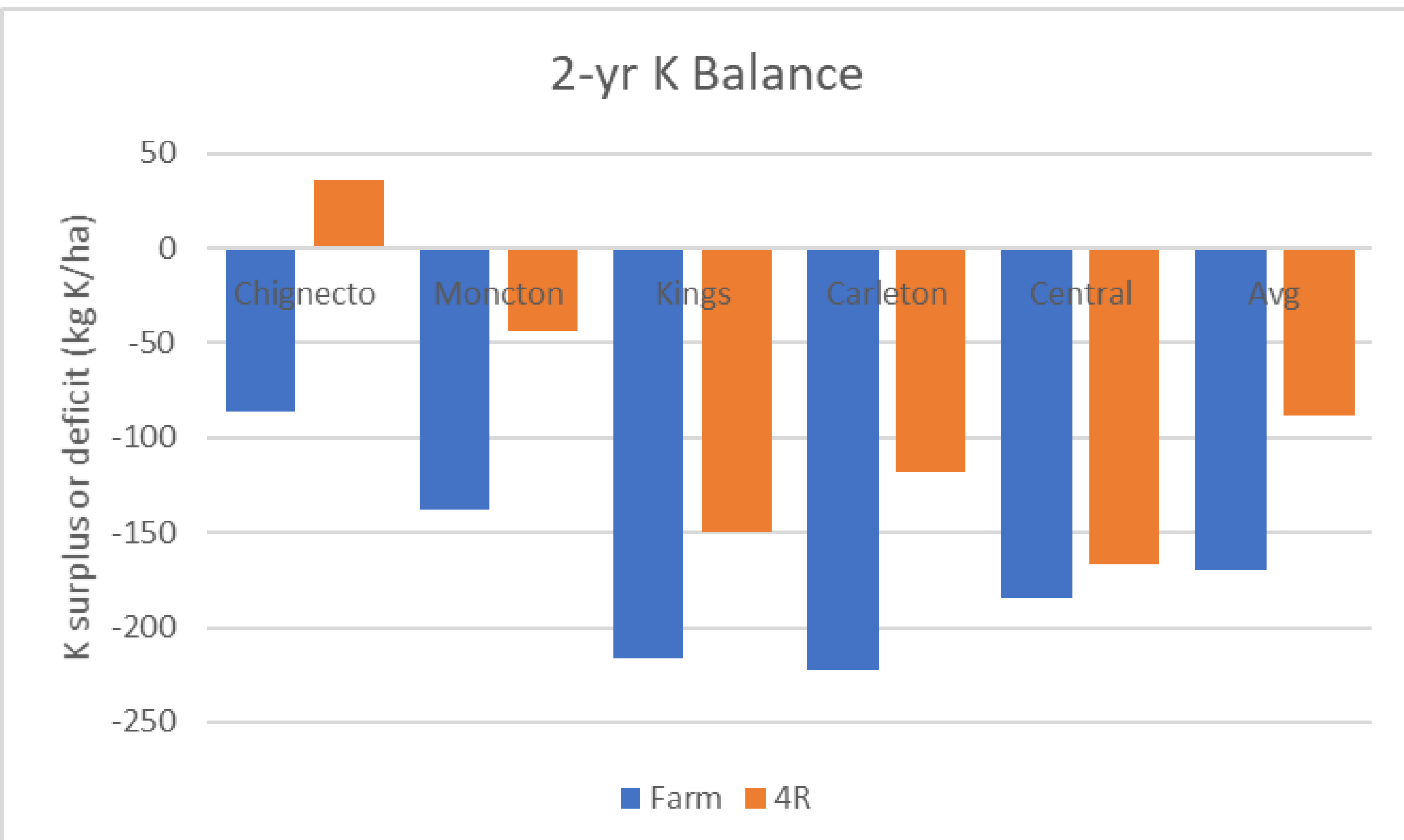


Figure 5. 2-yr K Balance

Forage quality analysis for 2021 and 2022 is reported in Table 1 and Table 2 respectively. Only once was a statistically significant difference in forage quality observed at p-value of 0.05. The Crude Protein in 2nd cut of 2021 was significantly higher in the 4R treatment. Generally, the farm treatment did not include a fertilizer application after 1st cut. With more available nitrogen present, the crop under the 4R treatment was able to achieve higher protein levels. The quality information in Tables 1 and 2 would indicate that harvests occurred past peak quality growth stage. This late harvest may have negated differences that would have been seen if harvest had occurred earlier. Different definitions of quality exist depending on the livestock being fed, so it can't be concluded if one program is better than the other.

With virtually no difference being observed between the farm treatment and the 4R treatment, the project team believes it should have sent more samples away for quality analysis. The team could have easily sent all 8 samples that had been collect for yield determination for quality analysis instead of doing just one composite sample from the 8. In future projects the team will consider situations like this and budget appropriately.

Table 1. 2021 Forage Quality Parameters on a Dry Matter Basis

Site-Treatment	Crude Protein (%)	ADF (%)	NDF (%)	TDN (%)	RFQ	Milk Yield (kg/t)
Cut 1 - 2021						
Chignecto-FARM	14.84	40.69	60.87	57.20	115	1444
Chignecto-4R	14.26	40.52	59.61	57.33	118	1463
Moncton-FARM	15.65	39.48	61.26	58.15	121	1462
Moncton-4R	17.02	38.11	58.01	59.21	131	1526
Kings-FARM	13.74	39.05	61.38	58.48	116	1445
Kings-4R	10.73	42.37	66.51	55.89	105	1376
Carleton-FARM	19.34	32.99	51.65	63.20	150	1615
Carleton-4R	17.63	38.46	59.89	58.94	129	1512
Central-FARM	14.69	42.39	62.06	55.88	119	1477
Central-4R	18.01	39.31	62.53	58.28	121	1472
Average Farm	15.65	38.92	59.44	58.58	124	1489
Average 4R	15.53	39.75	61.31	57.93	121	1470
p-value	**0.919**	**0.622**	**0.427**	**0.621**	**0.574**	**0.566**
Cut 2 - 2021						
Chignecto-FARM	16.36	42.48	58.79	55.81	110	1429
Chignecto-4R	18.02	37.31	56.09	59.84	123	1490
Moncton-FARM	18.07	38.38	56.15	59.00	129	1517
Moncton-4R	18.22	38.78	57.03	58.69	129	1541
Kings-FARM	14.51	36.95	56.35	60.12	138	1574
Kings-4R	17.28	38.00	51.78	59.30	128	1508
Carleton-FARM	13.23	38.66	50.37	58.78	154	1707
Carleton-4R	16.68	40.66	43.81	57.23	151	1696
Central-FARM	18.51	31.94	42.62	64.02	184	1794
Central-4R	21.27	31.12	42.93	64.66	202	1866
Average Farm	16.14	37.68	52.86	59.55	143	1604
Average 4R	18.29	37.17	50.33	59.94	147	1620
p-value	**0.020**	**0.706**	**0.149**	**0.704**	**0.526**	**0.560**

Table 2. 2022 Forage Quality Parameters on a Dry Matte Basis

Site-Treatment	Crude Protein (%)	ADF (%)	NDF (%)	TDN (%)	RFQ	Milk Yield (kg/t)
Cut 1 - 2022						
North Shore-FARM	21.44	27.46	44.48	67.51	209	1873
North Shore-4R	14.30	38.18	57.59	59.16	144	1600
Chignecto-FARM	14.57	31.15	47.76	64.63	187	1812
Chignecto-4R	15.32	31.64	47.83	64.25	181	1783
Moncton-FARM	14.61	31.74	48.77	64.17	180	1794
Moncton-4R	16.85	34.39	43.91	62.11	174	1747
Kings-FARM	10.94	34.36	54.47	62.13	158	1706
Kings-4R	10.84	38.25	54.61	59.10	150	1668
Carleton-FARM	11.23	38.50	50.05	58.91	160	1689
Carleton-4R	16.17	36.98	56.64	60.09	157	1684
Central-FARM	12.99	35.12	51.43	61.54	165	1724
Central-4R	9.50	43.24	53.27	55.22	143	1583
Average Farm	14.30	33.06	49.49	63.15	177	1766
Average 4R	13.83	37.11	52.31	59.99	158	1678
p-value	**0.800**	**0.084**	**0.320**	**0.084**	**0.118**	**0.085**
Cut 2 - 2022						
North Shore-FARM	15.61	34.90	45.21	61.71	176	1760
North Shore-4R	11.37	40.00	56.79	57.74	140	1593
Chignecto-FARM	15.56	35.92	47.93	60.92	164	1702
Chignecto-4R	16.66	36.86	53.26	60.19	148	1627
Moncton-FARM	16.98	34.28	44.53	62.20	172	1752
Moncton-4R	19.39	28.65	42.36	66.58	212	1894
Kings-FARM	*	*	*	*	*	*
Kings-4R	*	*	*	*	*	*
Carleton-FARM	14.82	36.76	48.87	60.26	160	1709
Carleton-4R	16.45	35.79	52.82	61.02	169	1733
Central-FARM	17.50	36.20	47.18	60.70	171	1759
Central-4R	16.53	38.47	54.53	58.93	158	1696
Average Farm	16.09	35.61	46.74	61.16	169	1736
Average 4R	16.08	35.95	51.95	60.89	165	1709
p-value	**0.991**	**0.858**	**0.082**	**0.858**	**0.817**	**0.622**

A simple cost comparison between the 4R program and the farms standard practice is shown in Figure 6. A modest value for the forage was assumed (10 cents per dry matter pound, the value used for the 2021 Hay West program). When averaged across sites and both years were combined, there was a slight advantage with the 4R program. It is important to note that the project team took every attempt to adjust for any deviations that had occurred to the prescriptions that had been supplied (ex. additional manure application, missed fertilizer application, etc.). If any amendments were applied beyond the prescriptions provided, they were assigned a dollar value and included in the ROI calculation. It is also important to note that equipment costs were not considered in the ROI as it was assumed to be equal for applying the 4R treatment and the farm treatment.

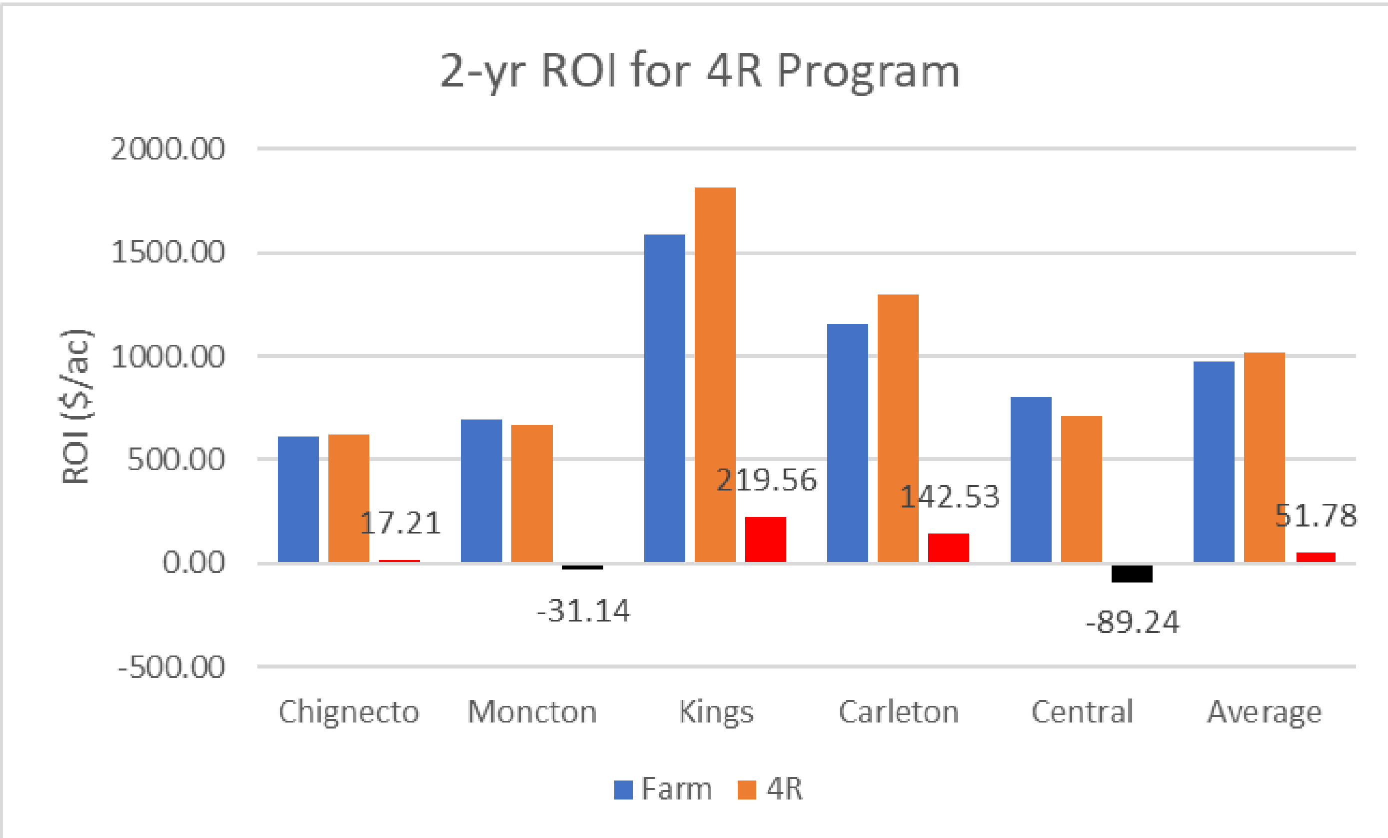


Figure 6. 2-yr Return on Investment of 4R Program vs. Farm Standard Practice

Determining the average cost to produce a tonne of high-quality forage is challenging and may not be a usefully number to ascertain. Producers need to know the cost for their own operation and this is highly dependent on the land they have, the equipment they have, access to various alternative soil amendments that would reduce production costs, etc. The term high-quality forage needs also be defined on an individual farm and will be determined by the specific type of livestock being raised. Since the time of this project's application, the project team has found cost of production information from OMAFRA that can be used by individual farms to calculate their specific cost of production. That information can be found in OMAFRA's Publication 60, Field Crop Budgets (https://files.ontario.ca/omafra-field-crop-budgets-pub-60-en-2023-01-18.pdf).

Conclusions:

New Brunswick Alfalfa Tissue Study

The data collected in the NB alfalfa tissue study indicates that sufficient sulfur is available to NB alfalfa crops. A history of livestock manure on most fields sampled is believed to supply enough S to the crop. If producers start to push their alfalfa crops for increased yields, they should continually monitor that S does not become limiting.

Producers need to monitor Potassium, Boron and Magnesium as they were frequently low to deficient in the samples collected and correct deficiencies with a good fertilizer program.

New Brunswick Forage 4R Nutrient Stewardship

A 4R forage fertility program can increase forage yield, but it is not statistically better than the practices being used on the 6 cooperating farms.

A 4R forage fertility program did not improve on the forage quality that the 6 cooperating farms were able to obtain with their standard practices.

A 4R forage fertility program did show a slight ROI compared to a farms standard practice.

A 4R program should be constantly evaluated an adjusted to ensure soil mining of nutrients doesn't occur and that it is meeting the goals of individual farm operations.

Cost of production information should be figured for individual farms and not simply provide an average value that would not be useful in farm financial planning and budgeting. Templates already exist to help producers determine their COP (OMAFRA Publication 60).

Required Next Steps:

This project was completed as written and nothing further is required for these deliverables.

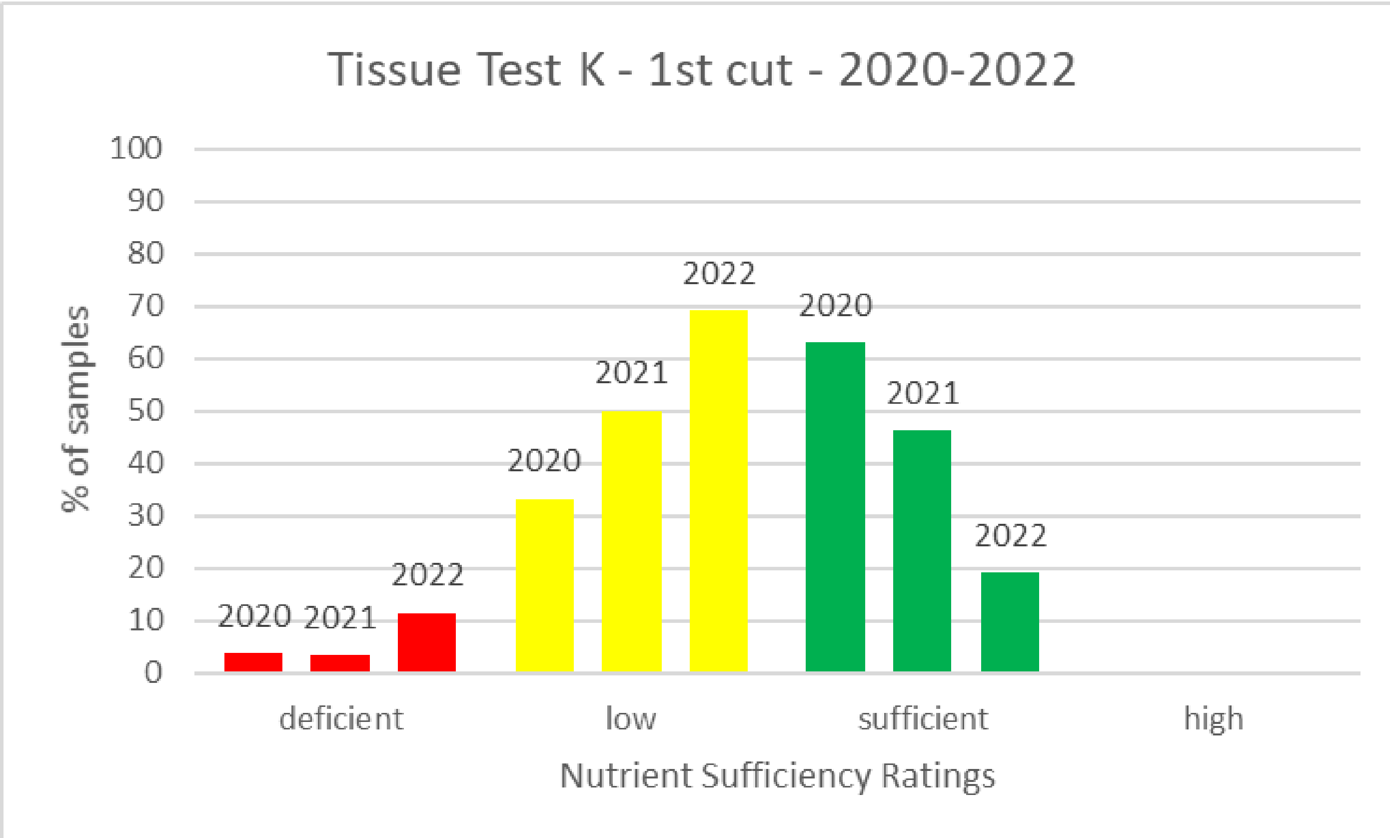
Future projects related to alfalfa fertility management should be considered.

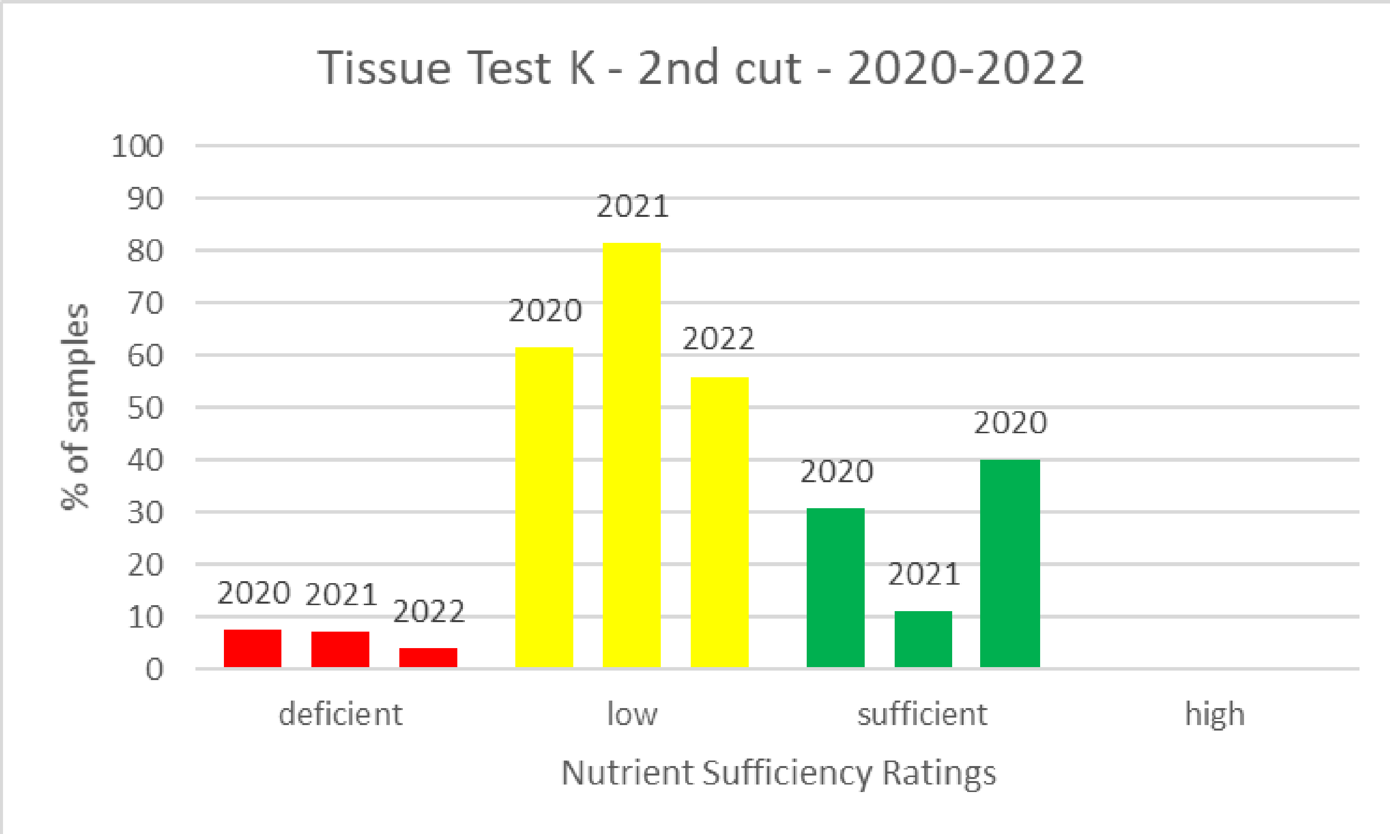
Forage 4R work is to be included in the AAFC living labs initiative and will hopefully do a more detailed investigation into cost of production.

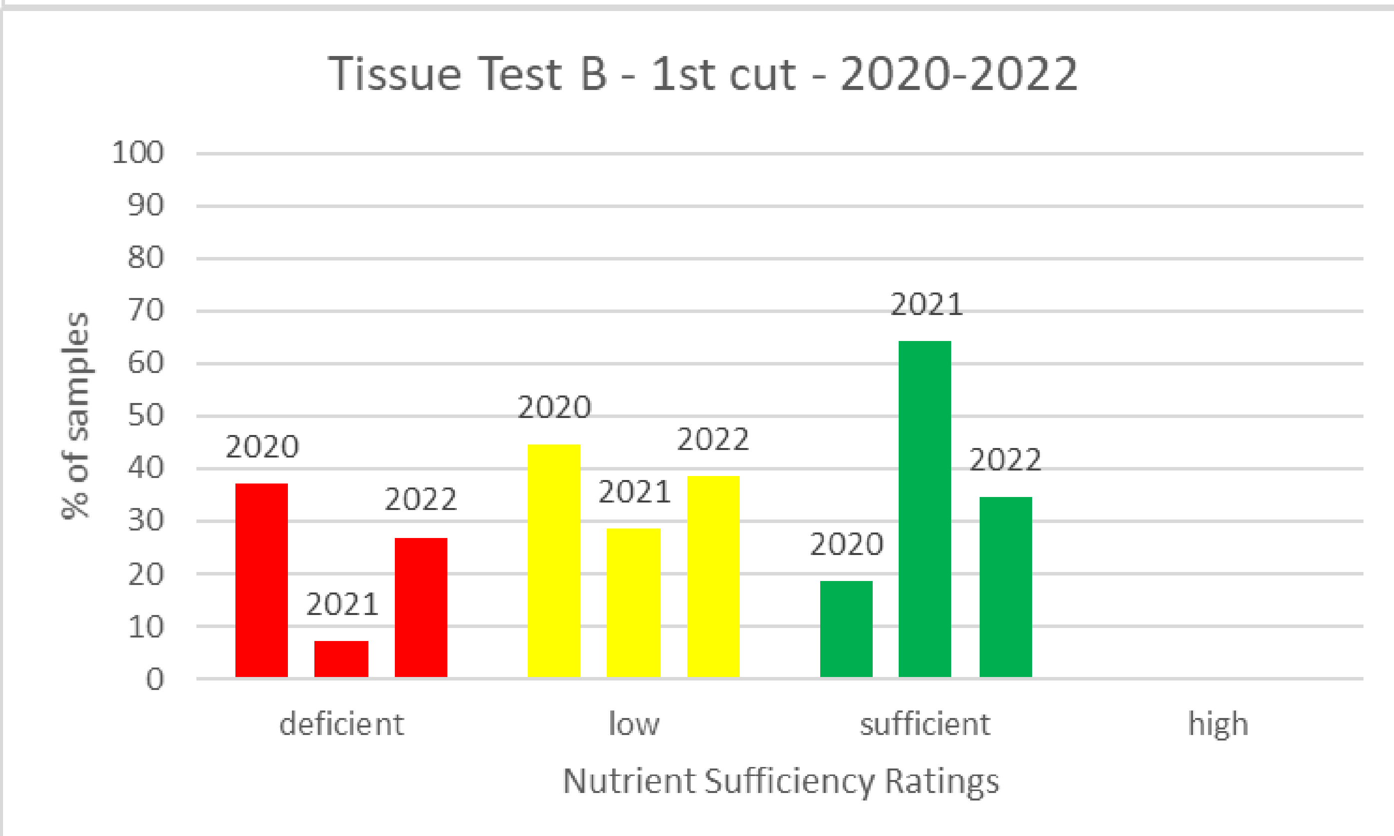
Communication:

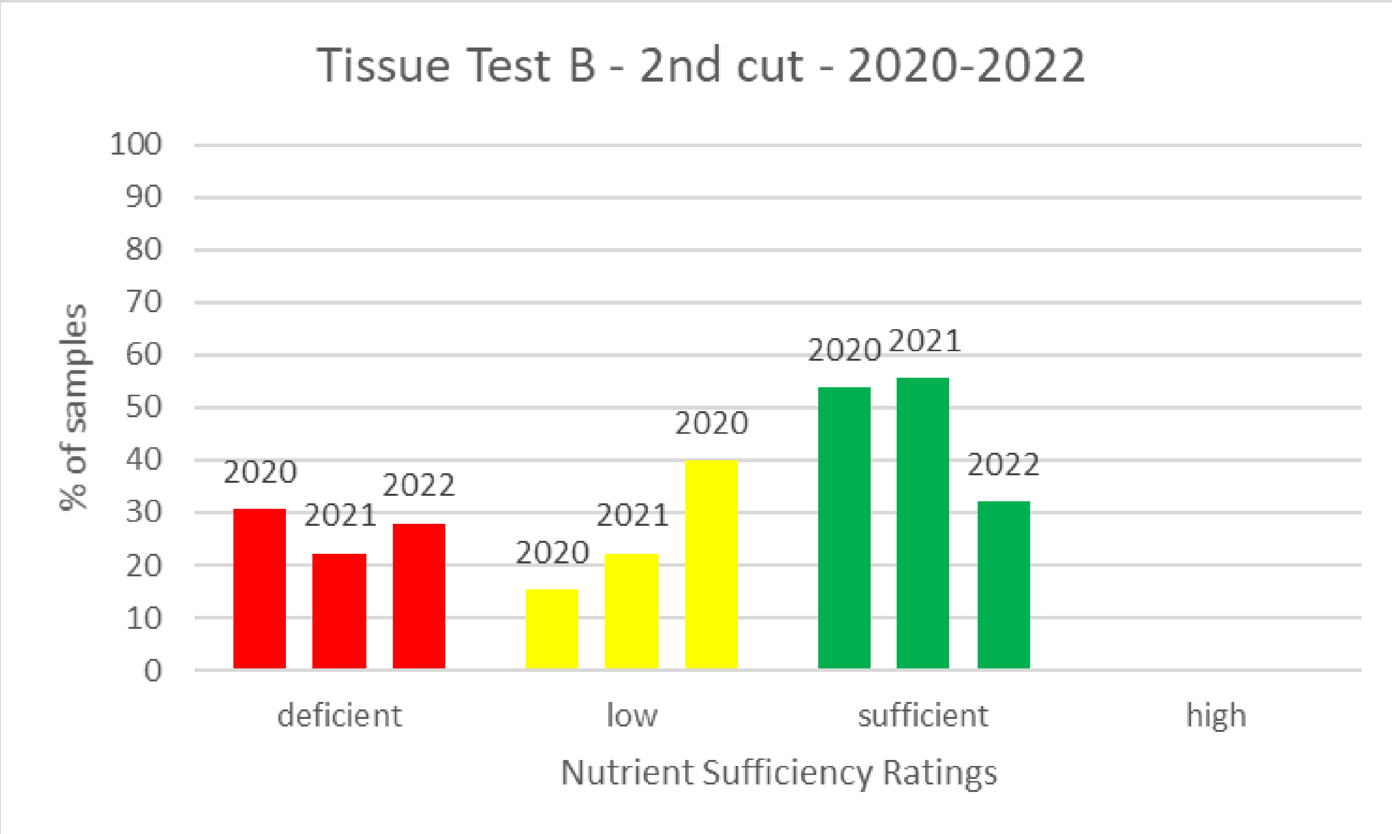
Multiple interim reports have been submitted. Results have been presented in various NBSCIA newsletters and annual reports. Results have been presented virtually and in-person at various NBSCIA meetings. Results and work are discussed during farm visits.

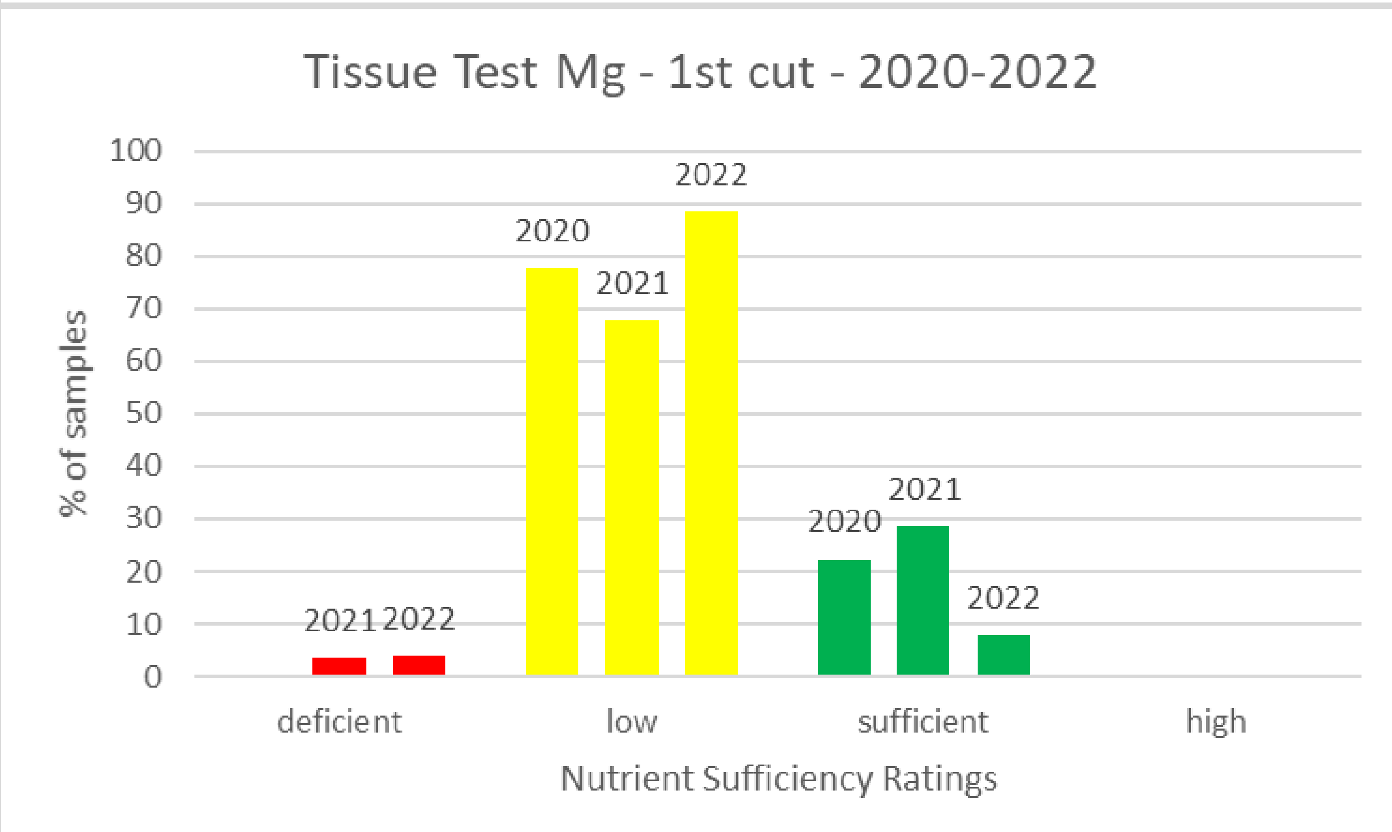
Appendix A. Tissue Test K, B and Mg

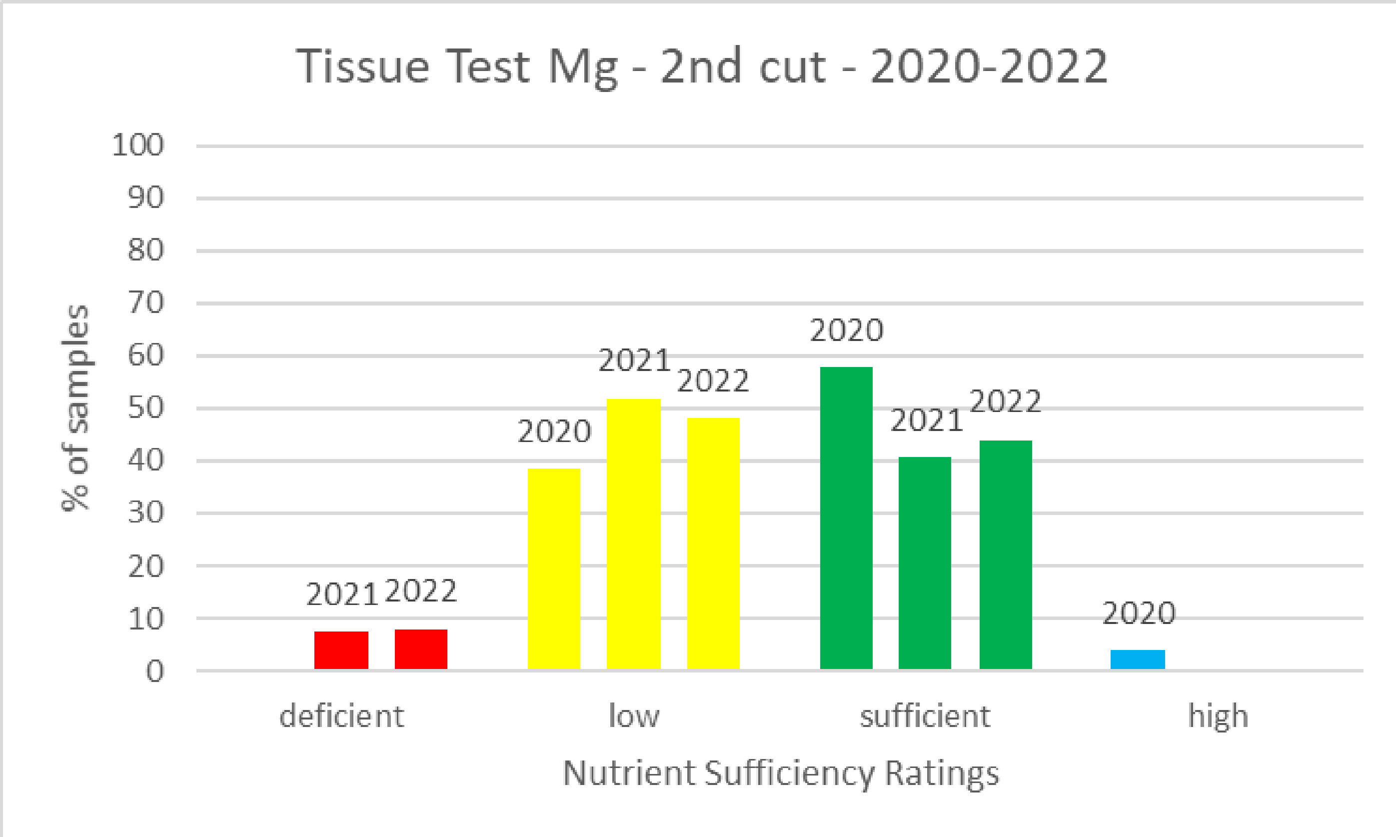



Tissue Test K - 2nd cut - 2020-2022
100
90
80
70
60
50
40
30
20
10
0
% of samples
2020
2021
2022
2020
2021
2022
2020
2021
2020
deficient
low
sufficient
high
Nutrient Sufficiency Ratings


Tissue Test B - 1st cut - 2020-2022
100
90
80
70
60
50
40
30
20
10
0
% of samples
2020
2021
2022
2020
2021
2022
2020
2021
2022
deficient
low
sufficient
high
Nutrient Sufficiency Ratings

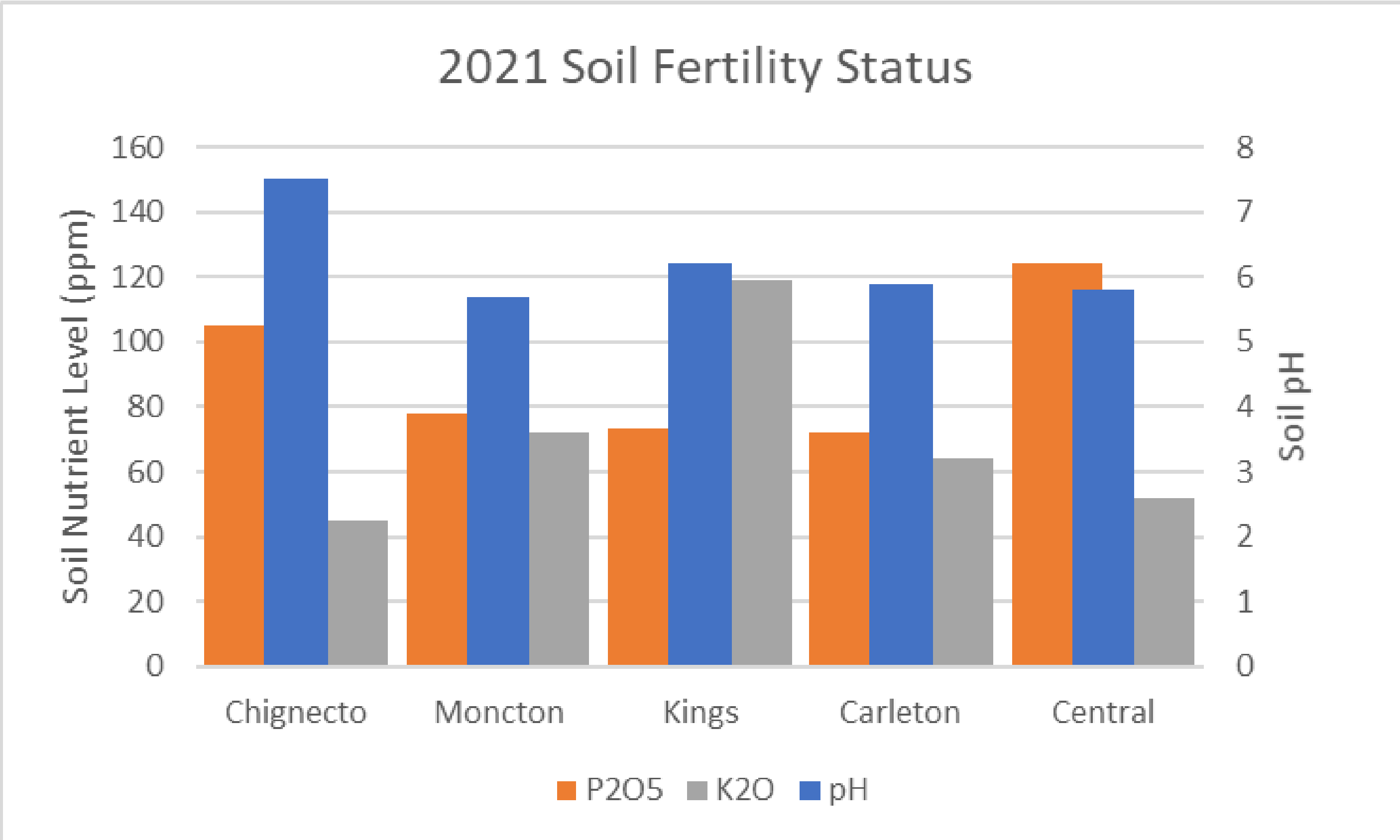

Tissue Test B - 2nd cut - 2020-2022
% of samples
100
90
80
70
60
50
40
30
20
10
0
2020
2021
2022
2020
2021
2020
2020
2021
2022
deficient
low
sufficient
high
Nutrient Sufficiency Ratings

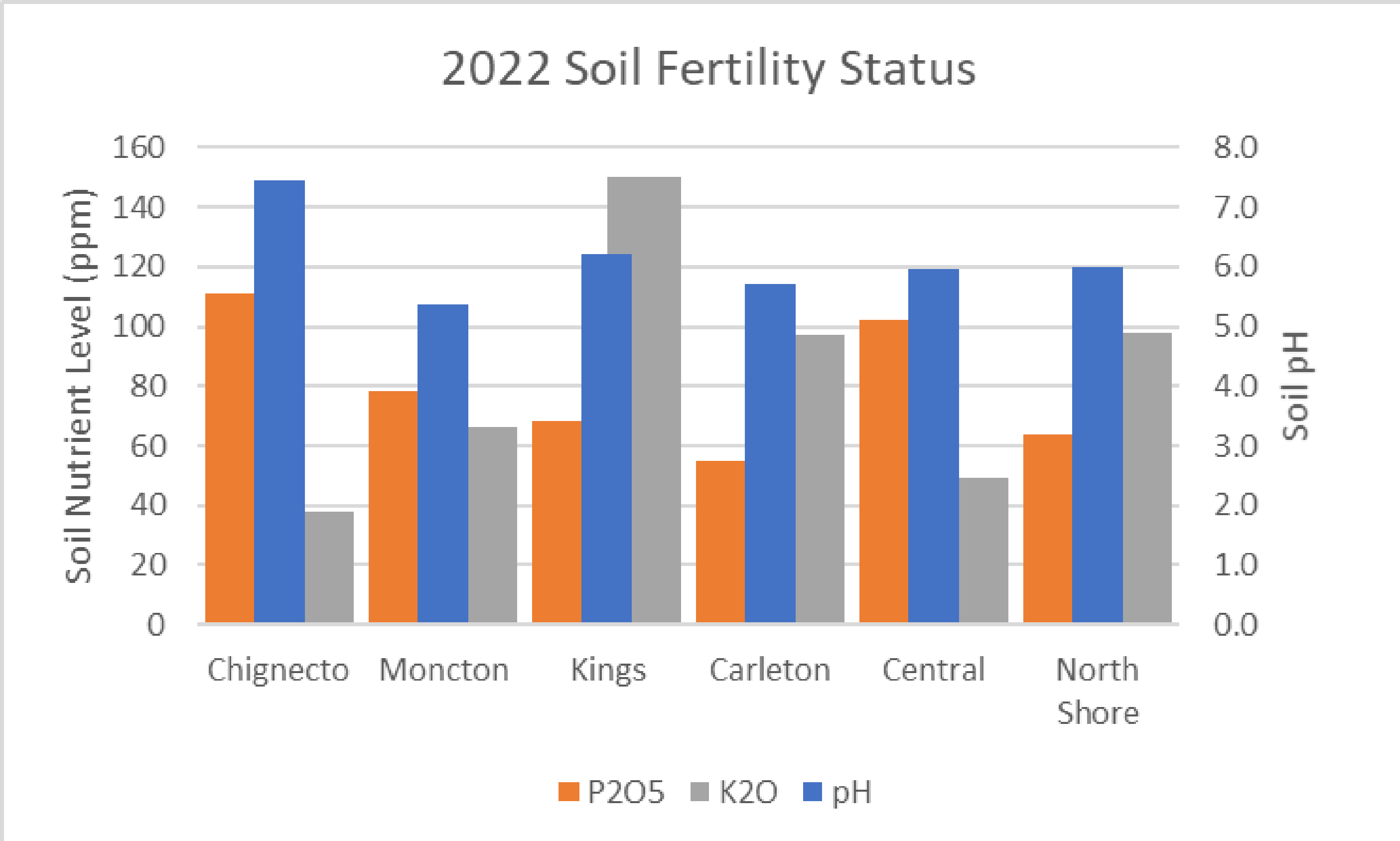

Tissue Test Mg - 1st cut - 2020-2022
% of samples
100
90
80
70
60
50
40
30
20
10
0
2021
2022
2020
2021
2022
2020
2021
2022
deficient
low
sufficient
high
Nutrient Sufficiency Ratings

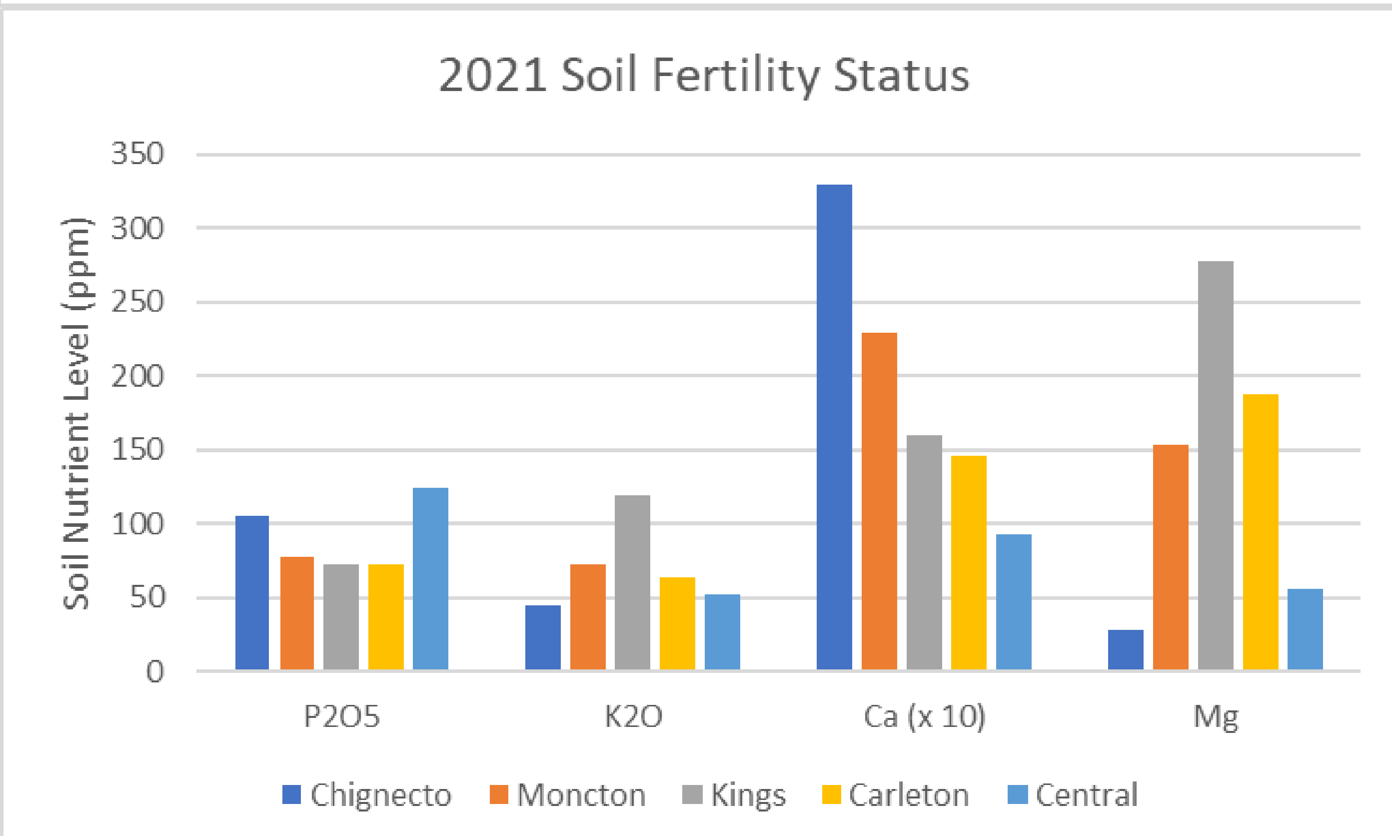


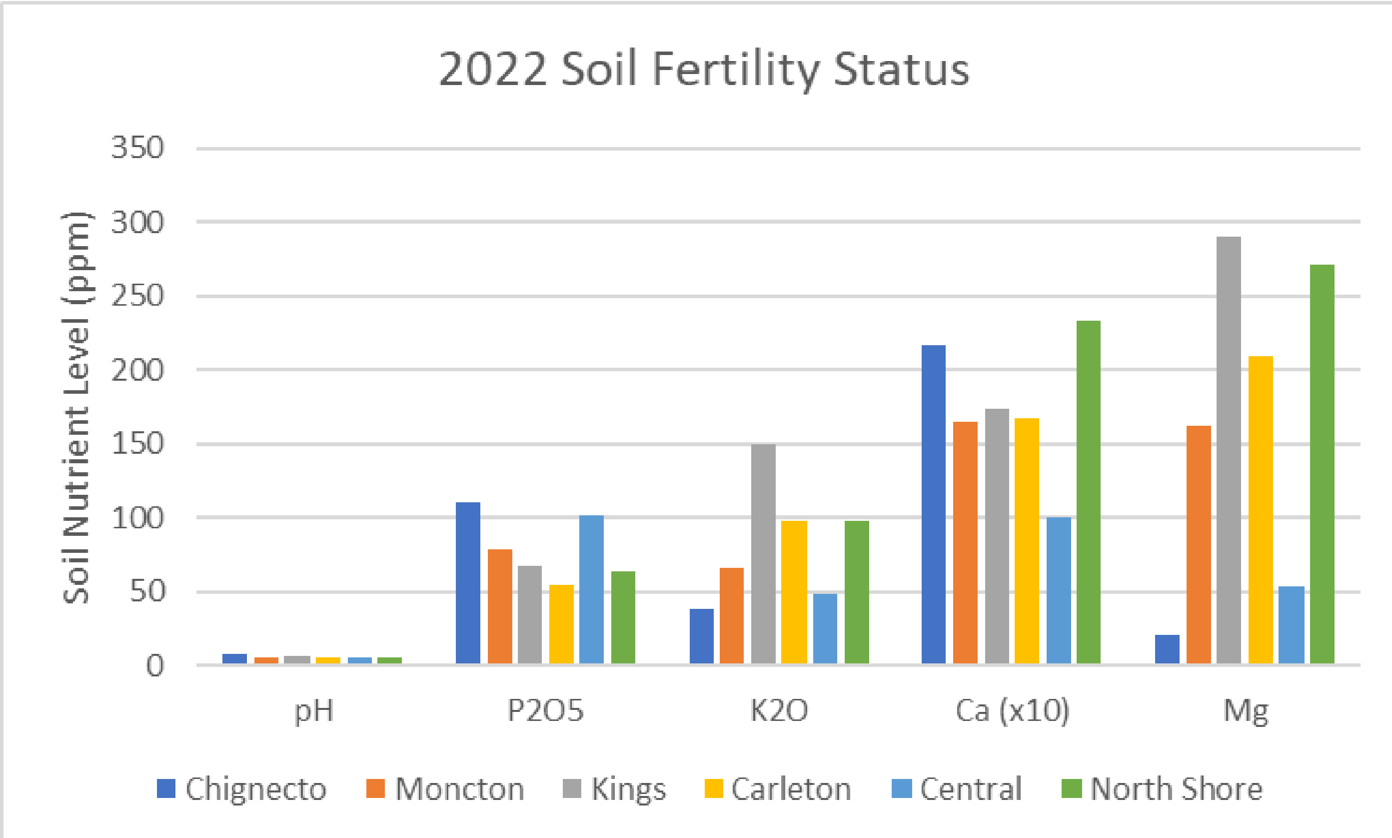
Tissue Test Mg - 2nd cut - 2020-2022
% of samples
100
90
80
70
60
50
40
30
20
10
0
2021
2022
2020
2021
2022
2020
2021
2022
2020
deficient
low
sufficient
high
Nutrient Sufficiency Ratings

Appendix B. Site Soil Fertility Status




2022 Soil Fertility Status
Soil Nutrient Level (ppm)
160
140
120
100
80
60
40
20
0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Soil pH
Chignecto
Moncton
Kings
Carleton
Central
North Shore
P2O5
K2O
pH


2021 Soil Fertility Status
Soil Nutrient Level (ppm)
350
300
250
200
150
100
50
0
P2O5
K2O
Ca (x 10)
Mg
Chignecto
Moncton
Kings
Carleton
Central


2022 Soil Fertility Status
Soil Nutrient Level (ppm)
350
300
250
200
150
100
50
0
pH
P2O5
K2O
Ca (x10)
Mg
Chignecto
Moncton
Kings
Carleton
Central
North Shore