2012

Demonstration Reports

THE LEARNING CENTER
at Monmouth, Illinois

Technology Development & Agronomy by MONSANTO℠

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GREETINGS FROM MONMOUTH, ILLINOIS

First of all, thank you for visiting the Monsanto Learning Center at Monmouth, Illinois this past summer! As you know, crop production science and technology is changing at an ever-increasing pace. Our goal here at the Learning Center is to help you keep up with those changes and provide up-to-date, relevant agronomic information that will benefit you and your operation. With that goal in mind, this booklet contains summaries from a number of our key trials and demonstrations focusing on corn and soybean management systems.

For 2013, we plan to continue showcasing our current and future technologies, such as the upcoming launch of Monsanto's new Roundup Ready® Xtend Crop System and our new Integrated Farming System(SM). We hope you find the information within these pages, as well as the rest of our field trials and demonstrations, to be valuable to you and your operation. Please feel free to contact us if you have any questions about these summaries or any of the other projects here at the Learning Center.

Thank you, and we look forward to hosting you again in 2013!

Sincerely,

Troy Coziahr, Manager
Monsanto Learning Center at Monmouth, IL

A bird's eye view of the Monsanto Learning Center at Monmouth, IL and the acres of demonstration plots surrounding it.

IMPROVEMENTS IN MODERN CORN AND SOYBEAN PRODUCTION

Historical increases in grain yield have been attributed to genetic improvements by traditional breeding programs in conjunction with more efficient cultural practices[3]. Initially, biotechnology helped protect from potential yield loss from weed competition or insect feeding; however, it may have indirectly contributed to yield gain because the traits helped protect the rooting system, which could have allowed for a greater probability of nutrient and water uptake[2]. Using these three pillars, Monsanto is committed to helping farmers double corn, soybean, and cotton yields by 2030. This trial was designed to compare historic farming practices for corn and soybean with those of today; looking specifically at how breeding, biotechnology and agronomic practices have led to an increase in yield over time, as well as where it could potentially go in the future.

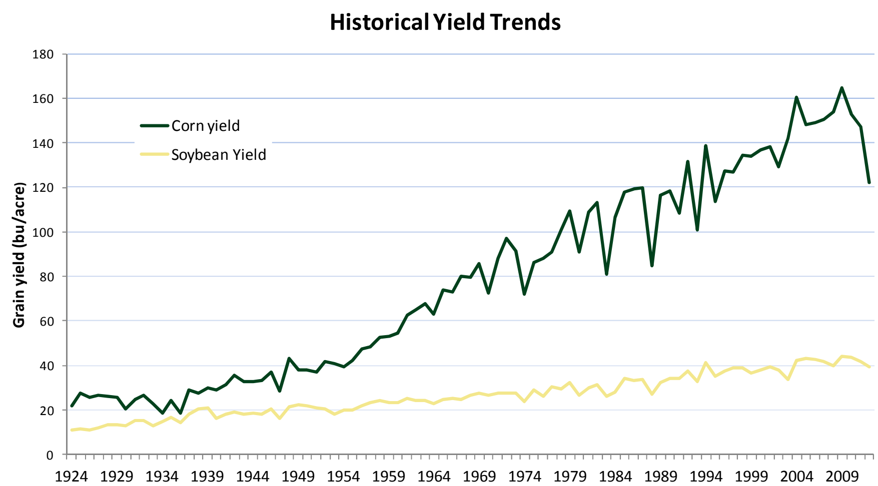

Figure 1. Historic yield data for both corn and soybean crops.
Source: United States Department of Agriculture National Agricultural Statistics Service (USDA NASS)

Materials and Methods: Corn Trial

A corn demonstration trial was conducted at the Monsanto Learning Center at Monmouth, IL to evaluate the yield response of corn to three different treatments representing past, current, and potential future production methods. Corn was planted May 17th, 2012 into soybean-corn rotated ground prepared with a chisel plow in the fall, followed by a soil finisher in spring. Nitrogen (N) was applied as 32% UAN at two levels per period treatment: a maximum N rate based on the amount of N needed to produce one bushel and a reduced rate to determine performance in low N environments.

Past Treatment: A 111 relative maturity (RM) non-traited corn product was planted at a seeding rate of 28,000 seeds/acre in 30-inch rows. Force® 3G insecticide was applied in-furrow. Weed management consisted of a pre-emergence application of Bicep II Magnum® herbicide, followed by post-emergence applications of Accent® and Hornet® herbicides. Nitrogen was applied at 220 lbs/acre (1.2 lbs N/bu) or 150 lbs/acre as 32% UAN.

Current Treatment: A 111 RM Genuity® VT Triple PRO® corn product was planted at a seeding rate of 36,000-38,000 seeds/acre in 30-inch rows. Weed management consisted of a pre-emergence application of Harness® Xtra 5.6L herbicide, followed by a post-emergence application of Roundup PowerMAX® herbicide. Nitrogen was applied at 200 lbs/acre (1 lb N/bu) or 140 lbs/acre as 32% UAN. Crops also received a foliar application of Headline® fungicide at the VT/R1 stage.

Potential Future Treatment: A 111 RM Genuity® SmartStax® corn product was planted at a seeding rate of 48,000 seeds/acre in a 22.5-inch twin-row configuration. Weed management consisted of a pre-emergence application of Harness® Xtra 5.6L herbicide, followed by a post-emergence application of Roundup PowerMAX® herbicide. Nitrogen was applied as either 280 lbs/acre split between 180 lbs/acre as 32% UAN combined with 100 lbs/acre applied in season (V6) as Koch Advanced Nitrogen® or 160 lbs split between 100 lbs/acre as 32% UAN combined with 60 lbs/acre applied in season (V6) as Koch Advanced Nitrogen®. GreenSeeker® technology was used to provide the 60 lbs/acre recommendation. Crops also received a foliar application of Headline® fungicide at the VT/R1 stage.

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Results: Corn Trial

Results of the three period treatments on corn production are shown in Figure 2. As expected, yield increased from the past to current and then again from current to future treatments. While it is not possible to draw any definitive conclusion from a single location trial, it is hypothesized that advancements in breeding technology, the addition of *B.t.*-traited corn products, changes in herbicide programs, and also changes in N application products and methods resulted in higher yield potential as the treatment periods progressed.

To investigate the nutrient uptake advantage proposed by Moose and Below in 2009, N response between the older, non-traited products and newer *B.t.*-traited products were compared. The N efficiency shown in Table 1 was calculated by dividing the N rate by yield for all the observations in the Past and Current treatments. Percentage gain was then calculated by subtracting Current from Past and dividing by Past. There was a 25% average increase overall. Research has also shown that products have improved in their efficiency to use plant available N under both optimal and stressful conditions[1].

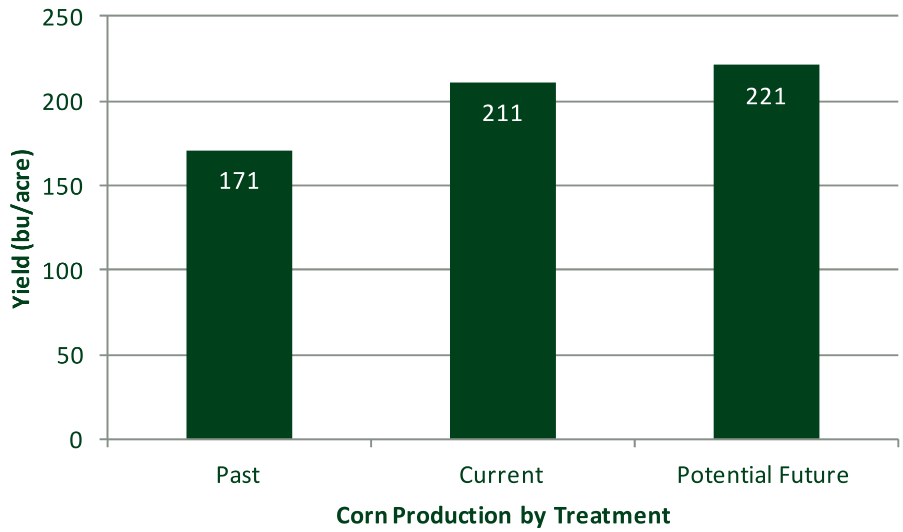

Figure 2. Corn yield shown by treatments: Past, Current, and Potential Future.

Table 1. Nitrogen efficiency for past and current treatments at both high and low N rates.

N Efficiency	Low N rate	High N rate
Past	0.88	1.29
Current	0.69	0.93
Percentage gain in N response	22%	28%

Materials and Methods: Soybean Trial

In 2012, a trial was conducted at the Monsanto Learning Center at Monmouth, IL to evaluate the yield response of soybeans to five different treatments representing a range of production methods from the past through potential future methods. Soybeans were planted May 18th, 2012 in a corn-soybean rotated field prepared with a chisel plow in the fall, followed by a soil finisher in spring.

Treatment 1: A 3.3 RM non-transgenic soybean product was planted in 30-inch rows at 180,000 seeds/acre. Weed management consisted of a pre-emergence application of Pursuit® Plus herbicide.

Treatment 2: A 3.3 RM non-transgenic soybean product was drilled at 200,000 seeds/acre. Weed management consisted of a pre-emergence application of DUAL® II Magnum® herbicide, followed by a post-emergence application of Cobra® herbicide and another post-emergence application of Assure® II herbicide.

Treatment 3: A 3.2 RM Genuity® Roundup Ready 2 Yield® soybean product was planted in 30-inch rows at 160,000 seeds/acre. Weed management consisted of a pre-emergence application of Valor® XLT herbicide, followed by a post-emergence application of Roundup PowerMAX® herbicide. A foliar application of Headline® fungicide and Warrior II with Zeon Technology® insecticide was made at R3 growth stage.

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Treatment 4: A 3.4 RM Genuity® Roundup Ready 2 Yield® soybean product was planted in 30-inch rows at 150,000 seeds/acre. Weed management consisted of a pre-emergence application of Valor® XLT herbicide, followed by a post-emergence application of Roundup PowerMAX® herbicide. A foliar application of Headline® fungicide and Warrior II with Zeon Technology® insecticide was made at R3 growth stage.

Treatment 5: A 3.4 RM Genuity® Roundup Ready 2 Yield® soybean product inoculated with Vault® SP was planted in 20-inch rows at 130,000 seeds/acre. Weed management consisted of a pre-emergence application of Valor® XLT herbicide, followed by a post-emergence application of Roundup PowerMAX® herbicide. Multiple foliar applications were made: CoRoN® 25-0-0 at R1 growth stage, Headline® fungicide at R1 and R5 growth stages, and Warrior II with Zeon Technology® insecticide at R1 and R5 growth stages.

Results: Soybean Trial

Results of the five period treatments on soybean production are shown in Figure 3. The largest yield advantage was recognized between Treatments 2 and 3 with a 23 bu/acre yield increase. The major difference between Treatments 1 and 2 versus 3 through 5 is the seed used. The introduction of the Genuity® Roundup Ready 2 Yield® soybean platform, as well as improvements in production practices had the most positive effect on yield potential based on trial results.

Figure 3. Soybean yield shown by period treatments 1-5 (1 representing oldest, 5 representing potential future, as described in text)

There is essentially no yield difference between Treatments 3 and 4, which is favorable given the only difference in treatments is the RM of the products and the seeding rate, which was actually reduced by 10,000 seeds per acre. Past data from Monsanto Learning Center trials would suggest that the narrower row spacing and more intensive management practices in Treatment 5 would lead to increased yields. However, the extreme heat and drought experienced in 2012 may have negated the gains we typically see.

Summary Comments

Overall, yield levels have increased over time in both corn and soybean due to better management practices, breeding improvements, and biotechnology.

Breeding for higher yield potential in corn appears to have also contributed to more efficient use of plant available N in both optimal and stressful N environments. Based on the experimental average, a 25% increase in N efficiency for modern products over older products was observed. As Monsanto continues toward the goal of doubling corn yields by 2030, breeding practices and biotechnology traits should continue to be focused on N utilization.

Weed management systems (particularly in soybean) were revolutionized by the Roundup Ready® trait that allowed for simplified solutions that limited weed competition within the crop. In soybeans, the Genuity® Roundup Ready 2 Yield® platform keeps the simplistic approach to post-emergence weed control, but also begins to build upon

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genetic improvements in yield potential through biotechnology. Moving forward, implementation of high-yield management strategies such as foliar fungicide, early planting, and especially the use of Roundup Ready® products is the key to further driving yield improvement.

Sources

[1]*Castleberry, R.M., et. al. 1984. Genetic yield improvement of U.S. maize cultivars under varying fertility and climatic environments. Crop Science vol 24:33-36.*

[2]*Moose, S.P., and F.E. Below. 2009. Biotechnology approaches to improving maize nitrogen use efficiency. p. 65-77. In: A.L. Kriz and A.B. Larkins (eds.), Molecular genetic approaches to maize improvement. Biotechnology in Agriculture and Forestry, Vol. 63. Springer-Verlag Berlin Heidelberg.*

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The information discussed in this report is from a single site, non-replicated, one-year demonstration. This informational piece is designed to report the results of this demonstration and is not intended to infer any confirmed trends. Please use this information accordingly.

BENEFITS OF USING RESIDUAL HERBICIDES IN ROUNDUP READY® SYSTEMS

Soil residual herbicides often have several potential benefits in both corn and soybean production. A study was conducted to evaluate the benefits of utilizing residual herbicides in Roundup Ready® Systems. Both Genuity® SmartStax® corn and Genuity® Roundup Ready 2 Yield® soybeans were examined.

Materials and Methods

On May 14, 2012, a Genuity® SmartStax® 111 day relative maturity corn hybrid was planted at 36,000 seeds per acre in 30-inch rows. The trial was harvested 128 days after planting (DAP). The field had been in a continuous corn cropping system for four years. The conventional tillage program consisted of Fall – chisel plow and Spring – 32% UAN solution applied at 240 lbs/acre with nitrogen incorporated and seed bed established using a soil finisher. There were two primary trial treatments: 1) Preemergence herbicide applied May 15, 2012, followed by Roundup PowerMAX® and 2) Roundup PowerMAX® alone. The preemergence herbicide applied was Harness® Xtra 5.6 at 2 qts/acre. Roundup PowerMAX® was used as a postemergence application at labeled rates.

In the soybean system, a maturity group 3.2 Genuity® Roundup Ready 2 Yield® soybean was selected for the trial. Soybeans were planted on May 15, 2012 at a rate of 130,000 seeds per acre in 30-inch rows. The trial was harvested 139 DAP. Conventional tillage consisted of Fall – chisel plow and Spring – seed bed established using a soil finisher. The soybean trial was designed around three primary herbicide treatments: 1) RoundupPowerMAX®, 2) Preemergence followed by Roundup PowerMAX® and 3) Preemergence followed by Roundup PowerMAX® plus Warrant® Herbicide. The preemergence herbicide used in this study was Valor® XLT applied May 16, 2012, at a rate of 3 oz/acre. Postemergence herbicides included Roundup PowerMAX® applied at labeled rates and Warrant® Herbicide applied at 1.5 qt/acre. All Roundup PowerMAX® applications included ammonium sulfate at 17 lbs/100 gal of spray solution. The main weed species present in the trials were giant ragweed, waterhemp and lambsquarters.

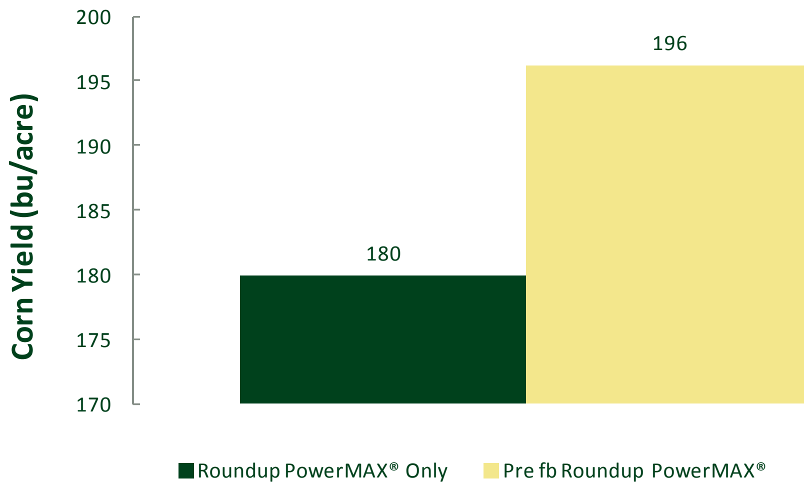

Figure 1. Genuity® SmartStax® 111 RM average corn yield by herbicide treatment. Monsanto Learning Center at Monmouth, IL, 2012.

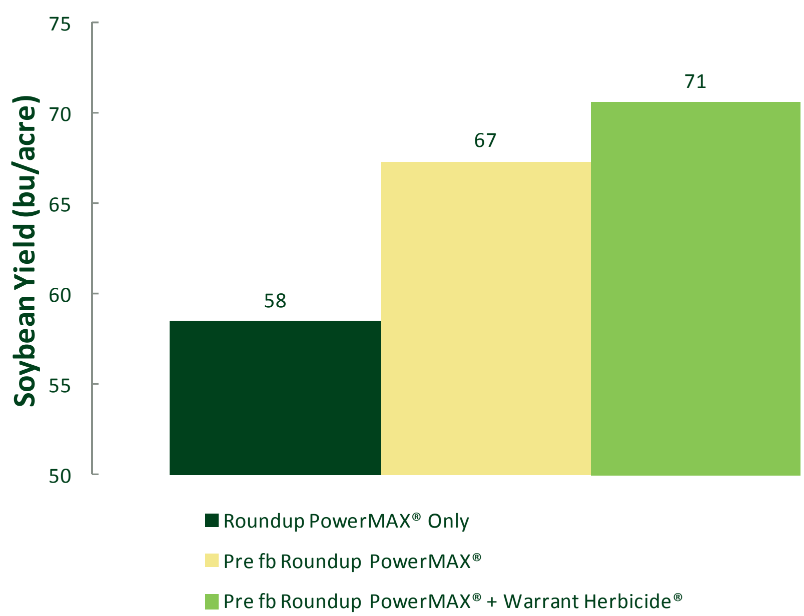

Figure 2. Genuity® Roundup Ready 2 Yield® MG 3.2 average soybean yield by herbicide treatment. Monsanto Learning Center at Monmouth, IL, 2012.

BENEFITS OF USING RESIDUAL HERBICIDES IN ROUNDUP READY® SYSTEMS

Results

The corn treatment consisting of only Roundup PowerMAX® had a measured yield of 180 bu/acre. In the second treatment, which used a preemergence herbicide followed by Roundup PowerMAX®, the yield was 196 bu/acre (Figure 1). Soybean study yields for 1) Roundup PowerMAX® alone, 2) Preemergence followed by Roundup PowerMAX®, and 3) Preemergence followed by Roundup PowerMAX® plus Warrant® Herbicide were 58, 67, and 71 bu/acre in this trial, respectively (Figure 2). In both corn and soybean systems, increased yields were obtained when residual herbicides were used with Roundup PowerMAX®.

Figure 3. Soybean Herbicide Trial - No preemergence herbicide and prior to Roundup PowerMAX® application. 17 DAP.

Figure 4. Soybean Herbicide Trial – Preemergence herbicide application to be followed by Roundup PowerMAX® application. 17 DAP.

Summary Comments

University studies have indicated that as weeds get larger they become more competitive for light, water, and nutrients. The use of residual herbicides (pre and post emergent) allows the crop more time to become established before weed competition. It also has the benefit of avoiding single mode of action selection pressure. A reduction in the weed seed bank is expected if weeds are not allowed to acquire the biomass needed to produce seed[1]. Data from this trial supports a yield advantage by utilizing residual herbicides as co-herbicides in Roundup Ready® systems.

Sources

[1]*Norsworthy J., et al. 2012. Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations, Weed Science. 60(sp1):31–62.*

Sprague, C. 2006. Benefits of soil-applied residual herbicide in soybeans. Michigan State University, Dept of Crop & Soil Sciences.

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CORN TRAIT RESPONSE TO CORN ROOTWORM INFESTATION UNDER DROUGHT CONDITIONS

Northern corn rootworm (NCRW) and western corn rootworm (WCRW) are economically important pests of corn. They are responsible for nearly a billion dollars annually in crop losses and control costs[1]. Historically, crop rotation has been an effective method for preventing larval root damage. However, in certain areas of the Corn Belt, rotation is no longer as effective due to extended diapause populations of NCRW and the soybean variant of WCRW. Growers must consider how to best protect their potential yield, including the use of insecticides and corn traits targeting insect control. Yield data provided by four trials carried out in harsh drought and heat conditions presented an opportunity to study the response of corn traits to corn root worm (CRW) infestation. The excessive heat and lack of moisture provided an excellent environment for highlighting the yield protection provided by Monsanto traits.

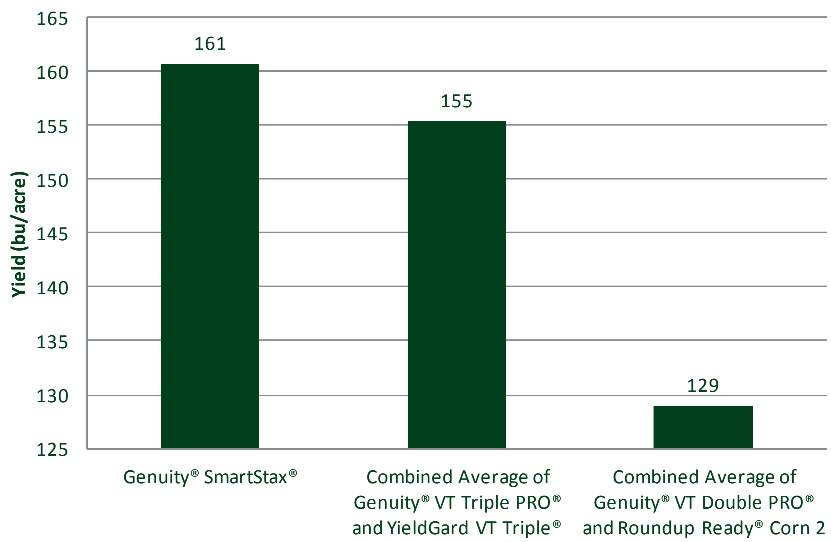

Figure 1. Effects of drought on corn yield by corn trait response to CRW infestation.

Materials and Methods

Four separate demonstration trials using several corn insect traits were conducted in 2012 at the Monsanto Learning Center at Monmouth, IL to investigate:

- Effects of CRW control measures on nitrogen (N) rate and uptake
- Impact of full rate insecticide application on CRW control and effect on potential yield
- Effects of CRW infestation on the timing and rate of N application
- Effects of fungicide application on stress mitigation

These experiments were established and maintained following common agricultural practices in the state of Illinois in a rain-fed agricultural system. The severe heat and drought during the 2012 growing season presented an additional opportunity to study the yield response of corn traits to CRW infestation under drought conditions.

Corn products with the following traits were used: Genuity® SmartStax®, Genuity® VT Triple PRO®, YieldGard VT Triple®, Genuity® VT Double PRO®, and Roundup Ready® Corn 2. Planting was carried out between April 25 and 27, 2012 on 10' x 100' conventional-till, continuous corn plots at a seeding rate of 36,000–38,000 seeds/acre. There were 1-3 replications of each of the four trial treatments. Conventional tillage consisted of using a chisel plow in the fall and a soil finisher in the spring. All Genuity® VT Double PRO® and Roundup Ready® Corn 2 plots received an application of Force® 3G insecticide at planting. All experiments were harvested between September 12 and 13, 2012. Yield data was adjusted to 15% moisture content.

Results

The results of the four separate experiments were combined. Products containing the same CRW traits were grouped together regardless of their relative maturities. Average corn yield was substantially lower in products lacking CRW control traits compared to those with CRW control traits (Figure 1). Genuity® SmartStax® corn, with dual modes of action, outperformed traits with a single mode of action for CRW control (Genuity® VT Triple PRO® and YieldGard VT Triple®). CRW control

CORN TRAIT RESPONSE TO CORN ROOTWORM INFESTATION UNDER DROUGHT CONDITIONS

traits provide effective insect protection and enhance the plant's ability to assimilate N, Phosphorus, Potassium and other micronutrients such as zinc. They also provide better drought tolerance over non-CRW traited products[2,3].

Figure 2 shows the root system of a non-CRW traited corn product treated with Force® 3G insecticide (left) compared to a Genuity® product with CRW protection (right). The non-CRW traited corn product on the left, treated with Force® 3G insecticide, experienced more feeding and has a more compact root system, which can decrease the potential uptake of water and nutrients from the soil and can increase the potential for stalk stability issues.

Figure 2. Comparison of corn product effects of CRW infestation. Left: a non-CRW traited corn product treated with the insecticide Force® 3G. Right: a CRW traited corn product without insecticide treatment.

Summary Comments

Excessive heat and lack of moisture this season provided an excellent environment to assess the efficacy of various corn products against corn rootworm. Yield results demonstrated that while single mode of action CRW traited corn products outperformed non-CRW traited products, Genuity® SmartStax® with dual modes of action was the highest performer. Visual inspection also supported the benefit of CRW traited corn products. It is important that growers ensure all refuge requirements are properly implemented to help ensure long term durability and effectiveness of these insect control traits.

Sources

[1]*Burchett, A. 2001. Operation rootworm: Can biotechnology beat the billion dollar bug? Farm J. 125(11):16-18.*

[2]*Below, F.E, et. al. 2009. Mineral nutrition of rootworm resistant corn. Illinois Fertilizer Conference Proceedings. http://frec.ifca.com/2010/report9/*

[3]*Thompson, G. and K. Narva. 2009. Corn with transgenic insect protection traits utilized in combination with drought tolerance and/or reduced inputs, particularly fertilizer. United States Patent Application Publication. Pub. No. US 2009/0300980 A1.*

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EFFECTS OF NITROGEN RATE AND TIMING OF APPLICATION ON CRW RESPONSE IN CORN

Farmers today are faced with escalating fertilizer prices, especially for nitrogen (N). A more than five-fold price increase in the last fifty years has not deterred producers from exploring this crucial input in their production[1].

Corn rootworm (CRW) (*Diabrotica* spp.) is one of the most serious crop pests in North America. CRW feeding can cause reduced water and mineral uptake which may result in yield loss, especially when water is limiting. The number of acres planted to CRW-protected corn has increased in recent years. A growing body of evidence suggests that CRW-protected corn may have increased yield potential compared to their non-protected counterparts because of reduced stress from CRW larval feeding resulting in larger root systems and increased N-use efficiency.

Materials and Methods

A replicated trial was conducted in 2012 at the Monsanto Learning Center at Monmouth, IL to investigate the effects of nitrogen rate and timing on corn yield in CRW-protected and non-protected corn products. Two products with 105 and 111 day relative maturities (RM) were selected that contained Genuity® SmartStax®, which provides two modes of action for CRW protection, and the respective Roundup Ready® Corn 2 (RR2) isolines with a soil applied insecticide (RR2 + Force 3G). Force® 3G insecticide was applied to the Roundup Ready® Corn 2 product at planting.

Corn products were planted at 36,000 seeds per acre on April 25, 2012. Treatments were replicated two times in a continuous corn field using a conventional tillage system (Table 1).

Weed control for the trial consisted of 2 qt/acre Harness® Xtra preemergence followed by 22 fl oz/acre Roundup PowerMAX® when weeds were four inches tall or less.

Preplant nitrogen was applied with a ground rig and incorporated. Side-dress nitrogen was applied at the V5 growth stage. All nitrogen was applied as a 32% urea ammonium-nitrate (UAN) solution. Plots were harvested on September 14, 2012 and yield data adjusted to 15% moisture content.

Table 1. Nitrogen rate and timing of treatments.

Four Rates of Nitrogen Used	
Rate 1	Half rate Pre-plant 120 lbs N/Acre
Rate 2	Full rate Pre-plant 240 lbs N/Acre
Rate 3	Full rate—Split application 120 lbs N/Acre pre-plant followed by 120 lbs N/Acre at V5 stage
Rate 4	Full rate—Split Application 180 lbs N/Acre pre-plant followed by 60 lbs N/Acre at V5 stage

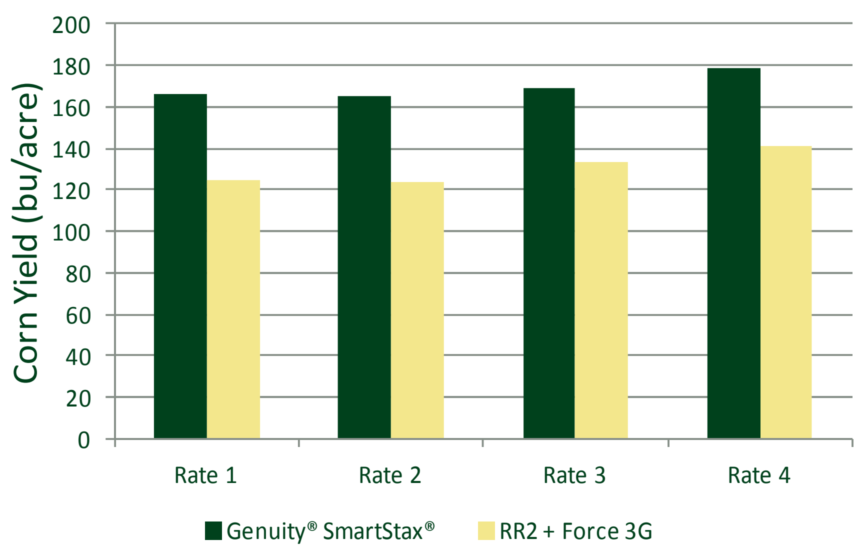

Figure 1. Yield response of CRW-resistant and non-resistant corn traits to nitrogen fertilizer in a drought year.

EFFECTS OF NITROGEN RATE AND TIMING OF APPLICATION ON CRW RESPONSE IN CORN

Results

The trend of yield response was nearly similar in both CRW-protected and non-protected products in all nitrogen treatments (Figure 1). However, CRW-protected products substantially out-yielded non-protected corn. This is due, in part, to the fact that insect control traits not only provide effective insect protection, but also enhance plants' ability to assimilate N, P, K, and other micronutrients, such as zinc. They also provide superior drought tolerance over non-protected corn products[2,3]. Thus, at locations with history of CRW infestation and/or water stress conditions, as experienced by the experimental site in 2012, products with at least a single insect control trait should be selected, even if insecticides will be applied. In this study, insecticide application did not provide sufficient protection to non-protected corn products.

Under the high heat and drought conditions of the 2012 growing season, split applications of N offered higher yields than single applications (Figure 2). In this study, Rate 4 offered a higher average yield than Rate 3. This could be due to the higher leaf area index (LAI) provided by the extra N during the vegetative phase of crop growth. Higher LAI coupled with increased leaf area duration effectively results in higher grain yields[4].

Every farming season, growers are faced with challenging decisions in the face of unpredictable weather conditions. Monsanto offers a superior product pool with accompanying agronomic practices to ensure maximum productivity even under great uncertainties.

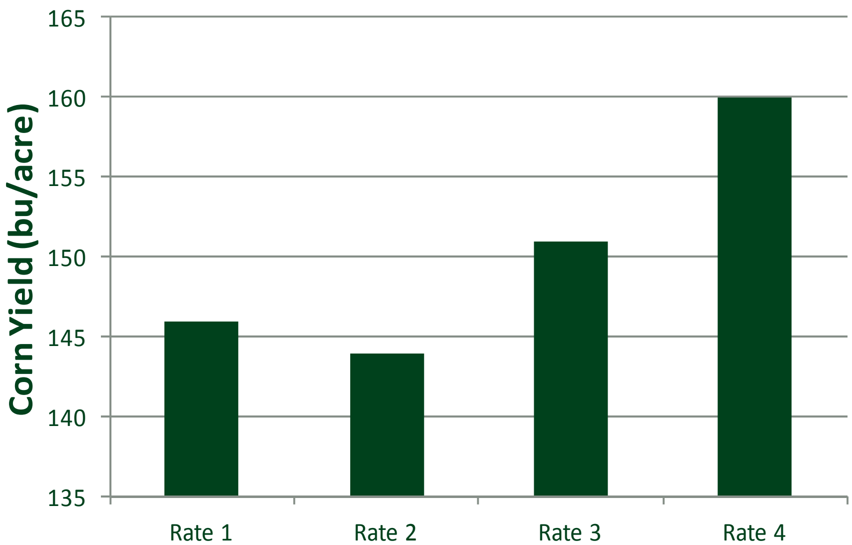

Figure 2. Effect of N timing and rate on corn yield in a dry year.

Sources

[1]USDA-ERS. Average U.S. farm prices of selected fertilizers 1960-2012. Table 7. Fertilizer Use and Price. Available on-line: http://www.ers.usda.gov.

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[3]Thompson, G. and Narva, K. 2009. Corn with transgenic insect protection traits utilized in combination with drought tolerance and/or reduced inputs, particularly fertilizer. United States Patent Application Publication. Pub. No.: US 2009/0300980 A1.

[4]Khalifa, M. A. 1972. Effects of nitrogen on leaf area index, leaf area duration, net assimilation rate, and yield of wheat. Agronomy Journal, Vol. 65 No. 2, p. 253-256. Crop Science Society of America.

Additional Resources: Laboski, C.A.M., et al. 2011. Do corn hybrid traits affect nitrogen use efficiency? Proceedings of the 2011 Wisconsin Crop Management Conference, Volume 50. Available on-line: http://www.soils.wisc.edu.

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INFLUENCE OF UREASE INHIBITOR ON CORN YIELD IN THREE TILLAGE SYSTEMS

Being one of the most used and expensive crop inputs, nitrogen (N) is an important part of modern crop production. Farmers today are faced with escalating fertilizer prices, especially N. Depending on form of applied product and environmental conditions, fertilizer N is vulnerable to loss soon after application if it is not immediately taken up by the corn plants. While anhydrous ammonia (NH_3) tends to be the most economical source of N, fertilizers with a urea component are popular with farmers who are uncomfortable with safety risks associated with NH_3 handling and application. When applied to the soil, urea is broken down to ammonium (NH_4^+) by the enzyme urease (Figure 1). NH_4^+ can be taken up by plants, assimilated by bacteria, or be converted to ammonia (NH_3) and lost to volatilization. In the ammonium form, the N is held by the negative charge associated with clay particles and organic matter. Additionally, if urea breakdown occurs rapidly, it can cause an increase in pH promoting the formation of ammonia gas and ammonia volatilization. Urease inhibitors can help increase N use efficiency by delaying the N transformation process so potential loss through volatilization is minimized.

$$\underset{\text{Urea}}{NH_2-\overset{\overset{O}{\|}}{C}-NH_2} + H2O \xrightarrow{\text{Urease}} \underset{\text{Ammonium carbonate}}{NH_2COOH} + H_2O + NH_4^+ \rightarrow 2NH_4^+ + HCO_3^-$$

Figure 1. Breakdown of urea by the enzyme urease in the soil .

Materials and Methods

A demonstration trial was conducted at the Monsanto Learning Center at Monmouth, IL in 2012 to assess the potential yield benefits of the urease inhibitor Agrotain® to surface-applied UAN in three tillage systems: conventional, strip-till, and no-till (Figure 2).

A 111 relative maturity (RM) corn product with Genuity® SmartStax® trait package was selected for the demonstration. All products were seeded at a population of 36,000 plants/acre. Strip-till and conventional plots were planted on April 19. Due to a rain delay, the no-till plots were planted on April 27. Nitrogen was applied pre-plant using 32% UAN solution at 240 lb N per acre. The field was divided into three blocks: no-till, conventional till, and strip till. All were in a continuous corn production system. Agrotain was applied to half the trial at 2.3 quarts per ton of UAN.

Weed control for the trial consisted of 2 qt/acre Harness® Xtra 5.6L preemergence followed by 22 fl oz/acre Roundup PowerMAX® when weeds were four inches tall or less.

Conventional and strip-till plots were harvested on September 12, 2012. No-till plots were harvested on September 20, 2012, and yield data adjusted to 15% moisture content.

Figure 2. Three tillage systems included in the demonstration trial at Monsanto Learning Center at Monmouth, IL.

INFLUENCE OF UREASE INHIBITOR ON CORN YIELD IN THREE TILLAGE SYSTEMS

Results

Yields increased in plots that received the Agrotain® application (Figure 4). The use of urease inhibitors can be beneficial to protect surface-applied UAN, especially when applied in fields with high residue. No-till conditions favor high levels of urease activity in surface soil due to high residue levels. UAN left on the soil and/or residue surface is susceptible to loss to the air, beginning about the third or fourth day after application and continuing until at least half an inch of rain occurs. The amount of loss varies with weather conditions; losses are greatest in dry soils and/or soils with high pH (Increased wind and humidity will also increase the rate of volatilization). Agrotain can help reduce this loss by retarding the rate of urea conversion to ammonium and increase yield potential by keeping the N intended for the crop in the soil and prevent off-target movement.

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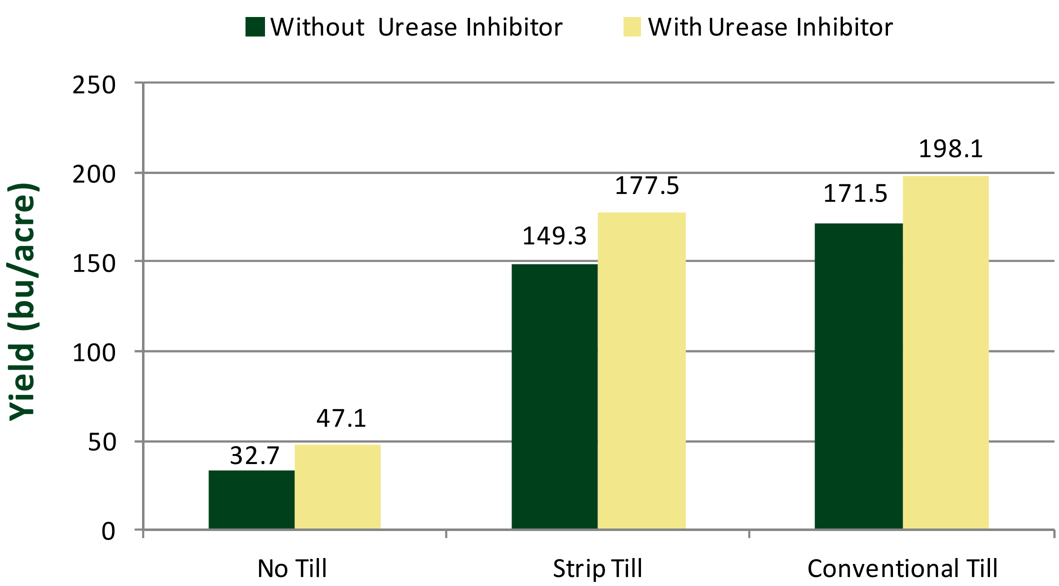

Figure 4. Corn yield response to the urease inhibitor Agrotain® in three different tillage systems in corn on corn rotation.

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LONG TERM EFFECTS OF CORN-ON-CORN SYSTEMS

In general, corn that is rotated with soybeans annually has a higher yield potential compared to 2nd year corn or continuous corn. A common belief is that 2nd year corn has lower yield potential than continuous corn; however, research data does not support this concept[1,2]. When evaluating crop rotation options, agronomics and economics should be considered.

Materials and Methods

A demonstration was established at the Monsanto Learning Center at Monmouth, IL to evaluate the effects of crop rotations with various years of corn in the rotation schedule on corn yields. A 112-day relative maturity (RM) corn with Genuity® VT Triple PRO® technology was planted on April 25th, 2012, at 36,000 seeds per acre in 30-inch rows. Nitrogen was applied in the spring as 32% urea ammonium nitrate (UAN) at a rate of 240 pounds per acre. Weeds were effectively controlled with a preemergence application of Harness® Xtra 5.6L followed by a postemergence application of Roundup PowerMAX® brand herbicide. Fertility was managed for high yield situations.

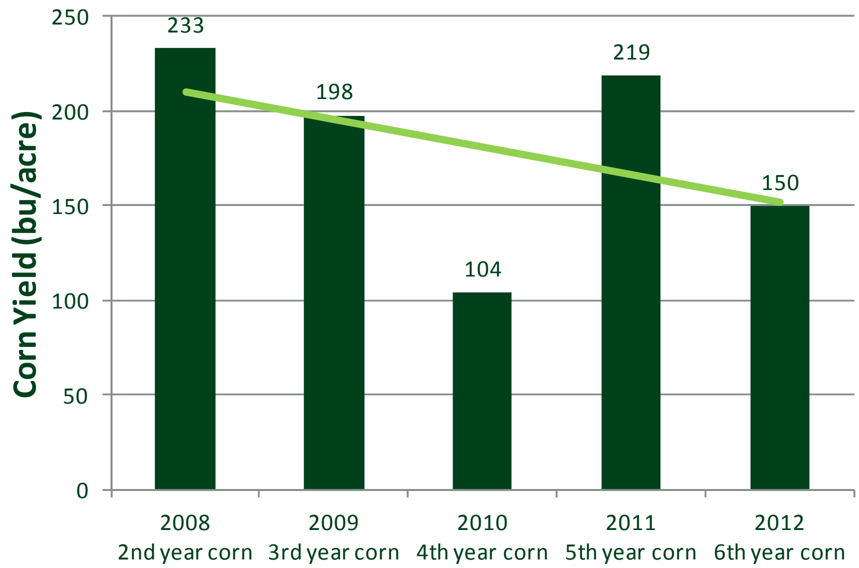

Figure 1. Average corn yields after various years of corn on corn.

Results

Corn Yields

Data collected from this demonstration illustrated that year and environment can have a larger effect on corn yield than the number of years of corn on corn in the rotation (Figure 1). The hot and dry conditions in 2012 likely contributed to a lower than normal yield.

Yields for 2nd year corn were greater than yields for rotations that had more years of continuous corn. This supports previous research and contradicts the common concept that additional years of corn on corn can help increase yield potential[1,2].

Table 1. Soybean yield needed for equal net profits of the average corn yields observed in various years of the demonstration.

	2008	2009	2010	2011	2012
Actual Corn Yield Averages (bu/acre)	233	198	104	219	150
Soybean Yield (bu/acre) With Same Net Profit	92	76	33	86	54

Grain prices used were $7.50/bu for corn and $16.00/bu for soybeans. Input costs were 2012 estimates[3].

LONG TERM EFFECTS OF CORN-ON-CORN SYSTEMS

Economics of Corn on Corn and Soybeans

The economics of corn on corn rotations were compared with soybeans by using 2012 input costs from Ag Decision Maker[3]. Grain prices of $7.50/bu of corn and $16.00/bu of soybean were used for economic comparisons based on market prices at the time the data was summarized. Table 1 provides the soybean yields that would have been needed to provide the same net profits as the corn on corn each year of the demonstration. Table 2 helps provide a perspective of what soybean yield would be needed to provide equal net profits for various corn yield environments.

Summary Comments

On average, yields decline in long-term continuous corn rotations and do not stabilize or rebound after the second year[1,2].

The negative effect continuous corn can have on yield potential may be enhanced or negated by factors that include weather conditions, soil type, and residue management.

Rotating corn with soybean can be beneficial for agronomic purposes including helping to manage corn rootworm populations, reducing inoculum levels of pathogens, and managing residue levels.

Although it is impossible to predict what conditions will be like in the growing season, the risk of drastically reduced corn yields under adverse conditions appears to occur more consistently in long-term continuous corn rotations than in corn-soybean rotations.

Continuous corn can be more profitable in some years; however, the trend for declining corn yields is a strong reason to plan for crop rotation. Periodically breaking the disease and insect cycle with another crop species can be profitable and have many other positive effects. The economic and agronomic conditions that favor rotation will vary by farming operation.

Table 2. Soybean yield needed to provide equal net profits of given corn yield environments.

Corn Yield Environment (bu/acre)	Soybean Yield (bu/acre) With Same Net Profit
120	41
150	54
180	68
210	82
240	95
Grain prices used were $7.50/bu for corn and $16.00/bu for soybeans. Input costs were 2012 estimates[3].	

Sources

[1] *Hoeft, R.G. et. al. 2000. Modern corn and soybean production. MCSP Publications. Champaign, Illinois. Pages 45, 121-131, 153-155.*

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The information discussed in this report is from a single site, non-replicated, 5-year demonstration. This informational piece is designed to report the results of this demonstration and is not intended to infer any confirmed trends. Please use this information accordingly.

Importance of Proper Spacing for Plants in Twin Row Configuration

Twin row technology allows for better spacing of plants than traditional 30-inch rows, but planters used for twin rows in the past were unable to accurately place each seed to maximize plant spacing. Research shows the way plants respond to change can be dependent on neighboring plants or weeds[1,2,3]. This demonstration trial explores the ability of the corn plant to "sense" its neighbors and adjust its growing pattern accordingly. In a synchronized planting pattern in the twin row configuration, the ability of plants to "sense" one another can be reduced; consequently, plant-to-plant competition can also be reduced.

Materials and Methods

Corn demonstration trials were conducted at the Monsanto Learning Center at Monmouth, IL to compare two twin row planting configurations: a synchronized (diamond) pattern versus an unsynchronized pattern (Figure 1). A 112-day relative maturity Genuity® VT Triple PRO® corn product was used for this demonstration. Corn was planted in both twin row configurations at three population levels: Low 28-30,000, Medium 35,000, and High 40-45,000 plants per acre. Both corn-corn (C-C) and corn-soybean (C-S) rotated ground was used. Conventional tillage consisted of using a chisel plow in the fall followed by a soil finisher in the spring to prepare the seedbed and incorporate nitrogen (N). Nitrogen was applied at 240 lbs/acre on the C-C rotation and 200 lbs/acre on the C-S rotation in the spring as 32% UAN, pre-plant incorporated (PPI). Corn was planted April 19, 2012 and harvested September 17, 2012. Weed management across the trial consisted of a pre-emergence application of Harness® herbicide followed by Roundup PowerMAX® herbicide.

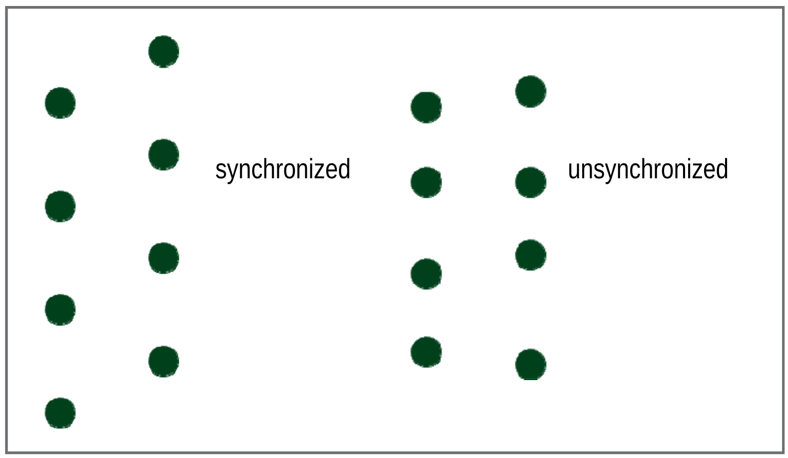

Figure 1. Twin row spacing demonstration.

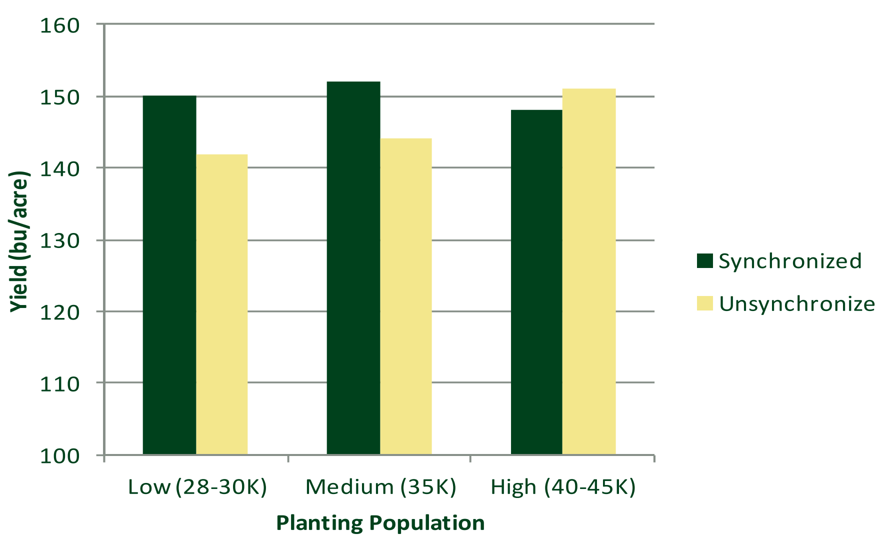

Figure 2. Twin-row corn: synchronized vs. unsynchronized seed placement. Data represents the average of three locations encompassing both C-C and C-S plots.

Results

In this demonstration trial, synchronized twin row corn yields outperformed unsynchronized yields in both low and medium plant populations (Figure 2). In both low and

IMPORTANCE OF PROPER SPACING FOR PLANTS IN TWIN ROW CONFIGURATION

medium populations, the synchronized spacing provided an average of 8 bu/acre yield advantage over the unsynchronized. In the higher population, the unsynchronized spacing performed only slightly better with a 3 bu/acre advantage. The results suggest that there may be an opportunity for increased corn yield potential with synchronized spacing in the low and medium plant populations. Although it is not possible to draw any definitive conclusion from a single location trial, it is possible that at higher populations, corn plants in a twin row configuration are close enough together to compete regardless of seed placement.

Summary Comments

Narrower rows are thought to be the solution for managing higher plant densities, but poor weather conditions can mask any potential benefits that you would expect to find in a more favorable growing environment. The primary benefit of narrow row configurations is to increase yield potential by increasing plant density per acre while also increasing plant-to-plant spacing. Drought conditions across most of the Corn Belt in 2012 were more likely to cause negative effects in high plant densities compared with low plant densities due to the added stress of interplant competition. Therefore, maximizing the space between plants may be most important at lower-to-normal planting populations due to the inability of neighboring plants to compete with one another in adverse environments. There are other factors that can be influential as well such as corn product, soil type and soil depth.

Figure 3. Synchronized pattern at 35,000 plants per acre.

The Monsanto Learning Center at Monmouth, IL will continue to evaluate synchronized versus unsynchronized twin row configurations in order to evaluate the experiment under different growing conditions.

Sources

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[3]*Rajcan, I. et. al. 2004. Red-far-red ratio of reflected light: a hypothesis of why early-season weed control is important in corn. Weed Science Vol 52:774-778*

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EFFECT OF SOYBEAN PRODUCT AND ROW SPACING ON SOYBEAN YIELD

Several university studies have indicated that narrower rows frequently out produce 30-inch rows[1,2,3]. Narrower rows allow for better weed control because typically, earlier canopy closure shades out weeds. Canopy closure also reduces soil moisture losses due to evaporation. Because of these potential benefits, a multi-year effort is underway at the Monsanto Learning Center at Monmouth, IL to evaluate row spacings that could optimize soybean yield potential. The 2012 trial was designed to demonstrate the effect of row spacing as well as soybean product on soybean yield potential.

Materials and Methods

From 2009 to 2012 a study has been conducted at the Monsanto Learning Center at Monmouth, IL to investigate the effect of soybean product and row spacing on soybean yield potential. In 2012, two Genuity® Roundup Ready 2 Yield® soybean products in maturity groups (MG) 2.8 and 3.4, were evaluated for yield potential in 15-inch row, 20-inch row, 30-inch twin row, and 30-inch row systems (Figures 1-2). Plots were planted on May 15, 2012. Conventional tillage practices consisted of a chisel plow in the fall followed by soil finisher in the spring. The herbicide program included Valor® XLT applied on May 17, 2012, followed by Roundup PowerMAX® applied on June 13, 2012.

Results

While overall yield was greatest with the MG 3.4 soybean across all row configurations, the two different soybean products responded similarly to row spacings (Figure 3). For both MG products, the 20-inch row configuration provided the highest yield, followed closely by the twin rows. The 20-inch single rows provided a 2 bu/acre advantage over 30-inch twin rows and 5 bu/acre over 30-inch single rows when averaged across soybean products (Figure 4).

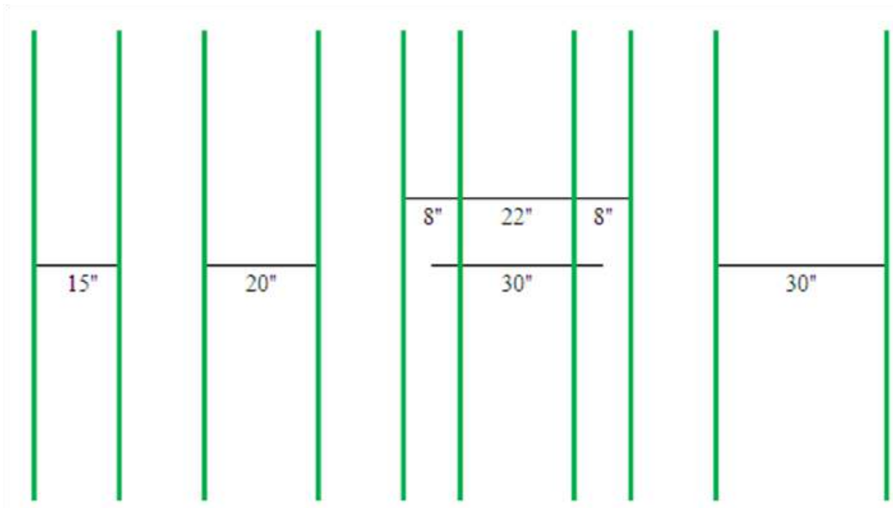

Figure 1. Row configuration side-by-side illustrations: 15-inch, 20-inch, 30-inch twin, and 30-inch.

Figure 2. Planted rows: A. 15-inch, B. 20-inch, C. 30-inch twin rows, and D. 30-inch.

EFFECT OF SOYBEAN PRODUCT AND ROW SPACING ON SOYBEAN YIELD

Summary Comments

In multiple experiments across Iowa, Dr. Pedersen observed that 15-inch rows produced average yields of 4.5 bu/acre more compared to 30-inch rows[1,2]. A similar yield advantage was observed for the MG 3.4 soybean variety in this trial.

In Figure 4, the 2012 yield data is shown averaged by row spacing. In the three previous years, average yield was highest when using twin rows. In each year, the top yield was captured using a narrow or twin row spacing. With the exception of a few anomalies, the average narrow row treatments out-yielded 30-inch rows at the Monsanto Learning Center at Monmouth, IL.

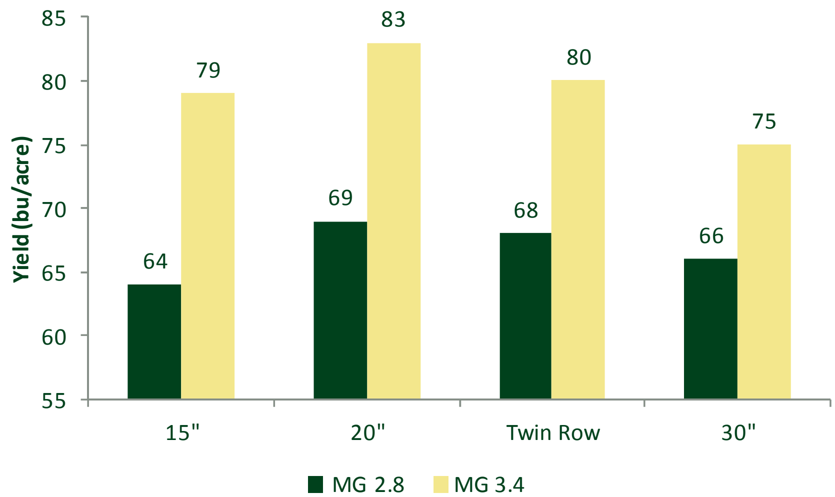

Figure 3. Effect of soybean product and row spacing on yield, 2012 Monsanto Learning Center at Monmouth, IL.

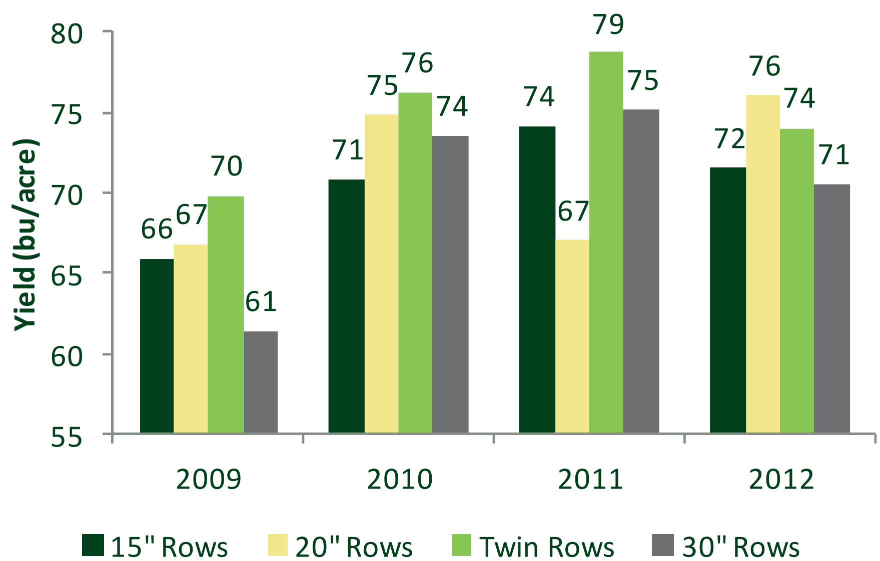

Figure 4. Comparison of average yield by row spacing across four consecutive years, Monsanto Learning Center at Monmouth, IL.

Sources

[1]De Bruin, J.L. and P. Pedersen. 2008. Effect of row spacing and seeding rate on soybean yield. Agron. J. 100:704-710.

[2]Pedersen, P. 2008. Row spacing is important to maximize your yield. Iowa State University Extension.

[3]Walker, E.R., et al. 2010. Plant population and row-spacing effects on Maturity Group III Soybean. Agron. J. 102:821-826.

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REPLANT DECISIONS IN SOYBEANS

Establishing and maintaining an optimum plant stand is important for profitable soybean yields. Injury to soybean stands occurs nearly every year from a variety of causes including hail damage, insect feeding, flooding, chemical misapplication, and seedling diseases (Figure 1). One of the most challenging decisions that soybean producers may face is the decision of whether or not to replant soybeans. The soybean plant is very resilient and can adjust to the final stand remaining in the field by adding branches, more pods per plant, and an increase in seed size. It is this ability of the soybean plant to compensate that makes the replant decision difficult. Several universities have developed charts, worksheets, and online tools to help growers with this decision[1,3]. Careful evaluation of plant stands can assist in the decision to replant suboptimal soybean stands[1,2,3].

Materials and Methods

A demonstration trial was conducted in 2012 at the Monsanto Learning Center at Monmouth, IL to evaluate the influence of soybean replanting on final yield. Maturity Group (MG) 3.4 Genuity® Roundup Ready 2 Yield® soybean products were planted on June 5, 2012 in 30-inch rows at a seeding rate of 130,000 seeds per acre. Various stand percentages were chemically removed in blocks to simulate spring stand loss scenarios with an application of Ignite® herbicide at 22 oz/acre plus ammonium sulfate (AMS) at 17 lb/100 gal on June 13, 2012. Treatments included the control (0% replant), Treatment 1 (30% replant), Treatment 2 (50% replant), and Treatment 3 (100% replant). Soybeans were replanted on June 19, 2012 at the same row spacing and population.

The field plot was conventionally tilled (chisel plow in the fall and soil finisher in the spring) and was in a soybean—soybean rotation the previous year. The herbicide program consisted of a preemergence treatment of Valor® XLT herbicide at 3 oz/acre followed by a postemergence treatment of Roundup PowerMAX® herbicide according to labeled rates plus AMS at 17 lb/100 gallon.

Results

Replanting decisions in soybean depend on several factors. In this demonstration study, soybean yields were closer to the control yield with Treatment 1 yielding 98% of the control, Treatment 2 yielding 93% of control and Treatment 3 yielding 70% of the control (Figure 2). Previous stand reduction studies have indicated more yield differences than observed in this demonstration study[2]. Several late-planted soybean trials conducted at the Monsanto Learning Center at Monmouth, IL in 2012 had an increase in yield compared to earlier planting dates. This is not a typical planting date response for this region

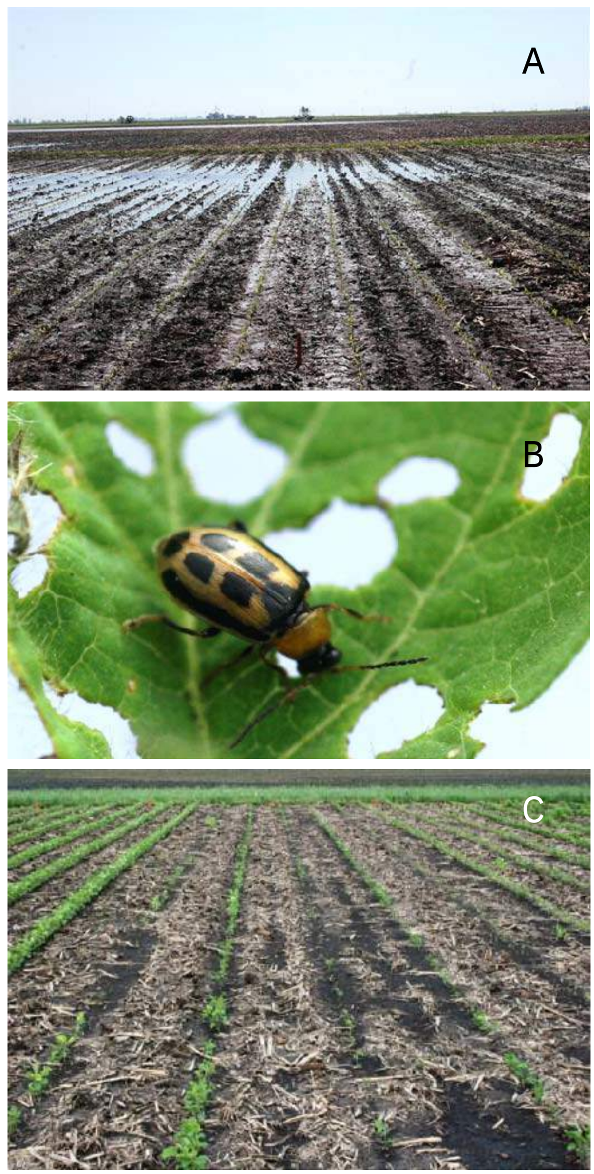

Figure 1. Injury to soybean stands can result from a variety of causes including: (A) flooding, (B) insect damage, and (C) chemical misapplication.

REPLANT DECISIONS IN SOYBEANS

and is most likely attributed to the opportunity for late-planted soybeans to take advantage of the rains and cooler temperatures experienced in late-August earlier in the reproductive growth stages.

When all factors are reviewed, the decision to replant may not warrant the replant investments. Soybeans compensate well for low populations. Scientists at Iowa State University suggested that a soybean stand that can yield 90% of the original production should not be replanted due to the costs associated with replanting, such as seed and fuel costs, herbicide restrictions, etc[3].

Sources

[1]*Brouder, S., et al. 2007. Corn and Soybean Field Guide. ID-179. Purdue University Extension.*

[2]*FAST (Farm Analysis Solution Tools). 2012. University of Illinois Extension. http://farmdoc.illinois.edu/fasttools. (verified 11/29/2012).*

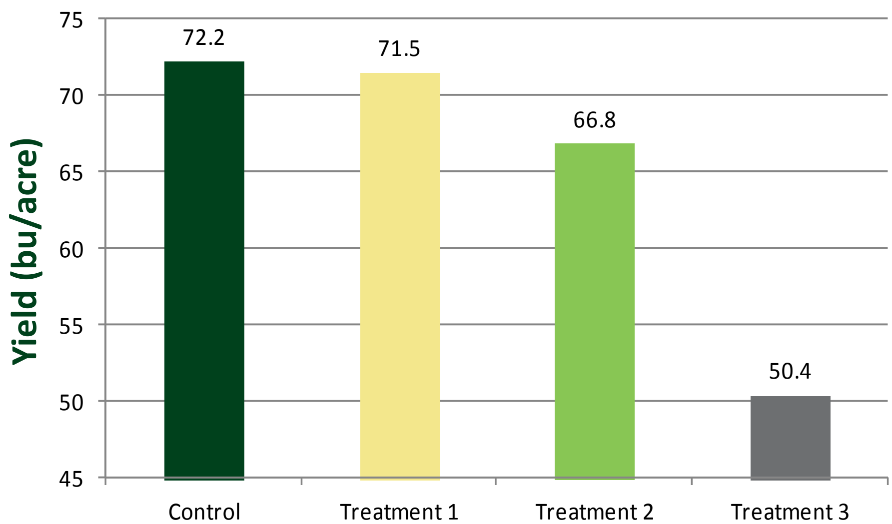

Figure 2. Effect of soybean replanting on final soybean yield at Monsanto Learning Center at Monmouth, IL in 2012.

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HOW THE 2012 GROWING CONDITIONS IMPACTED SOYBEAN MANAGEMENT DECISIONS

While soybean yield potential can be genetically determined, maximizing the actual potential yield also depends on environmental conditions and management practices. Growers are considering additional inputs and management practices to more fully exploit the genetic potential of soybean. Over the past four years, Monsanto has consistently shown that soybean yields can be increased when managed more intensively, with a particular focus on the following: planting date, maturity group, herbicide program, and foliar fungicides.

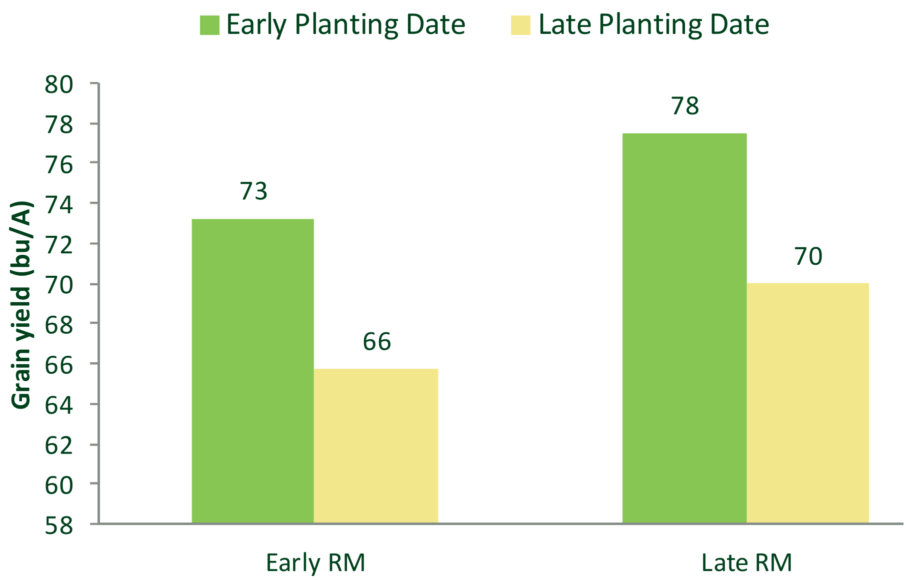

Figure 1. Multi-year Effect of Planting Date x Relative Maturity on Soybean Yield. Four year experimental average.

Materials and Methods for Three Different Studies

From 2009 to 2012 studies have been conducted at the Monsanto Learning Center at Monmouth, IL to evaluate how soybean yields are impacted by management decisions. A collection of soybean varieties with relative maturities (RM) 2.8 – 3.5 were evaluated for yield potential in 15-inch rows. Each variety was planted at 156,000 plants/acre. Plots were planted consistently at an early planting date (last week of April to first week of May) and a late planting date (last two weeks of May). All locations were in a corn-soybean rotation and tillage consisted of a fall chisel plow followed by a soil finisher in the spring. Weed management consisted of a PRE (either alachlor or flumioxazin) followed by a Roundup® agricultural herbicide.

Due to the extreme weather conditions of the 2012 growing season, this year's data was specifically compared to the previous years. In the 2012, studies were done on the soybean varieties using 2.8 and 3.4 RM products, which were both planted on two planting dates (April 23rd and May 16th, 2012).

In 2012, a high yield management soybean experiment was also conducted using 2.8 and 3.4 RM products. Plots were evaluated for yield in 15-inch rows and 30-inch rows. Each variety was planted at 156,000 plants/acre and 130,000 plants/acre, respectively. Plots were planted on April 24th, 2012. Foliar applications applied at the R3 growth stage consisted of: Headline® fungicide, Warrior® insecticide, and Headline® fungicide + Warrior® insecticide. Another application of Headline® fungicide + Warrior® insecticide was applied at the R6 growth stage. A control plot was also established.

A soybean variety trial was conducted to determine yield potential in 30-inch rows planted at 130,000 plants/acre. Four row plots, each 100 feet long, were planted on May 16th, 2012. All trials were in a corn-soybean rotation and tillage consisted of a fall chisel plow followed by a soil finisher in the spring. Weed management consisted of a PRE herbicide (Valor® XLT) followed by a POST application of Roundup PowerMAX® herbicide. All soybean products contained Genuity® Roundup Ready 2 Yield® trait and consisted of products ranging from 2.5 to 3.8 RM. Foliar applications consisted of: Headline® fungicide, Warrior® insecticide, and Headline® fungicide + Warrior® insecticide. A control plot was also established.

HOW THE 2012 GROWING CONDITIONS IMPACTED SOYBEAN MANAGEMENT DECISIONS

Results

Over the past four years, Monsanto has consistently shown that soybean yields can be increased when managed more intensively.

Planting date. Research from both the Monsanto Learning Center at Monmouth, IL and university trials have shown that it is beneficial to plant soybeans early if seedbed conditions are ideal. Yield potential often declines if planting is delayed past a specific date that is determined by your location (first week of May at this location). The average bushel advantage was 7 bushels/acre for early planting over late planting, regardless of RM from the 2009-2012 data. (Figure 1) However, in 2012, planting early was not advantageous. (Figure 2) The adverse weather this year likely resulted in the lack of response in the planting date.

Maturity Group. Full season varieties utilize the entirety of the growing season to help maximize yield potential, while using an earlier variety can limit soybean yield potential (inherent risks for both). Between 2009—2012 at the Monsanto Learning Center at Monmouth, IL, an average advantage of 4 bushels/acre when using full season varieties (3.4-3.5 RM) over shorter season varieties (2.8-3.0 RM) regardless of planting date was observed.

In 2012, yield advantages were gained from using full season varieties. Stressful conditions for July and much of August limited yield potential for shorter season varieties, while full season varieties were able to capitalize on the rains and cooler temperatures of late August and beyond. (Figure 3).

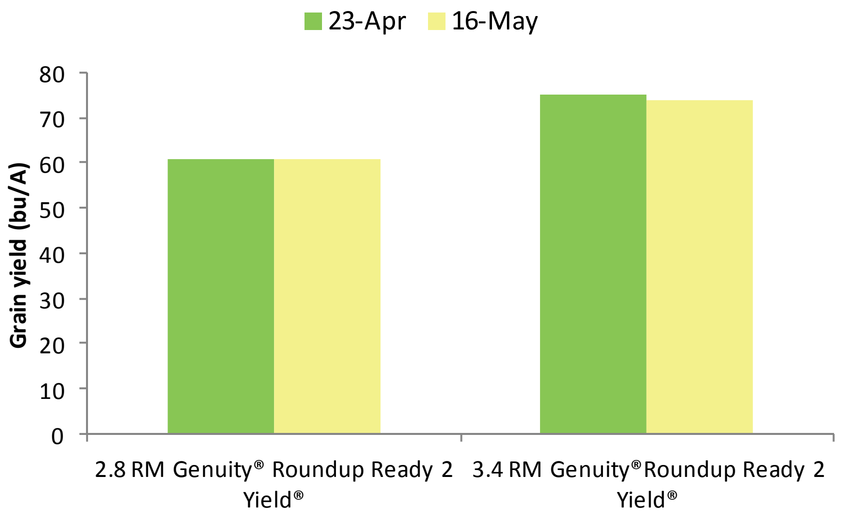

Figure 2. 2012 Data Effect of Planting Date x Relative Maturity on Soybean Yield.

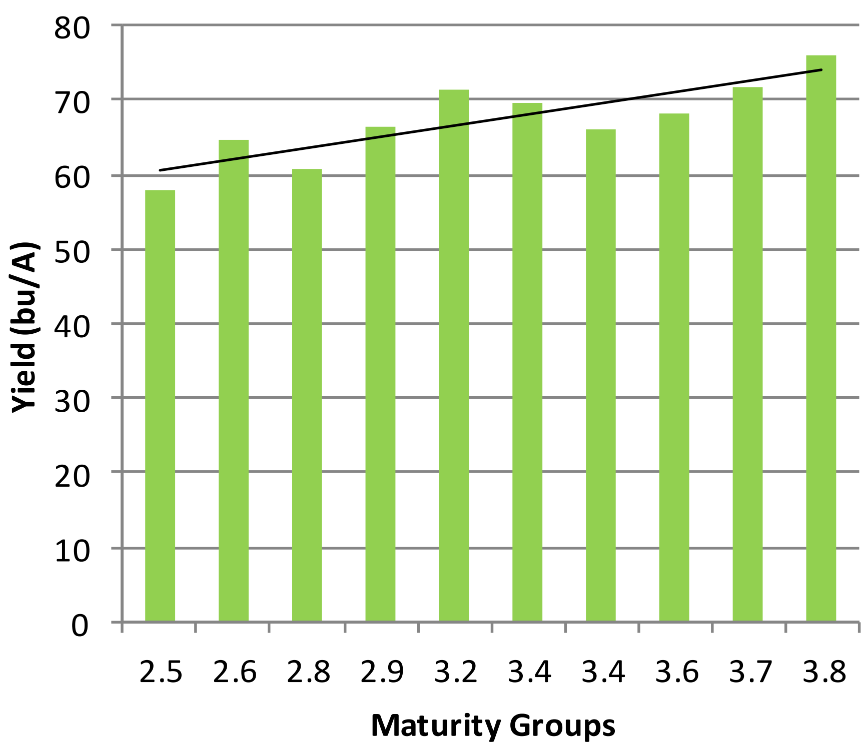

Figure 3. Effect of Maturity Group on the 2012 Soybean Crop.

HOW THE 2012 GROWING CONDITIONS IMPACTED SOYBEAN MANAGEMENT DECISIONS

Herbicide Program. Using multiple modes of action and controlling weeds at the proper height can limit yield loss that is associated with competition.

Foliar Fungicides. Timely application of fungicides can be very productive. There were very low levels of disease present this year due to the hot and dry conditions. This may have influenced the yield difference between the full season maturities over the shorter season maturities, since disease pressure usually has a more adverse effect on yield for full season maturities. The adverse growing conditions experienced at application (R3) and several weeks after resulted in an environment that was likely not conducive to a yield response (plants were stressed during reproductive growth when yield potential is adversely affected by water stress - Figure 4).

There were localized problems with spider mites and Japanese beetles in 2012, but no response to insecticide applications or combinations of insecticide plus fungicide was observed. Applications, in this study, were made in mid-July; however, spider mites became more noticeable in August. None of the R3 applications had an effect on yield.

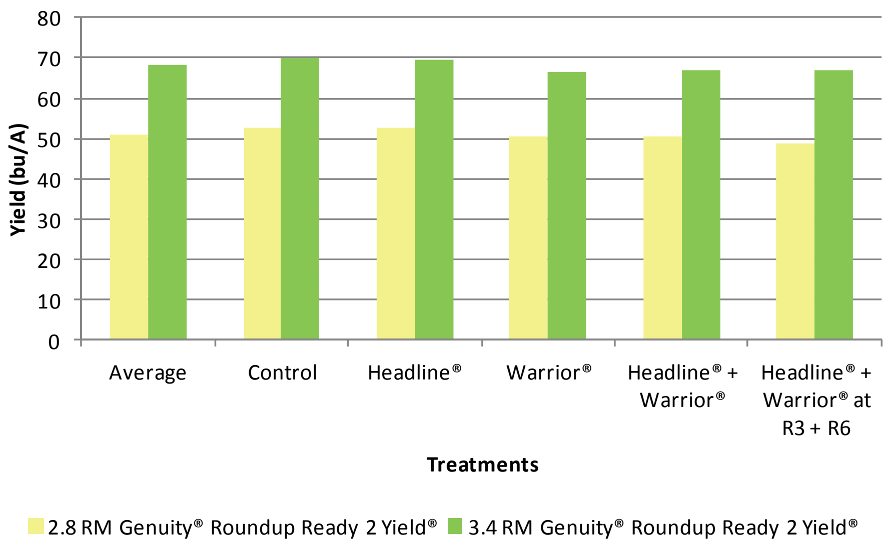

Figure 4. High Yield Management in Soybeans.

Summary

At the Monsanto Learning Center at Monmouth, IL, we consistently see higher yields in soybean by using the following cultural practices: plant early, use full season varieties that fit the region, and use a foliar fungicide during reproductive growth (R3). In 2012, there was no response to foliar fungicides, but in previous years yield advantages were observed.

Although we experienced adverse weather conditions (unusually warm and dry) throughout the months of July and much of August, planting full season varieties consistently resulted in the highest on-farm yields. However, we did not observe any yield benefits to planting early or making foliar applications at R3, most likely due to the stressful conditions of the 2012 growing season.

Sources

[1]*Extreme Beans New High-Yield Research. Corn and Soybean Digest. August 2012.*

[2]*P. Pederson. Soybean Planting Date. Integrated Crop Management. http://www.ipm.iastate.edu/ipm/icm/2006/4-3/soyplant.html*

[3]*Soybean Variety Selection. Plant Health Initiative – North Central Soybean Research Program (NCSRP). Available on-line: http://www.planthealth.info/crops_basics.htm*

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NOTES

NOTES

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Insect Resistance Management
Planting Refuges, Preserving Technology

Before opening a bag of seed, be sure to read, understand and accept the stewardship requirements, **including applicable refuge requirements for insect resistance management,** for the biotechnology traits expressed in the seed as set forth in the Monsanto Technology/Stewardship Agreement that you sign. By opening and using a bag of seed, you are reaffirming your obligation to comply with the most recent stewardship requirements.

RESPECT THE REFUGE®

Roundup Ready 2 TECHNOLOGY®

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Technology Development & Agronomy by MONSANTO

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