



***Highlights:***

- Nutrient uptake timing information
- Important nutrient ratios
- Important nutrient functions
- Information for water run & foliar nutrient planning
- Nutrients covered: N, P, K, Ca, Mg, Mn, Fe, Zn, Cu & B
- Conclusion: Micronutrient Program

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Peter Aleman,  
Bio-Gro, Inc.

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**Tel: (509)894-4110 - Fax: (509) 894-4105**

# Introduction

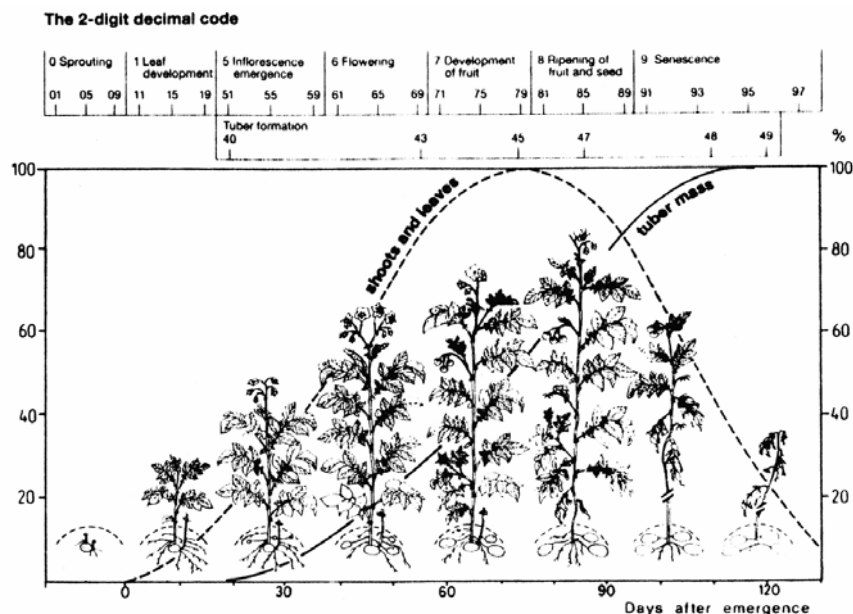
In the following pages; N, P, K, Ca, Mg, Mn, Fe, Zn, Cu & B are discussed. The focus is timing of potato uptake and function within a potato plant. Each nutrient explanation is accompanied with a chart based on nutrient uptake pattern for a 120 day after emergence crop. If your variety (growing area) is more or less, a spreadsheet is available from Bio-Gro, Inc. to adjust the *optimum* nutrient uptake window accordingly.

Based on a spreadsheet calculation of nutrient uptake timing and input numbers from Oregon State University, following are the lbs/acre of uptake in the total plant. The yield goal is 35 tons/acre (700 sacks)

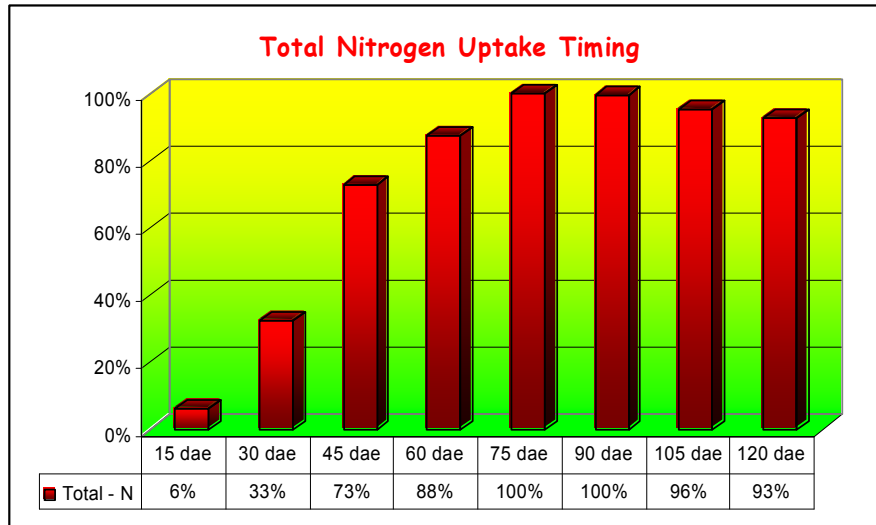
Note: Iron, Zinc, Boron and Copper are only based on the uptake timing of the stems. The uptake timing information only had N, P, K, Ca, Mg & Mn for leaves, stems & whole plant. For Fe, Zn, B & Cu the % of uptake timing for the stems was applied to the total amount required for the whole vine (stems & leaves) and applied to the total amount required for the tubers.

The object of this document is to evaluate the uptake timing of each nutrient and to discuss important facts about each nutrient and how it relates to potato production. The way to *apply* this information;

- 1) How does this timing line up with your program & timing?
- 2) When are you taking a petiole, compared to uptake timing?
- 3) If you preplant a mineral, is it available by the time the potato requires the largest amount?
- 4) Consider P, 54 lbs needed, how much do you put on and why? Minerals?



# Nitrogen



## Nitrogen Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 16     | 87     | 194    | 233    | 266    | 265    | 254     | 246     |
| 30      | 19     | 104    | 233    | 280    | 319    | 318    | 305     | 296     |
| 35      | 23     | 121    | 272    | 327    | 372    | 371    | 356     | 345     |
| 40      | 26     | 139    | 311    | 373    | 425    | 424    | 406     | 394     |

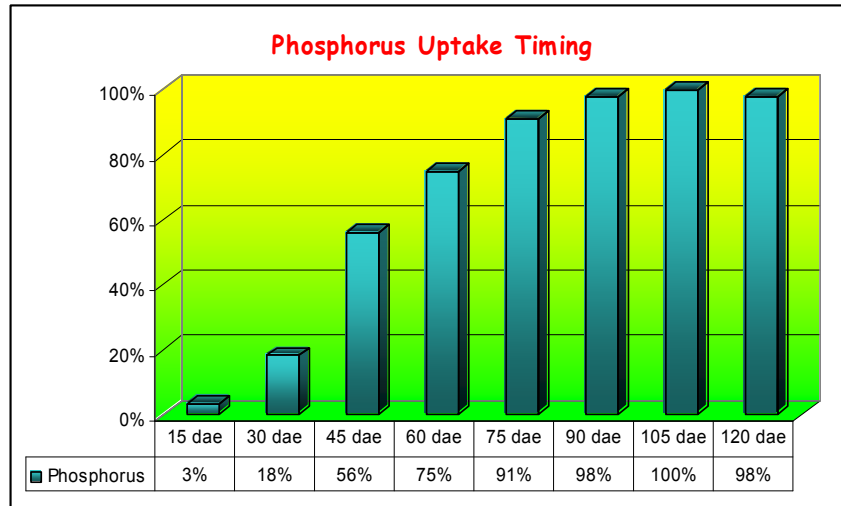
Nitrogen management in potato production is likely quite well understood and developed at this time. It is not the objective of this publication to change N application and management.

However, it does bring up some questions on the current N timing practices. The DAE period is set for a variety that grows for 120 days. The large increase in N usage between 15 & 45 DAE is likely related to the time the plant begins to grow on its own to full row closure and maximum vine length. Therefore, depending on the variety, it may be necessary to extend or shorten this window.

## ***Nitrogen Facts:***

| Nitrate N – <b>GROWS</b> a plant                                                                                                                                                                                                                                                                                                                                                                  | Ammonia N – <b>GREENS</b> a plant                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>➤ The plant continually absorbs nitrate as long as it exists in the soil.</li> <li>➤ Nitrate uptake can be depressed by ammonia.</li> <li>➤ An anion (NO<sub>3</sub>) is needed to increase uptake of important cations like K.</li> <li>➤ Nitrate uptake decreases as the soil pH goes above 6.0.</li> <li>➤ High Nitrate Suppresses P &amp; S</li> </ul> | <ul style="list-style-type: none"> <li>➤ Ammonia is toxic to a plant unless it is taken up with a carbon source to make an amino acid.</li> <li>➤ Ammonia requires carbon; uptake takes energy (carbon).</li> <li>➤ Plants high in ammonia uptake tend to be shorter than high in nitrate uptake.</li> <li>➤ Ammonia N uptake is optimal at neutral pH and lower in acidic pH soils.</li> <li>➤ High ammonia suppresses K, Ca &amp; Mg.</li> </ul> |

## Phosphorus



### Phosphorus Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 3.5    | 18     | 56     | 75     | 92     | 99     | 101     | 99      |
| 30      | 4.2    | 22     | 68     | 91     | 110    | 118    | 121     | 118     |
| 35      | 4.9    | 26     | 79     | 106    | 128    | 138    | 141     | 138     |
| 40      | 5.6    | 29     | 90     | 121    | 147    | 158    | 161     | 158     |

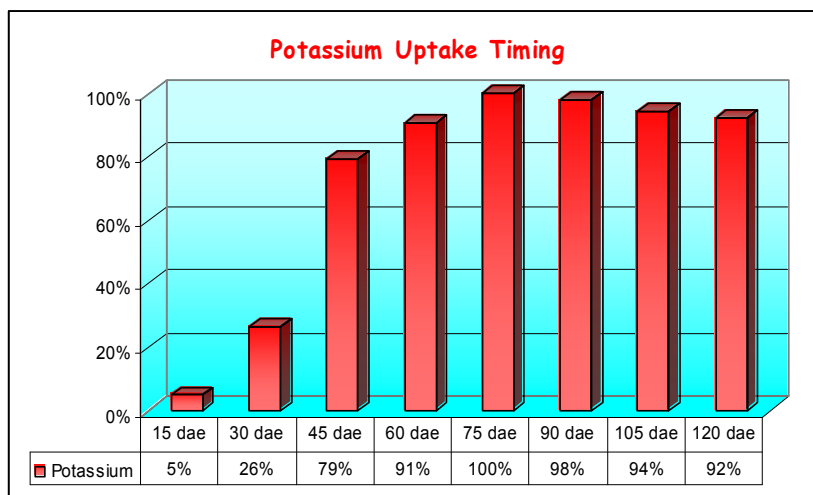
Like nitrogen, much of the P accumulated in the vine, is translocated down to the tubers. Unless soil pH ranges from 6.5 to 7.0, the most important part of P management is considering its availability at the optimum window of plant usage. Water running 10-34-0 or acid treatment with CHB 0-40-0, at the 15 to 45 dae range is optimum.

Foliar feeding P, especially in the form of  $H_2PO_4$ , is an excellent method of delivering P. However, many times not enough is used to make a significant difference in plant phosphate levels. According to P uptake information, a vine requires about 11 units of P and a tuber about 43 units of which 30+ units originates from the vine. Foliar feeding two applications of a minimum of 2 gal/ac NUE 8-22-0 will supply 25% of a vines total P requirement. Timing it at  $\frac{1}{2}$  &  $\frac{3}{4}$  of vine length would be good.

### ***Phosphorus Facts:***

- ✓ Low spring soil temperature suppresses P uptake.
- ✓ Although calcareous soils tie up P, increased Ca in solution increases P uptake because calcium stimulates transport of P into the cell. (NUE 8-22-0 mixes with Cal-8 and CN9) Total ratio P:Ca is about 0.9:1.
- ✓ Magnesium also stimulates the reactions in a plant involving P transfer. Total ratio of P:Mg is about 1.1 : 1
- ✓ High petiole iron can mean suppressed P availability and translocation.
- ✓ High P can suppress Zn. The total level of P is reached at 45 dae, whereas Zn is at 45% of total uptake at 45 dae. Optimum ratio of P:Zn is 142:1.
- ✓ Low P levels reduce translocation of starch from leaves.

## Potassium



### Potassium Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 26     | 143    | 427    | 489    | 540    | 529    | 510     | 499     |
| 30      | 31     | 172    | 513    | 587    | 648    | 635    | 612     | 599     |
| 35      | 37     | 200    | 598    | 684    | 756    | 740    | 714     | 699     |
| 40      | 42     | 229    | 683    | 782    | 864    | 846    | 816     | 799     |

85% of the total K content of vine is translocated to the tubers. At 45 dae to 90 dae, 75% of the K is translocated to the tuber. After 75 dae, ½ of the K should be already in the tuber.

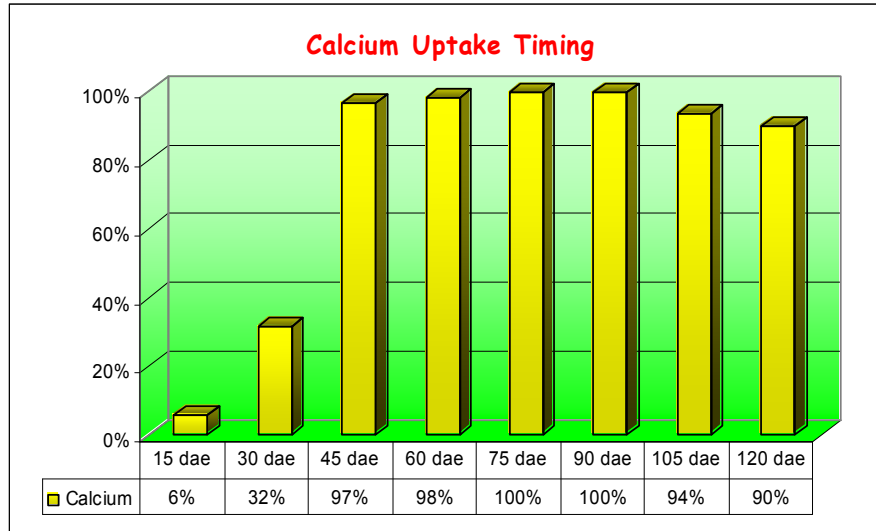
The NPK ratio of the whole plant is about 8:1:9, in short K is as important as nitrogen. Problem: Petiole testing for K is not an accurate indicator of K availability. K is very mobile in plants, therefore a petiole test indicates that K is low at the end of a 2' to 3' vine.

Water running 2 gallons of CHB Premium 6 at row closure has demonstrated 1-2% increases in petiole K, bloom is the optimum uptake timing for K in many plants, including potatoes. Water running K after bloom is not the most efficient method.

### **Potassium Facts:**

- ❖ K is involved is required for the accumulation (starch in tubers) and translocation (sugar to tubers) of sugars from photosynthesis.
- ❖ Growth is slowed when sugars accumulate in the vines (hot days = good photosynthesis + warm nights = poor translocation = poor solids)
- ❖ High N increases disease pressure, High K decreases disease pressure.
- ❖ K & N fertilization must be balanced; high K suppresses N in young plants and high N with low K results in increased "stem" growth & poor tuber development.
- ❖ Generally, high nitrate increases K uptake, whereas high ammonia suppresses K. Sufficient Ca nullifies the negative effect of ammonia on K.
- ❖ High K has a greater suppressing effect on Mg or Ca then either of these two has on K.
- ❖ High K suppresses the uptake of Calcium, ratio of K:Ca is 8.2:1.
- ❖ Soil uptake of K is more suppressed by low soil oxygen contents (over watering) than any other nutrient. Good water management = Good K uptake.
- ❖ At bloom stage, many plants can "luxury feed" K.
- ❖ Two important timings for K; Bloom (row closure) and bulking (60 dae to 80 dae).

# Calcium



Calcium Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 2.2    | 13     | 39     | 39     | 40     | 40     | 37      | 36      |
| 30      | 2.7    | 15     | 46     | 47     | 48     | 48     | 45      | 43      |
| 35      | 3.1    | 18     | 54     | 55     | 56     | 56     | 52      | 50      |
| 40      | 3.6    | 20     | 62     | 63     | 63     | 64     | 60      | 57      |

Note that almost NO calcium is translocated back the tubers. Calcium uptake is restricted to the growing tip of young roots. Once the outer cells of a root hair suberize, or root growth ceases, plants no longer take up Ca efficiently. Calcium uptake is closely correlated with K uptake, however, roots can assimilate K longer than Ca. Therefore, Ca should be applied in high amounts before high amounts of K.

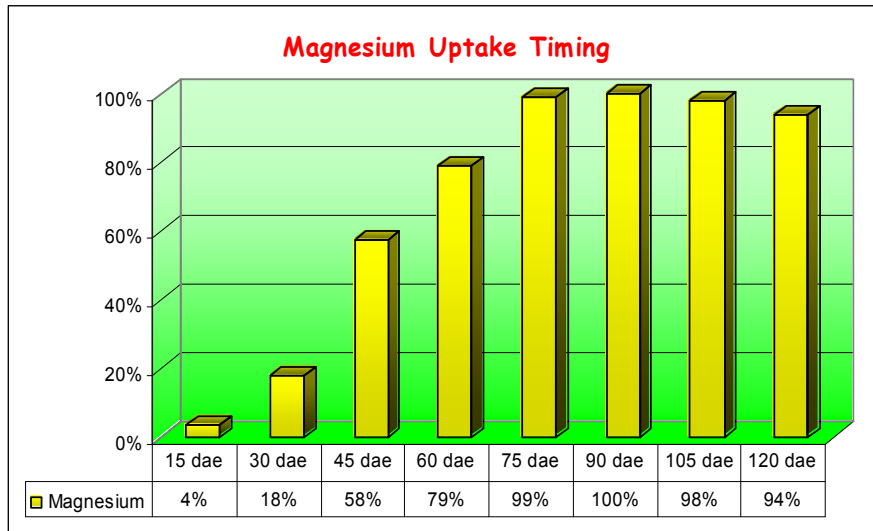
The golden rule in understanding calcium management in potatoes is that the reason potatoes bulk quickly is due to the limited amount of calcium in the cell wall. One ton of vine will contain up to 1.53 lbs of actual calcium, whereas one ton of tubers contains only ¼ lb of actual calcium (ratio of 6:1).

Bio-Gro, Inc. is the first company to implement a SAP-Calcium monitoring program. We have discovered that increases SAP-Calcium increase root development late in the growing season.

## Calcium Facts:

- ❖ Calcium uptake is suppressed by; NH<sub>4</sub>, Mg, K and then Na, in decreasing order.
- ❖ Ammonium can suppress Ca, while nitrate can increase calcium by supplying anions (negative charge) and triggering the root to excrete organic acids (especially important in high pH soils).
- ❖ Ca:Mg ratio in the foliage is 2:1 and in the tuber 1:2.
- ❖ Calcium & Boron are synergistic!
- ❖ Nitrate N is an anion for increased cation (Ca) uptake. Root uptake of nitrate also stimulates the production of organic acids for Ca uptake. Ammonia (a cation) can suppress Ca uptake. (CAN17 verses CN9?)

# Magnesium



## Magnesium Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 1.2    | 5.9    | 19     | 26     | 33     | 33     | 33      | 31      |
| 30      | 1.5    | 7.1    | 23     | 32     | 40     | 40     | 39      | 38      |
| 35      | 1.7    | 8.3    | 27     | 37     | 46     | 47     | 46      | 44      |
| 40      | 1.9    | 9.4    | 31     | 42     | 53     | 53     | 52      | 50      |

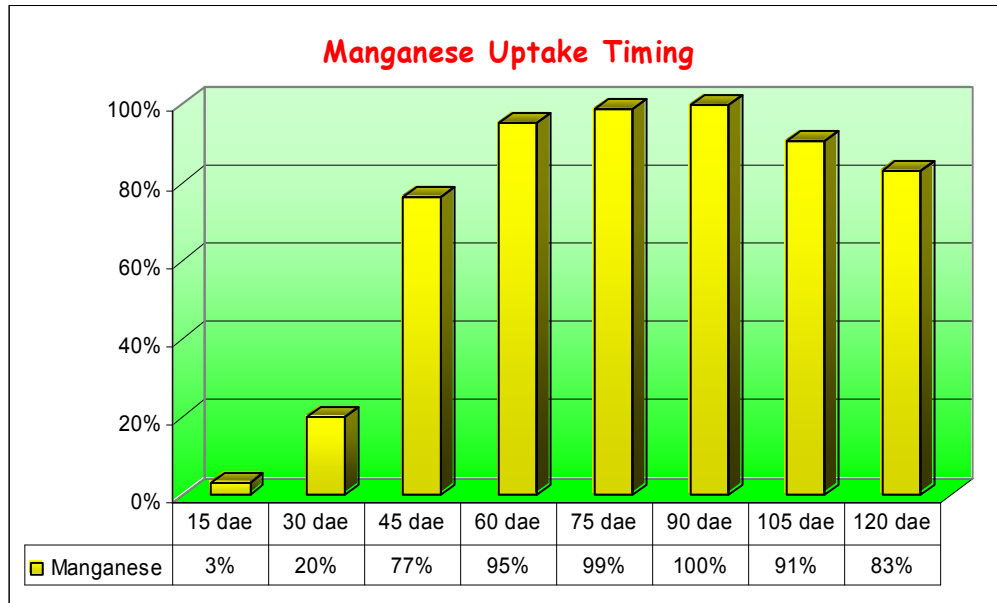
Magnesium is known because of its association with chlorophyll. However, if more than 20% of the plant's Mg is in the chlorophyll, it will suffer. In short Mg plays many other important roles in potato production. Due to the high demand of K, magnesium is often suppressed, especially in low CEC soils with low natural levels of Mg. This means that it should be supplied (in sufficient quantity) like other nutrients. Like Ca, magnesium is suppressed by high amounts of K. However, timing is important.

Calcium is taken up more efficiently by newly forming roots (optimum application window = 15 to 35 dae). Potassium is taken up readily, however optimum uptake timing is in the 30 to 60 dae window. Magnesium is accumulated in the leaves from 45 to 75 dae, slightly latter than K. Timing: Calcium > Potassium > Magnesium. Run the last 10-15 units of N with Magnesium Nitrate!

### ***Magnesium Facts:***

- ❖ Mg is mobile in phloem (can move into fruit), unlike Ca.
- ❖ Mg uptake is suppressed by; K, NH<sub>4</sub>, Ca and then Na (in decreasing influence).
- ❖ Calcareous soils (75-85% of CEC as Ca) with less than 15% Mg (less than 20% in CEC lower than 7.0) is a good candidate for water run Mg.
- ❖ Mg suppresses degradation of chloroplasts in older tissues. Mg is mobile from old growth to new growth. Supplying Mg late in the season will help keep vines alive longer.
- ❖ Starch translocation from the chloroplasts is reduced in low Mg leaves, before visual Mg a deficiency (yellowing) occurs.
- ❖ Low Mg results in lower levels of starch (solids) in potato tubers. This is negative affect is greater in higher temperatures, because Mg inhibits oxidation of chloroplasts.

## Manganese



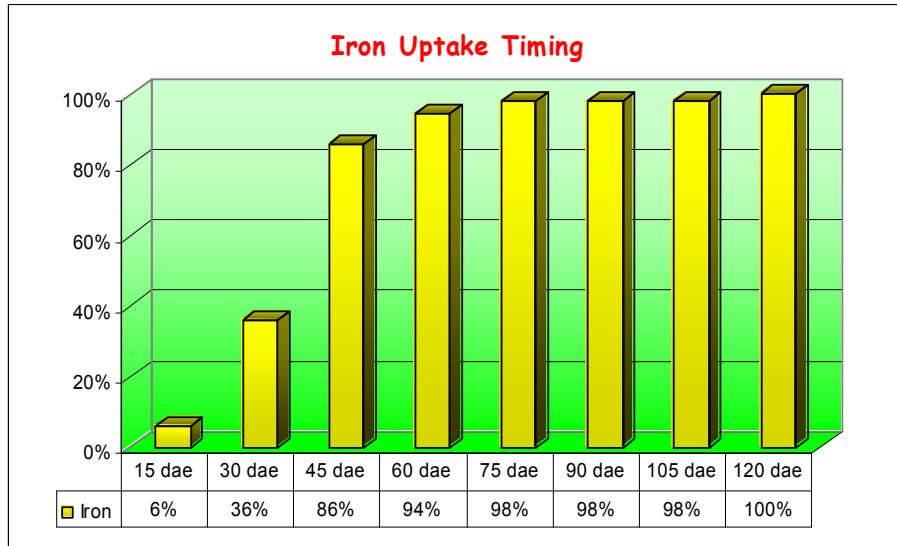
### Manganese Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 0.06   | 0.38   | 1.5    | 1.8    | 1.9    | 1.9    | 1.7     | 1.6     |
| 30      | 0.08   | 0.46   | 1.8    | 2.2    | 2.3    | 2.3    | 2.1     | 1.9     |
| 35      | 0.09   | 0.53   | 2.1    | 2.6    | 2.7    | 2.7    | 2.4     | 2.2     |
| 40      | 0.10   | 0.61   | 2.3    | 2.9    | 3.0    | 3.1    | 2.8     | 2.5     |

Manganese is primarily involved in photosynthesis processes. It should be supplied as the canopy develops. Actually, directly involved in the photosynthesis process are 5 atoms of Mn, compared to 4 atoms of Mg. Mn is most deficient in soils contain free carbonates (calcareous soils) and soils irrigated with high bicarbonate water.

Mn is required in relatively low levels. However, due to possible tie up, it is recommended to soil test for Mn availability at 20 to 30 dae. If soil ppm is low, water run & foliar apply Mn. Mn is antagonistic with Fe; an excess of one will suppress uptake and translocation of the other. Plants containing unusually high petiole/tissue levels of iron should be foliar fed with Mn as the canopy develops.

# Iron



**Iron Accumulation in Units/Acre in Relation to Yield**

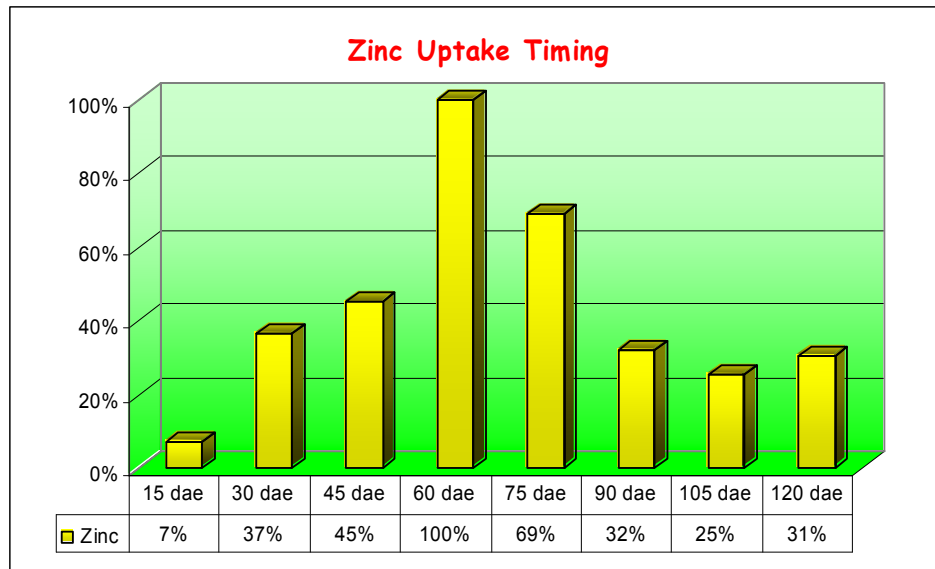
| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 0.02   | 0.09   | 0.22   | 0.25   | 0.25   | 0.25   | 0.25    | 0.26    |
| 30      | 0.02   | 0.11   | 0.27   | 0.29   | 0.31   | 0.31   | 0.31    | 0.31    |
| 35      | 0.02   | 0.13   | 0.31   | 0.34   | 0.36   | 0.36   | 0.36    | 0.36    |
| 40      | 0.02   | 0.15   | 0.36   | 0.39   | 0.41   | 0.41   | 0.41    | 0.42    |

80% of the iron is found in chloroplasts, directly involved in photosynthesis. To place it in comparison to Mg, there are 17-18 atoms of Fe, to 5 atoms of Mn to 4 atoms of Mg to 1 atom Zn to 1 atom Cu directly involved in the photosynthesis "production line."

Problem: Tissue testing Fe levels is not an accurate method of testing for biologically active iron. On the contrary, accumulating levels of Fe are usually (especially in calcareous soils) an indication of poor Fe activity.

Solution: Water run Fe with other minerals such as Zn, Mn & Cu during the optimum period of uptake; 20 to 45 dae. Iron is required by potatoes at much higher levels than Zn, Mn or Cu. Ratio in vines is 73 Fe : 3.8 Zn : 5.6 Mn : 1 Cu. Iron could be classified as a "secondary nutrient."

## Zinc



**Zinc Accumulation in Units/Acre in Relation to Yield**

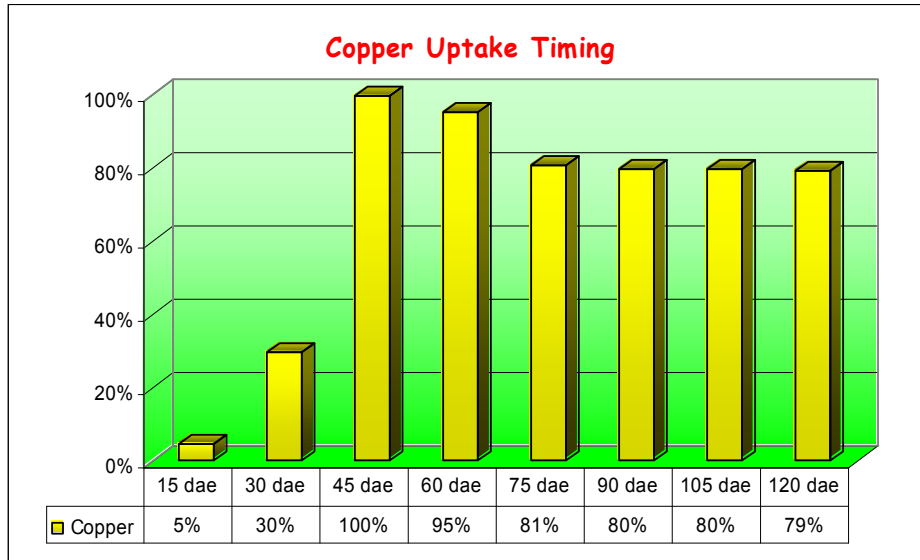
| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 0.01   | 0.07   | 0.09   | 0.19   | 0.13   | 0.06   | 0.05    | 0.06    |
| 30      | 0.02   | 0.08   | 0.10   | 0.23   | 0.16   | 0.07   | 0.06    | 0.07    |
| 35      | 0.02   | 0.10   | 0.12   | 0.27   | 0.18   | 0.09   | 0.07    | 0.08    |
| 40      | 0.02   | 0.11   | 0.14   | 0.31   | 0.21   | 0.10   | 0.08    | 0.09    |

Zinc is different from other micronutrients in 2 ways; it is taken up latter in the growth phase and 50%+ of the vines zinc is translocated to the tubers.

An enzyme (aldolase) requires Zn to function. In most plants, this enzyme regulates the transfer of carbohydrates from the chloroplast into the cell body. The effect of Zn on this enzyme is so specific, that the activity of this enzyme has been proposed as an indicator of the Zn nutritional status of plants. This suppression of carbohydrate translocation is evident long before visual deficiencies of zinc (small leaves) occur. Potatoes are quite simply an accumulation of starch; starch comes from sugar (carbohydrate) produced in the chloroplast, moved into the cytoplasm by Zn, which slows down before Zn is visually deficient. (The little things you don't see are what hurt you the most!)

It is known that high soil P suppresses Zn uptake and translocation. Ratio in potato vines of P:Zn is about 150:1.

# Copper



**Copper Accumulation in Units/Acre in Relation to Yield**

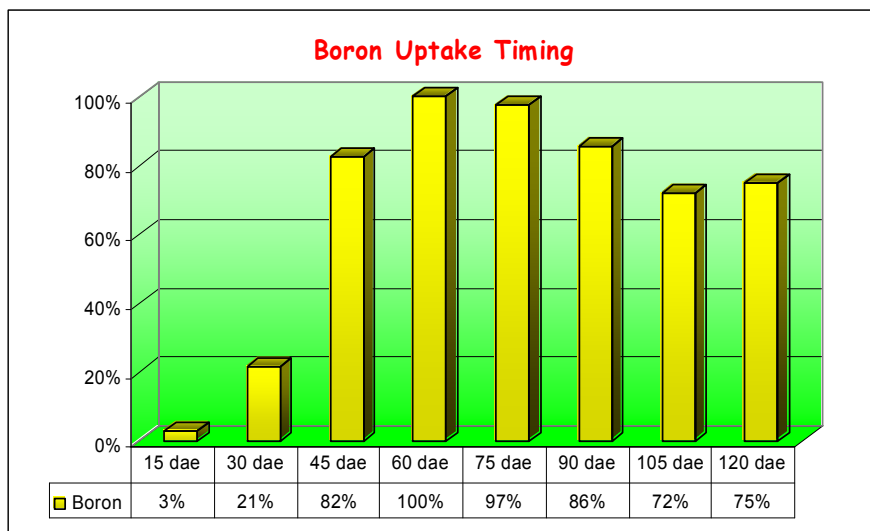
| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 0.01   | 0.07   | 0.22   | 0.21   | 0.18   | 0.18   | 0.18    | 0.18    |
| 30      | 0.01   | 0.08   | 0.27   | 0.25   | 0.21   | 0.21   | 0.21    | 0.21    |
| 35      | 0.01   | 0.09   | 0.31   | 0.30   | 0.25   | 0.25   | 0.25    | 0.25    |
| 40      | 0.02   | 0.11   | 0.35   | 0.34   | 0.29   | 0.28   | 0.28    | 0.28    |

Copper availability is strongly affected by both calcareous soils (solubility) and high nitrogen usage. Copper is easily "chelated" by amino acids.

High nitrogen is related to high amounts of free amino acids (especially with low K). These amino acids retard the translocation of Cu to new growth. Therefore, Cu should be applied in small amounts throughout the major development of the canopy.

Cu doesn't play a direct role in the chlorophyll development (the green of plants), but leaves low in copper utilize up to 50% less CO<sub>2</sub> (the main ingredient for sugar) than sufficient leaves. Excess copper may suppress uptake of Zn, but is thought to stimulate the uptake of Mn. Ratio of Zn : Mn : Cu in potato vines is 3.8 : 5.6 : 1. Ratio of N : Cu in vines is 4,600 : 1.

## Boron



### Boron Accumulation in Units/Acre in Relation to Yield

| Tons/Ac | 15 dae | 30 dae | 45 dae | 60 dae | 75 dae | 90 dae | 105 dae | 120 dae |
|---------|--------|--------|--------|--------|--------|--------|---------|---------|
| 25      | 0.00   | 0.03   | 0.12   | 0.15   | 0.15   | 0.13   | 0.11    | 0.11    |
| 30      | 0.01   | 0.04   | 0.15   | 0.18   | 0.18   | 0.16   | 0.13    | 0.14    |
| 35      | 0.01   | 0.05   | 0.17   | 0.21   | 0.21   | 0.18   | 0.15    | 0.16    |
| 40      | 0.01   | 0.05   | 0.20   | 0.24   | 0.24   | 0.21   | 0.17    | 0.18    |

Boron is an "interesting" element in potato production. It is generally recognized as one of the least understood elements in crop production.

Boron can be "toxic" to many plants including potatoes; therefore the low recommended levels of soil availability. One contributing factor of this toxicity is that plants quite easily take it up, but poorly translocate boron. Boron "toxicity" is directly related to calcium deficiency. This is illustrated by the fact that calcium added to soils high in boron helps decrease boron toxicity, especially in high pH soils. Boron availability is therefore reduced in calcareous soils.

### ***Boron Facts:***

- ❖ Low B suppresses bioactivity of phosphates (ratio of P:B in vines is about 80:1)
- ❖ High K suppresses B content of plants
- ❖ Ca:B ratio is very important, but ratio requirement varies between plants (potato vines = minimum 300:1)
- ❖ The most rapid response to B deficiency is loss of root growth (Ca is picked up through newly growing root tips). Cytokinins are produced by the root & translocated to the vine.
- ❖ Low B causes "plugging" of phloem (starch pipeline to tubers) due to any increased formation of callose. Building the canopy is equivalent to building a structure, which holds up "solar collectors" (leaves) and a pipeline system (xylem – up, phloem – down).
- ❖ Boron is poorly translocated, therefore required throughout the development of the canopy. It is a major micronutrient in vines, but less important in tuber development.
- ❖ Boron suppresses the destructive action of certain phenols in plant tissues, by complexation.
- ❖ These compounds are usually increased in high light intensity (hot days). Boron protects the plant, but is "used up" in the process.

## Micronutrient Summary

Evaluating the ratios of micronutrients is also an important exercise. First it shows that Fe (iron) is more like a secondary nutrient than a micronutrient. Therefore, when soil levels (especially in high pH) are lower than 15-20 ppm, iron could very well be a limiting factor.

Secondly, one sees the importance of boron in relation to Zn, Mn and Cu. Boron is much more soluble and available, but it is very immobile once in the plant.

Ratios of micronutrients in potatoes;

|        | <b>Fe</b> | <b>Zn</b> | <b>Mn</b> | <b>Cu</b> | <b>B</b> |
|--------|-----------|-----------|-----------|-----------|----------|
| Vines  | 73        | 3.8       | 5.6       | 1         | 4.9      |
| Tubers | 18        | 2.3       | 1         | 1.3       | 1        |

Micronutrients are an overlooked aspect of potato production, especially in high pH soils. Although required in small amounts, soil availability is a key aspect that many times is overlooked and applications are not adequate to supply available nutrient at the time needed.

For example, we recommend complete soil tests throughout the growing season, especially on problem fields. In one area we noted the following zinc levels in early June, a critical uptake period for zinc;

**“Fate” of Zn....**

| Field                  | Amt Zn    | Level 6/5 |                               |
|------------------------|-----------|-----------|-------------------------------|
| 1 <sup>st</sup> Circle | 0 lbs     | 1.1 ppm   | 28 lbs of ZnSO <sub>4</sub>   |
| 2 <sup>nd</sup> Circle | 10 lbs Zn | 3.3 ppm   | 1 ac = 43,560 ft <sup>2</sup> |
| 3 <sup>rd</sup> Circle | 10 lbs Zn | 0.6 ppm   | 1 lb/1,555 ft <sup>2</sup>    |
| 4 <sup>th</sup> Circle | 10 lbs Zn | 0.7 ppm   | (50' X 30' shop)              |
| 5 <sup>th</sup> Circle | 10 lbs Zn | 0.8 ppm   |                               |
| 6 <sup>th</sup> Circle | 10 lbs Zn | 1.4 ppm   |                               |

Notice that in spite of a 10 unit per acre application of preplant zinc, the June 5<sup>th</sup> level is still below adequate. Also consider the effectiveness of a broadcast application of zinc in a fertilizer blend. Even at a high rate (10 units/ac = 28 lbs/ac of zinc sulfate), it would still be like spreading a quart jar of zinc prills over a 1500 square foot area. Measure this out and try evenly spreading a quart jar of fertilizer. This is a very poor application.

The most effective way of micronutrient applications is in the planter band or side dressed, followed by water runs of a liquid micronutrient package and foliar applications during the development of the canopy. Attempting to foliar feed micronutrients late in the growing season is basically a waste of money. When one considers the dry matter accumulation rate of the canopy (6" to Row Closure) is usually 3 weeks, most micronutrients have a very narrow band of optimum application timing.

In the Bio-Gro CFS program we side band small amounts of Zn, Mn, Cu, Fe and B; based on soil analysis. At 6" we recommend a complete soil (with saturated paste extract) and we will recommend a water run micronutrient. Based on this information and a photosynthesis meter test, we will come up with a custom foliar nutrient blend for foliar feeding during canopy development.

## Bio-Gro CFS Summary

The sole purpose of this document is to point out the nutrient uptake timing of potatoes. We have implemented similar programs in onions and tomatoes, with similar enlightening results.

One of the most obvious points to take from this whole presentation is that in our business we take a soil test in spring or fall, throw out some nutrients, plant the crop and take the first petiole about ½ way to row closure. When one considers that it takes 2-4 days to respond to a petiole, the optimum window of opportunity has expired about 60% to 70%!

Add to this another overlooking fact; the first petiole is always good! Young, fast growing plants always look at test pretty good; therefore this first petiole rarely shows a deficiency that would alarm anyone. Therefore, by the time a second petiole is taken and one calculates the 2-4 days response time; the optimum window for Ca, Mn, Cu, Fe, B and a good part of Mg and Zn are past!

WATER is also a critical aspect of nutrient uptake; for calcium and magnesium it is essential to take saturated paste extracts of the soil from emergence to full row closure to monitor the effect of irrigation water on the levels of calcium, magnesium, sodium and bicarbonate in the soil solution. This also has an impact on Zn, Mn, Cu and Fe; although difficult to measure.

At Bio-Gro, Inc., we have a complete approach to nutrient management and the ability to put the known aspects of soil chemistry and plant physiology to work for you. Call Bio-Gro, Inc. today.

