Correlating a Ureide Tissue Test for Soybean with Field Inoculation Studies

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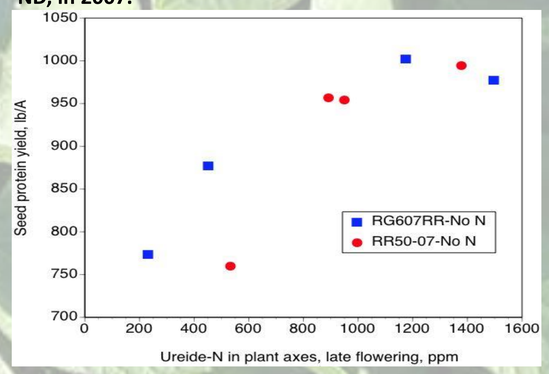
Introduction

Nitrogen requirements for soybean [*Glycine Max* (L.) Merr.] are usually provided via the symbiosis with Bradyrhizobium sp. Nitrogen flows from the roots of soybeans to the above ground biomass in the form of nitrate from the soil solution or from ureides created in nodules. The concentration of ureide-N in the plant is directly related to the activity of N fixation in the nodules. A new, simpler method for ureide analysis has been developed (Goos et al., 2015). The main objective of these studies was to relate the response of soybean seed and protein yield with the ureide-N concentrations of plant samples. A secondary objective was to correlate the number of soybean rhizobia in the soil prior to planting to the response of soybean to inoculation.

Materials and Methods

A previous inoculation study in 2007 in Carrington, ND, indicated that ureide-N levels of 1200-1500 ppm or greater were associated with adequate N fixation by soybean at flowering stage (Figure 1). Field inoculant studies were conducted in 2015 and 2016 in Minot, ND using different inoculation methods and soybean cultivars. The design was a RCBD with six replicates. The studies were conducted in soils with no history, or a limited history, of soybean production. Soil tests and counts of nodule-forming bacteria in soil were measured prior to planting. At V2-V3 growth stage and again at late R2 growth stage, plants were sampled. Leaf blades were separated and the remaining plant was analyzed for ureide-N (Goos et al. 2015). Plots were harvested when mature, and seed yield, protein content, and percent oil were determined.

Figure 1. Relationship between ureide-N in plant axes at late flowering and seed protein yield, Carrington, ND, in 2007.



Results

The highest yield and protein were observed when soybean seed was inoculated with two different forms of bacteria (Table 1). The 2016 Minot location had no history of soybean production, but the yield and protein response were similar for single and double inoculations. However, a significant difference was observed comparing inoculated to the untreated control. The yield response to double inoculation in 2016 was not significant compared to a single application. However, the protein and seed yield were correlated to high ureide-N levels at the R2 growth stage. This study suggests counts of nodule-forming bacteria in soil at planting of greater than 100 g^{-1} of soil are associated with adequate N fixation without inoculation. Bacteria counts of less than 10 g^{-1} of soil are associated with a significant plant response to seed inoculation (Figures 2 and 3).

Table 1. Effect of soybean inoculant type on ureide concentrations in plant axes, seed yield, protein content, protein yield, and oil content in Minot, ND.

Effect of type soybean inoculation on ureide concentrations in plant axes, seed yield, protein content, protein yield, and oil content in Carrington and Minot, ND, 2015 and 2016.

Treatment	Ureide in axes V2-3	Ureide in axes R2	Seed yield	Protein conc.	Protein yield	Oil conc.
	ppm N		bu/A	%	lb/A	%
2015						
Control	180	442	38.1	32.2	737	16.3
Liquid	158	605	35.5	31.4	668	16.6
Granular	116	1008	35.5	31.9	679	16.4
Both	142	1552	45.5	33.3	908	15.8
LSD (0.05)	NS	391	5.9	1.2	NS	0.4
2016						
Control	139	332	16.2	29.0	282	18.7
Peat	285	807	34.1	33.0	653	16.3
Granular	520	1494	33.3	34.6	627	15.9
Both	789	1326	33.7	35.6	720	15.2
LSD (0.05)	140	376	3.4	1.4	70	0.4

Figure 2. Relationship between ureide-N in plant axes at late flowering and seed protein yield, Minot, ND in 2015.

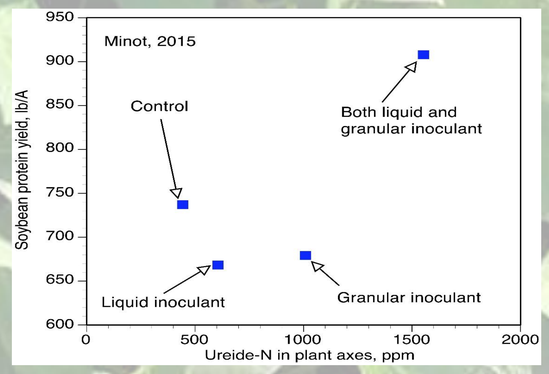
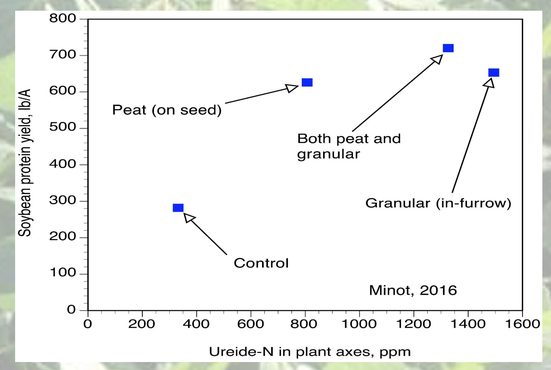


Figure 3. Relationship between ureide-N in plant axes at late flowering and seed protein yield, Minot, ND in 2016.



Discussion

Results from 2015 and 2016 were similar, but in 2016 the single inoculation of peat or granular resulted in similar yield to the double inoculation treatment. In 2015, the double inoculation resulted in significantly higher yields. The ureide concentrations at the R2 growth stage for the untreated in 2015 and 2016 were similar, but the seed yield was much greater in 2015. The differences observed in yield versus ureide-N levels for each year suggest that factors other than just N status contributed to yield. Protein content and protein yield were significantly higher for the double inoculated treatments and represent a method to increase protein content. Soybean produced in the northern tier of the US tends to have lower protein than southern states.

For all three site years, a ureide-N level of 1200-1500 ppm at the R2 growth stage was associated with the highest seed protein yields, while values of 1000 ppm or less were associated with inadequate N fixation.

Conclusions

Based on these data, ND soybean producers with little or no history of soybean production should use two types of Bradyrhizobium sp. for inoculation to ensure enough inoculation is present and ureide concentrations are above minimal levels.

When the ureide test is properly calibrated, it can be used as a simple test to predict the N-fixing system in soybean. This test also may be used to evaluate new soybean inoculant products.

Reference

Goos, R.J., N. Abdraimova, and B.E. Johnson. 2015. Method for determination of ureides in soybean tissues. Commun. Soil. Sci. Plant Anal. 46:424-429.

Appreciation is extended to the ND Soybean Council for funding support.