Best Management Practices for Nitrogen Fertilization of Potatoes

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With the tightening of profit margins and the desire to reduce environmental impacts, application timing and rates become an important strategy for growers to increase efficiency of fertilizer use and to reduce N-leaching. The potato research team at the University of Florida is developing BMPs to increase N use efficiency for potato production and to reduce N losses to the environment.

With approximately 25,000 acres of winter and spring potatoes, Florida is an integral part of the supply chain for freshly harvested potatoes in the United States, providing over a third of the nation's spring potatoes. Fertilizer for potato production in Florida accounts for more than 15% of the total production cost while cost for N fertilizers has increased by up to 350% since 2000 (USDA-NASS, 2013). Available N in the soil is highly soluble and is prone to leaching in Florida's sandy soils, especially during large rainfall events; therefore N application should be targeted to times of highest plant uptake to increase efficiency.

Nitrogen use efficiency has been well characterized for potatoes grown in the cooler climatic conditions of the Pacific Northwest. In contrast, the climate in northeast Florida is considerably warmer, which results in a shorter growing season where potatoes are planted during late winter and the season extends through early June. Seepage irrigation is utilized as a traditional method for water supply. Nitrogen fertilizer is traditionally applied to the soil at three key stages to supply the crop: first at about 30 days before planting when the field is being fumigated, second at plant emergence, and third when the plants are in vegetative growth stage (6 to 8 in. tall).

A study was conducted in 2011 and 2012 aimed at determining an optimal N rate for commercial potato production for Florida. Both years were characterized by overall rainfall below the historic average. This study was performed with grower collaboration in three locations throughout northeast Florida growing potato variety 'Atlantic.' Each field was supplied water through a seepage irrigation system. In this system, water is applied to the field along furrows (shallow open ditches) spaced every 16 planted rows (60 ft.) throughout the field. Water then permeates down through the soil profile and water table is raised up from an impermeable layer to just below the root zone, allowing soil capillary action to bring the water up into the range of the roots.

The experimental design was factorial with two factors: N rate at plant emergence and sidedress N rate at the 6 to 8 in. growth stage. In accordance with common grower practice, all plots received 50 lb/A of N as ammonium-nitrate (AN 34%N) at fumigation (about 30 days before planting). At plant emergence, 20 to 30 days after planting, the second application of N was applied at 0, 50, 100, or 150 lb/A from liquid urea ammonium nitrate (UAN 32%N). Subsequently, 40 to 50 days after planting, the final application of N (UAN) was sidedressed at rates of 50 to 100 lb/A. Total seasonal N rates ranged from 100 to 300 lb/A. The potato season was broken into six key stages, with soil and/or tissue sampling occurring at each: 1) Fumigation and pre-plant fertilization, 2) Planting, 3) Plant emergence and fertilization, 4) 6 to 8 in. stage and final fertilization, 5) Full flower, and 6) Harvest. Nitrogen content within the soil and N uptake into the plant were monitored throughout the season and potato yields were compared among treatments for the two years of the study.

Abbreviations and Notes: N = nitrogen; ppm = parts per million; BMPs = Best Management Practices. IPNI Project #FL30.

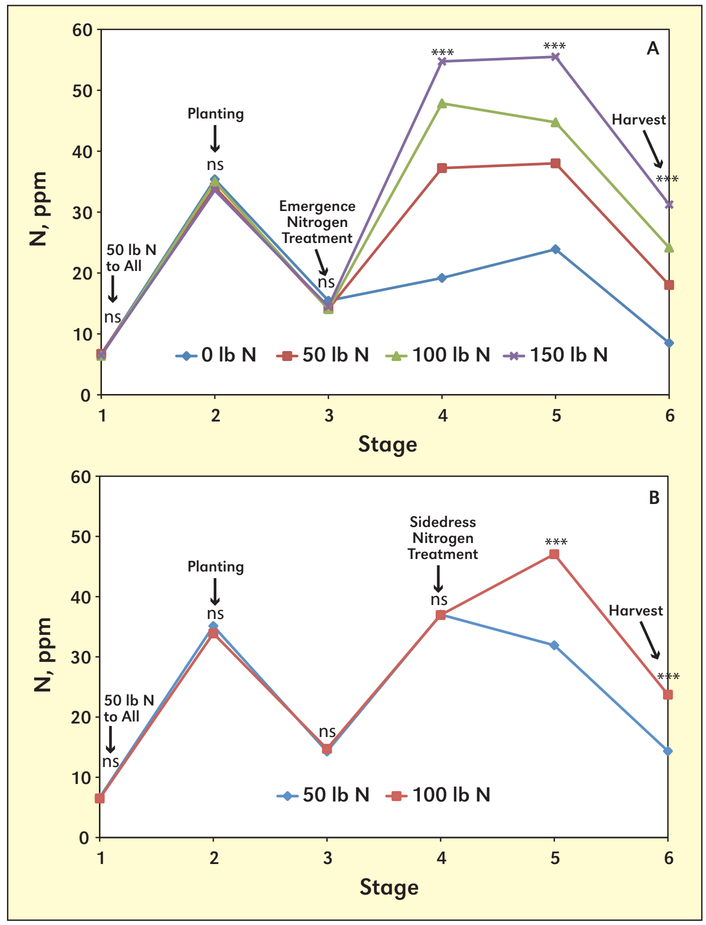

Figure 1. Soil mineral N content at 0 to 8 in. soil depth layer. Soil N content in response to emergence N rate application (A) and sidedress N rate application (B). ns = not significant, *** = p = 0.0001.

Soil Nitrogen Content

Soil N content throughout the season is shown in **Figure 1**. Before the potato seasons started the residual soil N was about 7 ppm mineral N (nitrate and ammonium). The preplant application of 50 lb N/A to all treatments increased the soil N to 34 ppm measured at planting. This residual decreased by more than 50% before plant emergence. Reduced soil N

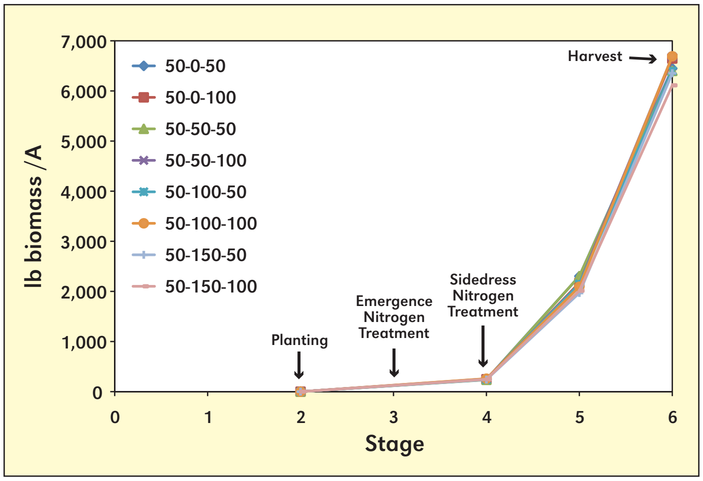

Figure 2. Total plant dry biomass (leaves, stems and tubers). There were no significant main effects or interactions from emergence N rate or sidedress N rate on plant biomass. p = 0.05.

content coincided with recent heavy rainfall events. Previous research has shown that potato plants do not draw N out of the soil until plant emergence, and rely on the seed-piece up to that point (Ewing, 1978). However, **Figure 1** shows that N concentration in the soil has decreased between stage 2 and 3, despite the fact that the plants were not taking it up from the soil during this time. As plant emergence did not occur until approximately 60 to 70 days after the first N application, it is likely that N has been lost due to leaching through the soil profile due to heavy rains, or volatilization into the atmosphere.

Following N treatments at emergence and 6 to 8 in. growth stage, soil N increased relative to N treatment application. Fertilizer rates above 200 lb N/A left 22 to 39 ppm mineral N in the soil after harvest.

Plant Biomass and Nitrogen Content

Fertilization treatments at emergence or 6 to 8 in. growth stage had no effect on plant dry biomass and by the end of the

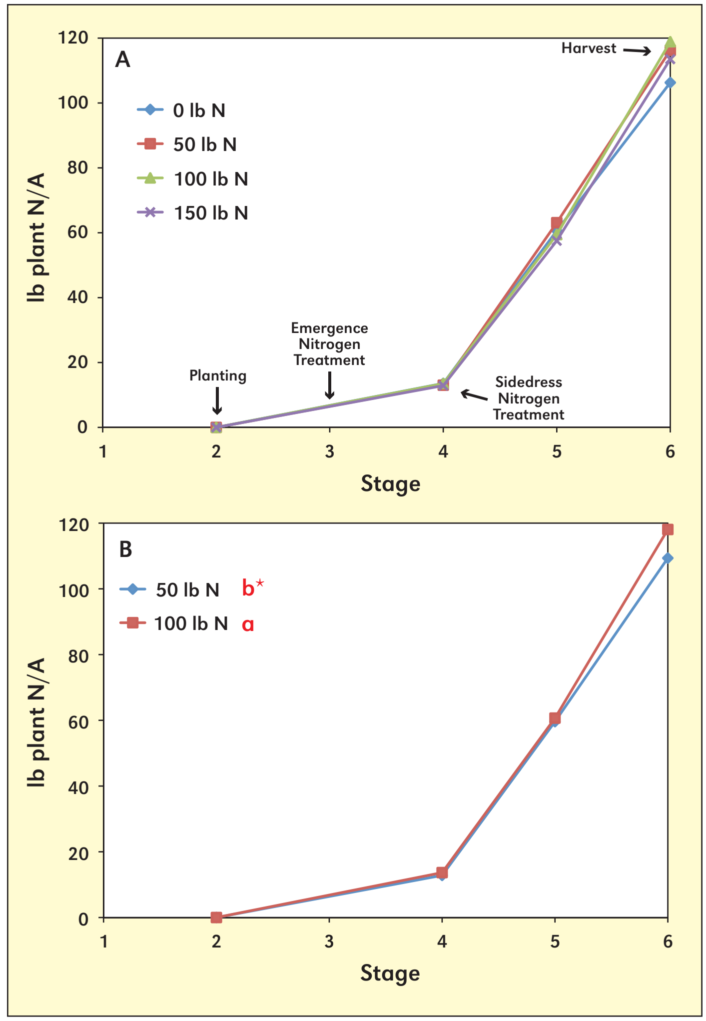

Figure 3. Plant N accumulation (aboveground and tubers). A) There were no significant effects on plant N accumulation due to emergence N. B) Plant N accumulation in response to sidedress N. *Treatments with the same letter are not significantly different at p = 0.05.

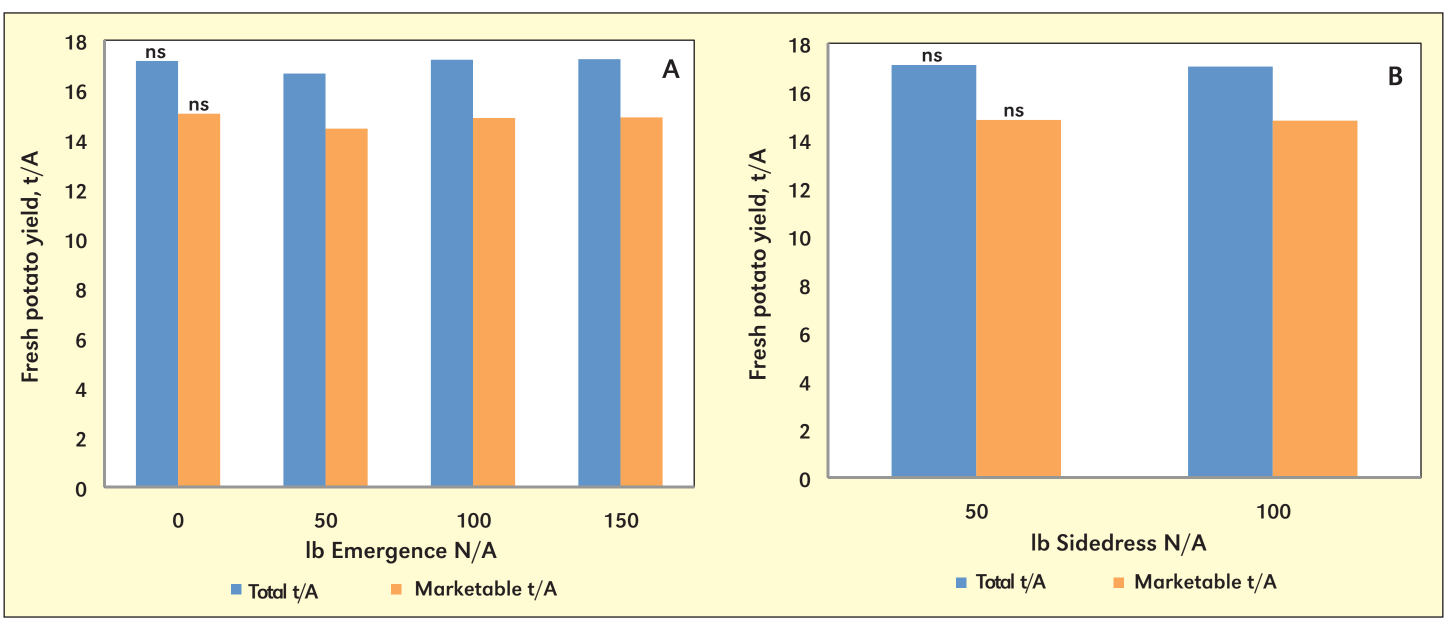

Figure 4. Total and marketable potato yield. A) Emergence N application had no main effect on potato yield. B) Sidedress N application had no main effect on potato yield. p = 0.05.

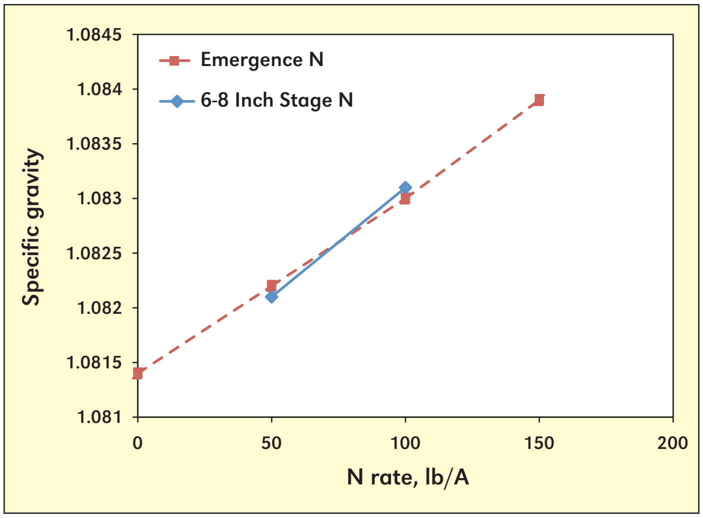

Figure 5. Specific gravity of potato from N treatments at plant emergence and 6 to 8 in. growth stage.

season the potato crop accumulated an average of 3.2 t/A of dry biomass (**Figure 2**). The potato tissues (leaves, stems and tubers) accumulated 98 to 111 lb N/A of over the season (**Figure 3**). There was no difference in plant N accumulation from the emergence N application. At the 6 to 8 in. growth stage the addition of 100 lb/A as compared to 50 lb/A slightly increased plant N, without an increase in potato yield (**Figure 4**).

Yield

Total potato fresh yield ranged between 16.5 and 17 t/A with no difference in yield from the N fertilizer rates at either application stage. Potato specific gravity was affected by both fertilizer applications, with higher values resulting from higher rates of fertilizer at both the emergence stage ($p = 0.0001$) and 6 to 8 in. growth stage ($p = 0.0001$) (**Figure 5**). Higher specific gravity of tubers is preferred as it indicates higher dry matter content of the potato which benefits the frying process.

Conclusion

In this study potato was supplied with total N rates ranging from 100 to 300 lb/A with treatments varying the levels of N at the emergence and 6 to 8 in. sidedress stages. These treatments were verified with soil N concentration tests reflecting the relative application rates applied.

Nitrogen added at the 6 to 8 in. stage only slightly affected plant N content; however this effect did not carry over into yield. Perhaps the most economically useful result of this study for growers is that there was little effect of the N treatments on Atlantic potato yield in dry years such as 2011 and 2012. This means that growers can save money by applying less N at sidedress without negatively impacting yield in dry years.

The results presented in this paper are part of the research program for BMPs for irrigation and fertilization of potatoes. Complementary studies are being carried out to evaluate the benefits of pre-plant N fertilization as well as irrigation management on potato production in northeast Florida. BC

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