Managing Fertilizer Applications for Improved Quality

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Main Points

- Nitrogen fertilizer applications that result in total available N (soil + fertilizer) above 350 lbs/acre did not increase total yield of Russet Burbank grown in Southeastern Idaho and tended to decrease tuber size, resulting in reduced carton yields.
- Petiole nitrate-nitrogen levels above 15,000 ppm in mid-August result in poor net development.
- It is important to balance nitrogen applications with adequate phosphorus, but keep in mind that high P does not reduce all the negative impacts of too much N.
- Potassium levels low enough to reduce yields have been shown to increase susceptibility to blackspot bruise. However, applying K above the level needed for optimum yield does not further reduce bruise susceptibility, and may decrease net development and specific gravity.
- Calcium has been shown to have an impact on bruise susceptibility in very sandy soils with low Ca availability.

We get a lot of questions about how fertilizer applications affect overall tuber quality, especially as it relates to skin set, net development and bruise susceptibility. This is an area that has actually been the subject of a lot of research, starting almost a century ago. While there are numerous reports on the impact of both macro and micronutrients on quality, most of the consistent results are associated with just four main nutrients – nitrogen, phosphorus, potassium and calcium. This article takes a more in depth look at each of these nutrients and the role they play in quality.

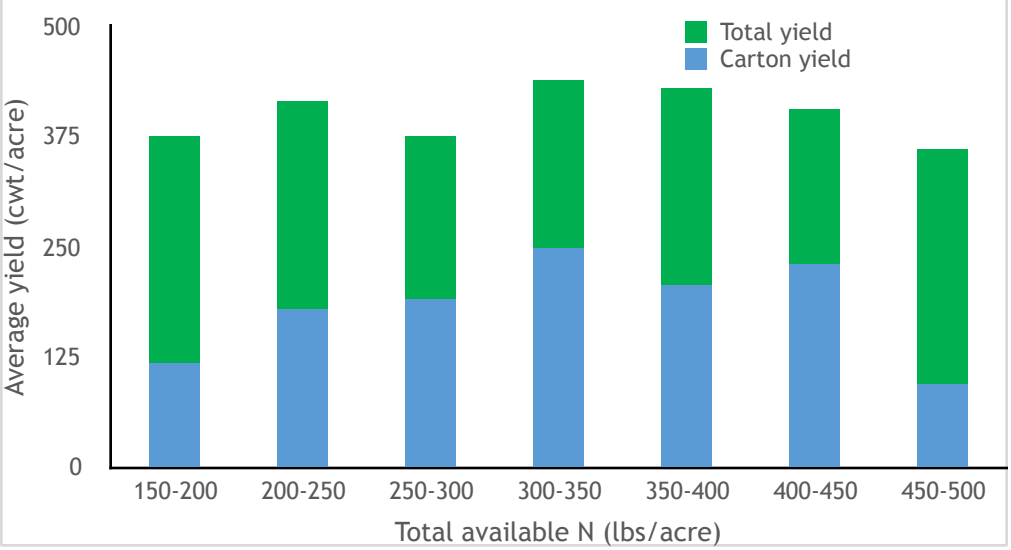
Nitrogen

Nitrogen fertilizer timing and amount can have big effects on bruise susceptibility due to the relatively large impact on maturity. Inadequate nitrogen can result in early crop senescence, and an increase in susceptibility to blackspot bruise if the tubers sit under dying or dead vines for a long period prior to harvest. A study in Idaho found that susceptibility of Russet Burbank tubers to blackspot bruising greatly increased when more than 70% of the vines in the field were dead prior to vine kill.

In contrast, excessive nitrogen (especially late in the season) can delay crop maturity, resulting in lower specific gravity and increased susceptibility to skinning and shatter bruise. We believe that late nitrogen applications can also contribute to increased susceptibility to blackspot bruise in situations where vines remain lush and using a lot of water towards the end of the season during the period where the root system is starting to decline. This can increase the risk for dehydration of tubers prior to vine kill, resulting in greater blackspot bruise susceptibility.

So how much is too much nitrogen, and how late is too late to apply? It is hard to make sweeping generalizations due to all the differences in yield potential, crop rotations, and varieties grown across Idaho, but there are some studies that give us a clear picture of the consequences of over-fertilizing with nitrogen. Jeff Stark led a study in the mid-1990's that looked at yield and quality on over 40 commercial Russet Burbank potato fields in Southeastern Idaho, and related the results to fertilizer applications (Figure 1). After averaging the yields for all of these fields and comparing them to the N application rates, they found that both total yield and carton yield peaked at around 300 to 350 lbs/acre of total available nitrogen (preplant soil N + fertilizer N). Applying higher amounts of nitrogen did not increase yield, but reduced tuber size to the point that fewer of the tubers were large enough to be packed in cartons.

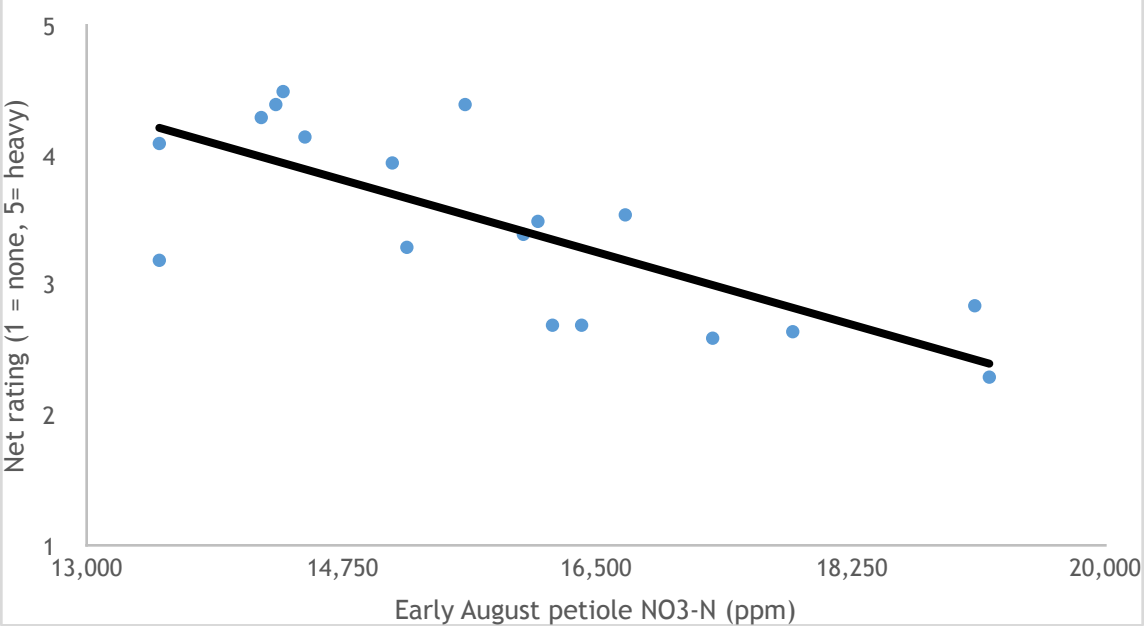
Figure 1. Yield as influenced by preplant soil NO_3-N plus fertilizer N.



Source: Stark, et al. (1996). Information management systems for on-farm potato research. Progress report to the Idaho Potato Commission.

They also found that applying nitrogen late in the season had negative impacts on net development (i.e. poor skin development). Fields that had petiole nitrate levels above the recommended level of 15,000 ppm by the second week of August had much poorer netting than those with lower petiole levels (Figure 2) and netting continued to decrease as petiole nitrate levels increased.

Figure 2. Relationship between tuber net rating and early August petiole NO3-N for 18 grower fields.



Source: Stark, J.C. (1987). Effect of late-season management on tuber quality. Proceedings of the University of Idaho Winter Commodity Schools.

We have noticed that some growers have been really pushing the limits on total nitrogen applications, and keep applying nitrogen fertilizer after mid-August in an attempt to increase yields. However, research indicates that tuber bulking slows down greatly after the end of August (Table 1). This is partly due to reduced leaf area as the crop starts to senesce and many of the lower leaves start to yellow and die. However, even if you manage to keep the vines green late in the season bulking rate still drops off due to the shorter days (fewer hours of sunlight) and lower temperatures (less optimum for growth) that occur in September.

Table 1. Yield increase over each two week period at Aberdeen, ID during the last 8 weeks of the growing season in 2003 – 2004.

	Two week period			
	July 31 to Aug 14	Aug 15 to Aug 28	Aug 29 to Sept 11	Sept 11 to Sept 25
Variety	---------- Yield increase (cwt/acre) ----------			
Russet Burbank	104	28	5	1
Russet Norkotah	18	2	0	0

Russet Norkotah (CO3)	103	62	27	10
Alturas	141	107	46	15
Ranger Russet	117	69	30	11
Shepody	116	43	11	2

Source: Bohl, W.H. and S.L. Love (2005). Potato tuber bulking greatly slows in late season. The Spudvine.

Phosphorous

In contrast to N, Phosphorous tends to facilitate tuber maturity and net development. Research in Idaho has shown that higher nitrogen rates, and later applications of nitrogen, require higher soil P concentrations to maximize specific gravity and net development. However, adding high rates of P will only partially correct the negative effects of excess N on tuber maturity. Keep in mind that phosphorus is primarily taken up by the root tips during active growth. Once the root system stops growing and starts to decline the uptake of P by the plant is greatly reduced. This means that application of phosphorus fertilizer after mid tuber bulking is not very effective.

Potassium

One of the earliest reports on blackspot bruise noted a direct relationship between potassium fertilizer amounts and susceptibility. When potassium is deficient in the plant the tubers produce more tyrosine. This is the compound that is oxidized into the black pigment seen when bruised tubers are peeled. Many growers have upped their potassium fertilizer programs in an attempt to optimize yield, but also to reduce bruise susceptibility. The problem is that research in Idaho has shown that when soil K concentrations are adequate for yield, additional fertilizer applications do not further reduce bruise susceptibility. However, excessive K fertilizer has been shown in some studies to also reduce specific gravity and net development, so over fertilizing can have negative impacts on tuber quality.

Keep in mind that if petiole tests show a deficiency in potassium at mid-season, it takes about three weeks after an application for the K to get taken up into the plant and produce a response. So just like for phosphorus, late season applications of K fertilizer are not very effective.

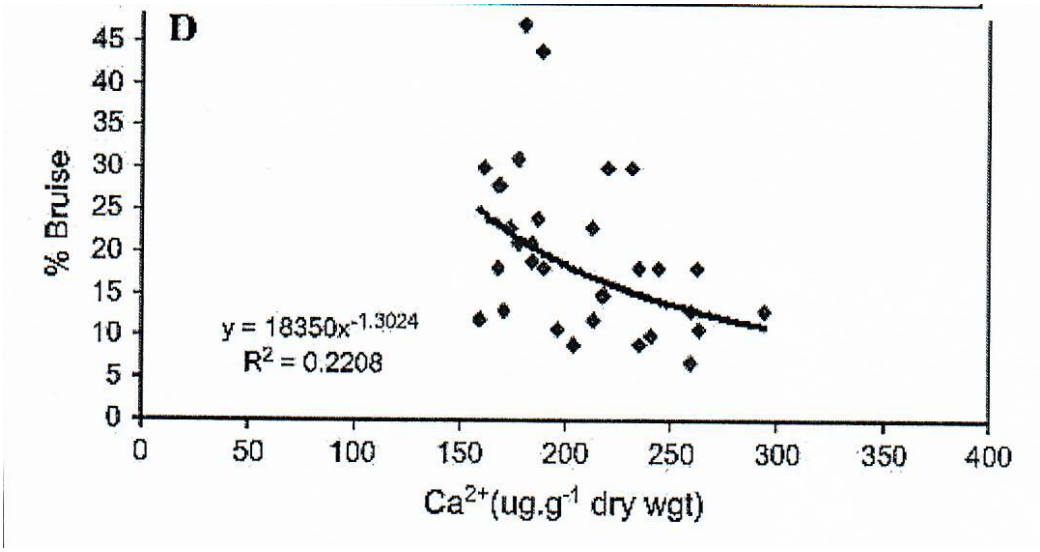
Calcium

Calcium is thought to have an influence on bruise susceptibility through its effect on the strength of cell walls. Cells with higher calcium content have been shown to have higher resistance to deformation and fracturing from impacts that occur during handling. Most of the data on the relationship between calcium and bruise susceptibility comes from central Wisconsin, where they grow potatoes on very sandy soils with low Ca content (Figure 3). The authors of that study reported that bruise susceptibility tends to be lowest in all varieties when tuber calcium concentration is above 200 to 250 micrograms per kilogram dry weight. However, note that high

calcium content does not eliminate bruise, it only reduces the level. It is not known if low tuber calcium level plays much of a role in bruise susceptibility on the heavier soils that are most commonly found in southern Idaho potato production.

Calcium uptake is somewhat similar to phosphorus in the sense that active root growth is required. Therefore, the most effective uptake occurs from early season applications.

Figure 3. Relationship between incidence of bruise during mechanical harvest and calcium concentration of medullary tissue over three seasons in Russet Burbank.



Source: Karlsson, B.H., J. P. Palta and P.M. Crump (2006). Enhancing tuber calcium concentration may reduce incidence of blackspot bruise injury in potatoes. HortScience 41(3): 1213-1221.