UNIVERSITY OF MINNESOTA EXTENSION

NUTRIENT MANAGEMENT

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Fertilizing Soybean in Minnesota

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Soybean is an important crop in Minnesota and provides a significant return in many farm enterprises. The fertilizer needs of the crop are frequently neglected while most of the attention is directed at fertilizing other crops in the rotation. Yields of the soybean crop will decrease when essential nutrients are deficient. Therefore, profitable fertilizer programs must be developed to maximize yields for this crop. This bulletin will discuss fertilizer suggestions that are a key component of profitable production.

NITROGEN CONSIDERATIONS

Soybean is a legume and, if properly inoculated, can use the nitrogen gas (N_2) in the atmosphere for plant growth via fixation in the nodules. The amount of fixation that takes place is related to the amount of nitrate-nitrogen (NO_3-N) in the soil. In general, the amount of N fixed in the symbiotic relationship increases as the amount of NO_3-N in the soil decreases. Although the amount of N fixed in the nodules is small when soil NO_3-N is high, some fixation still occurs and, if soil NO_3-N is suddenly depleted, N fixation by the soybean plant will increase rapidly in order to meet the N demand.

Concerns for environmental quality have encouraged the practice of applying livestock manures to fields planted to the soybean crop rather than applying excessive amounts on acres where corn is grown. Manure is an excellent source of phosphorus (P), potassium (K), all secondary nutrients, and the micronutrients. However, producers have been concerned about the effect of N in the manure on nodule development. During the 1990's, research was conducted at 10 sites throughout Minnesota to evaluate the effect of manure application on soybean production. That research effort produced several conclusions about the use of manure for soybeans. The soybean crop removed significantly higher amounts of N when compared to corn leading to the conclusion that rate of manure applied should be limited to the amount of N removed by this crop. The results of the study also showed that if manure-N was applied at rates to supply less N than was removed, nodulation quickly resumed in mid-season and the final N removal was similar for both manured and non-manured fields.

The application of manure to soybean fields had a consistent positive effect on grain yield. This management practice also increased vegetative growth which led to more lodging of some varieties. The increased vegetative growth also provided a more favorable environment for white mold growth and development. The effect of manure on production was the same for several soybean varieties. Therefore, decisions about variety selection should not be changed when manure is used.

In recent years, some scientific speculation has questioned the ability of the soybean nodule to supply adequate amounts of N late in the growing season -- a situation that could limit soybean yields. This speculation leads to suggestions, by some, for in-season fertilizer N application for the crop. In the late 1990's, University of Minnesota research was conducted at many locations throughout the soybean growing areas to evaluate the effect of in-season application of various N sources during the growing season on soybean yield. Results of the study were conclusive. In-season application of fertilizer-N had no effect on soybean yield.

The effect of nitrogen fertilizer use on soybean yield at one site is summarized in **Table 1**. Foliar application of nitrogen during the growing season can decrease yields (see **Table 2**). In-season application of fertilizer-N is **not suggested** for soybean production in Minnesota.

Table 1. Soybean yield as affected by nitrogen source, time, and method of application.

N-SOURCE	APPLICATION		
	TIME	METHOD	YIELD
			--bu/acre-
None	--	--	52.4
Ammonium Sulfate	Preplant	Broadcast	54.2
Ammonium Sulfate	Early bloom	Broadcast	54.3
Ammonium Sulfate	Early bloom	Knife	52.5
Ammonium Sulfate	Pod fill	Broadcast	53.2
Urea	Early bloom	Knife	51.5
Urea	Pod fill	Broadcast	52.4

*N rate = 75 lb per acre

Table 2. Yield of irrigated soybeans as affected by time and method of application of urea fertilizer.

APPLICATION TIME	APPLICATION METHOD	YIELD
		--bu/acre--
None	--	45.1
Early bloom	Broadcast	42.3
Early bloom	Foliar	42.4
Pod set	Foliar	31.8

*N rate = 75 lb per acre

Nitrogen fertilizer use for soybean production in the Red River Valley deserves special consideration. Research in the region has shown that use of fertilizer N may increase yields where producers have experienced problems in getting good nodulation and the amount of NO_3-N to a depth of 24 inches is less than 75 lb./acre. The use of some N in a fertilizer program (50 to 75 lb. per acre) could be beneficial for some soybean fields in the Red River Valley. Soybean growers in northwestern Minnesota are advised to measure carryover NO_3-N before they decide to apply fertilizer N. In fields where iron deficiency chlorosis occurs additional N may worsen the problem. In these cases additional N is not suggested.

PHOSPHATE AND POTASH USE

The use of phosphate fertilizer can produce substantial increases in soybean yields if soil test values for phosphorus are in the low and very low ranges. The magnitude of the increase is shown in **Table 3**.

Phosphate fertilizer suggestions for soybean production are listed in **Table 4**. The suggestions for potash use are listed in **Table 5**

Table 3. The effect of rate of broadcast phosphate on soybean yield.

P_2O_5 APPLIED	YIELD
-------------lb/acre-----------	-----------bu/acre---------
0	23.0
23	37.0
46	39.5
69	41.3
92	40.2

*Soil Test P was Low and Very Low

The suggested rates of phosphate and potash are not adjusted for placement. A summary of research in Minnesota and neighboring states leads to the conclusion that neither banded nor broadcast placement is consistently superior if adequate rates of phosphate and/or potash are used. If moisture is adequate, soybean yields have usually been slightly higher if the suggested rates of phosphate and/or potash are broadcast and incorporated before planting in many research trials where banded and broadcast placements have been compared.

The use of air seeders for planting soybeans is increasing in popularity. There are several options for placement of seed and fertilizer with this seeding method. One option involves mixing fertilizers and soybean seed in the same band. Results of trials with this placement, however, have shown that placement of any fertilizer in contact with the seed when both are in a narrow band reduces stand establishment of soybeans. The soybean seed is very sensitive to salt injury. Therefore, placement of fertilizer in contact with soybean seed is a risky practice. There is, as yet, no firm and consistent evidence that this placement is superior to broadcast applications. Any method of application that places soil between fertilizer and seed is satisfactory.

Table 4. Phosphate fertilizer suggestions for soybean production in Minnesota

YIELD GOAL	Phosphorus (P) Soil Test (ppm)				
BRAY:	0-5	6-10	11-15	16-20	21+
OLSEN:	0-3	4-7	8-11	12-15	16+
----bu./ac----	--------------lb. P_2O_5 / acre to apply*--------------				
Less than 30	50	30	0	0	0
30-39	60	40	0	0	0
40-49	70	50	0	0	0
50-59	80	60	0	0	0
60 or more	90	70	0	0	0

*Use the following equations to calculate phosphate fertilizer suggestions for specific yield and specific soil test values for P:

$P_2O_{5Suggested}$ = [1.752 - (0.0991) (Bray P, ppm)](Yield Goal)

$P_2O_{5Suggested}$ = [1.752 - (0.1321) (Olsen P, ppm)](Yield Goal)

No phosphate fertilizer is suggested if the soil test for P is greater than 10 ppm (Bray) or 7 ppm (Olsen).

No-till planting of soybeans raises special questions with respect to phosphate and potash fertilization. There's general agreement that phosphorus and potassium are not mobile in soils. So, broadcast applications in no-till systems can be questioned. A substitute would be to band phosphate and/or potash fertilizers below the soil surface, then plant on top of the band. Results of research conducted at the West-Central Research and Outreach Center at Morris show that yield responses to phosphate fertilization in no-till production systems are the same for both banded and broadcast applications. Apparently, the roots of the soybean plant that are actively involved in nutrient uptake are located near the soil surface. The fertilizer incorporation that takes place in the planting operation is apparently adequate in many no-till planting systems.

Table 5. Potash fertilizer suggestions for soybean production in Minnesota

YIELD GOAL	Potassium (K) Soil Test (ppm)				
	0-40	41-80	81-120	121-160	161+
--bu./ac--	--------------lb. K_2O / acre to apply*--------------				
< 30	55	30	15	0	0
30-39	65	40	20	0	0
40-49	80	50	20	0	0
50-59	100	60	30	0	0
60 or	110	70	30	0	0

*Use the following equation to calculate potash fertilizer suggestions for specific yield goals and specific soil test values for K:

$K_2O_{Suggested}$ = [2.200 - (.0183) (K Soil Test, ppm)](Yield Goal)

Timing of the phosphate application is an important consideration when fertilizing soybeans. If phosphate is suggested for fields having a pH of 7.4 or higher, the fertilizer should be applied in the spring before planting. This practice will reduce the time interval for contact between soil and fertilizer thereby reducing tie-up of phosphorus and the soybean plant will make more efficient use of the applied phosphate.

IRON DEFICIENCY CHLOROSIS

Frequently, soybeans that are grown on fields which have a pH of 7.4 or greater turn yellow, and, in some cases, die. This condition is described as iron deficiency chlorosis abbreviated as IDC. There is no deficiency or shortage of iron in the soil. Because of soil and/or environmental conditions, the soybean plant is not able to absorb or take up the amount of iron that is needed for normal growth and development.

There is no easy solution to the iron chlorosis problem. There are, however, several management practices that can be used to reduce the severity.

Careful variety selection is of major importance. The University of Minnesota publication, “Varietal Trials for Farm Crops,” has chlorosis scores for many varieties. The majority of the companies that market soybean seed also provide chlorosis scores for their varieties.

Damage can be reduced if stress on the soybean plant is at a minimum. There are several factors that can stress soybean plants. Some that are easy to identify are: 1) use of some post-emergence herbicides, 2) soils with a high “salt” content, 3) root damage from excessively deep cultivation, 4) soil compaction, and 5) seedling diseases. It is important to eliminate or manage as much as possible the factors that place stress on the soybean plant. In addition, nitrate carried over from previous crops has been found to increase the presence of chlorosis especially in less tolerant varieties.

Current research has shown that application of EDDHA-Fe chelates that contain most of the chelate in the ortho-ortho form may increase yields with an application of 1-3 lbs of active ingredient per acre directly on the soybean seed at planting. Additionally, oat companion crop seeded prior to planting at a rate of 1.5 bushels per acre and killed at 10 inches height has been shown to benefit soybean by reducing IDC for severely affected field areas. It is suggested that growers in IDC affected areas 1) plant a tolerant variety and 2) consider using either or both in-furrow EDDHA-Fe and an oat companion crop.

Additional information on managing IDC can be found in publication FO-08672 “Managing Iron Deficiency Chlorosis in Soybean”.

OTHER POSSIBLE NUTRIENT NEEDS

Research has shown a link between glyphosate tolerant soybeans and possible deficiencies of manganese and other micronutrients. Research trials conducted at several locations in Minnesota have shown that the soybean crop does not respond to the application of magnesium, boron, zinc, manganese, and copper. Therefore, additions of these nutrients to a fertilizer program are not suggested.

Several research studies have evaluated the use of sulfur for soybean in Minnesota. Soybeans may respond to sulfur application by increasing plant growth but yields were almost never increased and in some circumstances were decreased. Sulfur is only suggested in fields with a history of reduced yields for crops susceptible to deficiency such as alfalfa and corn, soil organic matter in the top six inches is 2.0% or less, and no sulfur was previously applied on the field for many years. Under these limited circumstances, an application of 10-15 lbs of S may be warranted. In most cases sulfate sulfur carried over from a previous application or mineralized from the soil will be enough for achieving maximum yield.

Additional information about nutrient management in all crops can be found in related publications. These are listed below.

Additional Publications

FO-00794-Sulfur for Minnesota Soils
FO-00792-Phosphorus for Minnesota Soils
FO-00723-Boron for Minnesota Soils
FO-00725-Magnesium for Crop Production in Minnesota
FO-06288-Understanding Phosphorus Fertilizer
FO-06794-Potassium for Crop Production
FO-00720-Zinc for Crop Production
FO-5956—Lime Needs in Minnesota
FO-08670 Managing Iron Deficiency Chlorosis in Soybean