



Agronomic Spotlight

Corn Product Selection: Are Value-Added Traits A Fit?

- There are many options to consider for corn product selection including products which are conventional, herbicide-tolerant, or insect-protected and herbicide-tolerant. Each farmer must determine what product offers the best opportunity to help maximize profitability on his or her farm.
- Field research trials from a variety of sources show that corn products with genetically modified (GM) traits have a number of benefits over conventional corn to help manage risk under variable yield conditions and protect yield potential.

The large productivity gains in corn production made during the last several decades have come primarily from advanced plant breeding techniques and improved management of the crop.

- Since 1934, about 50% of on-farm yield gains can be attributed to improved management practices.²
- Yield stability across a wide range of environments is a critical selection target for corn breeders.¹ Breeding and crop management interact to sustain increased production.
- Improved stress tolerance for higher planting densities coupled with greater tolerance to environmental and pest stresses helps maintain corn yield improvement.^{2,3,4,5,6}

Since 1996, corn products with biotechnology traits and associated agronomic practices have contributed to the steady increase in corn production by reducing pest and environmental stresses on highly productive new corn genetics. Genetically modified corn products (GM) have increased corn production over a wide range of growing conditions, helping promote yield stability and reduce production risks. Conventional corn products may offer lower seed costs and market premiums, but may require more intensive weed, insect, and other management practices that can result in higher overall costs, lower stress tolerance, or lower yield potential.

Benefits of Biotechnology Corn

Improved production practices and stress tolerance in corn products can help achieve maximum yield potential, which may allow a farmer to maximize net profits. A recently published analysis of 20 years of field research trials shows that GM corn has a number of benefits over conventional corn.⁶ The study evaluated 948 GM and 1250 conventional corn products.

The benefits for GM corn found in this research include:

- GM corn provided more yield than conventional corn.
- GM corn responded to higher plant densities more than conventional corn.
- GM corn helped overcome the continuous corn rotation yield penalty conventional corn experienced during the 2000 to 2005 comparison period.

For example, University of Wisconsin research shows that farmers planting GM corn products in a corn-on-corn rotation in 2000 had a lower potential risk of low yield (175 bu/acre) than farmers using a conventional corn-on-corn rotation. In 2005, the negative impact of the corn-on-corn rotation was not apparent for GM corn products but was still a problem in conventional corn-on-corn rotation.⁶

Weed Management Benefits

Corn is very sensitive to early-season weed competition and loss of corn yield potential can begin soon after planting. The critical period of weed competition is variable. Roundup Ready[®] 2 Technology provides crop safety and flexible application timing to adjust glyphosate applications to the scope and intensity of the weed infestation in each field to reduce the risk of lost yield potential. Benefits include:

- Reduced plant stress due to weed infestations to protect yield potential and plant health.
- Removes hosts for insects, diseases, and nematodes.
- Facilitates the use of reduced-tillage for soil and water conservation.
- Corn products with Roundup Ready[®] 2 Technology contain in-plant tolerance to Roundup[®] brand glyphosate-only agricultural herbicides. The system provides:
 - ◇ proven crop safety
 - ◇ over-the-top application flexibility
 - ◇ broad-spectrum weed control
- A system with corn products with Roundup Ready[®] 2 Technology can reduce potential yield loss from crop injury resulting in an average of up to 5.6 more bushels per acre than conventional corn herbicide programs.*
- Roundup Ready PLUS[®] Crop Management Solutions provides weed management recommendations for broad-spectrum weed control, utilizing multiple application timings and herbicide sites of action.

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Insect Management Benefits

European corn borer, corn earworm, western bean cutworm, fall armyworm, and corn rootworm feeding can cause stress and injury to plant tissues. This damage can reduce yield potential or allow fungi to infect, proliferate, and produce mycotoxins which have the potential to cause health problems in animals and humans.^{8,9,10} Insect protection in GM corn products protects the plant parts these insects feed on which can reduce the risks of lost yield potential or lower grain quality. Conversely, insecticide applications require precise application timing, rates, and coverage, and may affect non-target organisms.

- European corn borer (ECB) populations still threaten non-*B.t.* corn products. An analysis of historical ECB damage in Minnesota estimated that *B.t.* corn for ECB provided an average benefit of \$17.24/acre.¹⁸
- GM corn rootworm protection can have agronomic benefits in addition to insect management. Improved root growth and activity can allow plants to export more cytokinins from the roots and utilize nitrogen more effectively after flowering to promote higher kernel weight and yield potential.¹¹
- Higher corn plant densities can support maximum grain yield potential. Genetic improvements, including new GM traits such as insect protection from the *B.t.* gene, help support higher seeding densities.¹⁴

Summary

Farmers planting GM corn products with herbicide resistance and multiple mode of action insect protection traits can realize higher yield potential by using intensive corn management practices to:

- Reduce plant stress from corn borers, ear feeding insects, stalk boring insects, and rootworm root damage.^{15,16,17}
- Plant corn-intensive crop rotations.
- Maintain higher plant densities to help maximize corn production.
- Harvest better quality grain by preventing insect damage that can lead to stalk and ear rot diseases. Mycotoxins produced by these diseases have the potential to cause health problems in animals and humans.
- Reap the economic benefits of higher yield potential in feedstuffs for cattle.¹²

GM products protect corn yield potential and provide other benefits. The PG Economics annual report on the impact of GM crops shows that GM crops are credited with decreasing

Roundup Ready PLUS® Crop Management Solutions

- Centralized resource for weed and insect management that combines the knowledge of weed scientists, academics, agronomists, and industry partners
- Customized recommendations for a proactive, economical approach to controlling tough-to-manage and glyphosate-resistant weeds, plus best management practices for weeds and insects
- Cash-back incentives for corn, soybean, and cotton acres when you use Roundup® brand glyphosate-only agricultural herbicides with Roundup Ready PLUS® platform endorsed products
- Please see your local retailer or visit www.roundupreadyPLUS.com for additional information, recommendations and details

pesticide and fuel use, facilitating conservation tillage practices that reduce soil erosion, improving carbon retention, and lowering greenhouse gas emissions.¹³

Sources: ¹Mansfield, B.D. and Mumm, R.H. 2013. Survey of plant density tolerance in U.S. maize germplasm. *Crop Science* 54:157-173. ²Duvick, D.N. 2005. Genetic progress in yield of United States maize (*Zea mays* L.). *Maydica* 50:193-202. ³Lee, E.A., and Tollenaar, M. 2007. Physiological basis of successful breeding strategies for maize grain yield. *Crop Sci.* 47:S202-S215. ⁴Tollenaar, M., and Lee, E.A. 2002. Yield potential, yield stability and stress tolerance in maize. *Field Crops Res.* 75:161-169. ⁵Tollenaar, M., and J. Wu. 1999. Yield improvement in temperate maize is attributable to greater stress tolerance. *Crop Sci.* 39:1597-1604. ⁶Chavas, J., Shi, G., and Lauer, J. 2014. The effects of GM technology on maize yield. *Crop Sci.* 54:1331-335. ⁷Egerton, M.D., Fridgen, J., Anderson Jr., J.R., Ahlgrim, J., Criswell, M., Dhungana, P., Gocken, T., Li, Z., Mariappan, S., Pilcher, C.D., Rosielle, A. and Stark, S.B.. 2012. Transgenic insect resistance traits increase corn yield and yield stability. *Nature Biotech.* 30:493-496. ⁸National Research Council. 2010. *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States.* National Academies Press. ⁹Folcher, L., Delos, M., Marengue, E., Jarry, M., Weissenberger, A., Eycheenne, N., and Regnault-Roger, C. 2010. Lower mycotoxin levels in Bt maize grain. *Agron. Sustain. Dev.* 30: 711-719. ¹⁰Hutchison, W.D. 2010. Areawide suppression of European corn borer with Bt maize reaps savings to non-Bt maize growers. *Science* 330:222-225. ¹¹Haegele, J.W. and Below, F.E. 2013. Transgenic corn rootworm protection increases grain yield and nitrogen use of maize. *Crop Science* 53:585-594. ¹²Hartnell G. F. 2010. Feeding transgenic feedstuffs to cattle. *Proc. 21st Florida Ruminant Nutr. Symp., University of Florida, Gainesville, FL.* ¹³Brookes, G. and Barfoot, P. 2014. GM crops: global socio-economic and environmental impacts 1996-2012. PG Economics Ltd, Dorchester, UK. ¹⁴Mitchell, P. 2009. Information and the Use of New Technology: Evidence from Seeding Density Decisions of U.S. Corn Farmers. UW AAE Applied Economics Workshop, University of Wisconsin. ¹⁵Wu, F. 2006. Mycotoxin reduction in Bt corn: Potential economic, health, and regulatory impacts. *Transgenic Research*:15 277-279. ¹⁶Castillo-Lopez, E, Clark, K.J, Paz, Ramirez, H.A. Klusmeyer, T.H, Hartnell, G.F, Kononoff, P.J. 2014. Performance of dairy cows fed silage and grain produced from second-generation insect-protected (*Bacillus thuringiensis*) corn (MON 89034), compared with parental line corn or reference corn. *J. Dairy Sci.* 97 :3832-3837. ¹⁷Munkvold, G.P. and Hellmich, R.L. 1999. Genetically modified insect resistant corn: Implications for disease management. APSnet. ¹⁸Ostlie, K.R., Hutchison, W.D., and Hellmich, R.L. Bt corn and European corn borer, long-term success through resistance management. University of Minnesota. Web sources verified 10/08/15. 141015200843

*433 field-trial comparisons, same Roundup Ready® 2 Technology product.

For additional agronomic information, please contact your local seed representative. Developed in partnership with Technology, Development, & Agronomy by Monsanto.

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