In-season Fertilization for High Yield Soybean Production

By R.E. Lamond and T.L. Wesley

The soybean is a nutrient dense, high protein seed. Consequently, nutrient requirements of a soybean crop are rather high. One bushel of soybeans contains more than 3.5 lb of N, 0.9 lb of P_2O_5, and 1.3 lb of K_2O in the grain alone. Symbiotic N_2 fixation supplies N for soybeans. In most cases, preplant or planting-time N applications are not recommended. Their effects on soybean grain yield have been measured in many studies with inconsistent results.

What are the reasons for the inconsistencies? Many factors are likely involved. The fact that successful N_2 fixation in soybeans is dependent on bacteria which can be affected by many factors such as soil pH, moisture, temperature, fertility, organic matter, and soil nitrate-N (NO_3-N) levels complicates the situation. Whenever symbiotic N_2 fixation is slowed or stops, fertilizer N may become more important. Additionally, well nodulated soybean roots don't necessarily guarantee efficient N_2 fixation. Any one or all of the soil parameters mentioned can play a role in whether or not soybeans will respond to N fertilizer application.

Most states do not generally recommend preplant or planting time N fertilizer for soybean production. Some states do recommend some fertilizer N where soybeans have never been grown before or on ground coming out of the Conservation Reserve Program (CRP). This is in addition to a recommendation for thorough seed inoculation.

> Kansas research showed that soybean yields were increased by late-season nitrogen (N) fertilization at six of eight sites. Differences between N rates were minimal, and N sources performed similarly. In nearly all cases, 20 lb N/A was sufficient to achieve the positive responses noted. The two nonresponsive sites had yields below 50 bu/A. Results suggest that soybeans with high yield potential (greater than 55 bu/A) may not be able to supply enough N during peak demand via atmospheric N (N_2) fixation.

Late-Season Supplemental N Fertilization

Past research has shown the period of peak N demand in soybean production is during pod fill or growth stages R1 to R6. The N demand at this time is great, and fixed N alone may not be enough to meet it. Both soil N and fixed N may be necessary for maximum soybean yield, particularly under high-yield environments.

Producers of irrigated soybeans are now routinely achieving yields in excess of 60 bu/A. A 70 bu/A soybean crop requires nearly 250 lb N/A to be translocated into the developing seeds during pod-fill. Late-season supplemental N may increase yields in these instances. In addition, future soybean marketing strategies may include protein and oil concentrations. Late-season supplemental N also has potential to affect these seed quality considerations. We initiated work in Kansas in 1994 to evaluate the effects of late-season N fertilization on the yield and protein and oil contents of irrigated soybean with high yield potential.

This research was conducted in 1994 and 1995 at four irrigated sites. Several N rates and sources were evaluated at each location as shown in the following details.

Locations: Johnson County (JO94, JO95), Shawnee County (SN94, SN95), Reno County (RN94, RN95), Stafford County (SF94, SF95)

N Rates: 0, 20, 40 lb N/A applied at R3 growth stage (first pods 1/4 to 1/2 in. long)

N Sources: urea ammonium nitrate solution (UAN), urea, urea + NBPT, ammonium nitrate (NH_4NO_3)

TABLE 1. Location and cultural practice for research sites.

Location	Site	Row spacing, in.	Variety	Seeding rate, seeds/A
Johnson County	JO94	30	Asgrow A4138	160,000
Brunker Farm	JO95	30	Asgrow A4138	160,000
Shawnee County	SN94	36	Asgrow A3935	180,000
Parr Farm	SN95	36	Asgrow A3935	180,000
Reno County	RN94	7.5	Asgrow A3935	200,000
Seck Farm	RN95	7.5	Asgrow A3834	200,000
Stafford County	SF94	30	Resnick	125,000
Sandyland Field	SF95	30	KS3494	125,000

TABLE 2. Selected soil characteristics of research sites.

Site	pH	Bray-1 P	K	Organic matter, 0-6 in.	Profile N 0-6 in.	Profile N 6-24 in.
		ppm[1]	ppm[1]	%	ppm	ppm
JO94	6.9	41	125	0.7	4.1	–
JO95	6.8	44	165	0.8	3.0	5.5
SN94	7.3	65	305	2.8	6.7	–
SN95	7.7	67	240	3.1	7.9	6.3
RN94	6.8	50	210	1.2	2.7	–
RN95	6.8	48	190	1.7	3.0	2.2
SF94	6.9	31	140	0.9	3.1	–
SF95	6.7	52	130	1.3	7.8	4.5

[1]ppm = parts per million

All sites were in a corn/soybean rotation and were managed for optimum production. **Tables 1** and **2** summarize cultural practices and soil test information, respectively, for the study locations. An important component of any high yield system is adequate fertility of phosphorus (P), potassium (K), and other nutrients. Cooperators in this study had built high to very high soil P and K levels through a history of balanced fertilization.

Late-season supplemental N application increased irrigated soybean grain yield at six of the eight locations (**Table 3**). Nitrogen sources performed similarly, except the 40 lb N/A rate of UAN which resulted in reduced yield. The high rate of UAN caused severe leaf burn at most locations. The UAN was applied through flat fan nozzles with a backpack sprayer in 40 gallons per acre (GPA) total volume. Leaf burn would not be a problem with UAN applied through an irrigation system. Visual inspection of soybean root systems indicated prolific, healthy-looking nodules at all study locations.

Soybean protein concentrations were increased at four of eight locations, and oil concentrations were increased at three of seven sites by the application of N at R3 growth stage.

The 11 percent (7 bu/A) overall yield increase with late-season N fertilization makes this practice economically viable for producers of high-yielding irrigated soybeans.

(continued on page 11)

Kansas studies showed positive responses to late-season N application for irrigated soybeans with high yield potential.

TABLE 3. Spearman Rank correlation (p-value) for the standard deviations of selected soil properties. Comparisons are between standard deviation of area means of "moving windows."

	StdD-OM	StdD-Bray P1	StdD-K	StdD-Mg	StdD-Ca	StdD-pH
StdD-Bray P-1	0.13(n.s.)					
StdD-K	-0.08(n.s.)	0.51(**)				
StdD-Mg	0.34(n.s.)	-0.07(n.s.)	0.05(n.s.)			
StdD-Ca	0.44(*)	0.12(n.s.)	0.35(n.s.)	0.71(***)		
StdD-pH	-0.11(n.s.)	0.55(**)	0.40(*)	0.10(n.s.)	0.11(n.s.)	
StdD-CEC	0.66(***)	0.04(n.s.)	0.22(n.s.)	0.66(***)	0.86(***)	-0.10(n.s.)

*, **, *** = significant at the 0.05, 0.01, and 0.001 levels, respectively.

management and on liming, because variability in those components was measurable and technology for VR application was available.

The most cost-effective approach for inputs such as P, K and lime is still to build them to a level where they are not limiting. But with site-specific systems, that level can be determined for each management zone (or grid cell) within each field, based on the characteristics and productive potential of that individual zone. If the field has been well-managed under conventional systems, shifting to site-specific management will likely reduce the fertilizer application for parts of the field and increase it for others, but will usually increase the total fertilizer application and should generate an increase in yield potential. BC

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In-season Fertilization... *(continued from page 7)*

TABLE 3. Effect of late-season N rate and source on irrigated soybean yield.

N rate, lb/A	N source	Grain yield, bu/A JO94	JO95	SN94	SN95	RN94	RN95	SF94	SF95	Avg.
0	–	64	58	72	57	56	58	35	43	55
20	UAN	70	62	76	62	75	66	39	47	62
40	UAN	65	56	73	60	59	73	37	41	58
20	AN	64	66	78	64	61	71	38	47	61
40	AN	69	66	76	69	61	66	35	44	61
20	Urea	67	63	76	65	69	76	37	48	63
40	Urea	70	69	74	68	67	68	43	51	64
20	Urea + NBPT	64	63	79	65	82	72	41	46	64
40	Urea + NBPT	70	70	83	70	67	67	42	48	65
LSD(0.10)		5	5	7	4	11	9	NS	NS	6

Assuming soybean prices of $5.00/bu and $0.30/lb N, these results would show a return of $35.00 per acre for a $6.00 per acre investment in 20 lb N. BC

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