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Mitigate the Downside Risks of Corn Following Corn

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Indiana corn growers planted an additional 1.1 million acres of corn in 2007 compared to the previous season, for a total of 6.6 million acres (USDA-NASS, 2007). Essentially all of the additional corn acres came at the expense of a decrease in soybean acres. Consequently, the number of acres planted to 2^{nd}-year corn and/or continuous corn increased markedly. Farmers' planting intentions for 2008 are yet unknown, but the amount of aggressive tillage being conducted in corn stubble fields this fall would suggest that many farmers plan to continue planting corn following corn.

From an agronomic perspective, a continuous corn cropping system is fraught with hazards (Butzen, 2006; Lauer et al., 1997; Pedersen & Lauer, 2003; Vyn, 2004) and typically yields less than corn in a crop rotation system. Most growers understand this. However, some are equally concerned that soybean rust (*Phakopsora pachyrhizi*), soybean aphid (*Aphis glycines* Matsumura), or other major soybean stresses in coming years may result in unacceptably low soybean yields and/or high production costs.

Consequently, some growers are willing to accept the known risks associated with growing corn following corn in order to avoid the uncertain risks associated with soybean production. While most agronomists certainly do not encourage monoculture of any kind, they can at least offer suggestions for mitigating the downside risks of corn following corn for those growers who feel pressured to do so. More detailed information can be found in the references listed at the end of this article.

Nitrogen Fertility Issues.

Most agronomists agree that **optimum nitrogen (N) fertilizer rates** for corn following corn are higher than for corn following legumes (including soybean), with estimates ranging from 30 to 50 additional lbs of N required per acre (Butzen, 2006; Vitosh et al., 1995; Vyn, 2004). Coupled with the oft-cited 7 to 10% lower yield potential of continuous versus rotation corn, the higher required optimum N rates for continuous corn "adds insult to injury". Preliminary analyses of Purdue's 2007 Nitrogen Trials from five locations agree with previously published data in that 2^{nd}-year corn required, on average, 35 lbs/ac more nitrogen than corn following soybean even though 2^{nd}-year corn yields ranged from 7 to 22% less (data not yet published).

Nitrogen fertilizer prices continue their upward trend in response to high domestic natural gas prices, reduced domestic N fertilizer production, and a greater volume of imported N fertilizer (personal communication w/ Mike Hancock, Fertilizer Administrator, Office of Indiana State Chemist). Corn growers must remember to factor in higher N fertilizer requirements for corn following corn and possibly high N fertilizer prices when developing comparative budgets for alternative crop rotations.

Another consideration for growers who routinely sidedress most or all of their N fertilizer is the fact that obviously more days will be required for this operation if more corn acres are planted. However, sidedressing must be completed within a certain time period. Plant height limitations imposed by traditional ground-driven sidedress applicator tools add to the logistical headaches of covering more corn acres in a timely fashion. High-clearance applicators (e.g., Hagie™, Spra-Coupe™) that can either dribble liquid N between the rows or inject liquid N via coulters offer an option for lengthening the sidedress "window".

P & K Fertility Issues.

Corn removes more soil phosphorus and less soil potassium **per acre** than soybean (Vitosh et al., 1995). Per bushel of grain, corn removes 0.37 and 0.27 lbs of P_2O_5 and K_2O while soybean removes 0.80 and 1.40 lbs of P_2O_5 and K_2O. A 180-bushel corn crop therefore removes 67 lbs per acre of P_2O_5 and 49 lbs of K_2O while a 60-bushel soybean crop removes a total of 48 and 84 lbs of P_2O_5 and K_2O.

> A one-time move to second-year corn will have negligible effects on P & K soil fertility levels. Over a number of years of corn following corn, however, growers should monitor soil phosphorus and potassium levels and adjust P & K fertilizer application rates accordingly.

Stand Establishment Issues.

Higher levels of corn residue associated with continuous corn cropping systems on poorly drained soils in Indiana can create difficult stand establishment conditions due to slowed warming and drying of the soil. High levels of surface residue (including old "rootballs") often also physically interfere with the furrow opening and closing functions of the corn planter's row units (Nielsen, 2003).

Not only can germination and emergence be delayed or uneven, but so can initial seedling development. Delayed stand establishment thus lengthens the potential period of seedling exposure to seedling blights or insect pests and increases the risk of lower than desired populations and/or higher numbers of weakened plants that are less able to tolerate later-occurring stresses.

> **Mitigate the risk of poor stand establishment** by selecting hybrids with superior seedling vigor ratings. If you will be switching only part of your soybean acres to second-year corn, target better-drained fields in your farming operation. Where practical, consider burying the stalk residues with tillage to better facilitate seedbed preparation and planting. Consider adopting strip tillage practices (Vyn, 2004). In no-till corn with heavy surface

trash conditions, consider the use of row-cleaning attachments for the corn planter. Avoid planting excessively early in order to minimize the risk of sub-optimal soil temperatures during germination and early seedling establishment. Consider using starter fertilizer, especially nitrogen, in a traditional 2 x 2 placement at rates no less than 20 lbs/ac of actual nitrogen. Consider the use of either soil-applied insecticide or insecticide-treated seed if the risk for secondary insect pests (wireworm, seedcorn maggot, etc.) is high (Obermeyer et al., 2005a).

Disease Management Issues.

The risk of some corn diseases is greater when corn follows corn, especially when some form of reduced tillage is practiced that leaves greater amounts of non-decomposed, inoculum-bearing residue on the soil surface. Two such diseases that can devastate susceptible hybrids are gray leaf spot (*Cercospora zeae-maydis*) and, as some experienced in 2004 and 2005, northern corn leaf blight (*Exserohilum turcicum*). Other diseases that may become more prevalent in corn following corn are stalk and ear rots, including those caused by *Colletotrichum graminicola* (anthracnose), *Fusarium verticillioides*, *Gibberella zeae*, and *Diplodia maydis*.

Over the past 2 years there has been a lot of talk about substantial yield increases in field corn sprayed with strobilurin fungicides. Experimental data from repeated, replicated university trials suggest that economically beneficial responses to fungicide applications in commercial hybrid corn may occur approximately 60% of the time, but are linked closely with the actual occurrence of significant levels of disease. Economic yield responses to fungicides in the absence of disease are not well documented. On-farm tests in which single strips of untreated corn are used to evaluate the efficacy of treatment on most of the field can be misleading.

The decision to use a foliar fungicide should be based on known susceptibility of the hybrid to gray leaf spot or northern corn leaf blight and the likelihood that disease will develop. Disease risk depends, in addition to the abundance of corn residue in the field and the hybrid's susceptibility, on weather during the summer. Frequent, well-spaced rain (not necessarily heavy), high relative humidity, and dew that persists into the morning favor leaf blights. In the absence of good data to support the economic return of fungicides, it is a good idea to leave some check strips—preferably more than one, and assigned to random strips across the field (i.e., don't use portions of a field that have historically yielded less as your untreated check strips).

In the absence of research-based disease severity thresholds for fungicide application timing, many growers have opted to treat fields at or just before tassel emergence (VT). Stage VT typically occurs about 3 days before silks emerge (R1). If disease will become a problem in a field, treatment at this time will protect leaves during early grain fill and may reduce secondary inoculum that can cause more disease later. Therefore, it is a good idea to scout fields as they near the VT stage of growth. If there is little or no leaf disease evident at this time, application of a fungicide at this time may not be economically justified. Some fungicides can be applied after silking. Check labels for preharvest intervals for each product.

> **Mitigate the disease risk** in second-year corn by careful hybrid selection with emphasis on resistance to specific diseases as well as on overall good plant health characteristics (Thomison et al., 2004; Vincelli, 2004b; Vincelli, 2005). Where practical, consider burying the stalk residues with tillage to reduce the abundance of disease inoculum for next year. The use of fungicides is often not considered economical for disease control in commercial feed grain corn production (Vincelli, 2004c), although the experience of some farmers suggests otherwise. For more information on fungicide use in corn, see Nielsen (2007).

Insect Management Issues.

The major insect threat to corn following corn in Indiana is the Western corn rootworm (*Diabrotica virgifera virgifera*). The yield and production cost consequences for corn following corn is particularly meaningful for growers in areas of the state where crop rotation remains a viable control option for this insect pest (i.e., areas where the variant rootworm has not yet appeared, primarily the southern and eastern parts of Indiana [Obermeyer et al., 2005b]).

There are other notable belowground pests of corn, however, particularly early in the growing season. As indicated earlier, greater levels of surface corn residues in corn following corn can delay corn emergence and growth. This results in a lengthier exposure of corn seedlings to secondary soil pests (e.g., wireworms, seedcorn maggots, white grubs and slugs) that in turn may result in weakened plants and/or stand reductions. A combination of surface corn residues and live winter annual weeds in the spring can attract cutworm and armyworm moths for egg laying, leading to corn seedling damage/death from subsequent larval feeding on plant tissue. Given all of these factors, pressure levels from these pests could potentially increase in corn following corn.

On the other hand, second-year corn should not experience greater populations or damage from European corn borer (*Ostrinia nubilalis*) or Southwestern corn borer (*Diatraea grandiosella* Dyar). In both cases, adult female moths find and fly into cornfields each year to lay eggs. The use of a continuous corn cropping system over a wide area over several years may increase the risk of elevated corn borer pressure and potential yield/harvest losses, simply because of the increase in potential food sources and associated increased pest populations.

> **Mitigate the insect risk** in second-year corn by the judicious use of soil-applied insecticides, insecticide seed treatments (high rate formulations), or transgenic resistance (Bt-rootworm) for rootworm (Obermeyer et al., 2006). Scout fields during seedling emergence for cutworm and armyworm damage to leaves and stems to determine the possible need for rescue treatments of foliar insecticides.

Consider using hybrids with Bt-corn borer traits where appropriate.

Hybrid Selection Issues.

Good hybrids for rotation corn tend to be good hybrids for continuous corn. Therefore, growers should first seek out hybrids that demonstrate consistent high yield performance across multiple environments (years and/or locations). Consistent performance across multiple sites is important because multiple sites represent possible weather patterns your farm may experience in the future. Consult closely with your seed sales representative and check out the latest corn hybrid performance results from non-biased sources such as Purdue's Crop Performance Program Web site[1].

Once you have identified otherwise good yielding hybrids, then further filter among that group for hybrid characteristics important for a continuous corn cropping system. Such characteristics include hybrid traits for disease resistance, stalk strength, stalk and root health, seedling vigor, and overall stress tolerance. While always important, these traits take on extra meaning when adopting continuous corn strategies because of the increased risk of diseases and often-greater risk of early season stress during the stand establishment period.

Weed Management Issues.

Growing continuous corn limits growers to fewer herbicide options than growing corn in rotation with soybeans or another crop. In addition, the greater amounts of crop residue associated with a continuous corn system can decrease the efficacy of many soil-applied herbicides and favor certain weed species that thrive in an environment of higher residue and greater soil surface moisture. Consequently, certain annual grasses, johnsongrass (*Sorghum holepense* (L.) Pers.), and certain small-seeded broadleaf weeds can be more problematic in continuous corn. If using soil-applied herbicides, use full rates to compensate for the effects of greater residue to best manage weeds in continuous corn.

If plans include greater reliance on post-emerge herbicides, ensure that weeds are not taller than 6 inches before making such applications. In the long run, a combination of preemergence and postemergence weed control strategies will usually result in the most effective weed control.

Weed management concerns in second-year corn will be influenced by the performance of the previous year's weed management program. In 2004, for example, early planting and subsequent wet conditions diluted soil-applied herbicides, resulting in widespread instances of giant ragweed (*Ambrosia trifida* L.), burcucumber (*Sicyos angulatus* L.), and giant foxtail (*Setaria faberi* Herrm.) breaking through the soil-applied treatments. In 2005 and 2007, lack of rainfall to activate soil applied herbicides resulted in widespread instances of poor control giant foxtail, lambsquarter (*Chenopodium album* L.), and giant ragweed.

In 2006 and 2007, many growers waited until weeds were excessively large before making postemergence herbicide applications and weed control failures were obvious.

[1] http://www.agry.purdue.edu/pcpp. [URL accessed 10/31/07].

The fields with moderate to high densities of weeds that emerged with corn and were not controlled until the V3 corn stage or when weeds were in excess of 4-6 inches tall likely suffered significant yield losses and allowed weeds to produce seed. In addition, many growers apparently reduced their use of residual herbicides in corn production. Consequently, late-season emergence of grass weeds such as crabgrass (*Digitaria sanguinalis* (L.) Scop.), barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) plus broadleaf weeds such as waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer.) and redroot/smooth pigweed (*Amoranthus retroflexus* L., *Amaranthus hybridus* L.) were very evident.

Fields with such weed escapes leave behind a good supply of new weed seed in the soil seed bank. Furthermore, giant ragweed, burcucumber, waterhemp, and crabgrass have relatively long emergence periods in Indiana and two pass weed control programs are always more successful on these weeds.

Mitigate the risk of poor giant ragweed and burcucumber control by adjusting weed management plans to include the use of postemergence herbicides that provide residual activity on these weeds. Shifting atrazine use from preplant to postemergence application will extend the residual window of activity and reduce late season weed emergence. Callisto™, Hornet™, and Peak™ (Spirit™) containing products also provide foliar and residual activity on these weeds, unless the giant ragweed is ALS resistant and would be well suited to use as postemergence treatments.

For better control of late-emerging grass weeds and some small seeded broadleaf weeds, consider adding a reduced rate of an amide (metolachlor (Dual™ and other formulations), acetochlor (Degree™ or Surpass™ and other formulations), dimethenamid (Outlook™), or flufenacet (Define™) to the postemergence herbicide treatment. Amide herbicides will not control emerged grass weeds. If grass weeds have emerged, a postemergence grass herbicide will be required to control them. All of the chloroacetamide products listed above are labeled for application to emerged corn.

Mitigate the risk of yield loss due to late postemergence herbicide treatments by using residual herbicides at planting and making postemergence treatments before the V3 stage of corn growth. Use the WeedSOFT® Yield Loss Calculator (Univ. of Nebraska, 2006) to assist in your understanding of the impact of early-season weed competition on corn yield.

Glyphosate-Resistant Weeds. Glyphosate-resistant marestail (aka horseweed, *Conyza canadensis*) is widespread in southeast Indiana and southwest Ohio and effective postemergence control of marestail with glyphosate alone in this region is unlikely (Loux et al., 2006). In addition, glyphosate-resistant marestail has now been documented in 15 states in the U.S. In 2006 and 2007, we observed frequent giant ragweed and lambsquarter control problems with glyphosate in soybean and corn. Lambsquarter biotypes with elevated tolerance to glyphosate have been reported in Indiana and Ohio. Purdue and Ohio State weed scientists have conducted extensive field and greenhouse experiments on giant ragweed biotypes with elevated tolerance to glyphosate and have documented populations that show a low level of resistance to glyphosate.

Mitigate the risk of glyphosate resistant weeds by including a variety of herbicide modes of action, especially on weeds that are most problematic to control with glyphosate alone. You could also consider using corn hybrids that contain the Liberty Link™ trait and Liberty™-based herbicide programs. If glyphosate-resistant corn was grown in a particular field in the previous year, one should also strongly consider using herbicides that rely on other modes of action on the most problematic weeds to reduce selection pressure for glyphosate-resistant weeds. This is particularly important in fields where the grower has noticed increased difficulty in controlling giant ragweed and common lambsquarter.

Marestail, lambsquarter and giant ragweed are effectively controlled by many postemergence herbicides in corn. The most effective control of these weeds are usually provided by dicamba, 2,4-D, Hornet™, or Callisto™-based products containing atrazine, provided the applications are made before weeds are 6 inches tall. Giant ragweed and lambsquarter can also be controlled with Liberty-based products. However, Liberty alone will be weak on marestail, so a tankmix partner for marestail should be included.

Lambsquarter is easily controlled with tillage and many soil-applied herbicides, so effective management is not difficult if one doesn't rely solely on postemergence herbicides. If you will be relying on glyphosate in Roundup Ready® (RR) corn and the field has lambsquarter and giant ragweed, the labels for the initial RR corn events limited the glyphosate rate to 0.75 lb ae/A. However, the labels for the Roundup Ready 2® (RR2) events allow the use of up to 1.125 lb ae/A. Most of the corn grown in Indiana and Ohio is the RR2 event and allows the use of higher rates of glyphosate.

We have shown that it is critical to use a high enough glyphosate rate and tankmix partner which is most likely to be effective with the first postemergence treatment, rather than trying to control escapes with higher rates in a second postemergence treatment. Thus, we would recommend that if you have weeds which are tough to control with glyphosate such as giant ragweed, lambsquarter, marestail, and morningglories you should not hesitate to use the 1.125 lb ae/A rate of glyphosate in the first postemergence treatment. In addition, you can use state weed control guides such as the **Weed Control Guide for Ohio and Indiana – Bulletin 789** (Loux et al., 2007) to determine the most appropriate tankmix partner with glyphosate to provide effective control of emerged broadleaf weeds.

For more information on glyphosate-resistant weeds and specific recommendations on tough to control weeds in RR cropping systems, weed scientists in the North Central region began producing publications on this topic and launched a website to distribute this information. The "Glyphosate, Weeds, and Crops Group Web Site" can be found at http://www.glyphosateweedscrops.org (URL accessed 11/1/07).

Harvest Season Issues.

Obviously, planting more corn acres will effectively lengthen the corn harvest season because of time and capacity demands on harvest machinery, drying facilities, transport, and storage. Some portion of the corn crop will likely remain in the field longer into the fall. Deterioration of mature stalk tissue, especially if already stressed with stalk rots, greatly increases the risk of stalk breakage and mechanical harvest loss if fields suffer severe wind damage prior to harvest. The greater risk of leaf diseases in corn following corn also indirectly increases the risk of stalk rot development if photosynthetic output is severely compromised during grain fill. Excessively dry grain may lead to greater than normal mechanical harvest loss at the header.

Mitigate the risk of stalk breakage by selecting hybrids with superior overall plant health and stalk strength characteristics. If you will be switching only part of your soybean acres to second-year corn, target better-drained fields in your farming operation. Scout fields for the occurrence of stalk rots prior to harvest and prioritize their harvest schedule if necessary to harvest "weak-kneed" fields early. Consider beginning harvest earlier than usual to avoid finishing in late fall when rain and snow prospects typically increase.

Bottom Line

The decision to switch significant soybean acres to second-year corn acres should be made cautiously with careful attention to both the economics and agronomics of such a choice. While short-term economics may favor second-year corn over soybean production (Schnitkey & Lattz, 2005), long-term economics are very much dependent on the economic assumptions made when calculating comparative crop budgets. Growers should recognize that second-year corn yields will range from 7 to 10% less than corn following soybean. Consideration of the risks outlined in this article will help minimize the downside dollar potential of second-year or continuous corn relative to corn following soybean.

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