Row Crops Newsletter
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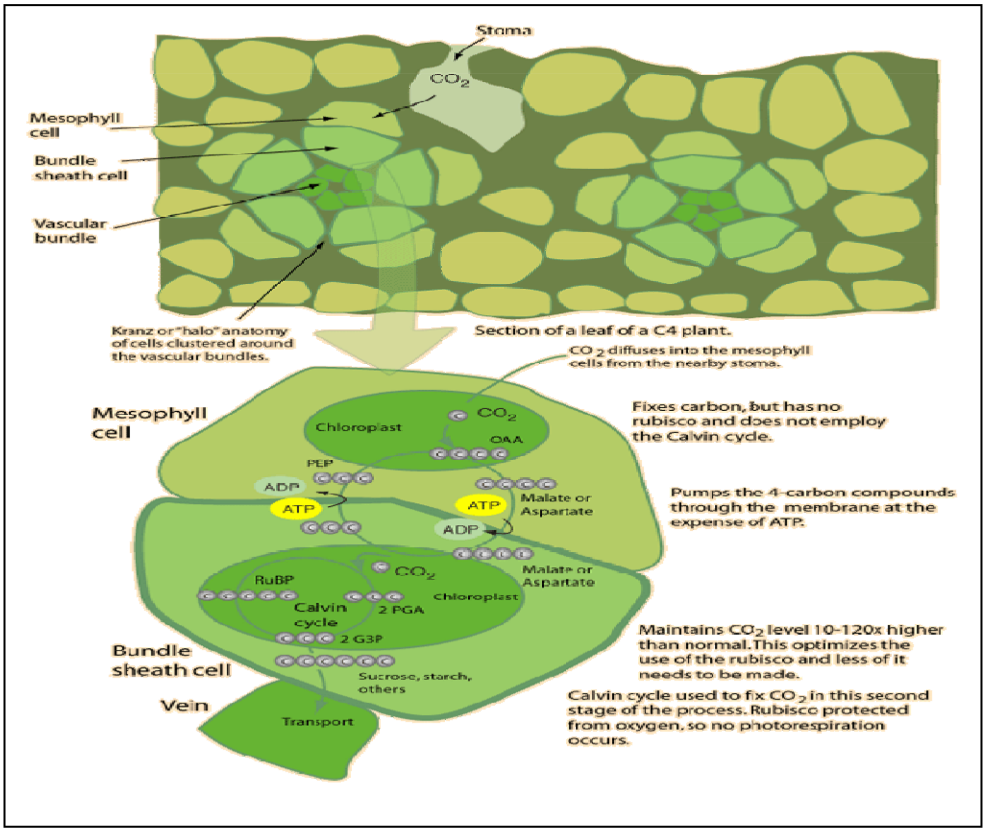
Corn Production

Introduction: Corn is a good crop but has limitations in our area due to no irrigation and corn draws much water and nutrients during the reproductive stage. Heat during pollination can also be a problem greatly reducing yield potential. Despite these issues, we can make adequate corn yields with the hybrids today. Corn is a crop that can tolerate higher temperatures due to its physiological mechanism allowing better assimilation of carbohydrates.

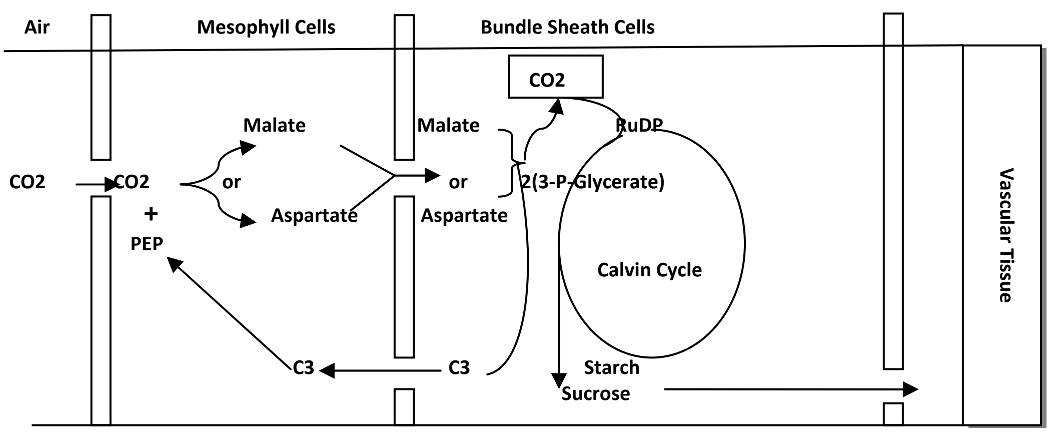
Corn is classified as a C-4 plant due to its photorespiration (consumption of oxygen and evolution of carbon dioxide in the presence of light) pathway and because this path produces four carbon molecules. Photorespiration is a necessary evil allowing the assimilation of carbohydrates via photosynthesis while producing energy via respiration and the release of carbon dioxide. This process is great during cooler temperatures but can greatly deplete carbohydrate production under high temperatures in some crop species (C-3 plants). C-4 plants have a way of dealing with photorespiration which include the processes occurring in different leaf cells (mesophyll and bundle sheaths) allowing carbon dioxide to be fixed twice instead of once as in C-3 plants. This process is more efficient in carbon utilization than with C-3 plants. The first fixation of carbon dioxide in C-4 plants occurs in the leaf mesophyll in the form of HCO3 which is more soluble and moves easily between cells. The HCO3 binds to phosphoenolpyruvate (PEP) forming a C-4 compound called oxaloacetate. The enzyme (PEP carboxylase) involved in the process cannot act as an oxygenase which is good since oxygenase enzymes limit plant growth. The C-4 compound is then yields a four carbon acid called malate or aspartate and is transported to the leaf bundle sheath where carbon dioxide is released forming pyruvate. In the second fixation, carbon dioxide goes through the Calvin Cycle as seen in C-3 plants. The pyruvate is eventually transported back to mesophyll cell and is re-converted to PEP along with ATP (Adenosine Triphosphate) which generates plant energy. This process also prevents Rubisco (an enzyme that triggers carbon dioxide fixation) from acting as an oxygenase which favors carboxylation (a process that is good and allows the production of plant favorable compounds) and allows C-4 plant to have little or no photorespiration under high temperatures. This pathway is why corn functions well under high daytime temperatures, intense sunlight, limited nitrogen and carbon dioxide and low soil moistures. C-3 plants so named due to the formation of three carbon molecules do undergo photorespiration. In this process it will waste the Rubisco which can act as an oxygenase (bad enzyme) or carboxylase (good enzyme) and will waste the energy generating ATP. One form produced by the oxygenase is glycolate which is basically useless to the plant and will produce hydrogen peroxide, an activated oxygen species that in some cases is bad for the plant. C-3 plants follow what is called the Calvin Cycle where carbon dioxide and water is converted to carbohydrates. The reduction of carbon dioxide stores energy in chemical bonds and creates raw materials for plant use. However, this process of photosynthesis is very sensitive to temperature. At low temperatures there are two functional molecules of glycerate formed that is conducive to plant growth and development. At high temperatures, the process produces one functional molecule (glycerate) and one molecule that is not very useful to the plant (glytcolate). Corn is also classed as a moderate tehrmophille (tolerates a temperature of up to 45 to 65° C) allowing it to tolerate high temperatures. Also, corn has an intrinsic ability that provides short-term protection from drought via leaf rolling. Corn is also a monocot that grows from meristems at the base of the plant. The fact it only has one embryonic leaf there is little opportunity for it to break its neck during emergence as is often seen with dicots (corn and cotton). The major difference physiologically between cotton, soybeans and corn is the fact that corn is a monocot (one cotyledon) while cotton and soybeans are dicots (two cotyledons) and cotton and soybeans are moderate thermophilles that follow a C-3 pathway while corn is a moderate thermophill that follows a C-4 pathway. Despite what is thought about cotton being a warm temperature loving plant, corn is more physiologically efficient than cotton and definitely soybeans. This is not to say corn will survive in spite of the environmental conditions is not true because corn still needs adequate levels of water and nutrients to yield high.



C-4 Plant Photorespiration

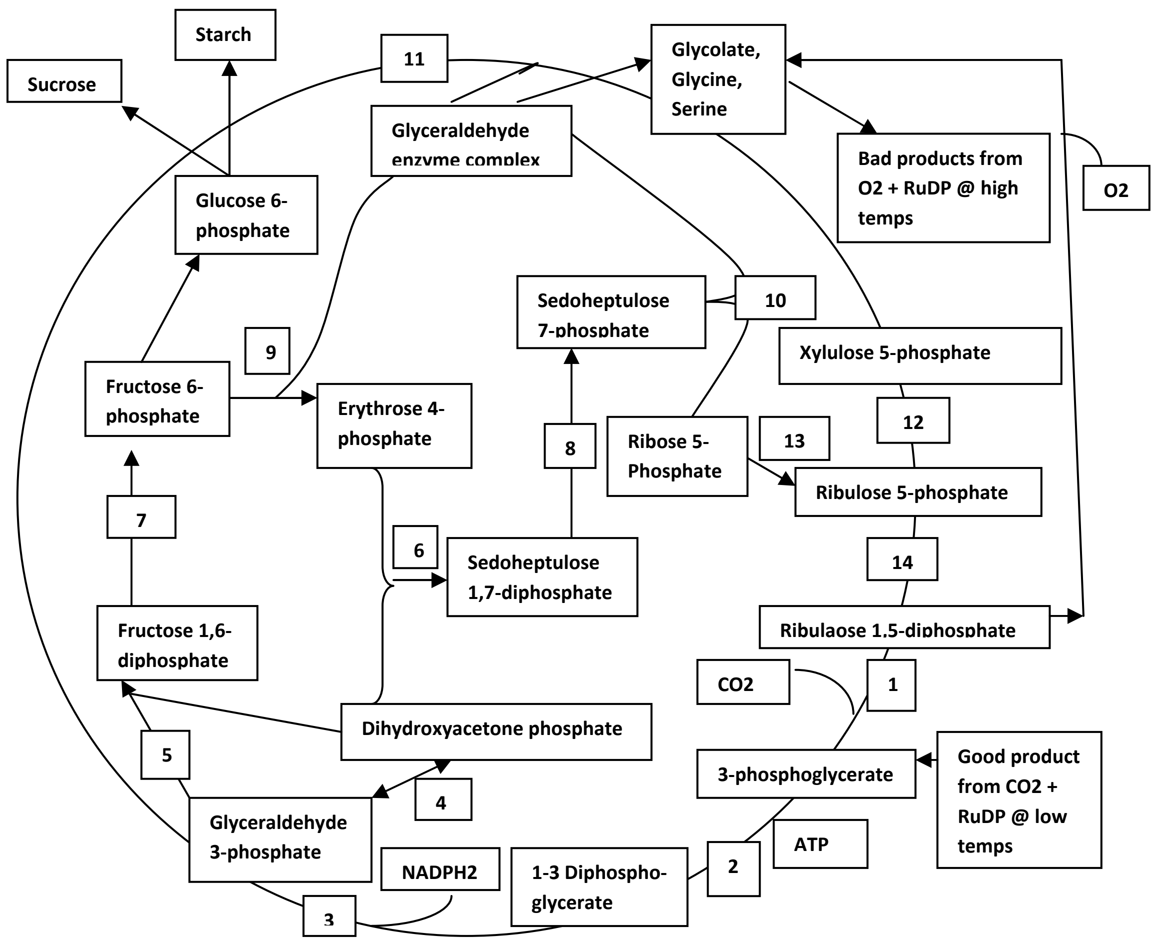
This diagram shows the leaf functions of a C-4 plant (Most grasses). CO2 enters the stomata on the lower leaf surface and then enters the mesophyll where is converted to Malate or Aspartate that crosses the membrane to the bundle sheath where the Calvin cycle occurs and the sugars are loaded into the vascular tissues for transport. Here the enzymes are prevented from becoming oxygenases and carbon fixation is very effective. This is unlike what occurs in C-4 plants.

Here is a simplified version of the C-4 pathway.



As shown, CO2 is absorbed via stomata (tiny openings in the leaf that lets water out and CO2 in) in the leaf and transported from to the mesophyll cells (possess large intercellular spaces and important for gas exchange) where it combines with PEP (phosphoenolpyruvate) to form a four carbon molecule (Aspartate or Malate) that moves into the bundle sheath giving off CO2 that merges with RuDP (Ribulose Diphosphate) where in the presence of the enzyme RUBISCO produces two usable glycerate molecules that will proceed to yield sucrose (sugar) that is transported to the vascular tissues for movement. In C-3 plants the Calvin Cycle only exists and under high temperatures there is more oxygen in the system than CO2 forcing RUBISCO to act as an oxygenase instead of a carboxylase producing one molecule of glycolate (instead of the sugar forming glycerate) and one molecule of glycerate. This reduces the overall capability of the plant to produce sugars.

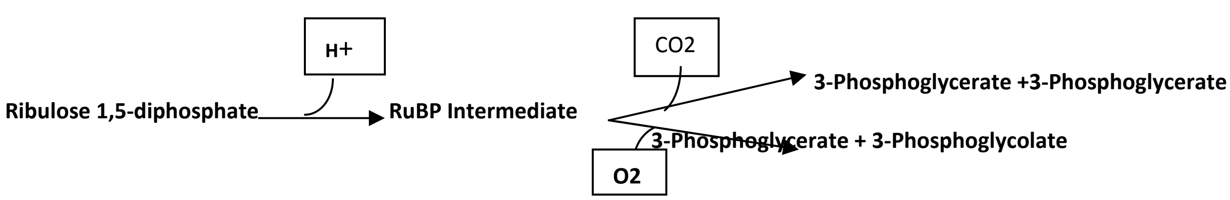
Calvin Cycle



Enzymes in Calvin Cycle: 1. RuDP carboxylase; 2. 3-P-glycerate kinase; 3. NADP glyceraldehydes-phosphate dehydrogenase; 4. Triosphosphate isomerase; 5 & 6. Sugardiphosphate aldolases; 7&8. Sugardiphosphatases; 9,10&11. Transdetolases; 12&13. Pentosephosphate isomerases; 14. Ribulose-5-phosphate kinase.

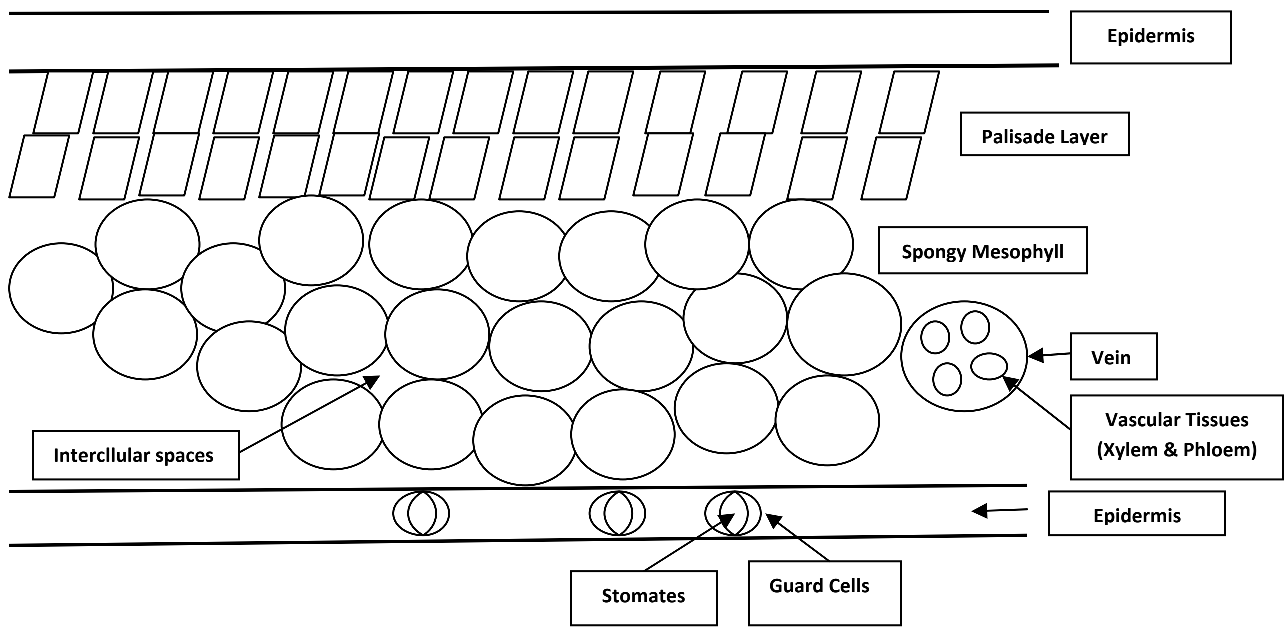
The interesting thing about this cycle is the number of times a phosphate containing product occurs showing the importance of phosphorous in photosynthesis and carbohydrate production. This is why plant nutrition is so important and linked to plant health and yield. Also, note that the enzyme RUBISCO can act as an oxygenase at high temperatures in C-3 plants converting RuDP to practically non-useable forms and it can act as a carboxylase under normal temperatures converting RuDP to an end product of sugar and starch. This makes C-3 plants less effective under high temperatures. The following example is how RUBISCO acts under high oxygen levels or CO2 levels in C-3 plants.

RUBISCO as carboxylase under high CO2 and low temperatures



RUBISCO as oxygenase under high O2 and high temperatures

Leaf structure is a very interesting organelle. It is comprised of an upper and lower epidermis (skin), palisade layer below the epidermis (generally on the upper side) is where most of the photosynthesis occurs and houses the chloroplasts used for light absorption, the stomata (comprised of guard cells and when open allows water out of the plant in exchange for CO_2), mesophyll (large, random cells with intercellular spaces for gas exchange) and the vein that is associated with the vascular tissues.



CO_2 enters the stomata when the guard cells are hydrated opening the stomata and water out via the transpiration process. CO_2 moves through the intercellular spaces of the mesophyll (important for gas exchange and storage of amino acids and sugars) to palisade where the chloroplasts are housed and then sugars are transported to the vascular tissues following photosynthesis.

Soils and land preparation for corn: Corn grows best on rich and well drained soils that have a texture ranging from medium to light textures. However, good yields have been reported on soils of a higher Cation Exchange Capacity (more clay). Soils that are shallow compact greater and reduces yield potential. Soils in this area possess a low Cation Exchange Capacity (high sand) that also compact easily making deep breaking very important. Internal drainage is crucial in obtaining a healthy corn stand and good root development in the early growth stages. Corn performs well on many types of seed beds ranging from a prepared seed-bed to no-tilling into old beds to planting flat where internal drainage is good.

Advantage of a raised seed-bed is they warm quicker, improve drainage during the spring and allows the ability to knock the tops of the beds down to enable planting into moisture. This further allows earlier planting, more uniform stand and more rapid grow-off. It has also been shown to improve performance by breaking the hard-pan with a subsoiler or chisel plow.

Corn also does very well under no-till environments making it a great crop for rotation purposes by planting into the old bed if the land is not rutted during the fall harvest of the subsequent crop. The best soils for this practice are well drained soils while heavier soils are not as well suited for no-till practices. This practice should not be done if the field is infested with hard to control perennial weeds where tillage is necessary. With no-till, it has been shown that mulch can be very important to preventing weed pressures and prevent soil erosion (requires at least 3,000 Lbs of mulch/acre). The problem with no-till is that the soil warms slower in the spring delaying planting and can increase disease and insect pressures. It has been my experience that corn fits a no-till planting program better than any crop we grow but I still like breaking pans to ensure a deeper root system. In a no-till or conventional situation, burn-down herbicides should be applied four to six weeks before planting. The control of weeds will facilitate the warming of the soil but more important will aid in soil water conservation since weeds will wick a significant amount of water from the soil. I like an early burn-down for these reasons and in addition can reduce the incidence of insects and diseases.

Hybrid Selection: There are many great hybrids on the market today that encompass many technologies resistant to specific herbicides and insect pests. We have already shown the results of many of these varieties from local trials and selecting the right variety for the right soil type and growing environment is very important. Select varieties from reputable companies who are willing to service their product, have a good breeding program and who conduct in-house and university trials. The primary selection criteria include yield, maturity, stalk strength, geography, technology needs, soil type, irrigation or dry-land, consistency across years and environments, desired planting rates and disease packages. Choose varieties based on consistency not solely on high yields. I have tested and recommended varieties that rank consistently number two or three across many locations. I often select these varieties over a variety that produces at the highest level at one location and last in another trial. Granted, I will position a variety of fickle nature for environments where its yield is maximized and will use it on a limited basis in a product mix. These varieties are considered race-horse types and can be fickle while some of the more consistent varieties are work-horses. These varieties are often not very showy but are like a Timex watch very consistent. In some cases there are varieties that show high yields while being consistent across many environments. I like to mix varieties and planting date to provide protection against environments and to extend the use of harvest equipment. Maturity is very important in selecting a variety. When selecting a maturity date, select a variety with a proven adaptability. In Mississippi, the earlier maturing varieties of 110 days are very common and seemingly work well. In Arkansas 112-118 day varieties seem to perform the best. Granted, there are corn hybrids that require 125 days for maturity and are considered full season varieties. These varieties are too late for us and will push reproduction into an un-conducive environmental situation and harvest date. Do not use price per bag as the sole selection process and use well tested and proven hybrids. In trying a new variety, I recommend planting only on a limited acre base.

Corn Planting: Corn growth and development is based on temperature and not photoperiod (length of day and night) like with soybeans. Therefore, calendar date is less important and should be based on soil and air temperatures at planting. For successful seed germination the soil temperature needs to be 50 to 55° F at a 2.0" depth. This can range from early March in southern areas to early April in the northern regions of the Mid-South. Frost may still occur during these planting dates but corn normally can withstand frost to above ground tissue with no permanent injury as long as the injury occurs before the sixth leaf stage of the plant is 12.0" tall. Prior to this point the growing point (meristem) has not risen above the soil line and is in a protected state below the ground. As long as the meristem is not damaged it will recover. The corn plant grows from the base upward unlike dicots like soybeans. In Mississippi, the suggested planting dates are Feb. 25 to March 4 for South Mississippi, March 5 to April 10 in South-Central Mississippi, March 15 to April 20 for North-Central Mississippi, and March 20 to April 25 for North Mississippi. Earlier plantings generally produces higher yields since there is greater soil moisture, greater rainfall, lower temperatures, lower insect pressures and longer day lengths occur during grain development. The corn seed should be planted 1.5" deep into adequate soil moisture. Germination and time of emergence will vary five to 30 days depending upon moisture and temperature. Warmer soil temperatures will hasten the rate of germination and provide quicker grow-off.

Seeding Rates: Seeding rates vary with hybrid, yield expectations and row width so check with your seed representative for the proper seeding rate. Seeding rate and final plant population will also vary depending on irrigation possibilities, soil strength and fertility level. Hybrids suited for Mississippi should be planted at a rate of 24,000 to 32,000 seed per acre. On good dry-land soils or where irrigation is available, plant populations of 26,000 to 32,000 plants per acre are needed to maximize yields. In less productive dry-land soil, a plant population on the lower side is required but do not fall below the recommended 24,000 plants per acre. In order to obtain a desirable plant population know what the percent germination is and adjust accordingly. It is recommended to plant 5-15% more seed per acre than the desired plant population since corn seed generally germinate at about 95% and another 5 to 10% may be lost to pests. Of course technology driven seed today are very expensive and you do not want to plant more than is required. Also, with the seed treatments available today, the protection against pest is much better which will increase the plant stand. Plant population can be very important in reducing lodging and increasing stalk diameter. Plants respond to one another within and between the row due to the Phytochrome Red : Phytochrome Far Red ratio. Under high populations the level of Far Red light and conversion of Phytochrome Far Red to Phytochrome Red is high increasing the hormone auxin (IAA) and gibberellins (GA) which controls upward, apical growth, less branching and less stalk diameter. Under recommended populations there is a greater amount of Red light infiltration and greater activated amounts of Phytochrome Red to Phytochrome Far Red. This increases the levels of the hormone Cytokinin that reduces Ethylene levels allowing the increase in stalk diameter. Red light also down regulates the activity of GA and IAA. This is the reason that under high plant populations the stalk diameter is narrow and lodging becomes a problem. Of course populations can become too low, negatively impacting yield.

Row Widths: Corn can be grown in row widths ranging from 30” to 40”. Increased yields can occur under narrow row spacing. Studies indicate a 10% yield advantage of a 30” row spacing compared to a 40” row width little advantage of reducing to a 20” row. Narrow rows provide better use of light, water and nutrients allowing higher plant populations without lodging and barren stalks becoming problematic. The limitation is equipment but should be a consideration when purchasing or modifying equipment. Narrow and wide row spacing will follow the same reasoning as cited above with the Red:Far Red ratio and hormone interactions. The wider spacing will increase Red and Blue light infiltration shortening internodes and thickening stalks while narrow spacing will promote tall spindly plants due to the higher incidence level of Far Red light.

Seed per acre at different spacing in the row				
Row Width (“)	Spacing in row			
	7”	8”	9”	10’
30	29,900	26,100	23,000	20,800
36	24,900	21,800	19,200	17,400
38	23,600	20,600	18,200	16,500
40	22,400	19,600	17,300	15,700

Corn Fertility: The best and cheapest way to know what the soil needs are is to take a soil sample. This quantifies what is occurring in the soil and removes the guess work. Corn performs best at a soil pH that ranges from 6.0 to 7.0. If the soil pH is below 6.0 lime is recommended. I like to recommend a high quality lime like calcitic or dolomitic lime. These limes have excellent neutralizing capabilities. The difference between dolomite and calcite is that dolomite contains magnesium.

Corn nitrogen requirements: Nitrogen is a very important nutrient in corn production and is typically the most limiting nutrient inhibiting high yields. A rule of thumb is the crop needs 1.3 pounds of actual nitrogen per bushel of corn produced. A greater amount of nitrogen is required per bushel on silty clay and clay soils than on sandy loam and silt loam soils. A minimum of 120 pounds of nitrogen per acre is recommended for non-irrigated corn with a yield potential of up to 125 bushels per acre. There are many schools of thought as what the best method is to apply nitrogen. Nitrogen can be applied before or at planting and again when the corn is 10 to 12” tall or about 21 to 30 days after emergence but high rates of nitrogen should be kept away from the seed or young and developing seedling. Many growers apply most of their nitrogen in a single application. However, some like applying nitrogen in a split application by applying 50% of the nitrogen prior to planting followed by the second application side-dressed or top-dressed after the stand is obtained. Research has shown that it is best to apply one-third of the nitrogen prior to planting and the remainder at the six leaf stage. I do like this method and in a dry-land environment should be applied in a knifed manner using Ensol since there is no control over obtaining rainfall in a timely manner. This method applies nitrogen at a time when the crop most needs it and reduces the chance of leaching. If more than 240 pounds per acre of nitrogen is to be applied, consider using a three-way split application.

Corn phosphorous and potassium requirements: Phosphorous (P) and potassium (K) should be applied based on a soil test. Both of these nutrients are needed early by the corn hybrid and should be applied based of soil test before planting generally in the fall. However, K will move a great deal in the low cation exchange capacity soils of this area and I would consider delaying application until January. Based on soil samples from this region K is one of the most limiting nutrients even where chicken litter has been used. A 200 bushel corn crop can remove up to 90 pounds of phosphorous and 60 pounds of potassium. This becomes important since we must account for this level being removed by the previous crop. Unless a soil test calls for something different, 40 to 60 pounds of each is all that is normally needed to account for this removal. In the plant P is required for plant energy production and root growth and K is aids in water movement plant cooling. In my opinion, K is one of the most over-looked of the primary nutrients in our business since it aids in maintaining parity between and within physiological processes by managing the plant’s ability to cool itself. Corn can exhibit a purplish discoloration caused by P even when there is adequate P in the soil. This will occur primarily in early planted corn where the soil and air temperature are below normal and the soil is saturated. Root growth is limited during these conditions and limits the uptake of P. The phenomenon is called physiological phosphorous deficiency and is short-term in its effects. Once the environment equalizes, the symptom will subside with little effect on yield. Planting early into cold natured soils is one of the only times I will use a starter fertilizer to prevent or at least mediate this issue.

No-till fertility: In no-till or reduced till situation where a cover crop is being grown, all the P needed can be applied for both the cover crop and corn at the same time. For K applied on sandy soils it should be applied in split applications where one-third is applied in the fall for the cover crop and the remainder applied at the time of the late winter application of nitrogen two to four weeks before planting. Of course, if this area is also used for hay production, be sure to add nutrients back to the soil before planting the corn since the haying process will remove a large amount of P and K. Also, if the field is ryegrass being grazed and is to be cut for hay, make sure the cattle are rotated quick enough and the hay harvested by early to mid-April to facilitate early corn planting. In this system corn should be top-dressed with nitrogen when the corn is 18 to 20” tall to bring the total nitrogen use rate to 160 to 180 pounds per acre.

Corn Growth Stages: Corn growth stages are divided into two main categories and they include the vegetative stage and the reproductive stage. These stages can be further divided into sub categories and are very important in timing management practices. We will cover corn growth stages in the next issue.

Pre-emerge Herbicides: These herbicides are applied before weed emergence and often require rainfall for activation. Many pre-emerge herbicides also have post activities when applied to young weeds or are a part of a pre-mix with a post-emerge herbicides. Most of the time we will put out pre-emerge herbicides at planting or shortly following planting. After last year I am strongly encouraging the use of a pre-emerge herbicide to provide us some residual weed control.

This is a great deal of information on crop physiology but can help you understand why we do the things like we do them and the plant is a system made up of an intricate highway system of communication, transport and production.

For more information feel free to give me a call at 601-813-7166.