FARMING IN THE 21ST CENTURY

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Preface

The U.S. agricultural industry is in the midst of major structural change — changes in product characteristics, in worldwide production and consumption, in technology, in size of operation, in geographic location. And the pace of change seems to be increasing. Production is changing from an industry dominated by family-based, small-scale, relatively independent firms to one of larger firms that are more tightly aligned across the production and distribution chain. And the input supply and product processing sectors are becoming more consolidated, more concentrated, more integrated.

Agriculture in the 21st century is likely to be characterized by: 1) adoption of manufacturing processes in production as well as processing, 2) a systems or food supply chain approach to production and distribution, 3) negotiated coordination replacing market coordination of the system, 4) a more important role for information, knowledge and other soft assets (in contrast to hard assets of machinery, equipment, facilities) in reducing cost and increasing responsiveness, and 5) increasing consolidation at all levels raising issues of market power and control.

These profound changes in the agricultural industry present new challenges and new opportunities that require new ideas and concepts to analyze and implement. They require new learning and thinking. Some of those new ideas and concepts are presented here, not as empirically verified truths, but as "thoughts" to stimulate different and better thinking. They have been developed based on observations, analysis and discussions with numerous managers and colleagues in agribusinesses in North America and Europe. This series focuses on Farming in the 21st Century; companion series are also available on Financing and Supplying Inputs to the 21st Century Producer (Staff Paper 99-11), and Value Chains in the Food Production and Distribution Industries (Staff Paper 99-10).

Our purpose in sharing these "thoughts" is to invite discussion, dialogue, disagreement — in general to encourage others to develop better "thoughts".

Keywords: qualified supplier, biological manufacturing, strategic risk, process control, economies of size, franchise grower

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Biological Manufacturing and Process Control

The transition of production agriculture from an industry that raises livestock and grows crops to one that biologically manufactures raw materials with specific attributes and characteristics for food and industrial use products is well underway. A key element of this transition will be the adoption of process control technology and the management systems that will implement process control in production activities — in farm fields and livestock feedlots and facilities.

Three components of process control technology are critical in biological manufacturing:

1. Monitoring/measuring and information technology,

2. Biotechnology and nutritional technology, and

3. Intervention technology.

Monitoring/measuring and information technology — The focus of this technology is to trace the development and/or deterioration of attributes in the animal and plant growth process, and to measure the impact of controllable and uncontrollable variables that are impacting that growth process. In crop production, yield monitors, global positioning systems (GPS), global information systems (GIS), satellite or aerial photography and imagery, weather monitoring and measuring systems, and plant and soil sensing systems are part of this technology. In animal production, systems to monitor humidity, temperature, air quality and other characteristics of the feedlot or building environment along with systems to monitor feed formulations, water characteristics, and animal waste and feed ingredient composition are included. In future years, in-animal sensors to detect growth rates and disease characteristics may be part of such information and monitoring/measuring systems. And these systems will be tied to growth models to detect ways to improve growth performance, as well as to financial and physical performance accounting systems to monitor overall performance. The computer technology to manipulate the massive amounts of information is readily available; new monitoring/measuring technology including near-infrared (NIR) and electromagnetic scanning is now being developed to measure a broad spectrum of characteristics of the animal and plant growth process.

Biotechnology and nutritional technology — The focus of biotechnology and nutritional technology is to manipulate the attribute development and deterioration process in plant and animal production. An improved scientific base to understand how nutrition impacts not only growth but attribute development is providing additional capacity to manipulate and control that process. And biotechnology is advancing our capacity to control and manipulate animal and plant growth and development including attribute composition through genetic manipulation. By combining nutritional and biotechnology concepts with mechanical and other technologies to control the growth environment (temperature, humidity and moisture, pest and disease infestation, etc.), the process control approach and thinking that is part of the assembly line used in mechanical manufacturing becomes a reality in biological manufacturing.

Intervention technology — The concept of intervention technology is to intervene with the proper adjustments or controls that will close the gap any time actual performance of a process deviates from potential performance. For example, servo mechanisms in a hog building automatically turn on the ventilation system, the coolers or a heating system if the temperature deviates from what is desired for optimal animal growth. Greenhouse production increasingly utilizes such technology to manipulate sunlight, humidity, temperature, and other characteristics of the plant growth environment. Irrigation systems are an example of this technology with respect to field crop production; modern irrigation systems tied to weather stations and plant and soil sensors automatically turn irrigation systems on when moisture becomes a constraint to plant growth, and automatically turn the systems off when moisture levels are adequate for optimum growth.

In confined livestock production, any-time intervention technology to impact the growing environment, change the nutritional regime, or prevent disease outbreaks are conceivable and will likely be commercially available in the near future. Systems for any-time intervention in extensive, land based crop production are more difficult to visualize, although a modified three boom center pivot irrigation system might be one possible any-time intervention technology approach. The first boom of such a system would be the sensing boom that detects what is the cause of the deviation between actual growth and growth potential — is it inadequate nitrogen, not enough water, too many weeds or insects, a missing micro nutrient, a disease outbreak, etc. The second boom would dispense water to resolve soil stress problems; the third boom would dispense whatever other chemical or ingredient is prescribed to eliminate the constraint or close the gap detected by the sensing boom.

Note that if such a technology is developed, it may be less essential to use biotechnology to resist certain insects or larger than necessary fertilizer applications to insure the highest yield if growing conditions are exceptional. Any-time intervention technology allows one to detect a problem when it occurs and real-time solve that problem rather than anticipate a possible problem and dispense control inputs that may be completely unnecessary (and thus costly) and possibly even harmful to the growth environment if that problem does not occur. For example, any-time intervention technology allows the detection of corn borers and the treatment of those borers once they meet an economic threshold during the season, rather than spending funds and using materials in anticipation that a corn borer infestation might occur which are unneeded if the infestation does not reach an economic threshold during the growing season.

It would be unrealistic to expect these process control technologies and methods to be as successful as they have been in mechanical manufacturing in reducing variability and systemizing the processes of producing manufactured goods and services such as automobiles, computers or even chemicals and industrial goods. However, it is also unrealistic to ignore the opportunities and the potential of these process control technologies in reducing variability and obtaining more control over biological growth processes so as to increase efficiency, reduce costs, improve quality, minimize environmental impacts and in general more systematically produce biological based specific attribute raw materials. In essence, this is what the concepts of biological manufacturing are all about — to use monitoring/measuring, biological and nutritional manipulation and any-time intervention technologies to systematically manufacture food and industrial use products.