Nutrients in Potatoes, Potato Leaves and Soil

Introduction

Measuring leaf petiole sap and tuber juice ions with meters like the HORIBA LAQUAtwin is extremely important for potatoes.

Sap measurements provide a real-time snapshot of nutrients actively moving within the plant — not just what is present in the soil. Soil tests alone are insufficient because nutrient availability and uptake can change daily depending on irrigation, growth stage, tuber initiation, and environmental stress.

The LAQUAtwin meters can measure K^+, NO_3^-, Ca^{2+}, Na^+, pH and EC in tubers, leaves, soil and water.
Measurements can be performed directly on: Leaf petiole sap, Tuber juice, Soil extracts, Irrigation water

Why Ion, pH, and EC Meters Are Essential for Potato Production

Modern potato production is no longer limited by fertilizer supply — it is limited by nutrient balance, timing, and uptake efficiency.

Disorders such as: Hollow heart, internal brown spot, black spot bruise, poor skin set, reduced dry matter, storage breakdown, excessive vine growth are frequently caused by in-season nutrient imbalance, not fertilizer deficiency at planting.

Real-time measurement tools — ion, pH, and EC meters — allow growers to manage nutrition proactively..

Why ion measurements matter

Ion-specific measurements (K^+, Ca^{2+}, NO_3^-, Na^+) provide direct insight into what the potato plant is absorbing and transporting at that moment. Unlike traditional tissue lab analysis (which is slow), sap measurements reflect current physiological status, allowing early correction.

Key advantages include:

- Early detection of excess nitrate driving excessive vine growth
- Monitoring K–Ca balance influencing tuber quality and internal disorders
- Preventing over-fertilization and nitrate leaching
- Adjusting fertigation during tuber bulking
- Improving storage quality and bruise resistance

In processing potatoes (e.g., Russet Burbank, Innovator, Fontane), nutrient balance directly affects dry matter, fry color, and storage performance.

Why pH and EC are equally important

While ion meters show what nutrients are present, pH and EC explain why uptake succeeds or fails.

- pH governs nutrient availability and ion competition at the root and leaf level. Even optimal Ca or K levels are ineffective if pH conditions restrict absorption.
- EC (Electrical Conductivity) provides a rapid indicator of total salt concentration and osmotic stress. Elevated EC reduces water uptake, suppress calcium transport to tubers, increase sodium accumulation, reduce tuber size and uniformity.

Together, pH and EC measurements allow growers to:

- Detect salinity stress early
- Diagnose irrigation and fertigation problems
- Interpret ion readings correctly and avoid misinformed decisions

Without pH and EC context, ion data alone can be misleading.

Preparing Sap from Potato Leaves or Tubers

Sample Collection:

1. Select leaves or fruits

- For leaves: Fully expanded leaves from mid-canopy, typically 4th–6th leaf from growing tip.
- For tubers (juice): Select 3–5 representative tubers, avoid damaged or sunburned tubers.

2. Extract the sap

- Leaves: Remove leaf blades, use petiole only. Chop and press with garlic press or sap press.
- Tubers: Slice or crush tuber, collect expressed juice, filter solids before measurement.

- If needed, dilute samples with deionized or distilled water so that the ion concentration falls inside the calibrated range of the meter.

STEP-BY-STEP PROTOCOL

Potato Leaf Sap (Petiole Sap) — Recommended Method

1 Sampling

When: Morning (8–11 am), avoid drought or heat stress

Which leaves:

- Fully expanded leaves from mid-cane position
- Avoid diseased or shaded leaves

How many: 20–30 leaves per field zone.

Remove leaf blades — use petioles only.. The blades dilute sap and increase variability.

2 Sap Extraction

Equipment

- Garlic press or handheld sap press
- Clean plastic cup
- Coffee filter or syringe filter (optional)

Procedure

1. Chop petioles into 5–10 mm pieces
2. Press firmly to extract sap
3. Collect ≥0.5 mL total sap

Typical yield: 20 petioles → ~0.4–0.9 mL sap.



3 Dilution (IMPORTANT for Patatoes)

Potato sap is often concentrated, especially for K^+ and NO_3^-.

Standard dilution (recommended starting point):

<table>
<tr><th>Meter</th><th>Dilution</th><td rowspan="5">How to dilute (example 1:10)
Take 0.10 mL sap and add 0.90 mL distilled / deionized water. Mix gently. Use disposable pipettes or syringes for accuracy.</td></tr>
<tr><td>NO_3^-</td><td>01:05</td></tr>
<tr><td>K^+</td><td>01:10</td></tr>
<tr><td>Ca^{2+}</td><td>1.5 to 1:10</td></tr>
<tr><td>Na^+</td><td>01:05</td></tr>
</table>

STEP-BY-STEP PROTOCOL, Potato Tuber Juice

1 Sampling

• 3–5 representative tubers.

2 Juice Extraction

1. Chop the tubers
2. Crush or blend
3. Filter solids
4. Collect clear juice

3 Dilution

• K, Ca: usually 1:5 or 1:10

• NO_3^-: often no dilution needed

Measurement

Before mesaurement the instrument must be calibrated.

1. Turn on the meter
2. Rinse the sensor with demineralized or normal tap water and dry carefully with a tissue
3. Place some of the 150ppm solution on the sensor and press the CAL button
4. Rinse the sensor with demineralized or normal tap water and dry carefully with a tissue
5. Place some of the 2000ppm solution on the sensor and press the CAL button
6. Rinse and dry the sensor
7. Place the extracted sap or juice onto the sensor
8. Wait for the reading to stablize (takes a couple of seconds)

EXPECTED VALUES

⚠ These are practical working, general, ranges, not absolute standards. Values are, amongst others, influenced by, variety, soil type, Irrigation, weather and growth stage.

Potato Leaf Petiole Sap (ppm, mg/L) (general)

Status	NO_3^-	K^+	Ca^{2+}	Na^+
Low	<800	<2500	<200	–
Adequate	800–1500	2500–4500	200–500	<100
High	1500–2500	4500–6000	500–800	100–200
Excessive	>2500	>6000	>800	>200

Excess nitrate late season delays tuber maturity.

High K suppresses Ca uptake.

Low Ca linked to internal brown spot and poor storage.

Sodium should remain low to avoid salt stress.

Potato Tuber Juice (ppm, mg/L)

	Range	Note
NO_3^-	<50	High nitrate reduces processing quality
K^+	1500–3000	High K reduces dry matter
Ca^{2+}	>50	Low Ca linked to internal disorders
Na^+	<50	Indicates saline stress

The K:Ca ratio strongly influences tuber quality and storage.

Practical, Stage-specific Sap Ranges

Below are practical, stage-specific sap ranges tailored for potatoes, using HORIBA LAQUAtwin NO_3^-, K^+, Ca^{2+}, and Na^+ meters, with cultivar adjustments where this really matters.

These are working target ranges, not textbook sufficiency levels. They're designed for decision-making, not lab diagnostics.

1 Leaf Petiole Sap (ppm, corrected for dilution)

Standard Fresh Market Potatoes.

Examples: Agata, Colomba, Maris Peer.

	NO_3^-	K^+	Ca^{2+}	Na^+	Ratio
Early Vegetative	1500–2500	4000–6000	200–400	<120	<12:1
Tuber Initiation	1000–1800	3500–5000	250–450	<120	<10:1
Tuber Bulking	800–1500	3000–4500	300–600	<120	<8:1
Pre-Harvest	<800	2500–4000	350–700	<120	<6:1

Key Focus:

- Uniform tuber sizing
- Good skin finish
- Avoid excess vigor late season

Processing Potatoes.

Examples: Russet Burbank, Innovator, Fontane, Shepody.

	NO_3^-	K^+	Ca^{2+}	Na^+	Ratio
Early Vegetative	1800–2800	4500–6500	200–400	<100	<12:1
Tuber Initiation	1200–2000	4000–5500	250–450	<100	<10:1
Tuber Bulking	800–1500	3500–5000	300–600	<100	<8:1
Pre-Harvest	<800	3000–4500	350–700	<100	<6:1

Key Focus:

- Control late-season nitrate to protect fry color.
- Maintain Ca during bulking to reduce internal brown spot.
- Avoid excessive K that reduces dry matter.

High Dry Matter / Storage Varieties.

Examples: Markies, Challenger, Ramos

	NO_3^-	K^+	Ca^{2+}	Na^+	Ratio
Early Vegetative	1600–2600	4500–6500	250–450	<100	<11:1
Tuber Initiation	1000–1800	4000–5500	300–500	<100	<9:1
Tuber Bulking	700–1300	3200–4800	350–650	<100	<7:1
Pre-Harvest	<600	2500–4000	400–750	<100	<6:1

Key Focus:

- Maintain Ca for long-term storage
- Reduce nitrate earlier than fresh varieties
- Keep K balanced to protect dry matter

2 Soil Conditions – Interpretation Tables

The following tables are root-zone soil solution targets, not total soil content.

Soil Nitrate (NO_3^- in soil solution, ppm)

Status	Range	Interpretation
Low	<10	Risk of reduced growth
Optimal Vegetative	10–25	Good early growth
Optimal Bulking	8–18	Balanced tuber growth
High	25–40	Excess vine growth risk
Excessive	>40	Delayed maturity, poor storage

Soil Potassium (Exchangeable K, mg/kg or ppm)

Status	Sandy Soil	Loam Soil	Clay Soil
Low	<120	<150	<180
Adequate	120–200	150–250	180–300
High	200–300	250–350	300–450
Excessive	>300	>350	>450

Excess soil K can suppress Ca uptake even when soil Ca is adequate.

Soil Calcium (Exchangeable Ca, mg/kg)

Status	Range	
Low	<800	Important: High Ca does not guarantee tuber Ca — transport depends on transpiration and EC.
Adequate	800–2000	
High	2000–4000	
Excessive	>4000	

Soil Sodium (Na^+, ppm)

Status	Range	
Safe	<50	High Na reduces Ca uptake and increases EC.
Moderate Risk	50–100	
High Risk	>100	

Soil pH

pH	Interpretation
<5.0	Risk of Al/Mn toxicity
5.2–6.0	Ideal for potatoes
6.0–6.5	Acceptable
>6.5	Risk of common scab
>7.5	Reduced micronutrient availability

Soil EC (Electrical Conductivity, mS/cm)

EC	Interpretation	
<1.0	Ideal	Potatoes are moderately salt sensitive.
1.0–2.0	Mild stress possible	
2.0–3.0	Yield reduction likely	
>3.0	Severe salt stress	

3 Integrated Interpretation Guide

If You See...	Likely Cause	Action
High sap K, low Ca	Soil K excess or high EC	Reduce K input, improve Ca delivery
High sap NO_3^- late season	Over-fertilization	Reduce N immediately
Low sap Ca, normal soil Ca	High EC or poor transpiration	Improve irrigation uniformity

Rising sap Na	Salinity issue	Check irrigation EC & water source
High soil EC + low sap Ca	Osmotic suppression	Leach salts, adjust fertigation
If You See…	Likely Cause	Action

Tips for Potatoes

1 Consistency

- Sample at similar times of day and environmental conditions to reduce variability.
- Morning sampling (8–11 am) under non-stress conditions provides the most repeatable results

2 Dilution & Compensation

- If ion concentrations exceed the meter's range, dilute the sample and apply a correction factor. For example, diluted plant sap readings must be multiplied by the dilution ratio

3 For best results:

- Monitor sap weekly during tuber initiation and bulking
- Monitor soil EC and nitrate every 2–3 weeks
- Keep K:Ca ratio declining through the season
- Reduce nitrate progressively toward harvest

What about pH and EC?

pH and EC are also important, but they serve a slightly different purpose than ion-specific measurements like K^+, Ca^{2+}, NO_3^-, and Na^+.

1 pH (Hydrogen ion concentration). Why it matters:

pH affects nutrient availability. Even if you apply enough Ca or K, if the pH is too high or too low, the plant cannot take it up efficiently. Typical ranges for sap are 5.8 to 6.8pH and for irrigation water 5.5 to 7.0pH.

Extreme pH can cause:

- Reduced uptake of Ca
- Mg availability
- Nutrient imbalances

Takeaway: pH is not an ion itself, but controls how well the plant can use other nutrients.

2 EC (Electrical Conductivity). Why it matters:

EC measures total soluble salts in water or sap.

High EC in water or sap indicates salinity stress, which can:

- Reduces tuber size
- Limits Ca movement
- Increases Na^+ risk

Typical target ranges for leaf sap are 2 to 5 mS/cm (varies by cultivar and growth stage), for irrigation water: <1.0 mS/cm.

Use in practice:

- Monitor EC in irrigation water and sap together to detect salt stress early.
- If EC is high you may need adjustments in the irrigation or fertigation systems.

3 How they complement ion measurements

Parameter	Use	Critical for
K^+, Ca^{2+}, NO_3^-, Na^+	Direct ion status	Quality & disorder prediction
pH	Nutrient availability	Ensures uptake efficiency
EC	Total salts / salinity	Detects salinity stress

In short:

- Always check pH and EC for irrigation water and sap.
- Ion meters + pH + EC = full nutritional picture

Advantages of LAQUAtwin instruments for Potato Farms:

The HORIBA LAQUAtwin instruments are uniquely suited to farm use because they combine laboratory-grade ion-selective technology with true field practicality.

Key advantages include:

- Direct sap and tuber juice measurement
- Minimal sample preparation
- Small sample volume required
- Portable and field-ready
- Fast results for same-day decisions
- Ion-specific accuracy
- Enables frequent monitoring during critical growth stages

The practical bottom line

Potato farms that integrate ion, pH, and EC monitoring move from calendar-based fertilization to data-driven nutrient management.

This results in:

- Improved tuber quality
- Better processing performance
- Reduced storage losses
- Lower fertilizer waste
- Reduced environmental impact
- Greater management confidence

Disclaimer: The sap value ranges and interpretations presented in this application note are **indicative guidelines only**. Actual optimal values may vary depending on cultivar, rootstock, orchard age, crop load, growth stage, climate, irrigation water quality, and management practices. Sap analysis should be used as a **decision-support tool**, not as a standalone diagnostic method. For critical nutrient management decisions, sap measurements should be interpreted together with visual assessment, soil analysis, irrigation water analysis, and periodic laboratory tissue testing.

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