Improving nitrogen use efficiency in vegetable production systems

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INTRODUCTION

The first question we may ask of our production systems is how efficient are we with our nitrogen (N) fertilizer use. But the answer to this can be tricky. There are many different ways to calculate nitrogen use efficiency (NUE) (as many as 14 have been identified!), but for the sake of simplicity, the paper will focus on four of them:

Partial factor productivity (PFP, yield / N applied) – this is a simple measure that can be used to survey an area. For example, if you know what your yield is and how much N you applied, you can compare this to previous years, across fields, and across the industry. This ratio can be used to calculate the economic cost of production.

Agronomic efficiency (yield gain over yield without N fertilizer / N applied) – this measure lets you know what you actually get when you apply fertilizer. For example, if you were able to get 100 bu/ac of corn with no fertilizer, but only 120 bu/ac of corn with 100 lb/ac of N, you really only earned 20 bu/ac of corn with the 100 lb/ac of N you applied. The ability to calculate the PFP relies on having yield data from an area not receiving N fertilizer.

Partial nutrient balance (N content of the harvested portion of crop / N applied) – this measure allows growers to know what their N balance is in their field. An ideal cropping systems has a partial nutrient balance of 1, where the amount of N applied is equivalent to the amount of N removed. The goal would be to obtain a partial nutrient balance as close to 1 as possible without sacrificing economic yield. A variation on this would be to calculate the difference between N exported from the system (as yield) and N imported (as applied N). If the difference is negative – this is the amount of N that was either lost from the system, remains in the soil, or remains in the crop residues.

Recovery efficiency [(N content of whole plant receiving N fertilizer – N content of whole plant not receiving N fertilizer) / N applied] – this measure assesses how much of the N applied actually ended up being utilized in the plant. In most cases, we cannot measure all of the plant material, specifically the roots. So this is often referred to as the "apparent" recovery efficiency, as we typically only collect above ground biomass, or in the case of potato, vines and tubers.

On sandy soils, using these NUE to evaluate agronomic systems also provides indications to the impact on groundwater quality, as any improvements in NUE will likely lead to a reduction in nitrate leaching losses.

NITROGEN USE EFFICIENCIES OF CENTRAL SANDS CROPS

Potato

Table 1. Tuber nitrogen uptake, total potato plant nitrogen uptake, partial nitrogen balance, and apparent recovery efficiency of potato across three nitrogen management practices in 2010 and 2011.

Year	N management	Tuber N uptake	Total N uptake	PNB	RE
		----------lb-N/ac ----------		---------- % ----------	
2010	250 AS/AN	101 a	145 a	40 b	35
	250 ESN	103 a	129 a	41 b	29
	200 ESN	98 a	134 a	49 a	39
	None	47 b	56 a		
	P>F	<0.001	<0.001	0.03	ns
2011	250 AS/AN	169 a	251 a	68 b	78
	250 ESN	178 a	244 a	71 b	75
	200 ESN	184 a	243 a	92 b	93
	None	121 b	138 b		
	P>F	<0.001	<0.001	0.002	ns

Sweet Corn

Table 2. Ear nitrogen uptake, total sweet corn above ground biomass uptake, partial nitrogen balance, and apparent recovery efficiency of sweet corn across three management practices in 2011.

Year	N management	Ear N uptake	Total N uptake	PNB	RE
		----------lb-N/ac ----------		---------- % ----------	
2011	200 AS/Urea	60 a	156 a	30 b	62 b
	170 ESN	45 b	105 b	30 b	48 b
	150 AS/Urea	58 a	151 a	38 a	79 a
	None	6 c	33 c		
	P>F	0.001	0.001	0.05	0.05

Snap Beans

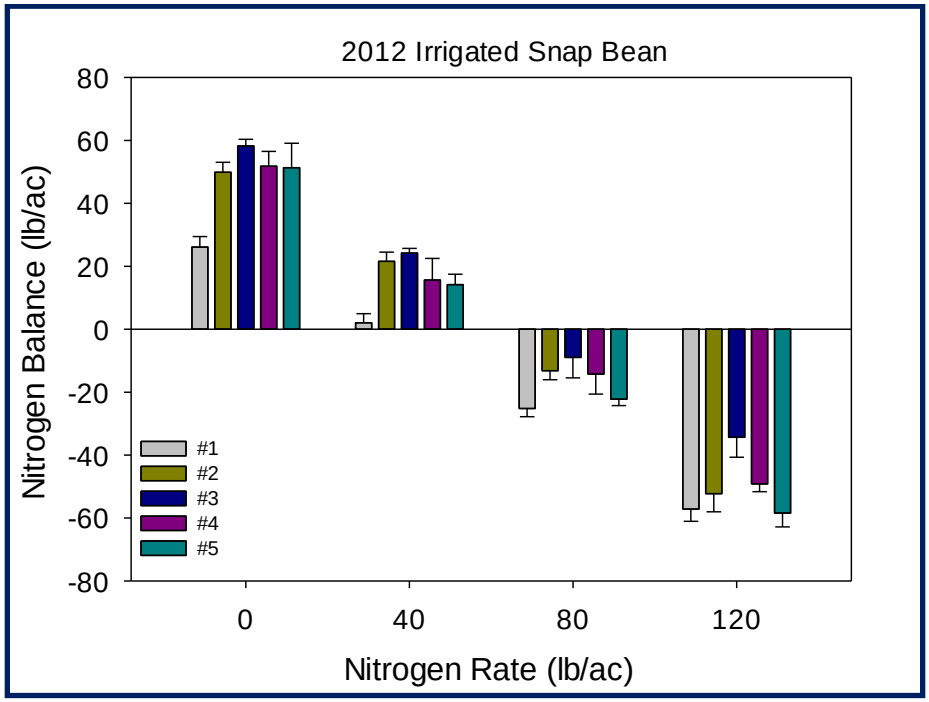

Figure 1. Nitrogen balance (N removed in pods – N added) across four nitrogen rates in snap bean. Colors represent different varieties. Error bars are standard error.

How can we improve?

Potato. For potato, which has a high N demand, and often needs supplemental N, improvement will come through use of controlled-release fertilizers (and understanding of release rates of these products) and improved in-season diagnostics (petiole testing,

Sweet corn. For sweet corn, which may be the closest of all the crops in terms of optimizing nitrogen use efficiency, the improvements will come from a reduction in N rate, with extra N only being applied when circumstances dictate they should.

Snap bean. For snap bean, we still have a lot to learn about what is the true NUE of these systems. When fertilizer N is added, this will delay or inhibit nodulation and N fixation. But when no fertilizer N is applied N fixation occurs much quicker. Subtracting the N uptake from the no-N plots may not be scientifically valid because this N uptake is just coming from another source (the atmosphere) and not necessarily the soil.

All crops. What is needed across all cropping systems is a better understanding of how rainfall amounts, intensity, and timing influence the amount of N leached out of the system. This will allow for efficient applications in-season. To date, nitrate leaching models have not been evaluated or used as a decision tool. Future research in the Central Sands will be to evaluate the usefulness of such models.