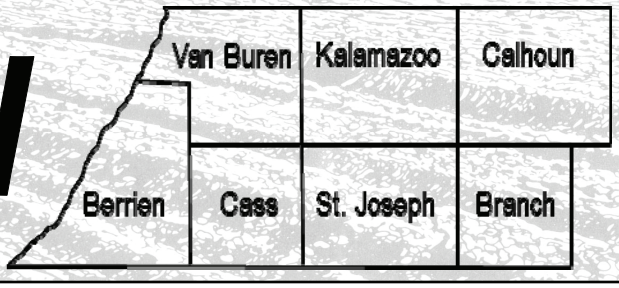
IN THE ROW



Volume 1 Issue 1 April, 2013 A Newsletter Serving Corn & Soybean Producers in Southwest Michigan

Dear Agricultural Producer:

In The Row is a new newsletter serving corn and soybean producers in Southwest Michigan. This is a cooperative effort involving the Michigan Soybean Checkoff, the Corn Marketing Program of Michigan and MSU Extension. All printing, postage and handling costs associated with the newsletter are covered by the Michigan Soybean Checkoff and the Corn Marketing Program of Michigan. MSU Extension is responsible for providing timely and relevant crop and pest management information for each issue. Please call Jon Zirkle at (269) 467-5511 if you prefer to receive the newsletter via e-mail.

Sincerely,

Jon Zirkle Mike Staton Bruce MacKellar Lyndon Kelley Dale Mutch

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Announcing the First Issue of *In The Row*

—By Tim Boring, Michigan Soybean Promotion Committee

The Michigan Soybean Promotion Committee, in partnership with the Corn Marketing Program of Michigan and Michigan State University Extension, is pleased to participate in this inaugural issue of *In The Row*, southwest Michigan's new extension newsletter.

In this issue and future issues, you will find timely and relevant crop production and pest management information unique to this corner of the state. We view this newsletter as a means to provide you, the producer, with quick access to high-quality articles and programming generated by Jon, Mike, Bruce, Lyndon, and Dale. As a commodity group, we frequently invest in field research studies aimed at improving the agronomic management of Michigan soybeans, but investing in communications initiatives is also a priority. Tools like this newsletter, designed to help you respond to challenges in the field, will be complementary to our research investments.

We welcome your feedback on this new venture as we look for new ways to improve Michigan corn and soybean production.

Nutrient Management Recommendations for High-Yield Soybean Production—*By Mike Station, MSU Extension*

Nitrogen:
Biological nitrogen fixation conducted by well-nodulated soybeans along with the nitrogen mineralized from soil organic matter provide sufficient nitrogen for optimum soybean production in most cases. The exceptions are very high yield environments (greater than 68 bushels per acre) and irrigated production on soils having low organic matter levels. If no other yield limiting factors are present, supplemental nitrogen may produce a profitable response under these conditions. Deep placement of slow-release nitrogen at planting and application of a readily-available nitrogen fertilizer are the recommended application methods to avoid reducing nodulation and biological nitrogen fixation. Twenty pounds of actual nitrogen per acre is sufficient with either method.

Phosphorus:
Soybean yield responses to applied phosphorus have not been demonstrated and are not expected when Bray P1 phosphorus levels exceed 20 ppm.

Potassium:
Maintain soil test potassium (K) levels above the critical K levels to maximize soybean yields. The critical level is calculated by multiplying the cation exchange capacity (CEC) by 2.5 and adding 75. For example, the critical K level for a soil having a CEC of 6 is 90 ppm [(6 x 2.5) + 75]. Broadcast applications have been shown to perform as well as or better than near seed placement at planting. Potassium fertilizer should be applied in the spring (two weeks prior to planting) and not in the fall on coarse-textured soils having CECs less than 6 meq/100gm or organic soils to avoid leaching losses.

Sulfur:
Due to declining atmospheric deposition, supplemental sulfur may be required to maximize soybean yields in Michigan. This is especially true in coarse-textured soils low in organic matter. Ammonium sulfate and gypsum are the recommended sources. Sulfur is required early in the season; fertilizer should be applied prior to planting. Twenty five (25) lbs./ac. of actual sulfur is sufficient to maximize soybean yields.

Boron:
Soybeans are classified as having a low probability of responding to applied boron even on soils having low soil test levels. Despite the low probability of a response, university research trials have shown modest yield responses to applied boron in the absence of deficiency symptoms. Boron is most likely to be deficient in coarse-textured soils, organic soils, and lake bed soils having high pH levels. Broadcasting 1 lb./ac. of actual boron blended with potassium fertilizer two weeks prior to planting is recommended. Boron can also be applied to the foliage during early bloom at a rate of 0.25 lbs./ac. Broadcast rates should not exceed 2 lbs./ac., and foliar applications should not exceed 0.5 lbs./ac. to prevent crop injury.

Manganese:
Manganese deficiency is the most common nutrient deficiency seen in Michigan soybeans. Deficiency symptoms are likely on muck or dark-colored sands with pH above 5.8 and lakebed or out wash soils having pH levels above 6.5. Because increasing the available manganese levels in the soil is difficult, deficiency symptoms will reoccur in the same areas each year that soybeans are grown. Broadcast applications are not recommended. Band application of chelated manganese is not recommended either due to high fertilizer costs. Foliar application of 1 to 2 lbs./ac. of actual manganese is the most economical and effective method for correcting manganese deficiency. Additional information on identifying and correcting manganese deficiency with foliar fertilizers will be provided in the next issue of *IN THE ROW* and is available online at: http://msue.anr.msu.edu/news/identifying_and_correcting_manganese_deficiency_in_soybean

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Recommendations for improving soybean inoculation performance—*By Mike Staton, MSU Extension*

Research conducted in Indiana, Michigan and Ohio has shown that inoculating soybean seed increases yields by 1 to 2 bushels per acre in fields previously planted to soybean.

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The following tips will improve inoculation performance:

- Select high-quality inoculation materials having high bacterial counts and several rhizobia strains.
- Apply a granular or liquid inoculation material in-furrow when inoculating a field for the first time.
- Store, handle, and apply the inoculation material according to the manufacturer's directions.
- Have the inoculation material commercially applied by your seed dealer when possible, and plant the treated seed within the recommended time frame.
- Maintain optimum soil fertility levels for all nutrients except nitrogen.
- Maintain soil pH between 6.0 and 7.2.
- Reduce soil compaction.
- Consider a fungicide seed treatment, though product, application method, and inoculant must be compatible.
- Don't apply fertilizers directly to the seed at planting.

Benefits, Risks, and Recommendations for Early Planted Soybeans—*By Mike Station, MSU Extension*

In most years, the first week of May is the ideal planting window for soybeans in the lower half of the Lower Peninsula. However, if soil conditions are favorable and producers manage the crop carefully, soybeans can be planted during the last week of April. University researchers have shown yield losses of 0.3 to 0.6 bushel per acre for each day that soybean planting is delayed past May 8th.

Benefits of early planting:

- Larger crop canopy at R1, increasing photosynthesis, and reducing evaporative water losses
- Longer planting window for producing high yields
- More nodes on the main stem
- Higher yields (especially on highly productive soils)

Risks of early planting:

- Poor germination and emergence can occur in cold soils due to longer exposure to insects and diseases. The embryo can also experience chilling injury when cold water is imbibed during the first 24 hours.
- Low temperature injury to the growing point following emergence. This risk is mitigated somewhat as germination and emergence are delayed in cool soils; air temperatures must reach 29ºF to damage the meristematic tissue or growing points.
- Early-planted soybeans are more likely to be damaged by bean leaf beetles, sudden death syndrome (SDS) and white mold.

Recommendations for early planting:

- Plant only when soil is dry enough to support equipment and allow planting equipment to operate properly.
- Treat the seed with a fungicide such as metalaxyl or mefenoxam that is highly rated for *Pythium* spp.
- Till the field or move the residue away from the row.
- Avoid planting in low-lying areas (frost pockets).
- Plant the highest quality seed possible, as overly dry or damaged seed will imbibe water rapidly, which increases the risk of the embryo experiencing chilling injury.
- Plant when the soil temperatures will be above 50ºF for the first 6 to 24 hours.
- Plant slightly shallower (1 inch) if moisture is available and planting equipment is providing uniform depth control and seed-to-soil contact.
- Plant SDS-tolerant varieties into well-drained soils that are free from compaction to reduce SDS.
- Treat the seed with an insecticide effective on bean leaf beetle if damage is expected.

Focus on the Planter: Tune-up Tips For Optimal Planter Performance

By Bruce MacKellar, MSU Extension

When it comes to planter tune-ups, we often focus on the performance of the seed-metering units and the monitors for insuring performance.

- On vacuum planters, check plates for warp and holes that are out of round, brushes and cutoffs for alignment, and the seed knockout for function. Check seals for leakage.
- On finger pickup planters, check the back plates for cleanliness and dimple wear, evaluate finger tension, and check the belt for brittleness or wear. Inspect the belt drive sprockets as well.

All of the mechanical or hydraulic systems that are upstream of the metering process are just as important to the overall planter operation.

- Check planter's clutches, drive sprockets, and main drive chains.
- Unit inspection: Check disc openers and press wheels for wear; adjust openers so that the disks touch each other; spin each to check for worn bearings. Check all sprockets, chains, and tensioners on each unit. Seed tubes should be free from obstructions. Sensors should be wiped clean from seed treatments and dust.
- Inspect alignment of the openers and the closing wheels. Also check each unit for "free float" to make sure the seeding depth control apparatus is in good working order.
- The planter should be checked for level operation, especially if this is the first time it has been hooked up to a different tractor.
- Check the fertilizer pump tubes and lines for obstructions

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- Check the hydraulic system for leaks.
- On vacuum planters, carefully check the air lines for leaks. Check the air or vacuum pressure levels.
- And finally, calibrate your metering system and monitor by collecting seed dropped at a known distance. Try to calibrate in actual field conditions to reduce the impact of drive wheel slippage.

Efforts put into planter maintenance before you hit the fields can pay big dividends by reducing delays during the planting "crush".

Getting Good Stands: Take your foot of the "gas" to optimize planter performance

Technology in agriculture continues to improve efficiency. However, there are practical limits to how much we should expect technology to help us when it comes to running equipment at top speeds. This may particularly be true of planters and drills. The ability of a planter to properly cingulate seeds and place them at the proper depth in the soil can be impacted by the speed at which we are trying to plant. In-row variability in plant spacing can contribute to challenges in producing top yields. Some recent university studies have not shown statistically significant yield reductions associated with plant spacing variability at various speeds when planting with a carefully adjusted, perfect working condition planter. However, higher speeds were shown to increase variations of within the row spacing of corn plants. If your planter happens to increase the number of skips and double drops that occur with increased planting speed, especially under drought stress conditions, it may push your fields into significant yield reductions. Since reaching optimal yields comes with managing as many potential yield limiting factors as possible, running your planter in the manufacturers specified planting speed range can reduce the risk that in row variability will impact yields.

Planting Depth: Optimal planting depth varies with soil conditions at planting time. Planting depths of 1" or less are not considered adequate for development of the nodal root system and can contribute to rootless or floppy corn syndrome. There is a general consensus among corn agronomists that a planting depth of 1.5 - 2" is advised. Planting somewhat deeper, especially in our lighter soils in years where soil moisture is short, can help to place seed into adequate moisture to allow for uniform germination and emergence. Dr. Robert Nielsen, Purdue Corn Agronomist, suggests that the depth of planting below 2 " is not extremely important as long as there is adequate soil moisture. The mesocotyl elongates pushing the coleoptile towards the soil surface. The ratio of red to far red light absorbed by the developing seedling changes as it approaches the soil surface, triggering a stop to the growth of the mesocotyl, which places the crown (base of the coleoptile) somewhere between 0.75 to 0.5 of an inch below the soil surface. Because the mesocotyl can extend quite some distance, the crown is in this depth range regardless of planting depth. Folks concerned about deeper planting are usually concerned about increased chances of seedlings leafing out underground or failed emergence due to crusting. Extended periods of cold soil temperatures, chilling injury, pre -emergence herbicide injury, insect damage, and excessive planting depth (or combinations of all of these) can lead to increased incidence of underground leaf out. Crusting generally is an issue when a pounding rainfall occurs after planting but before emergence, followed by a drying event. But if crusting is an issue, planting depth may prevent emergence regardless of planting depth.

Early Season Insects to Watch Out For as Crops Begin to Emerge —*By Bruce MacKellar, MSU Extension.*

Conditions were favorable for overwintering pest survival during November - mid January. When more normal temperatures returned in February and March, snow cover should have been adequate to help protect overwintering insects. The early season pests that we generally are concerned about following a soft winter include corn flea beetles, bean leaf beetles and alfalfa weevils, which overwinter in southwest Michigan. These insect pests overwinter as adults in field edges and woodlots under leaf litter. They break dormancy early in the season and may feed on winter annual weeds or plants along field edges. Damage from overwintering adults occurs early in the growing season, often as corn and soybean plants first emerge.

Corn Flea Beetles: While CFB can be a significant pest, outbreaks where corn flea beetles are numerous enough to cause problems for commercial corn is rare. But CFB is more of a concern to seed and sweet corn plantings, because these insects often carry the bacteria that causes Stewart's Wilt. Most commercial hybrids can tolerate Stewart's Wilt without significant infections that cause yield reductions, but the seed corn in-breds are much more susceptible. The major seed companies usually collect samples of CFB's and have them checked for the presence of the bacteria that causes the disease. *Treatment Threshold:* Commercial Corn—treat when half of seedling plants or more show feeding and there are five or more beetles per plant. Seed Corn—check with your seed company agronomist.

Bean Leaf Beetles: BLB numbers have been slowly increasing across SW Michigan in recent years. The beetle ranges in color from green to red and usually has a series of black square or dots on their backs. Overwintering BLB

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adults will feed on winter annual weeds and young soybeans. While they often cause defoliation of unifoliate and 1st trifoliate leaves, they seldom cause enough leaf loss to threaten plant health. Early season defoliation can indicate high populations, which may mean that the second generation could cause unacceptable damage to developing soybean pods. They also can carry a fungal pathogen that causes green stem, which can complicate fall harvest. *Treatment Threshold:* 25% or more defoliation throughout field; 50% defoliation of seedlings or 25% defoliation during pod setting/filling, or pod damage > 10%.

Black Cutworms: BCW larvae clip emerging plant stems around ground level. Early instar larval feeding injury is leaf feeding in the middle of the leaves. Black cutworms moths migrate to the state each spring from the south, being deposited in the area by thunderstorm events following a strong push of warm spring air. Early arrival often is associated with outbreaks; moths find thick mats of winter annuals that provide excellent places to lay eggs. When fields are sprayed or tilled, cutworm larvae in the field are ready to feed on crops shortly after emergence. Larvae are hard to find in the fields—they generally are nocturnal and hide during the day in burrows. Since moth deposition often is fairly concentrated, some fields or areas may suffer extreme stand losses while other nearby fields may suffer almost no damage. Keep an eye on fields where winter annual weeds were prevalent or cover crops were in the field longer than you would have liked. Also, if you plant Bt corn in fields, be aware that there are differences between the Bt proteins in controlling cutworm damage. See Chris DiFonzo's *Handy Bt Corn Chart* for more information on which types of Bt corn provide control for BCW larvae. *Treatment Threshold:* Treat when 5% or more of plants show signs of cutworm damage.

Armyworms: Armyworms, like black cutworms, migrate northward each spring on warm air currents. Armyworm moths like to lay eggs in grassy areas—wheat, other small grains, and late- destructed cereal cover crops make almost perfect habitat for armyworm larvae to feed. Unlike cutworms, I have never seen armyworm damage in soybean fields. They are capable of causing rapid defoliation in wheat and corn fields, however. Early instar feeding on corn plants appears as ragged leaf edges missing from plants. Feeding moves from the outer edges of the leaves towards the midrib. Defoliated plants often only have the mid-ribs remaining in corn. Armyworm feeding in wheat can remove most of the foliage and can clip heads. *Treatment Thresholds:* Corn—treat when 25% of plants have two or more larvae per whorl, OR 75% of plants have one larvae. Treat only if caterpillars are less than 1.25" long. Wheat—before heading, four or more larvae per square foot; after heading, two or more larvae per square foot.

During planting season, early season pests often get overlooked. Significant yield losses can occur if populations are over threshold. While we do not treat for these pests on a yearly basis, they should remain on your radar screen to prevent yield losses. For more information on field crop insect pests, visit Dr. DiFonzo's website at: http://www.msuent.com/extension/.

Controlling Annual Ryegrass and Cereal Rye Prior to Planting Corn and Soybeans

By Dale Mutch, MSU Extension

Annual ryegrass (AR) has become popular cover crop in the Midwest and Michigan because it produces such a massive root system. Its extensive root system makes annual ryegrass a valuable cover crop for improving soil quality. This same root system however, can offer some challenges when farmers are trying to control this cover crop. There has been a lot of research done by Mike Plummer (Illinois cover crop specialist), Dan Towery (Conservation Cropping Systems Specialist), Mark Mellbye (Agronomist, Oregon Seed Industry), and Andy Hulting, (Weed Scientist, Oregon State University). These researchers have recently published 2013 management recommendations for annual ryegrass. This fact sheet can be downloaded at www.ryegrasscovercrop.com. Here are some highlights of the fact sheet for controlling annual ryegrass:

- Control annual ryegrass when it is small—8 inches or before the first node (often around mid-April).
- Air temperature should be above 60°F.
- Try to spray on sunny days when the soil temperature is above 45°F, stop spraying about four hours before sunset to allow for maximum translocation of herbicide.
- Before planting corn or soybeans apply glyphosate at 1.25 to 1.50 lb a. e./a (48-64 oz/a of a 41% glyphosate product) add ammonium sulfate and surfactant.
- Always follow label and pH directions carefully. When mixing additives the order is important: add ammonium sulfate, other additives or citric acid to a full spray tank of water. Then agitate for 3 – 5 minutes.
- Add glyphosate after agitating the tank water.

For more information on planting, managing, and controlling AR, read the fact sheet from the link above.

Killing cereal rye should also be watched closely and terminated in a timely manner. Try terminating rye before it gets taller than 8-12 inches. Ideally you want the rye dead two to three weeks before planting to starve any insect pests that could move to the cash crop and to reduce any alleleopathic impacts if corn is being planted.
To learn more about managing cover crops, visit http://www.mccc.msu.edu.

Early Season Irrigation To Maximize Value of Crop Inputs

By Lyndon Kelley, MSU Extension/Purdue Extension

If you have irrigation available, consider applying water when a lack of rainfall threatens poor germination or poor use of your inputs. Most farmers appreciate a gentle rainfall the night after they finish planting or they have applied pre-emergence (soil applied) herbicides. Michigan State University Extension recommends that producers with irrigation can utilize their investment to make sure every irrigated field has the best chance for optimum plant populations, stand uniformity, and performance of herbicides and fertilizers.

Irrigated sandy loam soils in northern Indiana and southern Michigan need about a half inch of irrigation to wet the soil down to five to six inches. A single half inch application is often enough to germinate seed, assist in emergence (alleviate crusting), and incorporate fertilizers and soil-applied herbicides. Heavier loam soils may need 0.7 inch to 1.0 inch of water to wet the top 6 inches of soil to accomplish these tasks.

One potential problem that can occur when irrigating only enough to aid a crop through emergence is the potential of a dry layer of soil developing beneath the root zone of the young seedlings. Subsequent downward root development may be restricted if the young roots desiccate and die in the dry zone before reaching adequate soil moisture at deeper depths. This situation is not very common, but irrigators need to be aware of this potential problem so that they can apply additional irrigation to prevent seedling stress. Double crop situations (soybeans or snap beans following wheat, second crop of snap bean crops) often require extensive watering to establish the second planting during the warmer and drier summer conditions.

Many soil applied herbicide labels recommend using irrigation to improve performance (or warnings to expect weed escapes if lack of rain leaves the herbicide on the soil surface). One example of this is the herbicide label from the commonly used pre-emergence corn herbicide, Bicep II Magnum. The label states the following: "Dry weather following an application of Bicep II Magnum or a tank mixture may reduce effectiveness. Cultivate if weeds develop." This statement is followed by, "If available, sprinkler irrigate within two days after application. Apply half to one inch of water. Use lower water volumes (half inch) on coarse-textured soils, higher volumes heavier soils (one inch) on fine-textured soils." Look to the product label for pesticides you use on irrigated field for information on use of irrigation to improve performance or for the rain fast period to assure you are not reducing performance by applying water too soon.

The economics of using irrigation to help incorporate soil-applied herbicides are potentially very good in dry springs. The additional application cost alone is often greater than the cost of applying an inch of water. The cost of applying one half inch of water is between $1.00 and $4.00 per acre for most Indiana and Michigan producers. A post emergence rescue weed control program will often cost upwards of $15-20 per acre.

In drought conditions, irrigating fields prior to post-emergence weed control applications can often improve performance. Glyphosate-based herbicide labels often include the verbage, "apply to only actively growing weed." Drought-stressed weeds have difficulty absorbing and translocating the active ingredient where it is needed to provide effective weed control.

Not having the irrigation system ready to run was the reason most often cited for not addressing early season drought conditions. De-winterizing systems early and having pivots ready to run when you plant can make the difference between looking at a weed-free field with a uniform stand, primed for maximum yields or paying for more inputs and wishing the rest of the season you had a better start to the growing season.

For more information on maximizing the value of your inputs through the use of irrigation visit http://www.msue.msu.edu/stjoseph/ and look for "Irrigation" on the menu to the left.

Cottonseed, Manure, and Herbicide-Resistant Palmer Amaranth in Southwest Michigan

By Jon Zirkle and Bruce MacKellar, MSU Extension

Palmer amaranth is an aggressive broadleaf weed that has had farmers and university researchers buzzing since its discovery in St. Joseph County in 2010. This weed species has now been identified in 11 counties in southern Michigan. Five counties in northern Indiana have recently confirmed Palmer amaranth populations, as well.

The main concern is that this aggressive weed species has an impressive track record of developing resistance to herbicides. In the case of Palmer amaranth populations in St. Joseph County, the weed species has resistance to both glyphosate and ALS (acetolactate synthase) inhibiting herbicides. This is particularly troublesome for soybean production, as these two classes of herbicides are commonly used. More trouble may be brewing. There are populations of Palmer amaranth resistant to atrazine, the main herbicide component that has kept Palmer under control here in commercial corn and seed corn production. At least one Midwest strain of Palmer is cross-resistant to atrazine and HPPD inhibitors (Callisto and other bleaching herbicides). If introduced here, this could devastate our commercial and seed corn industry.

Herbicide cross resistance means growers have fewer weed control options to work with. As the number of herbicide resistant weed species increases, so does the cost per acre needed to provide adequate control. So do the headaches. Hand removal of Palmer amaranth escapes has become a reality for growers in the South in order to keep this aggressive weed in check, adding a considerable cost.

How is Palmer amaranth getting to Michigan? Weed seeds are hitching a ride as we import products and equipment from areas of the South that are infested with glyphosate resistant (GR) Palmer amaranth. This includes states like Tennessee, Georgia, Mississippi, Missouri, Texas, New Mexico, and more. With a tiny seed size, high germination rates, and huge production of seed per plant, this aggressive weed species has also succeeded in Michigan.

One source of Palmer amaranth seed to examine closely: fuzzy cotton seed. This byproduct of cotton production is high in fiber, protein, and fat, making it a popular component in dairy and beef feed rations. The University of Nebraska reported finding Palmer amaranth seed in this byproduct of the cotton cleaning process. Fuzzy cottonseed is being brought in to feed suppliers as well as directly to farms. When the cotton seed is fed, cows may ingest weed seeds that come out in the manure. Manure that is spread can introduce weed seeds to new fields.

Cottonseed is certainly not the only way in which Palmer amaranth may be coming into our region. Various types of farm equipment may have weeds snagged on the undersides, making their way up north. Other feedstuffs from the South and Southwest, including hay, may also contain tiny weed seeds that aren't sorted out from seed cleaning.

The bottom line is that crop producers in Michigan should be aware that they are at risk from this aggressive weed species. If you are allowing dairy manure to be applied to your farm, ask if the operation you are obtaining manure from is currently feeding (or has recently fed) fuzzy cottonseed in the ration. You also should be concerned about equipment movement from area to area without power washing between farms. If you are purchasing equipment from out of state, has it been thoroughly cleaned?

Dr. Christy Sprague, MSU weed specialist, is busy documenting Palmer amaranth outbreaks, testing samples for herbicide resistance, and researching ways to control this potentially devastating weed species. In the meantime, it is critical to identify Palmer amaranth weed escapes and to remove the female plants as you discover initial infestations. This is particularly true if you find Palmer in corn fields treated with atrazine, Lumax, or Lexar. Report incidences of PA escapes in corn to us so that we can help reduce its spread.

To learn more about preventing herbicide resistance on your farm, visit the MSU Weeds webpage at www.msuweeds.com.

Palmer amaranth found in St. Joseph County.

Starter Fertilizer for Corn Production

There are several reasons for using starter fertilizers when planting corn: 1) enhance early growth; 2) increase corn yields, 3) accelerate corn maturity, 4) apply phosphorus efficiently; and 5) carry micronutrients. Increasing corn yields is the reason most growers apply starter fertilizer. However, the yield benefit of using starter fertilizers depends on several factors. Conditions that increase the probability of starter fertilizers improving corn yields include: 1) cool, wet soils; 2) reduced tillage systems having significant surface residues; 3) low phosphorus and/or potassium soil test levels; 4) pH levels below 6.0 or above 7.0; and 5) low organic matter.

Table 1. Potential for a yield response to phosphorus starter fertilizer applied to corn for areas south of Lansing.

Planting Date	*P Test (ppm)*	*Minimum Tillage*	*Conventional Tillage*
Before April 25	< 15	H	H
	15 - 30	H	M
	> 30	M	L
April 25 - May 10	< 15	H	H
	15 - 30	H	M
	> 30	M	L
After May 10	< 15	H	H
	15 - 30	M	L - M
	> 30	L	L

Dates will shift from earlier to later going from south to north.
Source: Dr. Darryl Warncke

Michigan State University recommends placing the starter fertilizer 2 inches to the side and 2 inches below the seed (2 x 2) at planting. This placement method provides a high degree of crop safety and maximizes the opportunity for root interception of the fertilizer. Using this placement, MSU recommends applying at least 25 lbs. of actual nitrogen per acre. The nitrogen rate should be increased to a maximum of 40 lbs. per acre in no-till or other high residue conditions. In many situations nitrogen in the starter fertilizer is more beneficial than phosphorus.

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Table 2. Potential for a yield response to nitrogen starter fertilizer applied to corn for areas south of Lansing.

Planting Date	*Pre-Plant Nitrogen*	*Minimum Tillage*	*Conventional Tillage*
Before April 25	PPN	L	L
	No PPN	H	M
April 25 – May 10	PPN	L	L
	No PPN	M - H	M
After May 10	PPN	L	L
	No PPN	L - M	L - M

PPN = preplant nitrogen knifed in or incorporated prior to planting corn. Dates will shift to later going farther north.
Source: Dr. Darryl Warncke

Including potassium in starter fertilizer is more beneficial in high residue and cool, wet soil conditions. Potassium should be included in the starter in no-till/strip-till or when the soil test level is less than 90 ppm.

Potassium and nitrogen fertilizers can burn the seed so the total amount of N plus K_2O should not exceed 100 lbs. per acre for coarse-textured soils and 125 lbs. per acre for fine-textured soils. The preceding application rates apply to a 2 x 2 fertilizer placement. If you plan to place the fertilizer directly in contact with the seed, please read the precautions below.

Pop-up Fertilizer Precautions
Fertilizer placed in direct contact with the seed has the potential to reduce germination. This is especially true when planting into dry soil. As a general rule, never apply more than 5 pounds of N plus K_2O on soils having cation exchange capacities (CECs) of 5 meq/100g or less and no more than 8 pounds of N plus K_2O soils having CECs of 8 meq/100g or more. Urea, ammonium thiosulfate and boron should not be applied in direct contact with the seed as they are known to adversely affect germination. 2005 research conducted by Dr. George Rehm at the University of Minnesota showed that zinc placed in contact with the seed can also reduce emergence in sandy soils.