

MEASURE AND MANAGE

Feeding Soybeans

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General Fertility

Soybean, corn and wheat have been a traditional and popular rotation on Ontario cash crop farms for many years. When it comes to soil fertility and fertilizer applications corn has been the dominant crop to receive the fertilizer applications of P and K and micronutrients. Wheat receives some P in a starter and of course the N application in the spring, and soybeans receives as a rule very little if any direct fertilizer application.

The reason for the lack of direct fertilization has been the apparent lack of fertilizer response to direct application to soybeans. However soybeans do respond to fertile soils. It therefore becomes prudent to maintain soil fertility in the rotation at a high rating. This can be achieved by soil testing and appreciating the crop removal levels of the entire corn, soybean, wheat rotation.

Estimated Crop Removal	pounds per acre					
Crop	N	P	K	Mg	Ca	S
Soybean (50 bus)	200	45	70	9	11	5
Corn (150 bus)	149	55	45	13	1	10
Wheat (75bus)	90	45	28	12	2	6
Total	439	145	143	34	14	21

Note that 50 bus of soybeans removes more K than 150-bus corn crop. Failure to replace these nutrients can bring about a reduction in soil test values for P and K of 5 ppm and 12 ppm. respectively in the rotation.

Soil pH and Liming Practices

Soybeans have demonstrated an ability to grow well at a pH as low as 6.0 provided there is adequate calcium and no toxicities of manganese as a result of low pH. Our precision farming overlays of yield maps on pH maps proves this point. Calcium levels of 1200ppm or base saturation of at least 55% are indicator numbers to reference from on loamy soils. Clays would need to be higher, as well a clay soil will benefit structurally from lime applications.

However we must be cognizant of the field variability when using bulk composite samples, fields that average 6.0 may have significant areas below 6.0 and may need the addition of lime. Liming to the proper pH assures an adequate supply of calcium and or magnesium depending on the choice of calcitic or dolomitic limestones. Lime additions need to be determined by a soil test for pH and Buffer pH. The pH determines if acid conditions are present and the buffer pH determines the quantity of acidity and therefore the rate of lime needed to raise the pH to target values. The extractable magnesium and calcium will determine which type of lime to use. Liming also improves the overall nutrient availability and enhances beneficial micro-organism activities. Rhizobium bacteria operate more productively near a neutral pH.

Over liming soils with pH greater than 6.2 increases the risk of inducing micronutrient tie up especially manganese.

Limestone quality as defined by the Ag-index is also a necessity our lime recommendations assume a lime with an Index of 75. A lime with an index of only 25 would require the rate to be increased 3 times to equal the neutralizing value of a 75 index limestone.

Growth Stages

There are definite growth stages that a soybean plant progresses through from emergence to maturity, by understanding these stages and their significance we can better manage for stress reduction and high yields.

The stages are identified by vegetative (V) and reproduction (R).

VE	emergence
VC	cotyledon
V1	first-node
V2	second-node
V3	third-node
Vn	n-nodes number of nodes depends on the variety and maturity rating.
R1	beginning bloom
R2	full bloom
R3	beginning pod
R4	full pod

- R5 beginning seed
- R6 full seed
- R7 beginning maturity
- R8 full maturity

The rate of plant development is related to temperature the length of time between stages varies directly with the weather. Nutrient deficiencies, lack of moisture or any other stress increases the length of time between vegetative stages and decreases the time between reproductive stages. Plant densities affect the physical appearance with high densities causing tall plants with fewer branches, pods and seeds per plant, high pod set, prone to lodging and low densities cause a bushier appearance with multiple branches pods and more beans per plant.

Germination and Emergence

Seeds begin germination after the imbibing of water equal to 50% of the seed weight. The radical or primary root emerges first and anchors the plant so the hypocotyl can straighten up and pull the cotyledons out of the soil (VE). As the cotyledons unfold to expose the growing point or epicotyl and the unfolding of the first primary leaf marks the initiation of VC. Nutrients and food reserves in the cotyledons feed the young plant for the next 7 to 10 days. The loss of one cotyledon has little effect on yield the loss of both can reduce yields by 9%. If you are a 45-bushel grower that means a loss potential of 4 bushels per acre.

The unifoliolate- leaf unfolding marks the beginning of the V stages at this point photosynthesis starts and begins to feed the seedling. All subsequent V stages are counted after this one. The only difference being that each new node is a trifoliolate leaf.

Soybean planting depth should not exceed 2 inches, deeper planting slows emergence, the cooler soil at depth decreases nutrient availability, slow emerging plants have a longer window for disease and insect infestations. Placement of starter fertilizers to the side and below the seed may increase early season growth, placing fertilizer on the seed greatly increases the risk of seed burn.

Inoculation of seed with rhizobium japonicum is recommended on new fields. As well it is used as insurance to make sure that nodulation takes place to fix N₂. The nodules fix about 66% of the N needs the rest is taken up from the pool of nitrate in the soil much the same way as non-legumes do.

The rate of dry matter accumulation is slow in the early V stages but increases steadily from V1 to R1. Dry matter accumulation starts to decrease at R6. At about R3 to R6.5 the dry matter shifts from the vegetative parts to the pods and developing seeds. This progression of dry matter transfer starts at the lower nodes and continues upward until R8 or maturity when all the leaves have fallen.

Root growth begins when the primary root emerges and continues steadily with dramatic increases in depth and lateral branching at V6 to R2. Most growth occurs in the top 12 inches and may reach depths of 2 to 4 feet. At R6 most root expansion has stopped although some minor growth occurs right up to maturity.

N Fixation

About 66% of the N required by soybeans is made available by the fixation of N₂ gas by the rhizobium japonicum bacteria infection on roots to form nodules. These nodules form as early as V1 and continue to increase in number and size and rate of fixation. At R2 there is a dramatic increase in activity peaking at R5.5 then a decline. Active nodules are pink in color inside where non-active ones are green or brown.

The relationship is a symbiotic one with the rhizobium providing nitrogen and the plant providing sugar to the nodules. Plants that respond to N applications may be a sign that soybeans are low in potassium.

Flowering

Flowering is initiated at R1 on the 3rd to 6th node and progresses in either direction, it is not unusual to have plants with small pods, flowers and buds all at the same time. By R5 most of the flowering has ceased

Three to four days after flowering pods begin to form it takes about 2 and half weeks for pods to fully elongate. Growth is most rapid between R4 to R5. Beans within the pods do not begin to grow until the pods are at full length. Whole plant growth begins to slow at R5.5 to R 6 as translocation of nutrients from vegetative parts begins and stops around R7.

The stage R 5.5 has been defined as a critical growth point this marks a time of maximum dry matter accumulation the development of pods and beans and the initiation of mass transfer of nutrients from leaves and petioles to pods leaving very little food for root maintenance. This is the time for plant tissue testing, as leaves will be at a maximum nutrient content. Foliar fertilizing to enhance the nutrient profile has been popular at this stage and the subject of many debates.

Plant Analysis

Analyzing plant tissue just prior to R 5.5 would indicate the nutrient status of the soybean plant. Based on the analytical numbers and established critical ranges management decisions can be made concerning the need for any additional supplementation of essential nutrients.

There is a specific plant part to sampled and a sufficient quantity. At R 2 to R 3 flowering to pod beginning collect the last fully expanded trifoliolate leaf from at least 25 plants and submit to the laboratory for a Plant Tissue Analysis. Most test packages include a test for

N, P, K, Mg, Ca, Zn, Mn, Cu, Fe, B and S. The report also provides a interpretation based on established critical levels. From this analysis nutrients that are low to deficient can be considered in a management decision or imbalances can be observed. It is often beneficial when trouble shooting a given problem to include a soil test from the same area. Often times a lack of calcium and excessive manganese can be attributed to a pH problem. Excessive N levels can explain a low potash level or low magnesium can be the result of excessive potash levels.

Hidden Hunger and Stress Relief

Plants can appear quite normal and yet at the end of the year yields maybe unexplainably low. Hidden hunger can be the culprit just enough nutrient to grow not enough of a shortage to show a deficiency.

This is where a regular plant tissue program can safeguard against hidden hunger. Early detection can lead to treatment, which can relieve stress caused by a lack of an essential nutrient.

From R2 to R6 is the critical time for nutrient uptake root expansion and redistribution from leaves and stems to pods and beans with nutrient uptake stopping at R6. Redistribution of nutrients from older plant parts to newer locations is the primary source from some nutrients. Some nutrients are very mobile such as N, P and S. Some nutrients are very immobile such as Calcium, redistribution later in the season of mobile nutrients leaves behind calcium and causes an increased concentration in the leaves.

The remaining nutrients range in mobility of from highly mobile N to immobile Ca. Zn and Cu are redistributed but not as much as N. Mn, Mg, Fe, B are immobile but not as much as Ca.

Two of the most responsive nutrients are Mn and Mg due to their relative immobile nature.

Foliar feeding of Mn, Mg and some Boron have been the subject of research at U of Missouri where a combination of Mg and B increased yields by 3 to 4 bushels. Other studies at Iowa State using 2 –3 gallons of 3-18-18 at V5 stage increased yields in 1995 by 5.6 bushels and 1996 no response.

The general responses were positive when beans were under stress. Stress was evident in no till or reduced till fields with P levels in the tissue below 20 ppm and the response was from foliar Mg and B two immobile elements. Most foliar applications take place multiple times from V5 to R2.

In Ontario yield responses to Mn in deficient areas have been 5-7 bushels sprayed foliar. Yield responses have been sporadic to other foliar treatments. A sound soil fertility program monitored by plant tissue and sound agronomic advice is the best approach to maximizing soybean yields.

High Yield Management Advice

Fertilize and lime based on a current soil test.

Plant when fields are fit and avoid compaction and smearing.

Plant early May1 to May 15 allows for early wheat planting as well.

Select varieties strengths to match field weakness.

Plant by seed number achieve optimum plant populations.

Do not plant over 2 inches deep wait for moisture instead.

Crop scouting, weed control, insect control is a necessity.

Reduce and minimize harvest loss, 5 beans per square foot is a yield loss of 1 bus/acre.