Knowledge grows

2023 Season Recap

Yara Potato Incubator Farm, Columbia Basin, WA

toppotato™ by Yara

Knowledge grows

Incubator Farm in the Columbia Basin, Washington

Yara's commitment to professional research of practical solutions to apply to agriculture starts with discovery through our Incubator Farm Network. The Yara North America Incubator Farm in the Columbia Basin of Washington is located on a commercial potato farm in one of the highest yielding potato growing regions in the world. It was established in 2022 as a center for research, trials, and knowledge sharing with the goal of exploring solutions to support the decarbonization of the potato food value chain and grower prosperity through profitability, yield, and quality.

Utilizing 130 acre irrigated pivots, Yara and its partners can gather several layers of data and acquire knowledge of many aspects of the cropping system. The field scale research at the farm provides valuable insight into the conditions and challenges that growers and the potato industry face across the value chain.

In addition to research, the Incubator Farm is also as a place for partnerships with industry organizations to develop long-term relevant solutions for growers through collaboration and provides the opportunity to see first-hand the benefits of a complete crop nutrition solution.

2023 Season in Review

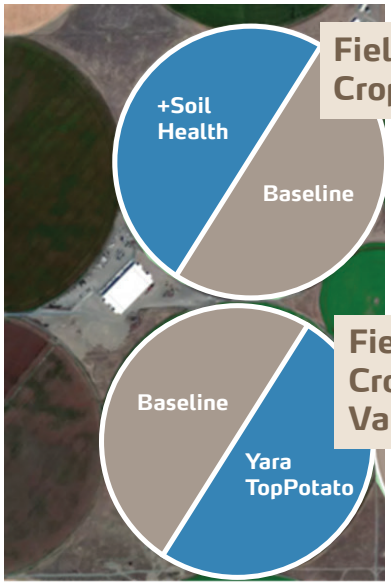
In 2023, the Incubator Farm was planted in cooler than average spring conditions which lasted throughout the month of April. Despite cool spring temperatures, the field showed good germination by early May. May through July had warmer than average high and low temperatures. However, the heat experienced in the summer of 2023 was less extreme and less prolonged than that of 2022. There was also a lack of significant wildfire smoke in the 2023 growing season, a stressor that is becoming more common in the region. August brought high temperatures, but they were within normal temperatures for the region. September and October brought cooler than average temperatures in time for harvest season. Precipitation was low across the growing season with some late season rain events impacting harvest. The Incubator Farm was harvested in early October. Across the region, some early maturing varieties experienced lower than expected yields due to delayed planting with cool, wet spring conditions. Yield for later maturing varieties across the region was excellent due to good growing conditions for most of the growing season. Yield and quality of the potatoes harvested at the Incubator Farm reflected this.

2023 Trial Goals and Design

The objective of the Incubator Farm research conducted in 2023 was to build and expand on our 2022 Incubator Farm learnings. In 2023, we continued our efforts to explore solutions to support the decarbonization of the potato value chain and grower prosperity through profitability, yield and quality. We also worked to understand the role of crop nutrition in building soil health across the potato rotation and began to investigate a soil health baseline for the fields of study.

In 2023, we carried out research on two fields that were 130 acres each. One field was planted to Clearwater potatoes with a half pivot of Yara TopPotato program compared to a half pivot of a Baseline nutrient management program. In addition to studying the impact of Yara's TopPotato program on crop performance, yield and quality, we also took soil samples to begin to understand the impact of Yara's TopPotato program on soil health compared to the Baseline program in the years that potatoes are grown.

The second field was in potatoes in 2022 and was planted to sweet corn in 2023. In this field, our goal was to establish a soil health baseline for the season following potatoes and begin to understand how specific practice changes impact soil health across a potato rotation. The specific practice change that we implemented in the sweet corn field in 2023 was the application of a microalgae product through the pivot at around the V4 stage. The goal of using this product was to promote soil microbial activity and improve soil structure, aggregate stability, and water holding capacity.



Field: WF7
Crop: Sweet Corn

Field: WF3
Crop: Potato
Variety: Clearwater

Potato Field WF3 Crop Details	
Planting date	3/27/2023
Seeding rate	2,100 lb/ac
Variety	Clearwater
Harvest date	10/2/2023

Potato Treatment Description (Field WF3)

The TopPotato program included a dynamic crop nutrition program that was optimized for high potato yield and quality:

- YaraVita® PENTAFLO™ applied in-furrow to promote early and rapid shoot and root growth, allowing the crop to take up water and nutrients earlier in the season and allow for earlier row closure.
- A portion of in-season nitrogen (N) needs replaced by YaraLiva® CN-9® at tuber initiation and then spoon-fed as UCAN17 through to bulking. Calcium is provided in an available form at tuber initiation and through to bulking, helping to build cell wall strength, improve tuber quality, and mitigate heat stress. Nitrate-nitrogen is available to the crop for quick and predictable uptake.
- Dynamic and proactive application of YaraVita® foliar crop nutrition based crop demand at different growth stages and needs detected through petiole and soil samples taken throughout the season.

Baseline			
Product	**Analysis**	**Timing**	**Total Volume Applied**
UAN32*	32-0-0	Spoon-fed through the pivot every 7-10 days with ATS to meet crop N needs.	82 gal/ac
Ammonium Thiosulfate (ATS)*	12-0-0-26S	Spoon-fed through the pivot every 7-10 days with UAN to meet crop N needs.	10 gal/ac
YaraLiva CN-9	9-0-0-11Ca	5/24/2023 6/3/2023 6/9/2023	18 gal/ac
Total lb N/ac applied: 362 lb N/ac			

***applied in 8:1 ratio of UAN:ATS through pivot**

All other inputs (fertilizers, pesticides, herbicides, etc.) held constant across entire pivot.

toppotato by Yara

Product	**Analysis**	**Timing**	**Total Volume Applied**
YaraVita Pentaflo	4-15-0-12.5Ca-3.7Mg-1.2B-2.5Zn	At planting in-furrow	3 pints/ac
YaraLiva CN-9	9-0-0-11Ca	5/24/2023 6/3/2023 6/9/2023	43 gal/ac
UCAN17 (65% YaraLiva CN-9 and 35% UAN32)	17-0-0-7.2Ca	6/15/2023 6/22/2023 6/28/2023 7/6/2023	40 gal/ac
YaraVita Solatrel	0-29-5-1Ca-2Mg-0.7Mn-0.3Zn	6/1/2023 and 6/20/2023	4 qt/ac total
YaraVita Mancozin	3-0-0-6.3Cu-18.8Mn-4.8Zn	7/3/2023	1 qt/ac
YaraVita Safe K	3-0-34	7/3/2023	2 qt/ac
UAN32	32-0-0	Spoon-fed through the pivot every 7-10 days to meet crop N needs after UCAN17 application complete.	15 gal/ac
YaraVita Magtrac	4-0-0-20Mg	7/24/2023	1 qt/ac
Total lb N applied: 338 lb N/ac			

Sweet Corn Treatment Description (Field WF7)

Baseline	Sweet Corn			
Soil Health Application	**Soil Health Application**	**Ingredients**	**Application Rate**	**Application Timing**
No algae-based soil microbe food applied	Algae-based soil microbe food	9% organic matter derived from algae	4 qt/ac	V4

Soil Mapping

In order to understand and best minimize the impact of in-field variability across our field, we collaborated with Deveron to map the soil in Field WF3 prior to the 2023 growing season. A SoilOptix® sesor was used to map the field and physical soil samples were taken for calibration purposes. Physical soil samples were taken in 8 acre blocks which were then sent to a soil testing lab for analysis. The SoilOptix® sensor uses a non-contact, pre-calibrated sensor that measures natural geological properties. A map of the field was then created using data from physical soil samples and SoilOptix® sensor.

Field WF3 had elevation change, variable organic matter, pockets of low and high levels of nutrients, high levels of magnesium and potassium and moderate to very high K:Mg ratios. The elevation change in the field likely led to some pockets of higher and lower concentration of nutrients – particularly those that are mobile in the soil. The high levels of magnesium in the soil is likely related to the soil's parent material (Columbia River Basalt Group lava flows). A high K:Mg ratio may have impacted the availability of magnesium during the growing season. To alleviate these potential issues, a proactive application of YaraVita Magtrac was applied during tuber bulking when carbohydrate movement is at its peak. Additionally, applications of soluble calcium as YaraLiva CN-9 may help to increase the availability of magnesium in the soil solution. Due to the CEC of the soil, calcium binds more tightly to soil particles than magnesium and can displace magnesium into the soil solution. Nitrate nitrogen uptake also increases magnesium in the soil solution by increasing the pH of the rhizosphere.

To account for in-field soil variability across WF3, "zones of likeness" were identified on both halves of the field based on soil test values linked to potato productivity. In-season measurements and yield samples were equally represented within these zones of likeness on both field halves to mitigate the potential for variability-biased results for either treatment.

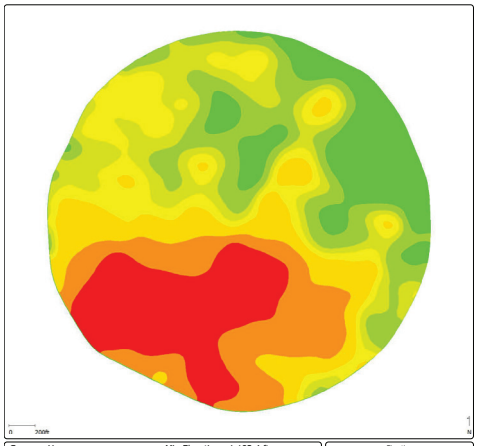
Field WF3 Soil Characteristics and Mapping Results

Soil characteristics: Quincy fine sand

Very deep excessively drained soils formed in sands on dunes and terraces.

These soils formed in sands from mixed sources, but contain significant amounts of dark colored basaltic sand.

Elevation



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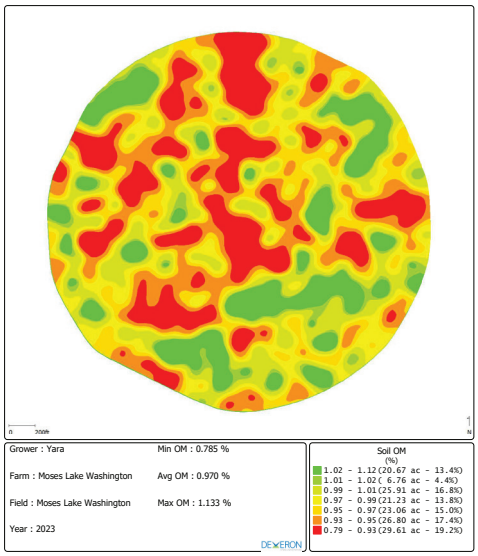
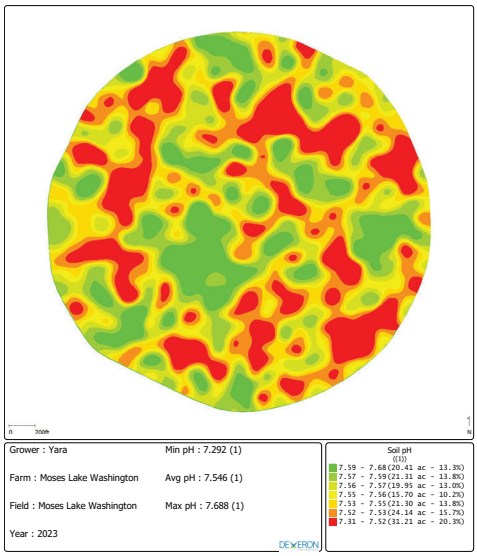
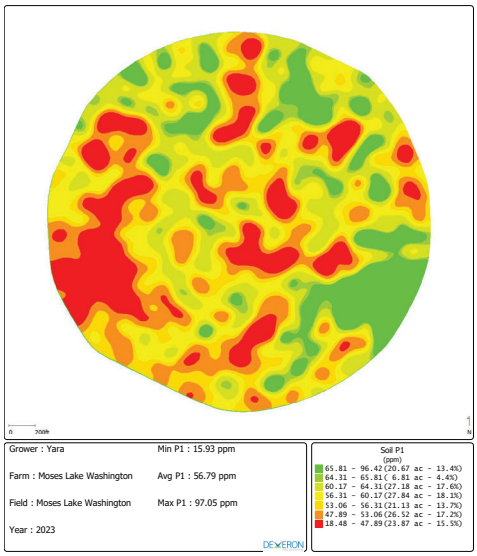


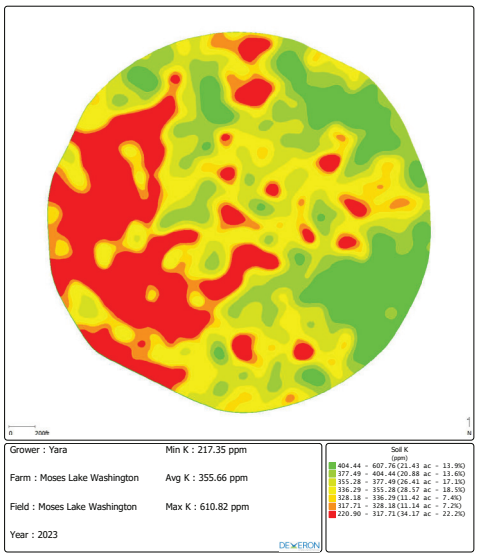
pH



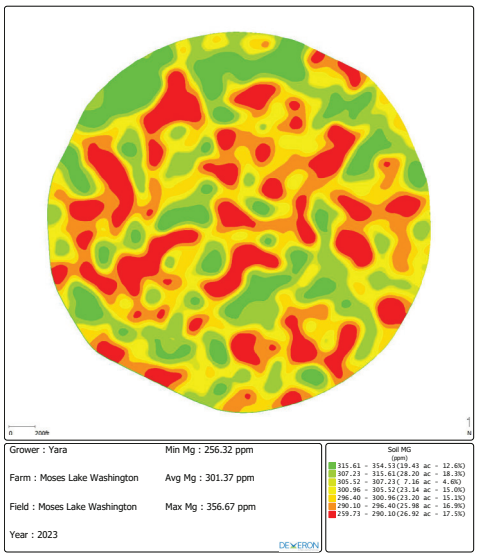
Phosphorus (P)



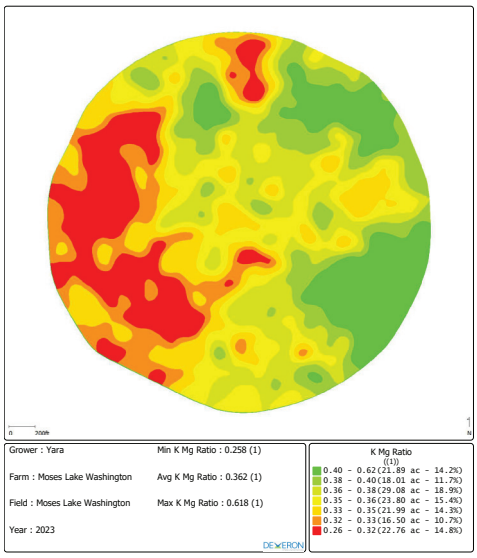
Potassium (K)



Magnesium (Mg)



K Mg Ratio



Data Gathered

During the season, the crop was monitored for agronomic performance including emergence, vigor, tuber set, size and consistency, stem count, canopy health, and onset of senescence.

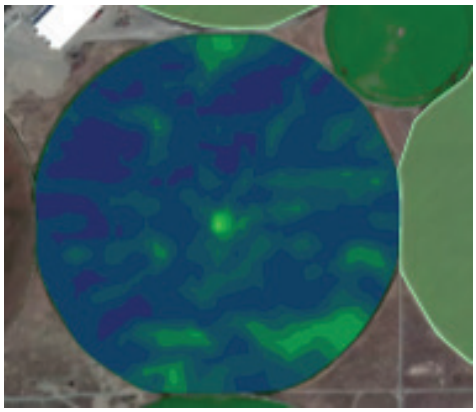
In addition, soil samples were taken before and after in-season nitrogen application in the potato field to be analyzed for parameters related to soil health. In the sweet corn field, soil samples were taken before and after algae-based microbe food application to be analyzed for parameters related to soil health.

In order to assess the impact of Yara's TopPotato program on yield, on the same day the fields were harvested, six replicates of 50-foot strips were dug on each half pivot by a two-row research potato digger. Dig sites were identified using soil characteristics mapped prior to planting and historical NDVI data from the last time the field was in potato in order to minimize the impact of in-field variability on yield and quality data. Yield, size profile, and marketable yield were calculated from these 50-foot strips. Samples were taken to send to Dr. Jake Blauer, a potato post-harvest physiologist at Washington State University (WSU), for a detailed analysis of fry processing quality at harvest and in cold storage.

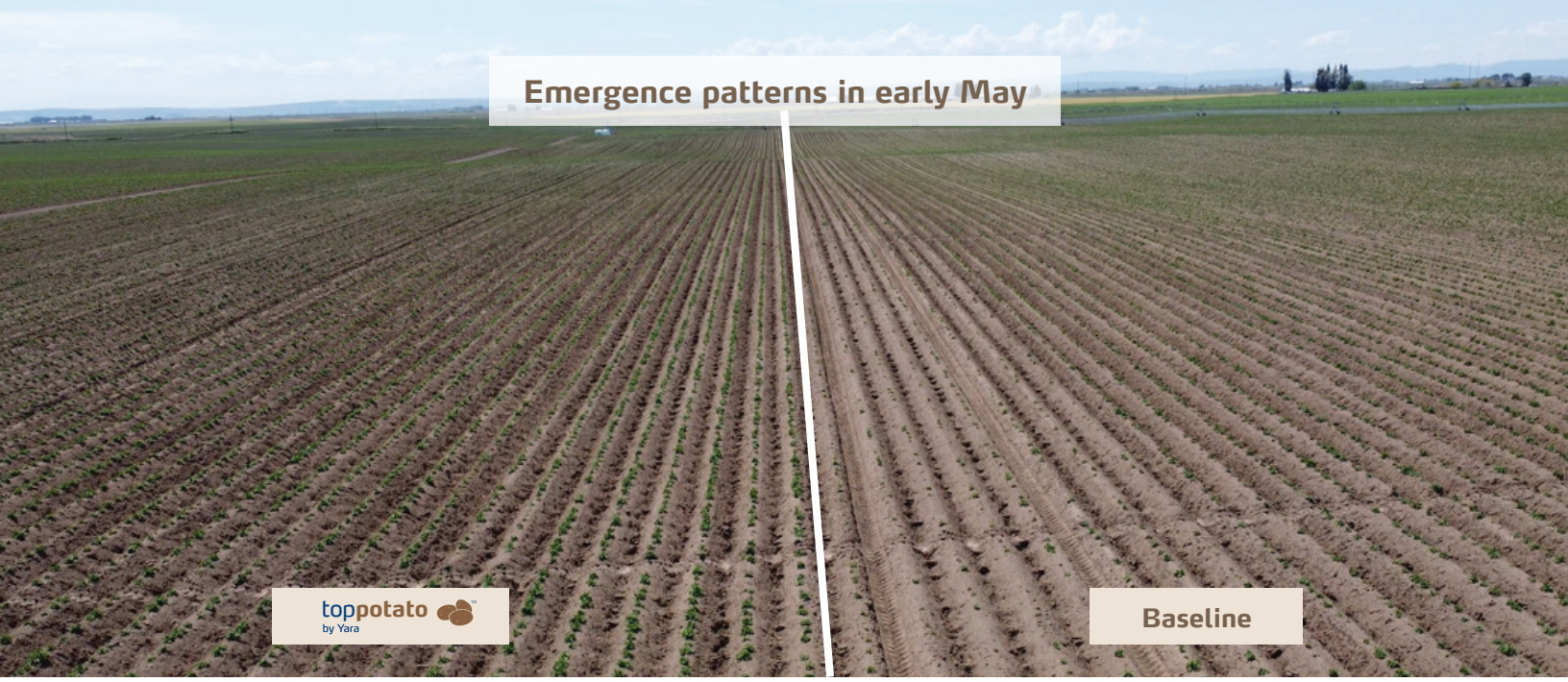
In addition, the grower harvested each half-pivot separately and recorded total yield. They also used a yield monitor when digging the field and produced a yield map. We identified comparable zones from each treatment half that had similar soil characteristics and historical NDVI patterns. We then compared yield from each of these zones, using yield mapping data from the yield monitor in the 2023 growing season. In doing so, we could compare yield from the Yara TopPotato treatment to yield from the Grower Standard treatment while reducing the effect of in-field variability on the data. The grower also monitored and recorded information on potato quality coming out of storage from each half-pivot.

Historical NDVI

(last season in potato – no treatments applied)



Soil Health Parameter Tested	Sample Timing	
	WF3 (potato)	WF7 (sweet corn)
Organic Carbon	Pre-emerge	Pre-emerge
Soil Nutrient Composition	Pre-emerge	Pre-emerge
CO2 Respiration	Pre-emerge Crop maturity	Pre-emerge 4 weeks post-application
Aggregate Stability	Pre-emerge Crop maturity	Pre-emerge 4 weeks post-application
Active Carbon (POX-C)	Pre-emerge Crop maturity	Pre-emerge 4 weeks post-application



In-Season Observations

Early season

The trial field was planted on March 27th in cooler than average temperatures. In early May, seed in the Yara TopPotato treatment had longer sprouts and more root mass than in the Baseline treatment. By May 15th, the Yara TopPotato Treatment had more even and more advanced germination compared to the Baseline Treatment. YaraVita Pentaflo applied in-furrow at planting provided nutrients (N, P, Ca, Mg, B, Zn) that the crop needed in close proximity to the germinating seed piece early in a cool spring to allow for quicker and more robust root growth and vigor and improved early germination.

Mid Season

Tuber initiation was reached in mid-late May with marble sized tubers by June 1. YaraLiva CN-9 was spoon-fed through the pivot starting at tuber initiation. This provided the crop with a predictable and available source of nitrogen and a consistent source of available calcium to the forming tubers. In addition, applications of YaraVita Solatrel, YaraVita Mancozin, YaraVita Safe K, and YaraVita Magtrac were made in response to crop need identified through knowledge of crop nutrient uptake and need at different growth stages and identified through petiole sampling.

On July 3rd, stem count was assessed and plants in the Yara TopPotato Treatment had slightly fewer stems per plant but more consistent stem count compared to the Baseline Treatment. On July 26th, plants were dug from each treatment to measure tuber set and size. The plants sampled from the Yara TopPotato Treatment had more stems per plant and smaller tubers than the plants sampled from the Baseline Treatment. For these samples, the location for each dig was chosen based on soil health index data. However, the sample location for the Yara TopPotato Treatment was on top of a hill and the sample location for the Baseline Treatment was towards the bottom of a hill, likely impacting the data gathered.

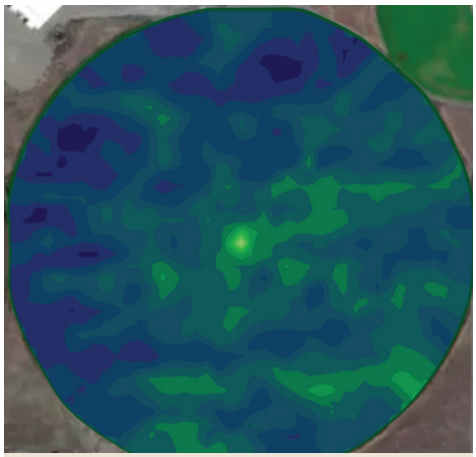
Around this time (early-mid July), the field started to show significant variability in plant vigor and NDVI in clear patterns in the field. Crop vigor and NDVI patterns observed in 2023 aligned with historical NDVI patterns for the field. This indicates that the NDVI and crop vigor patterns observed in the 2023 growing season in the same distinct patterns were not a function of the treatment applied in 2023. For all measurements taken after July 26th, samples were taken from zones with comparable crop vigor in the previous potato growing season so as to minimize the impact of in-field variability as much as possible on data collected.

Samples were again taken to assess tuber set and size on August 1. In this dig, the Yara TopPotato treatment had fewer tubers that were larger compared to the Baseline Treatment. Compared to the samples taken on July 26th, tubers in the Yara TopPotato Treatment showed a 0.02 lb/tuber size increase while the tubers sampled in the Baseline treatment were smaller on average than those sampled on July 26th. The Baseline Treatment had much higher tuber set with many small tubers in this dig.

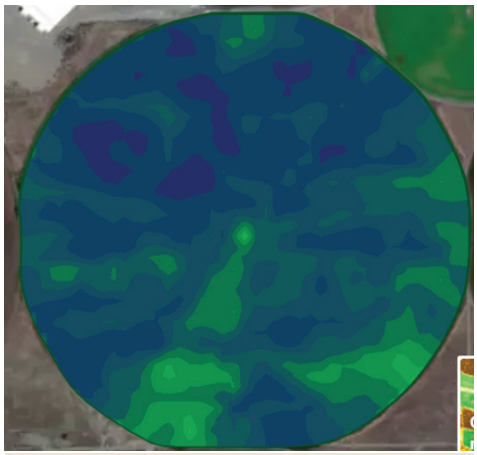
Late Season

August was a hot month but within historical temperature averages. Differences in crop senescence were related to in-field variability rather than treatment applied in 2023. The season brought cooler than average temperatures and precipitation in September. Field was harvested on 10/2 and 10/3 with light precipitation during harvest.

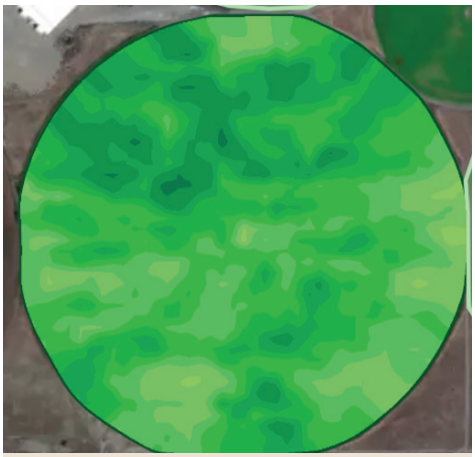
NDVI Imagery of Field WF3 in 2023 and Last Time Field WF3 Was in Potato



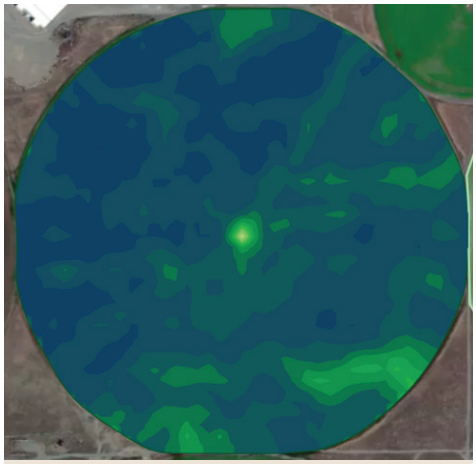
July 10, 2023



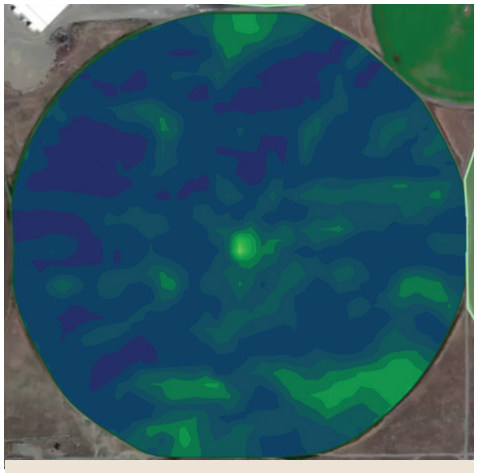
July 22, 2023



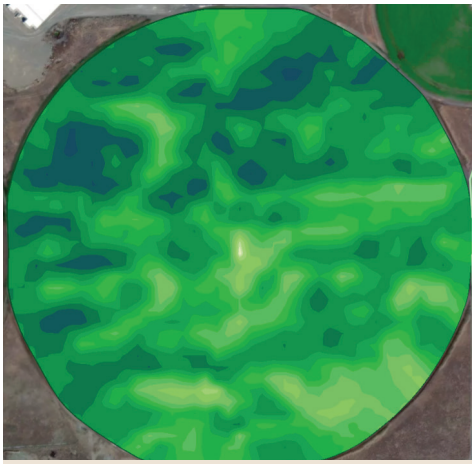
August 21, 2023



July 10 last season in potato



July 22 last season in potato



August 21 last season in potato

7/25 Digs

8/1 Digs

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Baseline

	Stem Count (stems/plant)	Stem Count (stems/plant)	Number of Tubers	Avg. Tuber Weight (lb/tuber)	Number of Tubers	Avg. Tuber Weight (lb/tuber)
	July 3	July 26			August 1	
toppotato by Yara	3.2 (2-4 stems in each plant)	3.25	52	0.25	50	0.27
Baseline	3.4 (1-5 stems in each plant)	2.55	52	0.33	87	0.19

Potato Field WF3 Yield, Quality, and Storage Quality Results

Yield and Quality at Harvest

Field	Treatment	Total Yield (ton/ac)	% Marketable	Marketable Yield (ton/ac)
WF3	Baseline Program	34.5	91.9	31.7
	Yara TopPotato	34.8	93.1	32.4

+0.7 ton/ac

Yara's TopPotato program led to a percent marketable increase of 1.2% and increased marketable yield by 0.7 t/ha. There were fewer culls and undersized potatoes in the Yara TopPotato Treatment at harvest, leading to an improvement of marketable yield over the Baseline program.

Processing Quality at Harvest

At harvest, samples were sent to Dr. Jake Blauer at WSU, to analyze for specific gravity and processing quality at harvest and in storage.

WSU Fry Color Samples

Yara TopPotato OM

Baseline Program O M

WSU analysis showed that fries from the Yara TopPotato program (42.7) had slightly lighter color than fries (higher numbers represent lighter fries) from the Baseline program (42.2), though both treatments had acceptably light color fries (25+). While the difference between the bud and stem end was acceptable for both programs (less than 9), potatoes from the Yara TopPotato program were significantly more uniform than those from the Baseline program.
Specific gravity was significantly higher in the Yara TopPotato program compared to Baseline program although gravities were good in both treatments.

WSU Fry Color and Specific Gravity

Treatment	Specific Gravity	Photovolt (Reflectance)		
		Stem	Bud	Diff
Baseline Program	1.084	42.2	42.6	4.3
Yara TopPotato	1.086	42.7	42.0	3.1

These results indicate the Yara TopPotato Program led to improved tuber quality and a reduction in culls at harvest and fry quality was excellent in both treatments at harvest.

Quality in Storage: Research Samples

Yara TopPotato 60 Days at 48°F

Baseline Program 60 Days at 48°F

WSU Fry Color and Specific Gravity 60 Days at 48°F

Treatment	Specific Gravity	Photovolt (Reflectance)		
		Stem	Bud	Diff
Baseline Program	1.085	44.8	48.1	4.3
Yara TopPotato	1.088	44.3	47.4	3.9

After 60 days of storage at 48°F, WSU analysis showed that fries from the Yara TopPotato program (44.3) had slightly darker color than fries from the Baseline program (44.8), though both treatments had excellent colored fries (25+). While the difference between the bud and stem end was acceptable for both programs, potatoes from the Yara TopPotato program were significantly more uniform than those from the Baseline program. Specific gravity was higher in the Yara TopPotato program compared to Baseline program although gravities were good in both treatments.

Yara TopPotato 60 Days at 40°F

Baseline Program 60 Days at 40°F

After 60 days of cold storage at WSU at 40°F, all treatments developed excess color differences (9+) between the stem and the bud end of the fries, though Yara TopPotato program was slightly better. Fries from the Yara TopPotato program (20.5) were slightly lighter than fries from the Baseline program (19.2) but neither were within acceptable range (25+).

Fry recovery was slightly lower in the Yara TopPotato program in both 2-3 inch fries and by total weight of tuber compared to recovery in Baseline program. This was due to the fact that the tubers in the Baseline program were longer (higher LxW ratio) which improved recovery. While the Baseline program had better LxW ratio, this parameter was acceptable for both treatments.

WSU Fry Color and Specific Gravity – 60 Days at 40°F

Treatment	Specific Gravity	Photovolt (Reflectance)		
		Stem	Bud	Diff
Baseline Program	1.086	19.2	38.3	19.2
Yara TopPotato	1.087	20.5	38.7	18.2

WSU Length and Fry Recovery

Treatment	Fry Recovery		
	LxW Ratio	%Fries (2-3 in)	% Fries (by total wight of tuber)
Baseline Program	1.92	75.6	93.2
Yara TopPotato	1.88	75.0	92.7

Potatoes from the Yara TopPotato program demonstrated improved specific gravity and significant improvements in uniformity compared to potatoes from the Baseline Program in each time point and storage temperature analyzed. Potatoes from the Baseline Program were longer than those from the TopPotato program, leading to a small improvement in fry recovery for the Basline program, although recovery was good for both treatments.

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Bulk Storage Tuber Quality and ROI

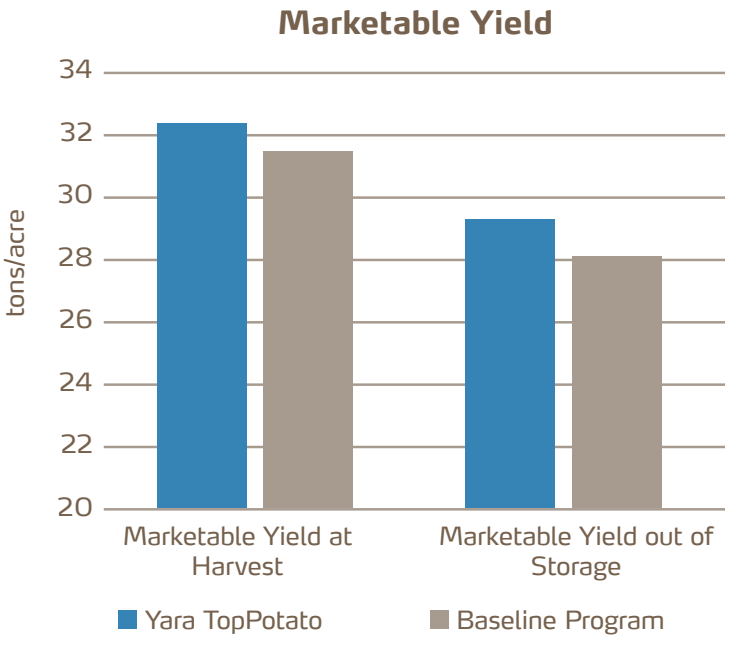
Potatoes from each half pivot were stored in the same bay of the grower's bulk storage and it was noted where potatoes from one treatment ended, and the other treatment began. As potatoes were pulled from storage, tuber quality and crop value from each treatment was monitored. Crop value took into consideration both premiums or penalties incurred from tuber size and quality.

Tubers from the Baseline program were pulled out of storage first, between 106 and 120 days after harvest. Tubers from the Yara TopPotato program were pulled out of storage between 123 and 133 days after harvest.

Field	Treatment	Usable (%)	Process Culls (%)	Culls (%)	6 oz (%)	Bruise Free (%)
WF3	Baseline Program	81.6	8.71	9.67	56.7	78.5
	Yara TopPotato	84.6	8.68	6.69	57.6	75.5

Potatoes from the Yara TopPotato program coming out of storage had higher usable %, fewer culls and process culls, and more 6 oz potatoes compared to potatoes in the Baseline program. In addition, there were fewer bruise-free potatoes in the Yara TopPotato program. Overall, these quality improvements led to a $/ton increase of $7.94 in the Yara TopPotato program compared to the Baseline program.

Field	Treatment	Total Yield at Harvest (ton/ac)	% Marketable out of Storage	Marketable Yield (ton/ac)	$/acre
WF3	Baseline Program	34.5	81.6	28.2	$5,799.29
	Yara TopPotato	34.8	84.6	29.4	$6,298.48
	Difference	+0.3	+3.0	1.3	+499.19



Taking into account a marketable tonnage increase of 1.3 ton/ac out of storage and $/ton increase of $7.94 from improved storage quality, Yara TopPotato Program led to an increased crop value of $499/acre. After taking into account program costs, the total net return of the Yara TopPotato program was $174/acre.

+$174/ACRE

TOTAL NET RETURN


YARA

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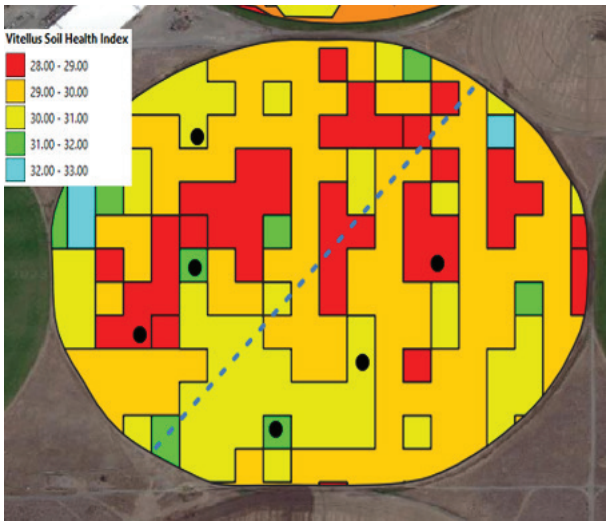
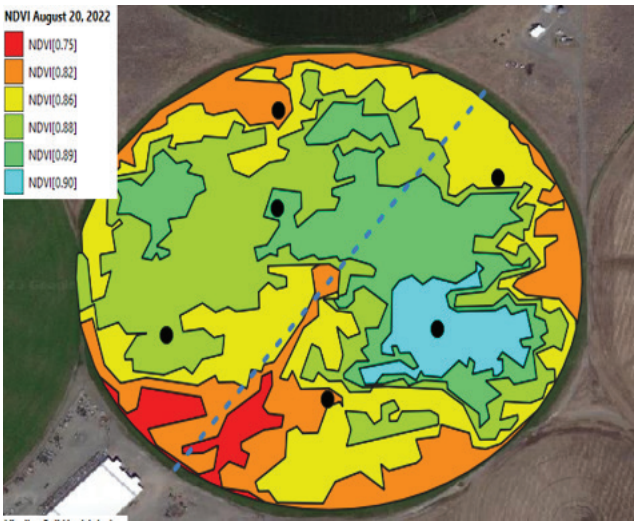
Soil Health Across the Potato Rotation

Soil samples were taken in fields WF3 and WF7 to establish a soil health baseline and begin to understand the impact of a set of treatments on soil health indicators during the 2023 season. Soil samples were pulled from the same location at multiple points during the growing season from comparable areas of each treatment half. For potato field WF3, the sample points were identified based on Vitellus Soil Health Index (A&L Canada Laboratories, Inc.) determined from soil mapping conducted pre-plant. For corn field WF7, soil health sample points were identified using historical field NDVI data.





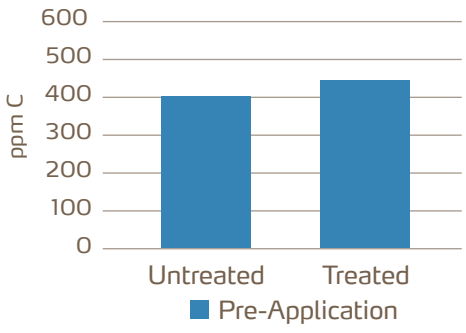
Soil tests carried out

Test	Timings	
Organic Carbon	Pre-Plant	
CO2 Respiration	Pre-Plant	Post-treatment application
Aggregate Stability	Pre-Plant	Post-treatment application
Active Carbon (POX-C)	Pre-Plant	Post-treatment application*

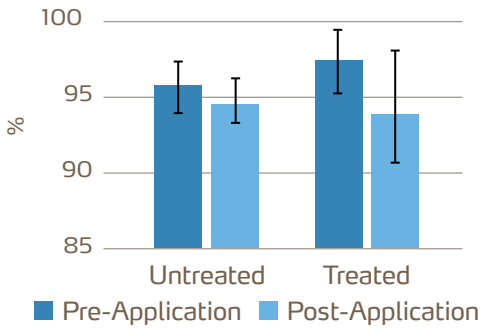
**sample missed for field WF7*

WF7 Sweet Corn Soil Health Results

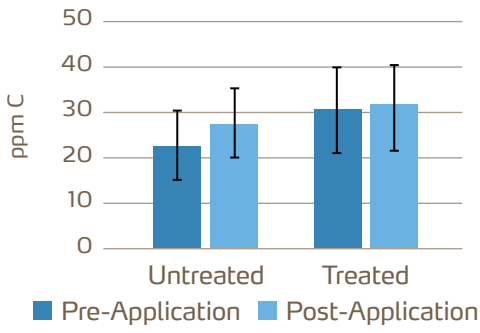
POX-C



Water Stable Aggregates



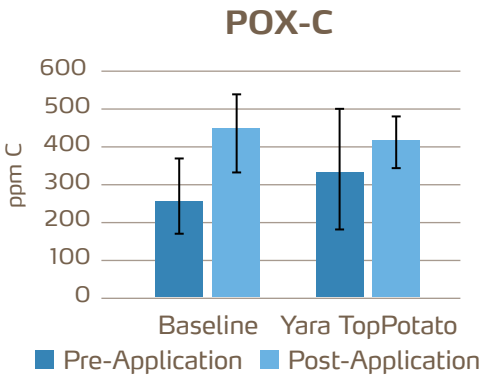
CO_2 Soil Respiration

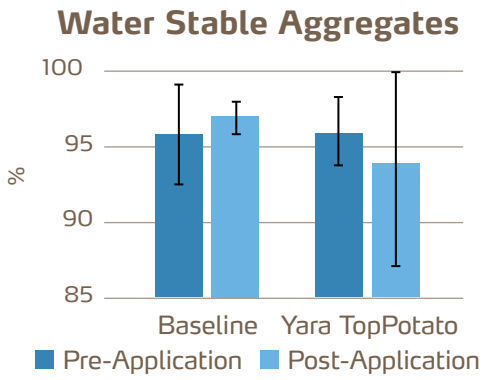


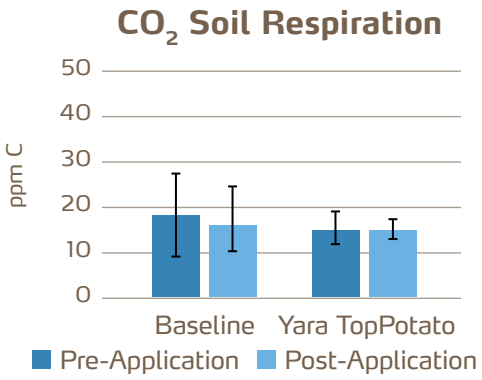
The samples taken in 2023 help to establish a baseline for soil health indicators in these fields and in this region for Quincy fine sand. We hypothesized that some of our treatments may impact soil health indicators during the growing season in which they were first applied. Specifically, we hypothesized that the application of algae-based soil microbial food in the sweet corn field WF7 may positively impact respiration and water stable aggregates by providing a food source to soil microbes. However, the application of this treatment did not significantly positively impact either factor compared to the untreated section of the field. In potato field WF3, the application of the TopPotato Treatment also did not significantly impact any of the soil health indicators measured compared the Baseline Treatment. In all cases, large error bars indicate a high level of variability in the data. Trends in soil health can take many seasons to quantify accurately and impact significantly. The data collected in 2023 help to set a baseline understanding of different soil health indicators in the specific fields of study. In order to work towards understanding which practices positively impact soil health across a potato rotation, it is recommended to continue to monitor soil health indicators and the impact of targeted practice changes in these fields with a larger and more robust sample program over a longer period of time.

Field	Organic Carbon (%C)
WF3 Potato	0.482-0.633
WF7 Sweet Corn	0.397-0.506

WF3 Potato Soil Health Results





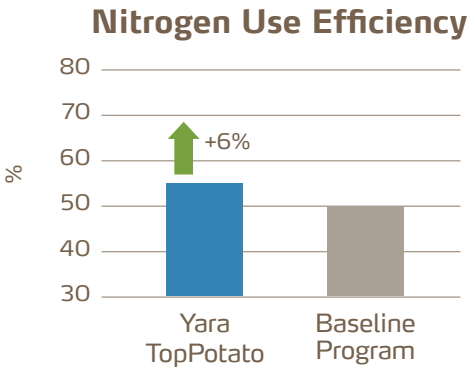


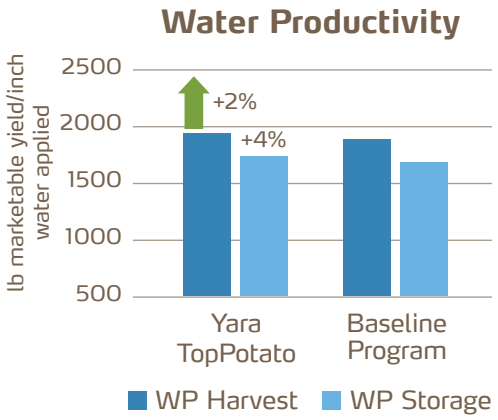
Knowledge grows

Sustainability Metrics

Our goal on the Potato Incubator Farm in 2023 was to provide the crop with a dynamic and optimized nutrient program to achieve high yield and quality and improved sustainability metrics. In the 2023 growing season, we were able to improve nitrogen use efficiency and water productivity, reduce waste, and reduce greenhouse gas emissions associated with potato production per acre and per ton of potato produced.

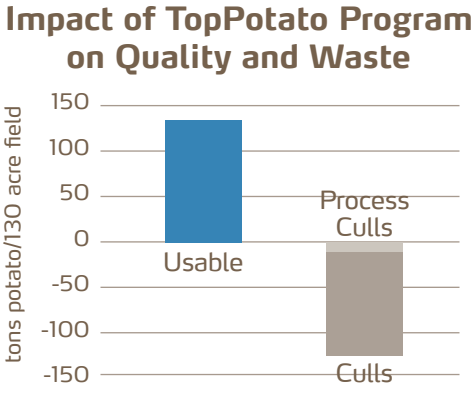
In the 2023 growing season, we applied 6.5% less total pounds of nitrogen fertilizer to the Yara TopPotato half of the field and achieved a marketable yield improvement compared to the Baseline program. By spoon-feeding YaraLiva CN-9 and UCAN17 according to crop need throughout the season, we supplied a predictable amount of available nitrogen to meet and not exceed crop needs. Additionally, UCAN17 (65% YaraLiva CN-9 and 35% UAN) is an AAPFCO-accepted high efficiency fertilizer. By applying highly efficient sources of N at the right time and rate, we were able to improve nitrogen use efficiency by 6% in the Yara TopPotato program compared to Baseline program.





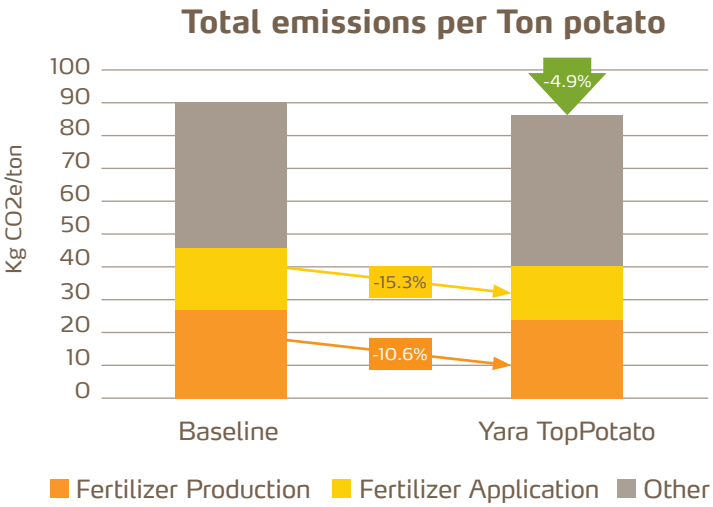
Thirty-three inches of water were applied through the center pivot over the course of the growing season. Both Baseline and TopPotato programs received the same irrigation program and the same inches of water applied. Water productivity (lb marketable yield/inch of applied water) increased by 2% in the Yara TopPotato program at harvest and by 4% out of storage. Because irrigation was applied consistently across the field, the main factor impacting water productivity between treatments was yield at harvest and marketable tonnage coming out of storage.

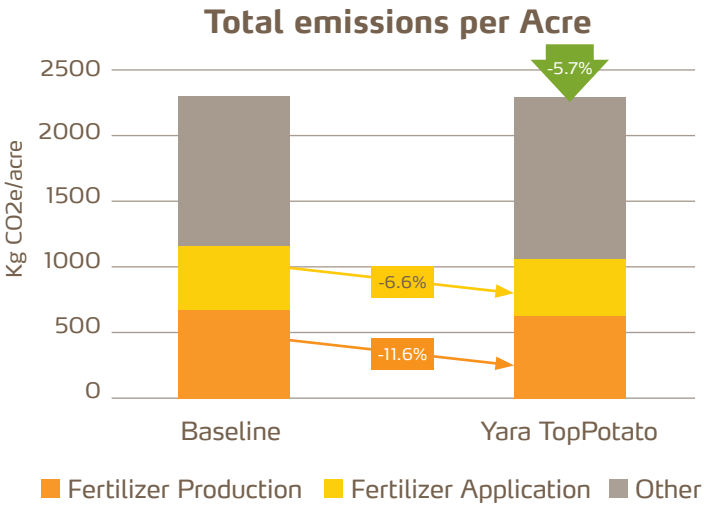
Good crop nutrition impacts both yield and the quality of potatoes going into and coming out of storage. Calcium is particularly important for tuber quality- strengthening cell walls and helping combat physical tuber damage and damage from rots and pathogens. It is clear that the Yara TopPotato program had a positive impact on tuber quality and storability. When considering the impact of the observed improvements in tuber quality on the scale of an entire field, the incremental improvements in % usable and % bruise and decreases in processing culls and culls has a significant impact on quality and waste. On a field level, the quality improvements in the TopPotato treatment led to 135 tons more usable potatoes (134 tons fewer culls and 1 ton fewer process culls).



For the potato field WF3, we collected data in order to conduct a full carbon footprint assessment of emissions associated with potato production in the field. Overall, fertilizer (production + application) made up 50.5% of in-field emissions associated with potato production. In this study, factors associated with the manufacture of the fertilizer impacted emissions more that those associated with in-field application of fertilizer (including rate, source, and form).

In the Yara TopPotato program, 22% of the nitrogen applied to the field was YaraLiva CN-9 which is manufactured with a low carbon footprint. Yara utilizes a nitrous oxide abatement catalyst when manufacturing YaraLiva CN-9 which reduces the manufacture carbon footprint by 50-60% compared to nitrate nitrogen produced outside of the European Union. Additionally, the Yara TopPotato treatment had 6% less total lb of N applied to the field. These factors, along with an increase in marketable yield in the Yara TopPotato program led to a reduction in greenhouse gas emissions per acre and per ton of potato in the Yara TopPotato program compared to the Baseline program.





On a per acre basis, the Yara TopPotato program had a 5.7% reduction in greenhouse gas emissions overall compared to the Baseline program. When looking at the impact of the program on emissions associated with the manufacture of fertilizer, the Yara TopPotato program led to a 6.6% reduction compared to the Baseline program. When considering emissions associated with the in-field application of fertilizer, the Yara TopPotato program led to an 11.6% reduction compared to the Baseline program.

On a per ton of potato produced basis, the Yara TopPotato program led to a 4.9% reduction in greenhouse gas emissions overall compared to the Baseline program. When looking at the impact of the program on emissions associated with the manufacture of fertilizer, the Yara TopPotato program led to a 10.6% reduction compared to the Baseline program. When considering emissions associated with the in-field application of fertilizer, the Yara TopPotato program led to a 15.3% reduction compared to the Baseline program.

The best approach to take when seeking to lower in-field emissions associated with fertilizer use is a well-rounded one. It is important to consider source (both form of nitrogen and manufacturing source), rate, and the impact of a nutrient management program on yield and quality when seeding to reduce in-field emissions. By optimizing the nitrogen rate for crop needs, using efficient sources of nitrogen fertilizer, improving yield and quality, and utilizing nitrogen fertilizer manufactured with a low carbon footprint, we were able to reduce emissions associated with potato production on both a per acre and per ton basis.

Knowledge grows

Yara TopPotato in the Columbia Basin: Two Season Summary

This was the second year of trials on the Yara Potato Incubator Farm. In total, three fields of potatoes were evaluated - two fields in 2022 and one field in 2023. Across the two seasons and three fields (390 acres total) of Clearwater potatoes studied on the Columbia Basin Potato Incubator Farm between 2022 and 2023, the Yara TopPotato Program led to improvements in yield and quality at harvest, storage quality, processing quality, improved efficiencies and reduced greenhouse gas emissions, and a positive grower ROI.

Harvest Yield & Quality

Marketable Yield*

+7%	-9%	+2%
Field 1 (2022)	Field 2 (2022)	Field 3 (2023)

+3% (across all fields)
% Marketable

Storage Quality

+4%	-27%	+5.3%
% usable	% culls	% 6 oz

Improved storage quality led **458 tons** more usable potatoes across three fields.

Processing Quality

Improved fry color and consistency out of storage

Nature Positive

-5.7%	+6%	+2%-4%
kg CO2e/ac in 2023	in 2023	in 2023
Carbon Footprint	Nitrogen Use Efficiency	Water Productivity

Farmer Prosperity

Positive ROI in 100% of fields

+$139/ac
average net return

**By mapping the field in 2023 (Field 3), we were able to reduce the impact of in-field variability on yield data. To account for in-field soil variability, zones of likeness were identified on both halves of the field based on soil test values linked to potato productivity.*

Executive Summary

The 2023 growing season in the Columbia Basin of Washington was excellent for potato production and the yield and quality of the potato crop on the Incubator Farm reflected that. The Yara TopPotato program led to a yield improvement and an improvement in percent marketable at harvest.

Complete in-season nutrient management supports the production of a higher quality crop going into storage which helps reduce losses in storage. Calcium, provided by YaraLiva CN-9, is important for tuber quality and storability as it helps strengthen cell wall structure, protect from bruise and physical damage and rots in storage. Storage data showed consistent quality improvements in the Yara TopPotato program throughout the storage period. The Yara TopPotato program led to improved specific gravity, usable %, and 6 oz %, and reduced culls and process culls. These quality improvements led to a $/ton increase of $7.94. Storage quality improvements and improved marketable tonnage led to an overall ROI of $174/acre over program cost.

In contrast to the 2022 growing season, we were able to reduce greenhouse gas emissions per acre and per ton of potato produced by implementing the Yara TopPotato program in 2023. By optimizing the nitrogen rate for crop needs, using efficient sources of nitrogen fertilizer, improving yield and quality, and utilizing nitrogen fertilizer manufactured with a low carbon footprint, we were able to reduce emissions associated with potato production on both a per acre (-5.7%) and per ton (-4.9%) basis. We were also able to improve nitrogen use efficiency (+6%) and water productivity (+2-4%) by implementing the Yara TopPotato program in 2023.

One significant benefit of the Yara TopPotato program was improved tuber quality coming out of storage. These quality improvements led to reduced waste in the field, in storage, and at the processor – leading to a higher percentage of the overall tons of potatoes being processed into the end-product.

In addition to agronomic data, the soil health data collected on the Incubator Farm in 2023 helps to set a baseline understanding of different soil health indicators in the specific fields of study. In order to work towards understanding which practices positively impact soil health across a potato rotation, it is recommended to continue to monitor soil health indicators and the impact of targeted practice changes in these fields with a larger and more robust sample program over a longer period of time.

The Potato Incubator Farm is a multi-year study and our learnings across two growing seasons supports the conclusion that by providing the crop with a complete and optimized nutrition program, the Yara TopPotato program can support the decarbonization of the potato value chain and grower prosperity through profitability, yield and quality.

Thank You!

Yara would like to thank Weber Farms in Quincy, Washington for graciously hosting the Yara Potato Incubator Farm for the 2022 and 2023 growing seasons. It is through successful partnerships with engaged and innovative growers that the research carried out on the Incubator Farm is made possible. Thanks to Weber Farms for their partnership in this project!

toppotato™
by Yara

Our goal is to support comprehensive nutrition management programs in collaboration with our industry partners

Knowledge grows

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