DuPont

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Pioneer GrowingPoint™

Agronomy Research

Iowa Edition

SOYBEANS

DuPont Pioneer Agronomy Sciences

Introduction

Growers once considered their soybean crop much simpler to manage than their corn crop. However, this philosophy is changing as management systems evolve and new pest challenges arise. For example, soybeans are now planted earlier, so seed treatment use has grown dramatically. Increasing soybean aphid problems mean that scouting and spraying may now be necessary. Spread of soybean cyst nematode, sudden death syndrome, white mold and other diseases has increased management requirements for soybeans.

The record shows that soybean yield increases have not kept pace with those of corn over the last 25 years. DuPont Pioneer is dedicated to accelerating the pace of soybean yield improvement, both to meet global demand for grain and grower needs for increased production efficiency. The mission of DuPont Pioneer Agronomy Sciences is to help maximize grower productivity by delivering useful crop management information built on rigorous, innovative research. Our commitment to improved crop management is the foundation of our Pioneer® GrowingPoint® agronomy research structure – an industry-leading network of DuPont Pioneer agronomists and researchers across North America who conduct thousands of trials each year to provide growers with local, on-farm crop management insights.

This booklet serves as an introduction to DuPont Pioneer agronomic research, with examples of recent research results in several key areas of soybean management. Additional research reports and crop management publications are available from your Pioneer sales professional and at www.pioneer.com. We hope this extensive library of research-based agronomic information and the local expertise of DuPont Pioneer agronomists and researchers serve as valuable resources to help improve productivity in your soybean operations.

DuPont Pioneer Agronomy Sciences Team

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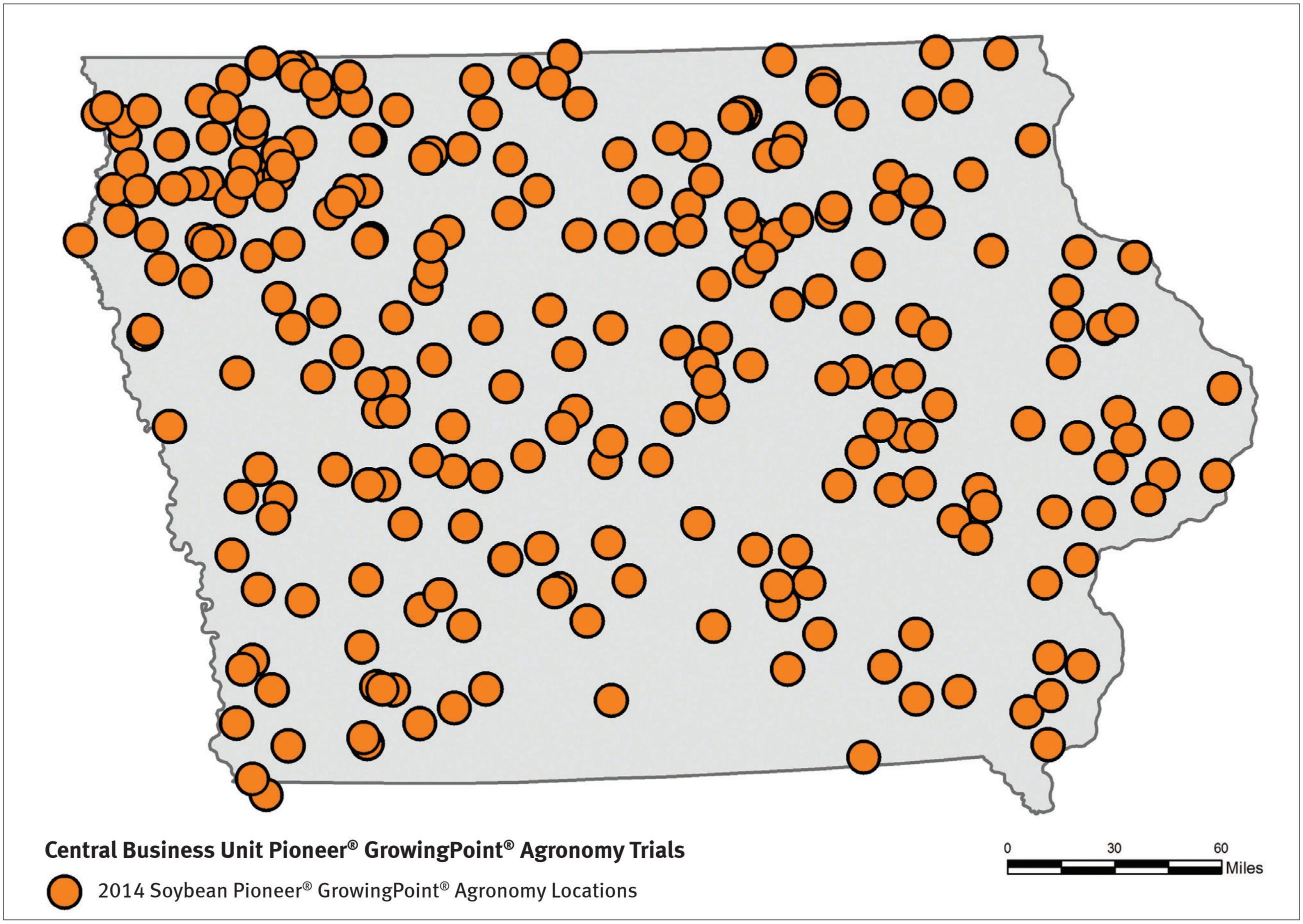
DuPont Pioneer Agronomy Research Soybean Management Topics:

- Variety Selection
- Seeding Rate
- Planting Date
- Stand Establishment
- Row Spacing
- Soil Fertility
- Disease Management
- Insect Management
- SCN Management
- Weed Management

2014 Agronomy Sciences Testing - Soybeans



Collaborative Research

Collaborations with university researchers are a critical component of the DuPont Pioneer commitment to innovative crop management research. Many of the research studies included in this book were conducted as a part of the DuPont Pioneer Crop Management Research Awards (CMRA) Program. This program provides funds for agronomic and precision farming studies by university and USDA cooperators throughout North America. The awards extend for up to four years and address crop management information needs of DuPont Pioneer agronomists, customers and Pioneer sales professionals.

Variety Selection

Soybean variety selection is the first step in producing a high-yielding soybean crop. Each variety has specific strengths that can make it highly suited for a certain environment, but less suited for another. Soybean maturity and disease tolerance are two of the most important traits to consider when selecting a variety. However, other traits may be just as critical for local environments, such as high pH soils.

Soybean maturity – Selecting the appropriate maturity is essential to maximizing soybean yield. Each variety has a relatively narrow geographical range in which it will perform as a "full-season" crop, utilizing all of the available growing season, but still reaching physiological maturity before frost. This geographical range is usually no wider than 100 to 150 miles north to south. This is because soybean development depends on summer day length, which is shorter in the South than in the North.

When the days shorten in the summer, a soybean variety in its ideal geographical range is triggered to flower. When a variety is grown north of its ideal geographical range, it will flower later in the season when the days shorten. Thus, the variety will mature later than normal and may be at risk of a killing frost. Conversely, if a northern variety is moved south, it will flower earlier than it would in its ideal geographical range. If flowering occurs before the variety reaches adequate height, yields may be reduced.

Ideal maturity is also influenced by planting date, as illustrated by a 2013 DuPont Pioneer study that evaluated the response of different soybean maturities planted at three timings. Maturity group 2.8 and 3.0 varieties had the greatest yield with mid-May planting (Figure 1). Longer maturity varieties yielded well with either late April or mid-May planting.

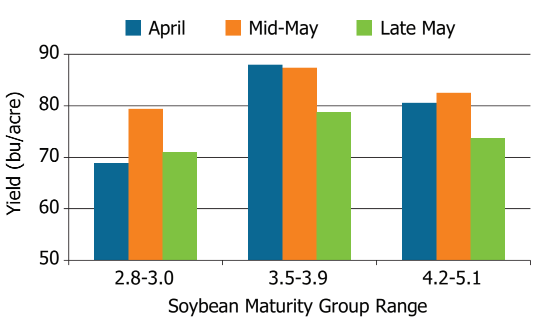


Figure 1. Soybean maturity group and planting date effects on yield in a 2013 study conducted near Owensboro, KY.

Disease tolerance – Another major consideration with soybean variety selection is genetic disease tolerance. This is especially true for hard-to-manage diseases such as white mold and sudden death syndrome (SDS).

There is no absolute resistance available to white mold, but differences in tolerance exist between varieties. The Pioneer rating system rates varieties on a scale of 1 to 9 (9 = tolerant). Varieties are rated from 3 to 6 for this disease. Ratings reflect varietal differences in the speed at which infection develops and the extent of damage it causes, and they are based on data from multiple locations and years.

Soybean varieties can also show dramatic differences in tolerance to SDS. A 2011-2013 DuPont Pioneer/Michigan State University study demonstrated the extent to which yield can be influenced by varietal tolerance. An SDS-susceptible variety (Pioneer® variety 92M82 (RR)) averaged only 10 bu/acre under severe SDS pressure, whereas a more tolerant variety with Peking SCN resistance (Pioneer® variety 92Y53 (RR)) averaged 50 bu/acre.

Figure 2. Differences in SDS symptoms between susceptible (left) and tolerant (right) soybean varieties in a DuPont Pioneer/Michigan State University research study near Decatur, MI, in August 2012.

IDC tolerance – Iron deficiency chlorosis (IDC) tolerance is a critical trait for soybean varieties grown on high pH soils. Varieties vary widely in tolerance to IDC, and variety selection is the first and most important step in managing this problem (Figure 3).

Figure 3. Differences in iron deficiency chlorosis symptoms between susceptible (left) and tolerant (right) varieties.

In a two-year DuPont Pioneer study conducted at several high pH sites in Minnesota, IDC-tolerant varieties outyielded susceptible varieties by an average of 18 bu/acre (Figure 4).

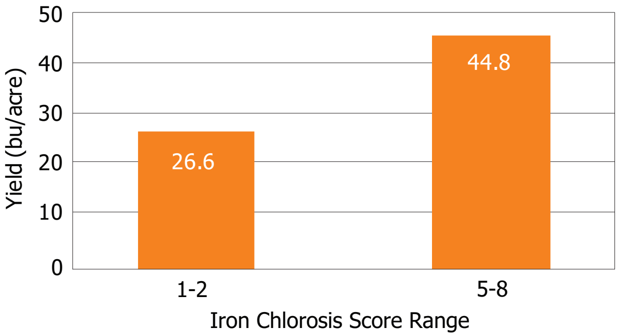


Figure 4. Average yield of soybean varieties susceptible (IDC score 1-2) and tolerant (IDC score 5-8) to iron deficiency chlorosis in a two-year DuPont Pioneer study conducted at four locations with high soil pH in Minnesota.

Seeding Rate

Improved genetic yield potential and management practices have helped to increase soybean yield. As new varieties enter the market, the need to identify optimal seeding rates continues to be important. Higher seeding rates can offer advantages such as earlier canopy closure and lower weed competition; however, this may not always result in greater profitability. DuPont Pioneer has conducted numerous studies evaluating variety seeding rates to help growers determine optimal rates to improve the profitability of soybean production.

In one study, multiple soybean varieties were compared at six different seeding rates at research locations across several Midwestern states. Average yield in this study was greatest at 250,000 seeds/acre; however, yields at 150,000, 175,000, and 250,000 seeds/acre were very similar (Figure 1). Soybean yield was significantly reduced at 25,000 seeds/acre but still achieved over 70% of maximum yield, demonstrating the ability of soybeans to adapt to reduced stands.

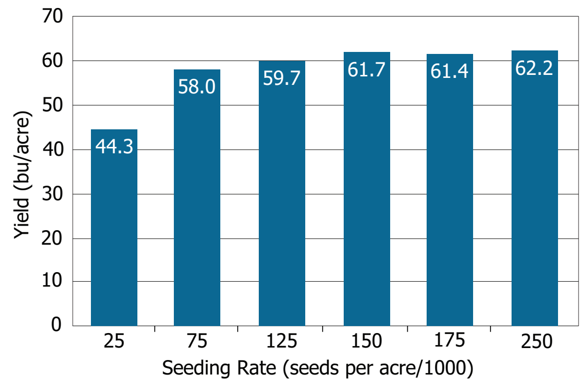


Figure 1. Average soybean yield response to seeding rates across nine research locations.

The optimum economic seeding rate is always lower than the agronomic optimum, as seed cost and soybean market value are taken into consideration. This rate can vary from year to year due to variability in the soybean market price and seed costs. The optimum economic seeding rates based on a $60.00 per unit seed cost and a soybean market price of $10, $12 or $15 per bushel are shown in Figure 2.

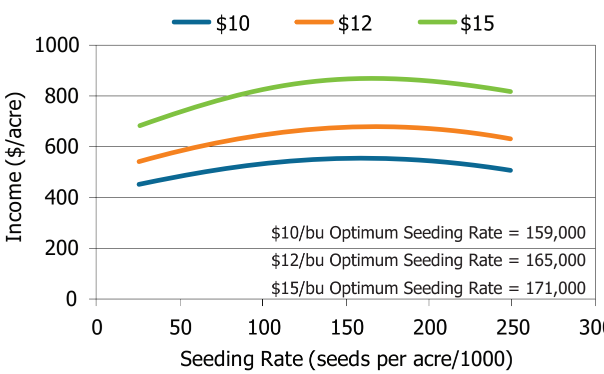


Figure 2. Optimum economic seeding rates at soybean market prices of $10, $12 and $15/bu and a $60/unit seed cost based on DuPont Pioneer studies at nine locations in IA, IL, IN, MN and NE. (Studies conducted in 30-inch rows; economic optimum seeding rates are likely greater in narrower rows).

A three-year DuPont Pioneer study conducted at nine Midwestern research locations showed that economic optimum seeding rates with early planting were influenced by the use of a fungicide seed treatment or fungicide + insecticide seed treatment (Figure 3).

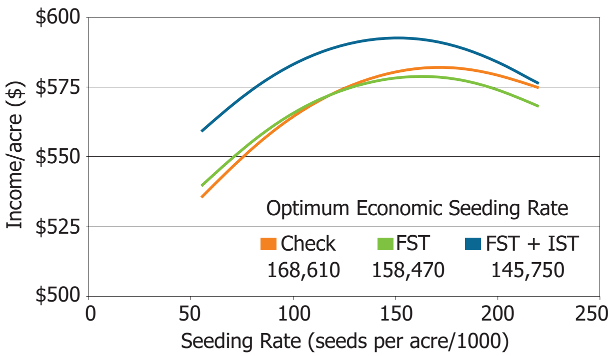


Figure 3. Optimum economic soybean seeding rates for early planting dates influenced by seed treatments in a three-year study. (Based on soybean market price of $10/bu. All locations were planted in 30-inch rows.)

Soybeans have a greater ability than corn to compensate for reduced stands. However, too much reliance on this ability may lead to poor stands and the need to replant in some situations. As a result, higher seeding rates may help prevent yield reductions or replanting when seedbed conditions, weather, or pests are likely to reduce soybean stands.

Planting Date

Pioneer research has consistently shown the value of timely soybean planting. Recent research efforts have also looked at the effects of planting varieties of different maturities at normal and earlier timings.

DuPont Pioneer scientists conducted a two-year study evaluating planting dates to see if there is an advantage to earlier planting (late April and early May) at nine Midwestern research locations. Results from this study indicate that yields were generally higher with a late April to early May planting date, compared to later planting dates (Figure 1). These yield increases can be attributed to soybean stage development and day length. Soybeans obtain higher yields when their critical developmental stages occur during longer summer days.

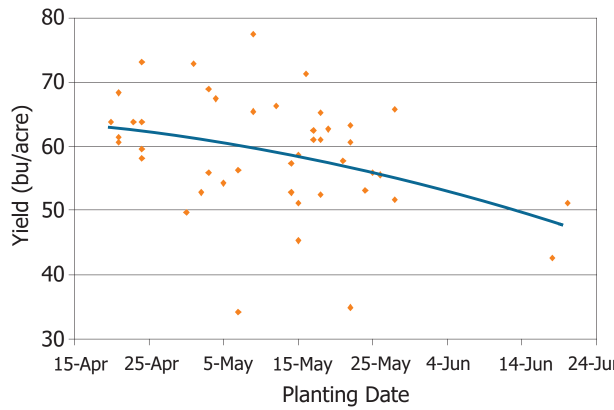


Figure 1. Soybean yield response to planting date in a three-year DuPont Pioneer study (23 site-years in IA, IL, MN and NE).

A subsequent research study evaluated the interaction of planting date and variety maturity on soybean yield. This study was conducted at 58 locations in Illinois and Indiana in 2011 and 2012.

In 37 locations, varieties differed by an average of one full maturity group. Results showed a significant interaction between planting timing and soybean variety maturity. Full-season adapted varieties had a greater average yield when planted early; whereas early maturing varieties yielded similarly across planting timings (Figure 2).

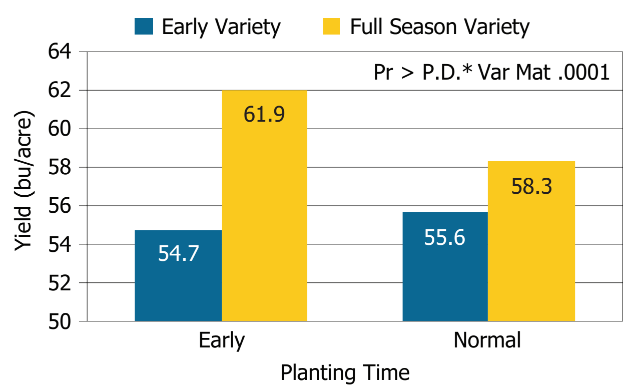


Figure 2. Influence of variety maturity at early (mid-April to early May) and normal (late May) planting times on soybean yield across 37 IL and IN locations in 2011 and 2012 where varieties differed by a full maturity group.

At the other 21 testing locations, varieties differed by half a maturity rating, on average. Varieties showed no significant interaction between planting timing and maturity (Figure 3).

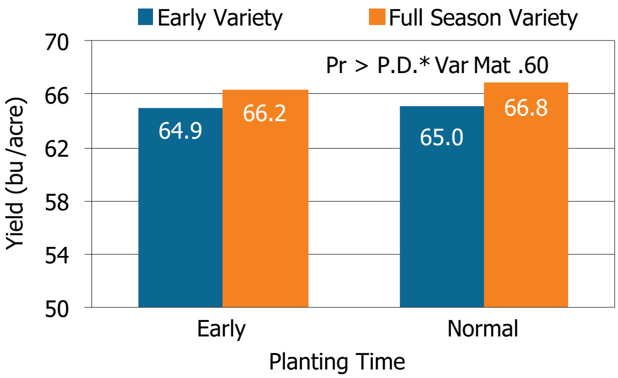


Figure 3. Influence of planting timing and variety maturity on soybean yields at 21 IL and IN locations in 2011 and 2012 where varieties differed by one-half maturity group.

Sometimes conditions do not allow for early planting, and growers are forced to plant later. With later planting, growers may need to reconsider management practices to maximize yield.

- Refraining from switching to an earlier maturity variety may increase yield unless planting is severely delayed (later than June 15th).
- Increasing planting rate by 10% might be beneficial after the first week in June.
- Planting in narrower rows may hasten canopy closure.
- Delaying planting might mean that harvest is delayed, leaving fewer available days for harvest.

Stand Establishment

Soybean seed treatment usage has increased as a way to help growers address concerns often associated with earlier planting dates. Other factors that put seedlings at a higher risk for poor emergence include no-till or reduced-till practices, cool and wet weather conditions, and heavy or compacted soils.

These factors can delay emergence and early plant development, increasing the window of vulnerability to disease and insect damage. Even minimal insect feeding can allow diseases to enter the plant, which can weaken or eventually cause plant death.

Adding a Pioneer Premium Seed Treatment (PPST) to a Pioneer® brand soybean variety adds an extra level of protection against early season insects and diseases.

EverGol® Energy fungicide seed treatment is a next generation technology with multiple modes of action that provides enhanced protection against a broad spectrum of seed and soil-borne diseases caused by *Rhizoctonia solani, Fusarium spp., Pythium spp.* and *Phomopsis longicolla.*

Over a three-year period, DuPont Pioneer evaluated the performance of EverGol Energy fungicide at 57 research locations. The seed treatment combination included EverGol Energy fungicide + an FST/IST (Allegiance® fungicide + Gaucho® fungicide) + PPST 2030 (Figure 1). PPST 2030 contains a biological component and a polymer.

Figure 1. A side-by-side comparison of non-treated soybeans vs. EverGol Energy fungicide + FST/IST + PPST 2030 in 2012.

Results from this study showed that the treatment with EverGol® Energy fungicide had a positive yield advantage over the non-treated check at 47 of the 57 research locations (82%). Across all locations, the three-year average yield advantage was 1.34 bu/acre (Figure 2).

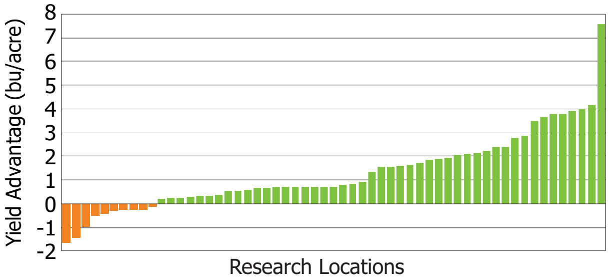


Figure 2. EverGol Energy fungicide + FST/IST + PPST 2030 yield advantage vs. non-treated checks at 57 replicated research locations from 2010-2012.

PPST 120+ is another seed treatment option available for growers. PPST 120+ is a premium on-seed inoculant plus extender product developed exclusively for DuPont Pioneer and its affiliates that delivers a high concentration of beneficial rhizobia bacteria to the soybean plant.

A Pioneer study was conducted in 2012 across 16 locations in Illinois and Indiana comparing seed treatment packages with and without PPST 120+. In all locations, results showed that soybeans treated with PPST 120+ yielded an average of 1.4 bu/acre more than soybeans treated without PPST 120+ and 2.3 bu/acre more than untreated seed (Figure 3).

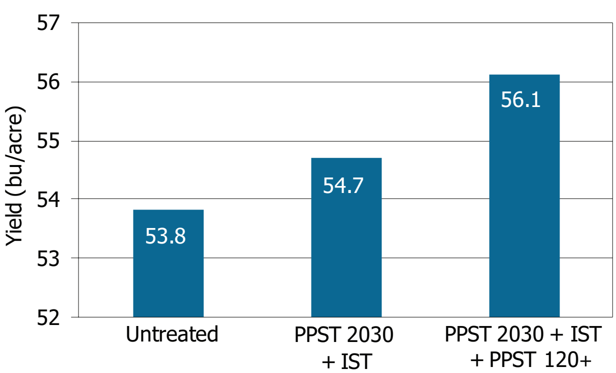


Figure 3. Average yield of seed treatments across 16 testing locations in 2012.

Row Spacing

Soybean row width preferences vary greatly across North America, with the four largest soybean-producing states showing substantial differences. The majority of growers in Illinois and Indiana currently favor 15-inch and narrower spacings, while growers in Iowa and Minnesota favor 30-inch rows (Figure 1).

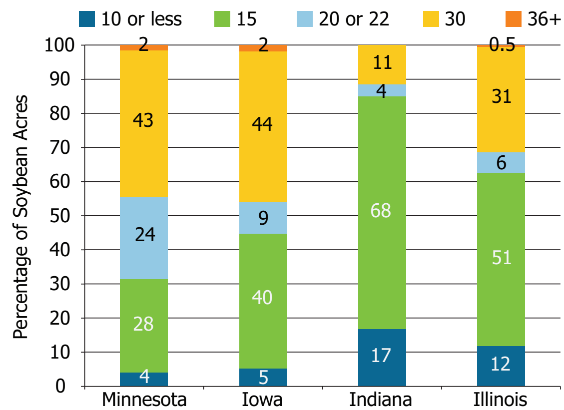


Figure 1. Soybean row spacings (inches) in the four largest soybean-producing states in 2012 as a percent of total acres (USDA-NASS).

Numerous research studies over the past 40 years have evaluated soybean row spacing. In the last 10 years, studies show a 3 to 4 bu/acre yield advantage for soybeans planted in drilled narrow rows and 15-inch rows over 30-inch rows (Figure 2).

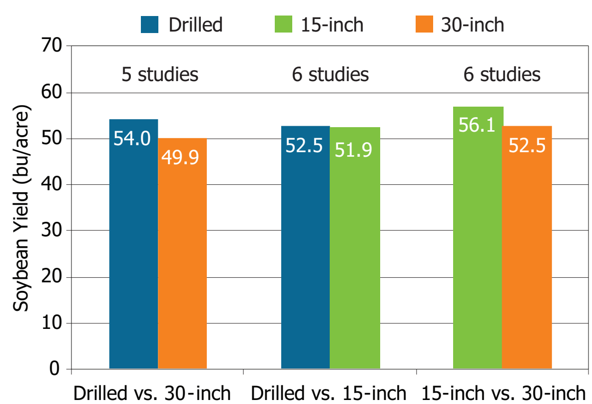


Figure 2. Average yield results from seven soybean row spacing studies published during the last ten years.

Other than yield, important factors driving soybean row spacing decisions include equipment and time management issues during the planting season. Larger enterprises are more likely to have a dedicated soybean planter; whereas for smaller farms, it may be more practical to share a planter with another crop, such as a drill with wheat or a 30-inch planter with corn.

Although row width preferences vary, a consistent trend across North America shows the decline in drilled soybean acres (Figure 3). In many cases, the decline in drilled soybeans has been accompanied by an increase in acres converted to 15-inch rows.

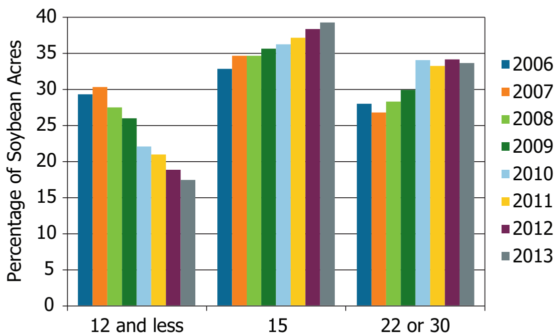


Figure 3. Changes in common soybean row spacing shown as a percentage of total soybean acres from 2006 to 2013 in North America. Source: DuPont Pioneer Brand Concentration Survey.

Environments favoring narrow row widths include: limited vegetative growth prior to flowering, shorter growing seasons, early soybean production systems to avoid drought, delayed planting situations and double-crop systems.

Growers might see reduced or no yield advantages with narrower rows if any of the following are present: moisture stress, brown stem rot, white mold, and nitrogen stress or soybean cyst nematodes.

In recent years, soybean acres planted in 30-inch rows has increased in some areas. This shift is likely due to white mold, also known as Sclerotina stem rot *(Sclerotinia sclerotiorum)* (Figure 4). White mold development favors cool and wet conditions during soybean flowering. A dense soybean canopy enhances these conditions, potentially increasing the severity of the white mold. Alternatively, wider row spacings increase light penetration and air movement in the lower canopy, making conditions less favorable for white mold development.

Figure 4. A dense soybean canopy enhances conditions favoring the development of white mold.

Soil Fertility

Soybeans have among the highest nitrogen (N) demands of agronomic crops due to a high concentration of protein in the seed. Symbiotic fixation supplies about half of the plant's N needs, and the remainder comes from soil and/or fertilizer.

Despite their high demand for N, soybeans have historically received little, if any, N fertilizer. However, some studies have indicated that fixed N alone may not be sufficient to supply the N required to produce maximum yields. In fact, adequate N_2-fixing capacity of soybeans declines rapidly after the R5 stage, which coincides with the peak soybean N demand for protein synthesis in seeds.

To better understand the potential for increased soybean productivity by using additional N, DuPont Pioneer conducted research trials to determine soybean yield response to late-season N applications.

In a 2011-2012 study conducted at five Illinois locations, 80 lbs N/acre was applied as a polymer-coated urea at the R2 growth stage. Results showed a significant positive yield response to the N fertilizer at all five research locations ($p < 0.10$). Yield increases ranged from 1.3 to 3.7 bu/acre (Figure 1).

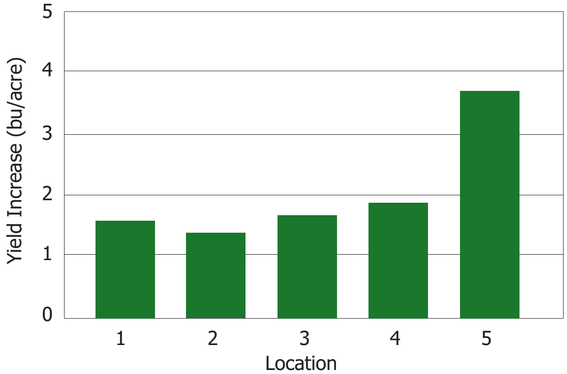


Figure 1. Soybean yield increases with R2 applications of 80 lbs N/acre at five Illinois locations in 2011-2012. All locations showed a significant ($p < 0.10$) yield increase.

In addition, a larger study conducted at 55 Illinois and Indiana locations over two years also showed a positive yield response to 100 lbs N/acre applied at the R2 growth stage. Across all locations, the average yield increase to the supplemental N was 1.1 bu/acre (Figure 2). The yield response to the added N was 0.4 bu/acre for short-season (‹ 3.0 MG) varieties and 2.1 bu/acre for full season (› 3.0 MG) varieties.

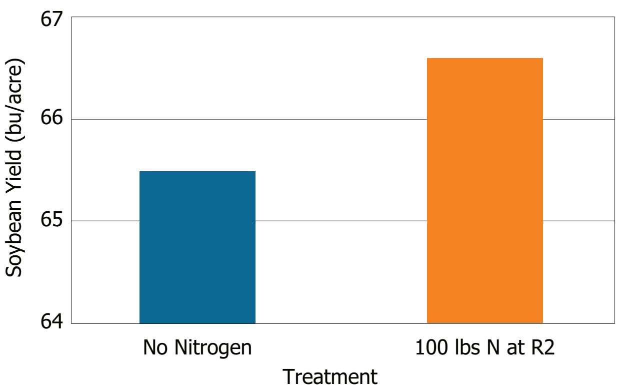
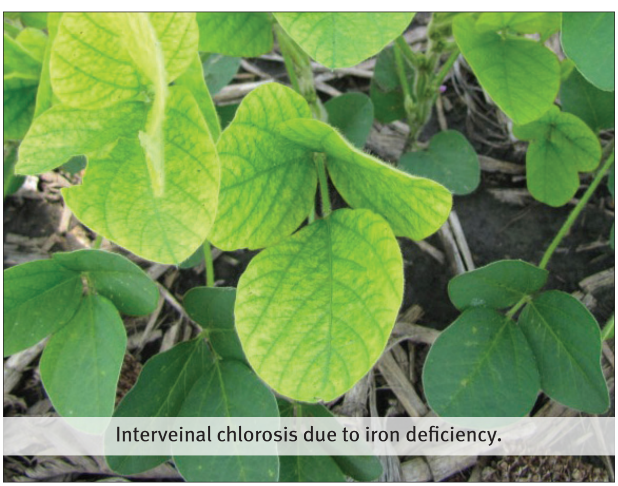


Figure 2. Influence of 100 lbs N/acre applied at R2 vs. no applied nitrogen on soybean yields at 55 research locations in Illinois and Indiana over a two-year period.

An iron deficiency can also hinder soybean productivity. Soybean iron deficiency chlorosis (IDC) is a nutrient deficiency disorder with symptoms that include chlorosis (yellowing) of the soybean foliage and stunting of the plant. This condition is yield-limiting in many soybean fields in the northern and western Corn Belt as well as parts of the southern U.S. Because soybean varieties vary widely in tolerance to IDC, variety selection is the first and most important step in managing this problem.



Interveinal chlorosis due to iron deficiency.

DuPont Pioneer conducted a study to determine if an in-furrow application of an iron chelate treatment at planting would help to mitigate IDC symptoms at 11 locations with a history of IDC in Nebraska and Kansas. Results showed that several soybean varieties with a range of IDC tolerance scores had a positive yield response to the iron chelate treatment (Figure 3). Visual differences, such as greener and more robust plants, were noted as well.

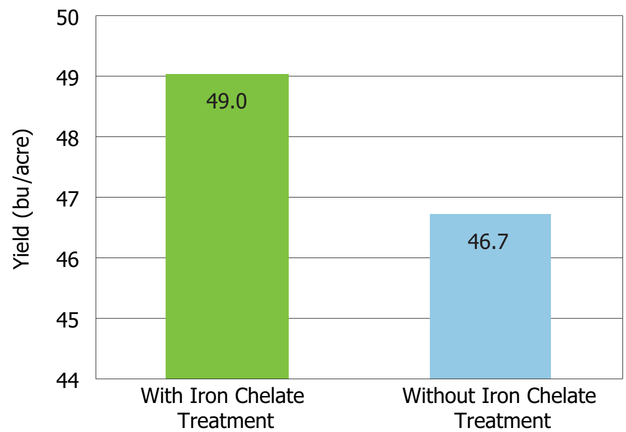


Figure 3. Yield response to iron chelate treatment averaged across 11 locations with a history of IDC in Nebraska and Kansas in 2012.

In another study, DuPont Pioneer and Auburn University investigated the use of a wheat cover crop to manage IDC on high pH soils in the Black Belt Region of Alabama.

Results from this 2012 study showed that using a cover crop increased yield of several soybean varieties that had a range of IDC tolerance scores. In fact, a cover crop increased the yield of the most IDC sensitive variety by 45 bu/acre. Other varieties showed yield increases ranging from 20 to 31 bu/acre in response to a cover crop (Figure 4).

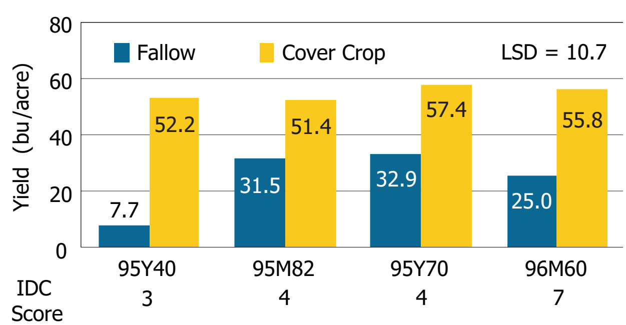


Figure 4. Soybean yield response comparing the impact of a cover crop vs. a fallow field in 2012. Pioneer® brand varieties used in the study were 95Y40 (RR), 95M82 (RR), 96Y70 (RR, STS), and 96M60 (RR).

Disease Management

In most soybean-producing areas, foliar fungicide use has increased to help manage common foliar diseases and potentially improve yields. Before using a foliar fungicide, it is important to scout and determine the type of disease(s) present. Foliar fungicides only control fungal diseases, particularly anthracnose, Septoria brown spot, Cercospora leaf blight, frogeye leaf spot, pod and stem blight, and soybean rust (Figure 1). Bacterial diseases, such as bacterial blight or bacterial pustule, and viral diseases, such as the soybean vein necrosis virus, are not controlled by fungicides.

Figure 1. Septoria brown spot (left) and frogeye leaf spot (right) are two diseases capable of reducing soybean yields and can be managed with foliar fungicides.

Not all fungal diseases are well controlled by foliar fungicides, mainly as a result of when the infection occurs. For example, stem canker can cause severe yield losses in soybeans, but results of fungicide applications have often been inconsistent. This is likely because infection occurs during early vegetative growth, and fungicides are generally not applied in time to prevent it. Charcoal rot and sudden death syndrome also can cause severe yield losses, but because infection occurs in the roots, they are not controlled by foliar fungicides.

To better understand the value of foliar fungicides in soybeans, DuPont Pioneer conducted extensive on-farm and small-plot research trials. On-farm trials were conducted over four years at various locations in 11 states and two Canadian provinces. Researchers conducted 148 trials comparing untreated soybeans to soybeans treated with foliar fungicides. Across all of these trials, 82% resulted in a positive yield response, and the average yield response to a foliar fungicide application was 2.5 bu/acre (Figure 2).

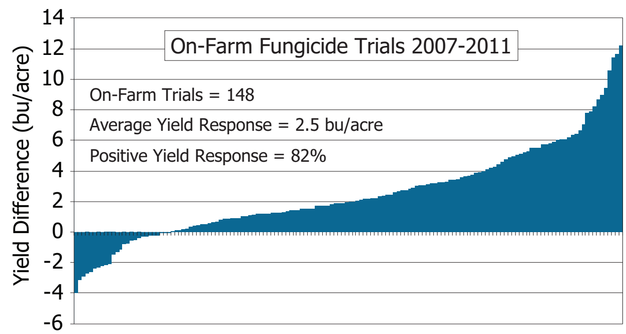


Figure 2. Average soybean yield response to foliar fungicide across DuPont Pioneer on-farm trials conducted from 2007 to 2011.

In addition to on-farm trials, Pioneer conducted small-plot trials in Illinois, Indiana, Iowa, Minnesota and Nebraska over four years. These small-plot trials compared yield response to foliar fungicides applied at different soybean growth stages (Table 1). Results showed that applying a fungicide around R3 (beginning pod development) provided the greatest average yield for a single application over the untreated check.

Table 1. Average yield response for fungicide treatments applied at different growth stages.

Growth Stage Applied	Years Tested	N*	Yield Response (bu/acre)
R1	2007	40	2.3
R3	2004-08	100	3.7
R5	2004-06	48	2.7
R3+R5	2004-06	48	4.6

N* = Number of comparisons.

Insect Management

Soybean insecticide applications have increased in recent years throughout most of North America, mainly due to a rise in soybean aphids. Growers and researchers are exploring the benefits of insecticide use, particularly by including an insecticide with a fungicide application.

Although this practice is efficient from an application standpoint, growers should be aware that a precise timing is usually required for optimum effectiveness of both components. However, insecticide applications are unlikely to be economically beneficial if pest pressure is low.

To better understand the potential yield benefits of insecticides applied with foliar fungicides, DuPont Pioneer conducted on-farm and small-plot research trials over multiple years and locations.

On-farm trials – Researchers conducted 200 on-farm trials over four years – 148 with only a fungicide and 52 with a fungicide + insecticide treatment. In these studies, the average yield response to a fungicide application was 2.5 bu/acre, compared to 5.3 bu/acre when an insecticide was also included (Figure 1).

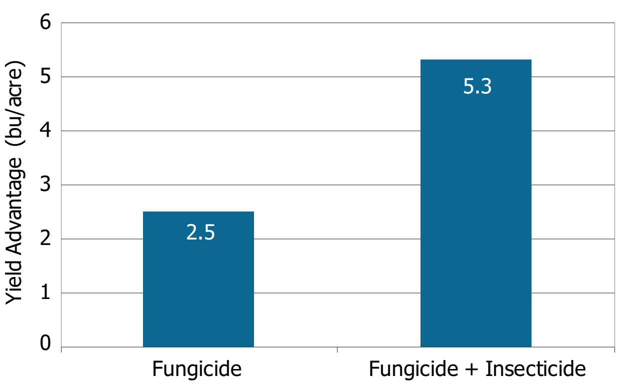


Figure 1. Average soybean yield response to foliar fungicide and fungicide + insecticide treatments across 200 on-farm trials conducted over four years.

Small-plot trials – Over five years, small-plot trials conducted in Illinois, Indiana, Iowa and Minnesota also showed an advantage for including an insecticide in the treatment (Figure 2).

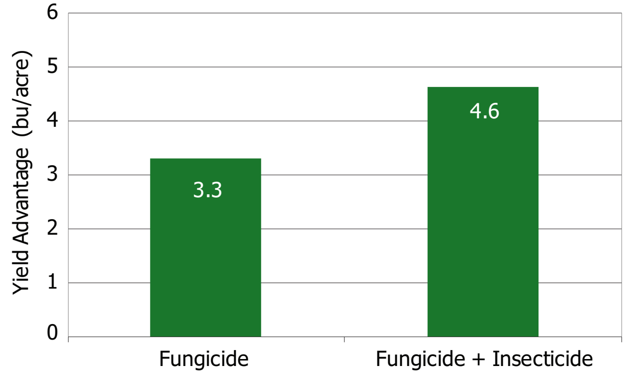


Figure 2. Small-plot yield advantages with fungicide and fungicide + insecticide applications averaged over a five-year period.

This study included one location where high soybean aphid pressure was observed. Yield response to insecticide treatment was much greater at this location than at locations with little or no aphid pressure (Figure 3).

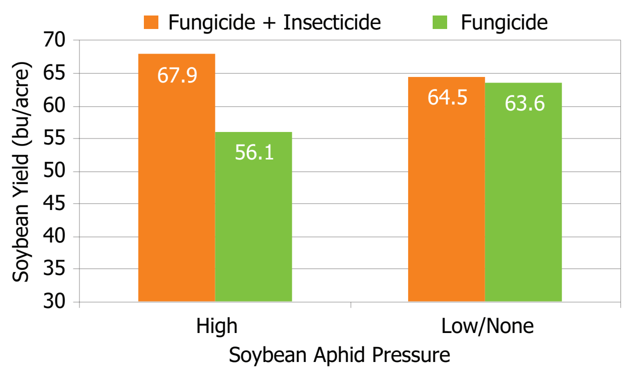


Figure 3. DuPont Pioneer small-plot research trials average soybean yield response to foliar fungicide + insecticide application vs. fungicide only. Also comparing a location with high aphid pressure to locations with low or no aphid pressure.

Soybean aphid management – For an insecticide application to provide an economic benefit, it is recommended to treat only if populations exceed the economic threshold (ET). For soybean aphids, the ET is currently established at 250 aphids/plant (average of 20 to 30 plants/field) during the R1 to R5 growth stages. If this threshold is exceeded, treating within seven days is required to prevent populations from reaching the Economic Injury Level (EIL) where yield loss exceeds the cost of treatment.

Soybean Cyst Nematode Management

Soybean cyst nematode (SCN) has long been a challenge for soybean production in the U.S. This worm-like parasite is reaching economic levels in more fields, often without obvious symptoms. Soybean yield may be significantly reduced, and many growers may be unaware of the cause.

For effective SCN control, a combination of strategies is needed, including planting SCN resistant soybean varieties, rotating crops and using seed treatments with a component for SCN control. A management program usually requires soil sampling to determine egg or cyst numbers and possibly SCN races. Monitoring SCN populations and races year after year can indicate if current practices are working or if further measures are needed.

In addition to planting SCN resistant varieties, nematologists recommend rotating sources of resistance. DuPont Pioneer offers varieties with the Peking source of resistance, which can be rotated with the common PI 88788 source used in over 90% of current soybean varieties.

Previous research has shown that SCN can increase the severity of sudden death syndrome (SDS) symptoms and yield loss. More recently, DuPont Pioneer and Michigan State University examined the performance of Pioneer® brand soybean varieties with differing levels of resistance to soybean cyst nematode (SCN) and sudden death syndrome (SDS). This 3-year study was established in a field with heavy SDS pressure and HG type 2 SCN pressure.

Results from the first year of the study showed that SCN reproduction differed among varieties, as indicated by the Pf/Pi ratio (Pf = final SCN count; Pi = initial SCN count). SCN numbers did not increase on Pioneer® variety 92Y53 (Peking source of resistance), while a 17-fold increase in the SCN population was observed on Pioneer® variety 92Y51 (PI 88788 source of resistance). The varieties without genetic resistance to SCN had an increase of over 40-fold (Figure 1).

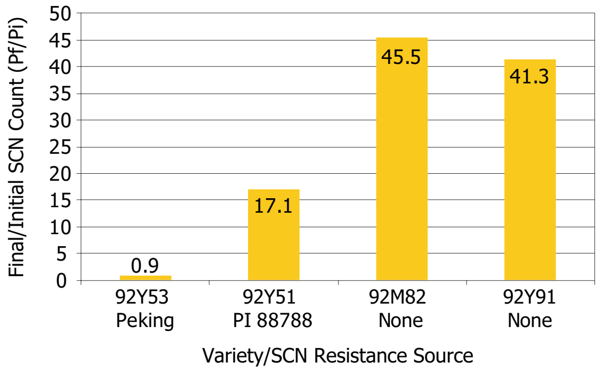


Figure 1. In the first year of a 2011-2013 DuPont Pioneer/University of Michigan study, SCN reproduction differed among varieties as indicated by Pf/Pi ratio (Pf = final SCN count and Pi = initial SCN count).

92Y53 had the best package of SCN and disease resistance for this environment and was the highest yielding variety in all three years of the study (Table 1). Pioneer® variety 92Y91, a non-SCN protected variety, had a relatively high disease index rating despite being moderately resistant to SDS. This finding supports previous observations that SCN can increase the severity of SDS symptoms and yield loss. In all three years, yield was lowest with Pioneer® variety 92M82, which has low SDS resistance and no SCN resistance. Results showed that knowing the SCN population type and matching the correct genetic resistance may help reduce SDS and SCN injury.

Table 1. SCN resistance and SDS score effects on soybean yields in a 2011-2013 DuPont Pioneer/Michigan State University study.

Variety/ Brand	SCN/ SDS	DX (Aug-15)*			Yield (bu/acre)*		
		2011	2012	2013	2011	2012	2013
92Y53 (RR)	Peking/6	0.9 a	0.0 a	0.0 a	48.9 a	44.3 a	56.9 a
92Y51 (RR)	PI 88788/6	0.7 a	9.8 a	23.8 b	43.4 b	31.0 b	38.3 b
92M82 (RR)	None/3	98 c	76.3 c	75.6 c	12.0 d	5.8 d	12.8 d
92Y91 (RR)	None/5	50.5 b	50.9 b	49.8 c	25.1 c	12.7 c	25.2 c

SDS was evaluated using a disease index (DX) rating. DX = (DS/9 * DI); where DS is disease severity using a 1-9 scale, and DI is disease incidence in 5% increments. *Values within a column followed by the same letter are not significantly different with 95% confidence.

Weed Management

With the rise in glyphosate-resistant weeds, growers are being forced to use additional or alternative management tools to achieve adequate weed control. A small number of weed species are resistant to multiple herbicides, leaving growers with very limited viable options for control.

The most troublesome multiple-resistant weeds for North American crop production are two pigweed species, common waterhemp and Palmer amaranth. Other important multiple-resistant weed species are common and giant ragweed, as well as kochia and horseweed (Figure 1).

A critical part of managing weed resistance is controlling resistant populations before they get out of hand, which means being aware of potential resistance issues in the area and watching for weeds that have survived a herbicide application.

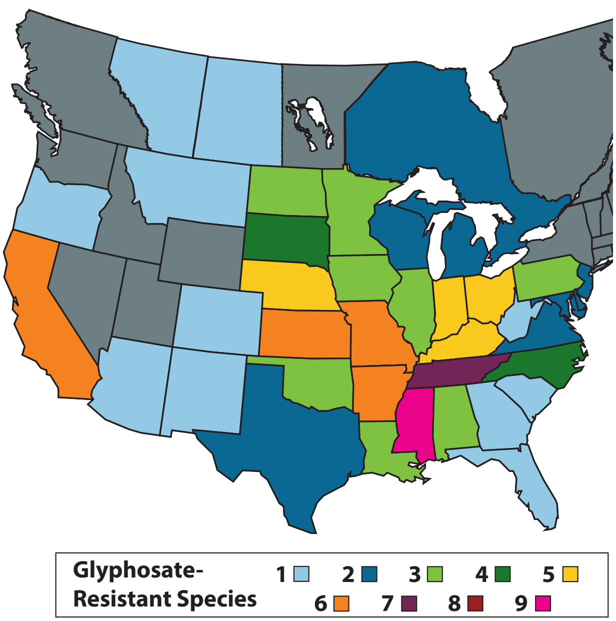


Figure 1. Confirmed glyphosate-resistant weed populations in North America.

DuPont Pioneer is working with the University of Illinois to identify glyphosate-resistant plants in fields where resistance is suspected and also to raise awareness that glyphosate-resistant waterhemp is increasingly becoming prevalent in Illinois.

In 2012, 379 plant samples were taken from 88 fields in which waterhemp plants survived a glyphosate treatment. DNA was then extracted from the plant samples, and molecular assays were used to test for resistance to glyphosate and PPO inhibitors.

Results were broken down on a plant basis and a field basis. On a plant basis, 54% of plants were confirmed as glyphosate-resistant, 12% of plants were confirmed resistant to PPO inhibitors, and 6% of plants were confirmed resistant to both glyphosate and PPO inhibitors.

Resistance Prevention and Management

- It is important to remember that herbicide resistance is a numbers game – the more plants that are exposed to a herbicide, the greater the likelihood of selecting a resistant individual. These individuals will then proliferate and result in a resistant population.
- In several weed species, resistance to glyphosate originated in continuous monoculture systems where glyphosate was the primary weed management tool used every year.
- Management practices, such as crop rotation and herbicide rotation, can reduce the selection pressure exerted by a given herbicide and prolong its usefulness.

On a field basis, 67% of fields were confirmed as glyphosate resistant, 24% of fields were confirmed resistant to PPO inhibitors, and 14% of fields were confirmed resistant to glyphosate and PPO inhibitors.

A total of 10 new counties in Illinois confirmed glyphosate-resistant waterhemp in 2012, and 16 new counties in 2013 (Figure 2). Although not shown in the figure below, the presence of glyphosate-resistant waterhemp in southern Illinois is well documented. Sampling for glyphosate-resistant weeds in Illinois in 2013 included Palmer amaranth in addition to waterhemp.

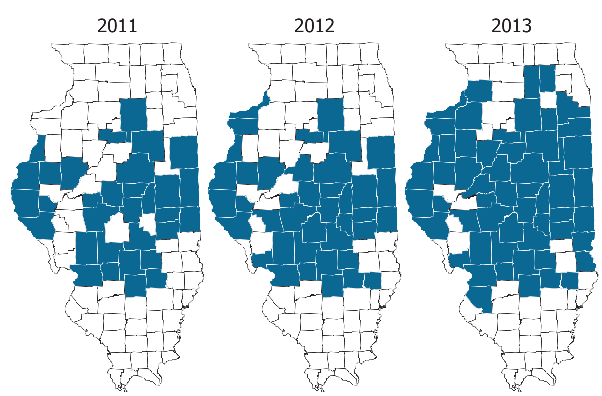


Figure 2. Illinois counties (blue) in which resistant waterhemp has been confirmed by molecular assay.

Agronomy Resources, Tools & Apps

Pioneer.com/Pioneer mobile

Growers can access extensive crop management resources at www.pioneer.com or take the resources with them using Pioneer mobile. They allow growers to have agronomy information at their fingertips. Some of the resources available include the following:

Field Troubleshooting Aids

- Videos
- Insects
- Diseases
- Environments

Current Research Trials

- By Locality

Field Tools

- Planting Rate
- Plantability
- GDU/Precipitation
- Growth Stage
- Yield Estimation
- Replant

Pioneer® Field360™ Plantability App

This planter settings calculator gives you precise planter settings for corn and sunflower seeds of all sizes and shapes.

- Select planter type and scan /type in a seed batch ID directly from Pioneer® brand seed packaging to view specific planter setting recommendations.
- See suggested plate or disc size, pressure or vacuum setting speed, and the singular setting, as well as the predicted seed drop for each batch and planter combination.

Pioneer Planting Rate Estimator

Allows user to examine historical yield response curves to help estimate an optimum planting rate for Pioneer® brand corn products.

Encirca℠ View

Keep your fields at your fingertips and capture important information with this GPS powered field documentation tool. Encirca View pinpoints your field location via satellite imagery so you can record notes or photos on the spot. Instantly organize your crop scouting information on your mobile device or through seamless integration with the Encirca View application, where you can also access aggregated data from a community of Encirca View users. You can also easily share notes with local experts to help inform management decisions.

encirca℠

Encirca℠ services helps you look at your operation through a sharper lens, to make smarter decisions that maximize profitability and yield. Taking three dimensional views of your soils, we gain understanding of how soil variables can drive and impact yields. By combining your yield targets for each field with productivity values, we create Decision Zones where your trusted advisors will tailor your seed and nitrogen rates - putting more where you need it and less where you don't.

Encirca℠ Yield *Stand* provides information to help maximize your corn or soybean stands, and early season yield potential, by looking at your fields in an entirely new way. Our Risk Analysis and Planting Priority tools allow you to easily adjust your plans in real-time, even under pressure of a difficult planting season. Learn from every field, every season, with insights from post-season yield analysis and consultation with your trusted advisor.

Encirca℠ Yield *Nitrogen Management* allows you to take the guesswork out of nitrogen application by minimizing loss and risk while maximizing return on investment. Gain insight into how much nitrogen is available in the soil and how much is being utilized at various growth stages. Validate how nitrogen will be utilized and depleted in a specific field over time, with simulations of potential outcomes powered by decades of local weather data. By looking at real-time nitrogen estimates, your trusted advisor can help you test and tailor a plan to maximize success. *Visit encirca.pioneer.com*

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Published February, 2015