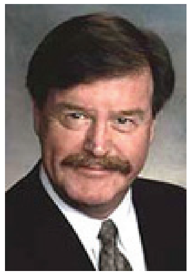
Have I Got A New Trait For You!



By: Alan R. Gould, Ph.D.
Director
Verdant Partners LLC

August 5, 2009

If you have attended a conference on crop agriculture recently, you will almost certainly have heard speakers talking about some new technology and its impending impact. The new technologies discussed often include new traits in crops, and although it is unfair to label these presentations as "Gee Whiz! Ain't Science Great?" it is noticeable that the focus is always on the technology and its supposed benefits, not on the relationship between benefits and costs

Agriculture is like most other globally important economic activities: new technology is expensive to develop, risky for early investors, uncertain of success, and difficult to value for its long-term financial return. It is very difficult for the end-user to see through the attractiveness and novelty of the technology and get a straight answer to the question: "How much is this going to cost me?"

The commercial history of transgenic traits in crop plants is a good example of cost structures evolving as agricultural markets adjust to new technology, and provides some clues to the direction that seed product pricing might take in the future.

The escalation in the cost of a bag of seed from BTT (before transgenic traits) to when single traits became available (ATT - after transgenic traits) and into the era of MST (multiple stacked traits) and beyond (NWT – new wave traits) is of great interest to germplasm suppliers, trait providers, seed companies, and growers as the purchasers and users of seed products. So what exactly are the components of the increasing price of a bag of seed?

As genetics and engineered traits have become increasingly intertwined, it has become more and more difficult for growers to associate the value of each component of performance (standability, disease resistance, insect resistance, herbicide tolerance, grain quality, yield, and many others) with the incremental price increase that each component adds to a bag of seed.

In the BTT era for a crop such as corn, growers wanted a performance package that included low lodging, disease resistance, stand survival, ear retention, low moisture content at harvest, and of course high eventual economic yield. A good insurance policy to spread risk across a moderately sized farm involved buying several different hybrids and brands so that there was genetic variety to deal with variable weather, soil, and weed and disease pressure conditions from year to year.

The complicating factor was that identical, or very similar, genetics were being sold under different brand names and hybrid numbers. Obviously, at that time different prices were being paid for the same or close to the same genetics. What did growers think they were paying for?

A study from the University of Minnesota compared 1991 price information from forty seed companies and analyzed the relationship between what growers paid for seed, and the performance characteristics that interested them most. The outcomes were surprising: prices paid were most closely related to moisture content and root lodging characteristics and not significantly associated with yield! This odd result is probably complicated by the intangible factors perceived as the total value delivered in a bag of seed, such as customer service, personal relationships, and brand loyalty.

Things changed dramatically in the ATT era. The introduction of transgenic traits into soybeans and corn transformed the pricing strategies of seed, and certainly influenced how growers calculated their profit opportunities. For herbicide tolerance (to glyphosate) in soybeans, introduced in 1996, the calculation of value could be based on the complete control of weeds and the savings associated with reduced herbicide application schedules, fewer trips to the field, and yield increases resulting from narrower row planting designs. Herbicide tolerance in soybeans also elevated the crop from a low-profit rotation to an economically viable alternative to other major row crops. In the long term, this trait also changed the balance in the year-to-year competition for acres between corn and soybeans.

The pricing strategies for insect resistance traits in the ATT period were also fairly transparent. For first generation Bt genes giving resistance to lepidopteran (moth-type) pests such as European Corn Borer (ECB) with variable infestation severity from year to year, the premium initially charged at retail seed level was between $7 and $10 dollars per acre. This was a good insurance bet, even in years with low infestation, because the dollar benefits of the trait were probably around $17 per acre on average. However, the pricing for the trait was also the thin end of the wedge in terms of technology fees. Previously, growers had not treated large acreages with insecticides to control ECB and so simple "insecticide cost replacement" calculations did not really work, and an "insurance" model was applied. Experts' widespread predictions that growers would never pay for genetic control of ECB were proved wrong. Although adoption of the initial ECB technology was slow compared to herbicide tolerance in soybeans, traits for borer control are currently priced at around $50 per unit, and acceptance of this technology has generated significant new revenue streams for trait owners.

Second generation Bt-related traits have offered protection against coleopteran pests, most notably corn rootworm. The benefits and value of prophylactic control of this annual pest of corn were easily appreciated by growers because the cost of insecticides for CRW control was consuming a well-defined fraction of crop input budgets. Second generation "coleop-active" (corn rootworm resistance or below ground pest traits) Bt genes in corn were adopted quite rapidly due to this clear value proposition and because borer control by genetic traits had already been demonstrated.

Now, in the MST (multiple stacked traits) era, important developments continue such as the announcement that the SmartStax™ system had received regulatory approvals back in July. This system, currently based on eight genes and four traits (two different herbicide tolerances, above ground insect protection and below ground insect protection) provides a good study of pricing strategies that growers may have to deal with in the near future.

Pricing a package of stacked traits depends on the real cost benefits for a specific stack, and that value varies from region to region and from year to year. A simple example would be a stack for herbicide tolerance plus corn rootworm resistance plus corn borer resistance. That combination of traits would clearly provide different values to growers in a county with severe infestations of rootworm as compared to growers in a region where rootworm is a negligible pest. This specific stack would also have different values in different years in the same location when ECB moth swarms were severe or absent.

Value differences for the same stack in different regions can be (and are being) dealt with by variable pricing from region to region (often referred to as ZIP Code pricing –well known in the energy industry). The grower has to calculate the real economic potential benefits of a particular hybrid, with a particular stack, for a specific environment against the price of the bag of seed in his county. Seed companies will have to price their seed across different regions based on their variable costs for trait technology fees. Fees for a single trait such as corn borer resistance are likely to be quite stable across different growing areas in a particular year, because this trait has been around for some time, and has proven value as an insurance policy against the variable pest pressure of borers from year to year in the same region. Similarly, herbicide tolerance traits have proven value across very broad areas and so will probably be priced similarly across different regions.

Things change when a trait is targeted against a pest, such as corn rootworm, that is endemic to some regions but absent or a very minor problem in others. The "insurance value across a wide area" model that works for corn borers does not work for corn rootworm so some version of ZIP code pricing is more applicable. This means that seed companies, and therefore growers, in different regions pay different amounts for the same rootworm resistance trait, but the situation becomes even more complex with multiple stacked traits.

Stacks of currently available traits will push the market to accept variable pricing of a bag of seed based on the need that a particular region has for the different traits offered in the stack. Also, growers have always had the choice to buy a newer high yielding hybrid over a more established variety, accepting the price differential associated with the newer high-performing hybrid. In the future, this price differential is likely to become more formalized as a "genetics premium fee."

The evolution of seed pricing over the past 20 years comes into sharp focus when considering that the cost of a bag of corn seed in 1990 was about $70 (no traits were commercially available back then). Before 1990 seed prices had been quite stable from year-to-year, and corn breeders often grumbled that their hard work in producing better and better hybrids by conventional breeding (and annual average yield increases of about two bushels per acre per year) was not rewarded by increases in the price of a bag of seed. With single, double and triple combinations of traits available, the $200 barrier was broken quite recently and the latest stacks combined with elite hybrids push the top end price of a bag of corn seed beyond $300. For some stacks, in some hybrids, in some counties, more than two thirds of this $300 will be due to traits. Growers today can pay more for traits in the bag, than they were paying for a bag of conventional seed in 1990.

Stacks let seed companies offer different combinations of traits to satisfy different customers' needs. In the future, seed companies could create seed with standard, deluxe and premium packages of stacks to fit different market segments. However, maintaining stocks of the same hybrid or variety with several different stack options would create inventory management problems that most seed companies would rather avoid.

So understanding the value of traits, the value of the underlying genetics package and assigning an asking price for a bag of seed containing them has become more complicated as the market moves from single, to double, to multiple stacked traits. But just wait – there is a whole new wave of traits ready to hit the market, and this is going to make the value-cost decision even more challenging, not just for the grower, but for the whole chain of trait discovery, development, deployment into elite genetics, and commercialization.

The escalation in cost of a unit of seed must have an upper limit beyond which it would be impossible for growers to recoup input costs, let alone make a profit. Introduction of a new trait without the benefits of at least some existing traits would be extremely difficult. Thus, new traits will have to be priced with existing traits, which could lead to multiple stacks that elevate seed costs beyond the grower's upper limit. An alternative would be to consider these new traits as general performance enhancers of the background genetics, sold as an integrated characteristic of the seed brand (rather than as a separate name such as Roundup Ready® or Herculex®) to increase market share and priced accordingly.

The next period of NWT (new wave traits) involves different categories, so various pricing strategies will apply. First, there are new genes that produce traits similar to those already in the marketplace. Glyphosate tolerance with different modes of action is one example, and Bt and related genes offering a different spectrum of insect control are another. Then there will be new genes offering tolerance to old herbicides such as 2,4-D (commercialized over 60 years ago) and dicamba. Especially in soybeans and cotton, these old and well-known chemistries could find new applications due to the related tolerance traits. Stacking new tolerance traits to these old chemistries with more established herbicide-tolerance traits could offer improved control weeds and new rotations for herbicide usage. Pricing models are likely to reflect existing herbicide tolerance traits with little variation across regions.

The NWT that really capture the industry's imagination, especially given environmental concerns such as climate change, nitrate run off, and salinization, seem to be traits related to drought and heat-tolerance, water-use efficiency, nitrogen-use efficiency, and salt tolerance. Improved grain yield and biomass accumulation traits also stimulate the imagination of the biofuels industry.

However, the new environmental-stress tolerance and yield enhancement traits are different in both technical and performance characteristics when compared to insect resistance and herbicide tolerance traits. Traits for herbicide tolerance and insect resistance have been seen as an extension of the agricultural chemical companies into the seed business and a prime motivation for acquisition of seed market share. Some of these new traits don't fit that motivation. For example nitrogen-use efficiency traits should decrease the demand for product from fertilizer companies, and water-use efficiencies will require different value calculations too.

In the discussion above about traits that are commercially available right now, the expression "traits sitting on top of genetics" was used. This is pretty much an accurate description of what is going on genetically and biochemically for most existing commercialized traits. This is not the situation for the new traits now being developed.

For example, traits for drought, heat, and salt tolerance most often depend on modified genes that exist as integrated functional units of the plant's genome. They interact with other genes in complicated signaling pathways that allow defensive responses to adverse environmental and climatic conditions. Therefore, modifying genes of this type can have complex effects on plant performance. For example modifying a gene to successfully achieve drought tolerance, but at the expense of reduced grain or biomass yield, is scientifically interesting but commercially unviable. Field-testing traits for environmental stress tolerance is also more challenging than testing an herbicide tolerance trait. Trying to demonstrate high levels of drought tolerance and protection of yield potential in a season or region where there is unexpected abundant rainfall usually results in inconclusive field trial results, and another year of testing and escalating research costs.

Pricing strategies for traits such as heat and drought tolerance could be based on the "insurance" concept and calculated in terms of the likelihood of severe drought and/or heat stress. For regions prone to prolonged or repetitive drought conditions, drought tolerance traits could be priced in relation to the level of yield protection offered. A look at the map of drought incidence in the U.S. for 2009 will confirm the potential value of drought tolerant crops in California, Northern Wisconsin, south central Minnesota, and especially south and central Texas, which has suffered the worst drought in 50 years. However, crops in Indiana, Illinois, Iowa and Missouri would not have benefited from drought tolerance traits this year, unless such traits have benefits above and beyond yield protection in very dry periods.

Pricing models for environmental stress tolerance traits provide a cautionary note for the small entrepreneurial companies that develop such traits in the hope of having them deployed by major seed companies. Technology fees now being charged for herbicide tolerance (HT) and insect resistance (IR) traits, when spread over large acreages for crops such as corn and soybeans, generate very large dollar numbers. Often trait discovery companies are built around financial models based on historical experience of HT and IR traits. These financial models are a poor fit for environmental stress tolerance traits, and not quite appropriate for nitrogen use efficiency and water use efficiency traits. Given the more complex nature of the effects of such traits, the difficulties of getting convincing field trial data, and the real value generated at grower level across regions and seasons, new trait developers may need to lower their expectations, or at least generate innovative pricing models.

Finally, the new wave traits discussed here are no longer really new (they have been under development for a number of years) and are unlikely to trigger the radical restructurings of the seed industry that were caused by the introduction of herbicide tolerance and insect resistance.

So what game-changing technologies are out there?

First, there are artificial chromosomes. Traits in "stacks" now come from different "insertion events" where genes have been individually introduced into the plant's chromosomes in a random manner. Genes in the "stack" (and therefore the trait they code for) sit in different places on different chromosomes. This makes combining different traits laborious for plant breeders. Artificial chromosomes can be built with multiple genes sitting in a line so that they can all be inserted into a crop plant in one step, and tracked as a single unit through a breeding program. When they are fully developed artificial chromosomes will revolutionize and accelerate the way that trait stacks are developed and delivered to the marketplace.

Then there are hybrid soybeans, a crop that has been a goal of breeders for many years. The challenges have always been finding parental lines that will make hybrids with the yield kick that comes from hybrid vigor, and developing a planting system that will allow pollen transfer efficiently between those parental lines. Multiple patents (going back to the 1980's) have been applied for and issued covering these challenges, and companies in the U.S., China, and elsewhere are developing hybrids for commercialization. If economically viable production of hybrid soybean seed can be achieved, and hybrid vigor is really significant, then the soybean crop will undergo a quantum leap in yield and profitability.

The pollen transfer problems for producing hybrid soybeans would be solved by the real holy grail of new crop technology, which is apomixis: the production of viable fertile seed without pollen transfer or fertilization. Many research groups and trait development companies have researched the possibility of making apomictic crop plants, which would reproduce asexually. So apomictic hybrid soybean or corn seed would be genetically stable from generation to generation and could be planted from year to year without loss of hybrid vigor or yield.

There's no shortage of new ideas out there, but the important thing to remember about these game-changing technologies as they sit on the far horizon is this: it is going to cost you.

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