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NEBRASKA

POTATO EYES

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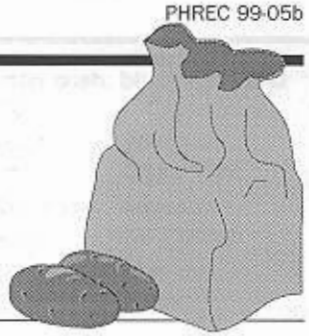

Cardy Nitrate Meter

There is a need for a portable, self-contained and easy method for measuring plant nitrate-nitrogen levels in the field. At the last 'Board' meeting, I was asked to report about a recently introduced instrument, the Cardy nitrate meter, available through Spectrum Technologies (800-248-8873; web site: www.specmeters.com) out of Illinois. Besides the above advantages, the Cardy meter reads undiluted petiole sap and doesn't require periodic calibration checks. Dr. Carl Rosen's group at the Univ. of Minnesota has been doing considerable amount of work on this instrument comparing it to other analytical methods and developing nitrate sufficiency ranges (NSR) for Russet Burbank and other varieties.

The Cardy meter is a flat membrane nitrate electrode. It measures nitrate-N concentrations in non-diluted sap of potato petioles. The petioles from recently mature leaves, 4th from terminal, are removed. Each is placed in a hand-held plant sap press, that comes with the meter, and squeezes out three drops (about 0.1 ml) of sap that is then placed on the membrane in the instrument. A direct reading is given on the meter. The range of readings potato petioles throughout the season will be between 500 and 2500 ppm nitrate-N. The meter has three scales; the highest scale (1000 to 10,000 ppm in 100 ppm increments) will be used early in the season and the middle scale (100 to 1000 ppm in 10 ppm increments) toward the end of the season. Readings are taken immediately in the field. Besides the meter and the press, the kit comes with a 2-point (20 and 450 ppm) calibration standard which should be used at the beginning of each season or with a change in the membrane. The nitrate-N ion membrane seems to be good for several thousands of readings.

Nutrients: Deficiency and Excess Symptoms

With planting starting, it's a good time to review the canopy and tuber symptoms related to both a deficiency and an excess of the major and some of the minor nutrients needed by potatoes. Factors that influence the deficiencies and excessiveness of nutrients are: soil pH, availability, presence in relation to other nutrients, ion exchange, organic matter, etc. For instance, in calcareous alkaline soils, boron, iron, manganese and zinc are less available to the plant for uptake. Tuber bulking is the stage of potato growth and development at which the most nutrient uptake occurs. Over 90% of the nutrients taken up end up in the tubers. Visual identification of symptoms can be misleading as many are similar to pathogenic symptoms. A chemical analysis of plant tissue is recommended when a deficiency or excess is suspected.

Nitrogen

The amount of N fertilizer for potato production varies with the intended market – tablestock, chipstock, frystock and seedstock. Amount and application timings also varies with the variety grown requiring varietal specific fertilizer management. General recommendations given for N fertilizer are based on residual soil nitrate-N levels. Soil samples should be taken from the 0 to 12-inch depth plus any additional depth of rooting for the specific variety being grown. Nitrogen in the presence of adequate phosphorus and potassium stimulates canopy growth, leaves and branches. It needs to be present from emergence to flowering to promote rapid canopy growth. Table 1 shows the effects of N levels on potato tuber yields (US#1 grade), dry matter content and sugar content of tubers. For tablestock, N fertilization is applied for yield because dry matter content is not a concern. Dry matter

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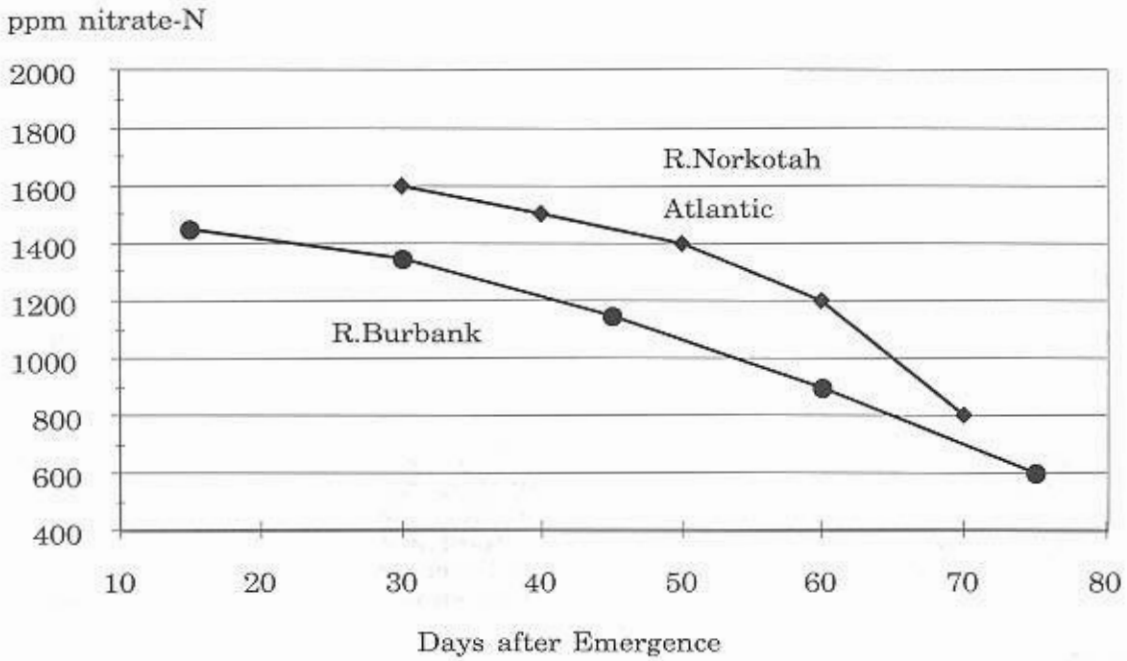
Nitrate Sufficiency Curve Using The Cardy Meter for Maximum Potato Yields



Nutrients: Deficiency and Excess Symptoms

content is critical for potato chip production and less N is applied for varieties going to this market. In French frying, tuber size is most important with yield; so for this market, more N is usually applied but dry matter content is carefully monitored to avoid going too low. Longer season varieties usually need more N to maintain a longer vegetable growth period. Ammonium nitrate effects dry matter content more than ammonium sulfate.

Table 1. **Nitrogen** effects on yield and process quality.

N Rate lb/acre	Effect on US#1 Yield	Effect on % Dry Matter	Effect on Sugar Levels
0-150	Increase	No Change	Decrease
150-400	No Change	Slight Decrease	No Change
>400	Decrease	Decrease	Increase

Nitrogen deficiency symptoms in the canopy are initially characterized by a general yellowing (chlorosis) of older lower leaves. These, in time, will turn brown (necrosis) and die. Young leaves tend to be green and yellow as they mature. Leaf veins stay green while the rest of the leaf turns yellow. Severe deficiency results in slow canopy growth even some stunting, an erect stature and small pale leaves. Tuber appearance doesn't seem affected but there are yield losses associated with very small tubers. Overly mature tubers are harvested and tubers are more susceptible to disease. Process quality is poor due to high sugar and low dry matter contents.

Too much nitrogen results in poor root development. Leaves may roll and deform ("nutrient leafroll"). Excess N around tuberization may delay tuber initiation and growth, and excess N during mid to late bulking can delay tuber maturity and canopy senescence. Tubers are smaller than optimal but many are still marketable, however, there is a yield loss. Tubers are immature, and tend to bruise easily and be more susceptible to diseases. Dry matter decreases with increasing nitrogen and sugar levels increase. This is especially possible with application during bulking. In general, care is needed when applying N after full bloom.

Phosphorus fertilizer application will help to improve quality (e.g., skin maturity and dry matter content) of tubers at harvest when potato crops have excessive nitrogen fertility levels.

Phosphorus

Phosphorus is essential for early plant growth. Since P is immobile in the soil, it can be all added as starter but it needs to be in the root zone. It's placed most efficiently as a band lateral to the seed piece during planting; this raises uptake and lowers P fixation (tying up in soil). Because of the market desire for larger tubers, the amount of P fertilizer is greater for tablestock and frystock potatoes than for chipstock and seedstock. Many soils used in potato production release only small amounts of P for plant uptake during the growing season. Table 2 shows the effects of P levels on potato tuber yields (US#1 grade), dry matter content and sugar content of tubers. For tablestock, P fertilization is applied to increase the proportion of tubers 10 to 11½ oz weight (70-80 count carton). For frystock, P fertilization increase tuber length and the proportion of tubers greater than 10 oz and 16 oz for French frying. No differences were reported between superphosphate, diammonium phosphate or monoammonium phosphate.

Table 2. **Phosphorus** effects on yield and process quality.

P Rate lb/acre	Effect on US#1 Yield	Effect on % Dry Matter	Effect on Sugar Levels
0-50	Increase	Slight Increase	Decrease
above 50	No Change	No Change	No Change
0-100	Increases Larger Tuber Size Grades		

Phosphorus deficiency easily occurs in calcareous soils due to increased P fixation. Leaves do not expand normally resulting in a crinkly appearance and a cup shape. Leaf margins roll upward and the degree of leafroll increases with the severity of the deficiency. They are a darker green and may have brown margins ('scorched'). Lower leaves drop. Severe deficiency can cause stunting and the stems to be spindly. There is a decrease in the root mass, and fewer and shorter stolons are formed. Tubers tend to have rusty-brown spots radially scattered inside. P-deficient plants produce very small tubers having higher sugar and slightly lower dry matter contents, and tending to be overly mature at harvest. Tubers are disease susceptible.

There are no negative effects directly associated with excessive P, but, especially in alkaline soils, too much P can lower the uptake and use of iron and zinc.

Potassium

Most soils cropped to potatoes in Nebraska contain large amounts of potassium (K). The intended market use of the harvested tubers influences the application of this nutrient more than N or P. K promotes larger sizing of potato tubers by increasing water accumulation in tubers resulting in a lowering of dry matter content. This lowering in the percent dry matter (specific gravity) can eliminate tubers from the chipping market. However, percent dry matter is less important for most frystock varieties for which tuber length, blockiness and weight are premiums. Univ. of Idaho recommends high K levels for frying varieties especially Russet Burbank. For tablestock, dry matter content is unimportant. For these two markets, more K may be desired. For seedstock, the target is to keep tubers smaller, 4-8 oz, than the other markets so less K is desired. Table 3 shows the effects of K levels on potato tuber yields (US#1 grade), dry matter content and sugar content of tubers. For tablestock and frystock, as with P fertilization, K fertilization is applied to increase tuber size grades. Dry matter content is decreased most by potassium chloride then by potassium nitrate and even less by potassium sulfate.

Table 3. **Potassium** effects on yield and process quality.

K Rate lb/acre	Effect on US#1 Yield	Effect on % Dry Matter	Effect on Sugar Levels
0-80	Increase	Decrease	Decrease
above 80	Increase*	Decrease	No Change

*Increase Larger Tuber Size Grades.

Deficit of K is most likely in leachable soil types especially sandy soils. Early symptoms of K deficiency are a dark greening or bluish greening of foliage. Leaves appear glossy. Tiny (1/25th inch), light green spots develop between the veins of larger leaves. In the upper canopy, leaf margins curl down and leaflets are small, cupped and crowded. They become crinkled and bronzed on their upper surface, and the lower surface has brown speckles, superficially similar to early blight. Older leaves turn bronze then brown (necrotic) and die early. The key symptom is the overall bronzing of the canopy. A severe deficiency results in short plants with shortened internodes, poor root growth and shortened

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stolons. The stem end of tubers harvested from K deficient plants have small (about 1/10th inch) sunken lesions that, upon drying, hollow out, surrounded by corky tissue. Tubers are predisposed to black spot bruising and are disease-susceptible. Sugar levels are high and dry matter low.

Excess K primarily affects dry matter content, specific gravity, in tubers since K stimulates water accumulation in tubers. Potassium fertilizer application influences the useability of tubers for French fry and potato chip processing differently. For French fries and tablestock, excessive K levels results in most of the tubers to be useable. While, for potato chips, it may result in rejection due to low specific gravity, too much water in tubers. These differences are related to the relative importance of the tuber size and dry matter content. Potato chip processors desire a higher dry matter content while French fry processors and the fresh market want longer tubers and count-cartons, respectively.

Sulfur

The minimum sulfur requirement for potato production is usually satisfied by irrigation water. The water may be tested for S content. In sandy, low organic soils as used in most potato production in the Northern States, a soil test will help determine S deficiencies. To avoid S deficiency symptoms, 25 lb S/acre is sufficient even in the absence of S in the soil or water.

There are no market pressures on S application as there are with N, P and K fertilization. However, there may be disease pressures affecting the desired amount of S fertilization. There is evidence suggesting that higher amounts of sulfur applied in-furrow can substantially decrease tuber infection by common scab and black scurf. Common scab is especially important in the tablestock and chipstock markets and somewhat important in the other two major markets. Black scurf is especially important in the tablestock and seedstock markets. The best form of sulfur to apply is ammonium sulfate (AS) placed in the furrow at planting. Table 4 gives the effect of AS and the equivalent S on these two soil-borne diseases.

Table 4. **Ammonium sulfate** on common scab, black scurf and yield when applied in-furrow at planting.

AS rate lb/acre	Common Scab % Tubers	Black Scurf % Tubers	Effect on US#1 Yield
0-210	Decrease	Slight Decrease	Increase
> 210*	No Change	No Change	No Change

*210 lb of AS gives 50 lb S and 44 lb N.

Table 5. Influence of nitrogen, phosphorus and potassium nutrient status of potato crops on plant characteristics.

Nutrient	Plant Part	
organ	Deficiency	Excess
Nitrogen		
Leaves	interveinal yellowing	"nutrient leafroll"
younger	green to yellow with age	deforming
older	yellow to brown	(severe excess)
Stems	slow growth, stunted erect stature	none
Roots	none	poor development
Phosphorus		
Leaves	crinkled, cupped upward leafroll dark green with brown margins	none
Stems	stunted, spindly	none
Roots	decreased mass	none
Stolons	shortened	none
Potassium		
Leaves	(early) dark - blue green (later) overall bronzing	none
younger	small, cupped, curled down brown specks (underside) crinkled, bronzed (upperside)	
older	bronzed to browning spots between veins	
Stems	stunted, short internodes	none
Roots	poor growth	none
Stolons	shortened	none

Table 6. Influence of nitrogen, phosphorus and potassium nutrient status of potato crops on harvested tuber characteristics.

Nutrient	Plant or Soil Fertility Level	
Deficient	Adequate	Excess
Nitrogen		
Very Small Tubers	Optimal-sized Tubers	Slightly Small Tubers
High Sugar Levels	Low Sugar Levels	High Sugar levels
Low Dry Matter	High Dry Matter	Medium Dry Matter
Few Useables	Most Useable	Many Useables
Over-mature Tubers	Mature Tubers	Immature Tubers
Disease Susceptible	Disease Resistant	Disease and Bruise Susceptible
Phosphorus		
Very Small Tubers	Optimal-sized Tubers	Optimal-sized Tubers
High Sugar Levels	Low Sugar Levels	Low Sugar Levels
Low Dry Matter	High Dry Matter	High Dry Matter
Few Useables	Many Useables	Many Useables
Over-mature Tubers	Mature Tubers	Mature Tubers
Disease Susceptible	Disease Resistant	Disease Resistant
Potassium		
Small Tubers	Optimal-sized Tubers	Optimal-sized Tubers
High Sugar Levels	Low Sugar Levels	Low Sugar Levels
Low Dry Matter	High Dry Matter	Low Dry Matter
Few Useable (fries)	Many Useables (fries)	Most Useable (fries)
Many Useable (chips)	Most Useable (chips)	Few Useable (chips)
Mature Tubers	Mature Tubers	Mature Tubers
Disease Susceptible	Disease Resistant	Disease Resistant

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Updates

Section 24c registrations have been granted for Maxim MZ (Novartis) and MZ cymoxanil (Gustafson) seed treatments.

A new seed treatment may become available next year after this season's trials. It's a mix of TOPS and Admire (Gaucho in grains). This will be a first, an insecticide applied to the seed with a fungicide. This is a Gustafson/Bayer project. (Bayer just bought half of Gustafson.)

Dyfonate will no longer be marketed by Zeneca; it has been voluntarily withdrawn due to the expense of re-registration.

Check out the Nebraska Potato Eyes on the WWW:

http://www.ianr.unl.edu/ianr/phrec/Peyes.htm

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Soil pH affect on availability

The availability of nitrogen, phosphorus, potassium and sulfur for potato growth and development is directly affected by the soil pH. For instance, in stongly acid or alkaline soils, N's availability is limited. Very little P is available even in moderately acidic soils and again around pH 8.5. Table 7 highlights the pH range for these nutrients.

Table 7. Soil pH range for optimal N, P, K, and S availability.

Nutrient	Optimal pH Range	
Nitrogen	6.0-8.0	gradual decrease above & below
Phosphorus	6.5-7.5	rapid decrease below and gradual decrease above to 8.5
	>8.75	very rapid decrease below to 8.5
Potassium	>6.0	gradual decrease below
Sulfur	>6.0	gradual decrease below

Sulfur deficiency is rare. There is a general yellowing of leaves and leaflets exhibit a slight upward roll. This yellowing is first observed with young leaves and is uniform on affected leaves.

There are no negative effects associated with excessive S.