Boosting Soil Health by Increasing PoX-C and Updates on Powdery Scab Research

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Brief discussion on study you and Myrold did, initial hypothesis, relevant finding that led to PoX-C, polyphenols, etc

Some years ago (2017), Myrold and Kleber were asked to investigate mechanisms that could make potato fields suppressive to soil borne pathogens, especially verticillium. We approached this by measuring and comparing soil health parameters between 20 healthy and 20 verticillium afflicted fields. The results were published in a Potato Progress Series "Soil Health and verticillium disease of potato, Part I-III (www.nwpotatoresearch.com). Among the most significant differences between healthy and diseased potato fields was the permanganate oxidisable carbon (PoxC) parameter, which was much higher in the healthy fields.

The permanganate oxidisable carbon is commonly interpreted as the active carbon or fresh organic matter that serves as a microbial food source. But when we investigated the chemistry of the compounds that reacted with the permanganate, we found that it was not the easily decomposable sugars and celluloses that responded. Rather, we found that complex aromatic compounds such as lignin gave strong reactions. More precisely, the group of chemical substances that are known as polyphenols are the ones that are detected by this method.

Initiated trial last year using tannic acid, discuss rates (use English measurements not metric – growers don't compute in metric)

Next we hit the literature to see what was known about the role of polyphenols in disease suppression, and found abundant evidence for a disease suppressive function of polyphenols. We decided to conduct a field trial, which was completed in 2021. We chose a soil low in organic matter and added a commercially available natural polyphenolic compound. We primarily wanted to know a) how much product would be needed to give us a response and b) if "more is better". Accordingly we raised the natural PoxC level of the soil by half (150%) and we also went very high by tripling it (going to 300%). Another question was whether a split application of the product would make a difference, with half applied at planting and the other half at about 40 days.

Where does tannic acid come from

The polyphenol product applied was commercially available tannic acid. This product is extracted from the argentinian Quebracho tree, it is very expensive and not sustainable because 75% of the argentinian Quebracho trees have already beenfelled for tannic acid production. But polyphenols are abundant in many plants native to the Pacific Northwest, such as conifer bark or Big Sagebrush. This means there is a local source that could be used if a respective processing industry were established.

Trial data from last year – yield, grade, and blackdot measurements, red skin color enhancement discovery

The outcome was a 18% yield increase in the 150% treatment, and a small yield decline in the 300% treatment, suggesting that a moderate polyphenol addition is beneficial while affirming that "more is definitely not better".

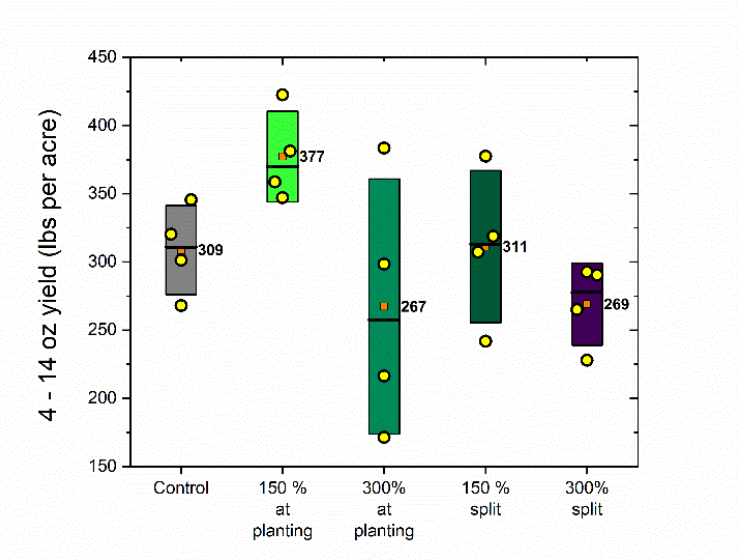

Figure Raising the soil concentration of permanganate oxidisable carbon through additions of tannic acid by half (150%) at planting led to a statistically significant increase **by 18%** in both total yield ($p > 0.038$) as well as in **marketable yield** (shown here, 4-14 oz size potatoes; $p > 0.026$)

Pre-plant soil analysis showed very low levels of *Verticillium dahliae, Colletotrichum coccodes, Spongospora subterranea, Fusarium spp.* In addition, soil analysis showed extremely low levels of root-knot, root-lesion, and stubby-root nematodes. Tubers were assessed for internal and external defects. There was no significance difference among treatments for intensity of red skin color; however, treatments with tannic acid applied at planting had darker skin color numerically based on a 1 – 5 scale (1= pink and 5 = dark red) compared to the untreated check. There was no significant difference among treatments for incidence and severity of powdery scab. Likewise, no significant differences were observed for external tuber growth cracks and knobs. No significant differences were observed among treatments for internal tuber disorders, hollow heart, brown center, vascular discoloration, and internal brown spot. There were significant differences for tuber blemish due to the *Colletotrichum coccodes* (blackdot) pathogen with treatment two having significantly less blemish compared to all other treatments.

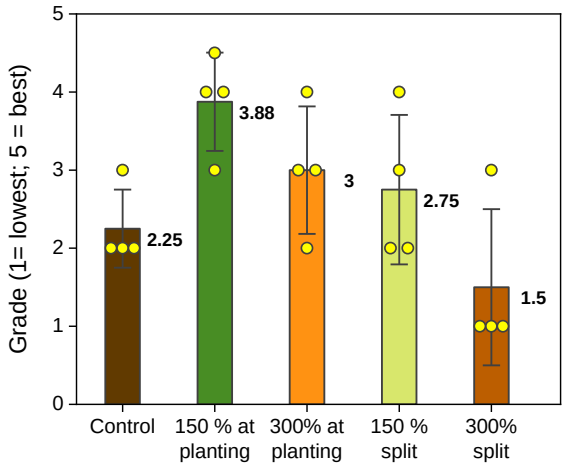

Figure: The 150% treatment not only produced the highest yield, it also had significantly lower tuber blemish due to the *Colletotrichum coccodes* (blackdot) pathogen than all other treatments.

Explain approach for this year's trial at two locations, planting dates, varieties chosen, any current soil analysis data

Given that an 18% yield increase would have serious implications for grower income, we believe that there is a need to obtain second year evidence to further confirm and investigate the potential of this management option to improve potato yields. Accordingly, we extened our reserach to include the following questions:

a) Can the observed beneficial effect of polyphenol additions be replicated?
b) Does the observed beneficial effect vary as a function of
   - soil type ?
   - potato variety ?
   - polyphenolic amendment type ?
c) Is there a change in efficacy when comparing two different polyphenolic amendments and does a synergistic effect occur in combination?

Where does lignosulfate come from

Polyphenols are a large family of compounds derived from secondary metabolism that are widespread in the plant kingdom and characterized by the presence of at least two phenolic groups associated in more or less complex structures. There are thousands of these compounds, and it would be unreasonable to expect them all to have the same functions and capabilities. In addition, some of these compounds are produced in relatively modest quantities by rare plants while others are produced in bulk volumes, such as lignin.

This obviously influences the market value of these materials: tannic acid is expensive, while lignin is relatively cheap. In our previous field study, we used tannic acid as an amendment because there is a robust literature reporting on the efficacy of tannic acids against soilborne pathogens. However, given the close molecular resemblance and near identical PoxC reactivity of commercial lignin powder and tannic acid, we propose to test whether the (relatively) inexpensive Lignin powder might be able to achieve the same beneficial outcomes for plant health and crop yield as the tannic acid.

Observed difference in irrigation penetration – installed Watermark Sensors

for Brian to add

If successful, how do we anticipate finding cheaper sources of these compounds, where would they be sourced from, etc

Polyphenols are natural plant products and are typically concentrated in protective organs such as tree bark, potato skins, grape skins etc. Incidentally, these materials are often available and marketed as organic waste materials, used for mulching or other low value applications. We believe that there is the potential for the development of an entire industry to make these materials available as a domestic resource for the Ag industry.

Figure: Red Fir bark marketed as mulch and native Artemisia plant, currently not utilized as a resource

Future study? Perhaps soil activity of PoX-C tapers off, may look at different application timings to enhance efficacy, etc?

At this time, we are still in the "proof of concept" phase of our research. If first year results are confirmed, concerted action would be warranted to develop the entire agronomic aspect of the matter (application technique, timing, effects on nutrient cycling etc). At the same time, agrochemical industry should be encouraged to develop industrial scale extraction, formulation and distribution procedures with the goal to generate a financially competitive product line.

Other additions you can think of?

not right now, but thousand possibilities conceivable