Tell Me, Crop, How Are You?

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During the winter of 1959-60, working for USDA-Soil Conservation Service in southern Florida, I wondered aloud to the late Howard Nelson, a salty Texas Civil Engineer and my supervisor, how we could determine the immediate need of crops for water and nutrients. Since crops don't normally speak to us (Moses was an exception), how could we determine whether they needed water, had too much water, needed nitrogen or other nutrients, or needed some other environmental improvement to function at their optimum.

Graduate study under Jan van Schilfgaarde at North Carolina State University provided the opportunity to learn how to measure the water potential of in situ soybean sufficiently well to follow the desiccation and rehydration of a plant in 1964. Although instrumentation drift and temperature control of the thermocouple psychrometry precluded field use, the work served as a basis for others, e.g. Glen Hoffman, to develop the technique for in situ soil use.

As I approached sabbatical leave qualification at Clemson University in 1969, Bill Splinter related that the now late Kees DeWit at Landbouwhogeschool in Wageningen, the Netherlands, was using computer simulation to model crop behavior. I was fortunate to study there during 1970, adding root zone behavior to the ELCROS, in CSMP, of that laboratory, as reported in Rehovot, Israel in 1971 with Frits Penning de Vries.

DeWit's accomplishments demonstrated to my delight that digital simulation of plant and crop behavior was feasible. My excitement grew as I realized we could thus probably simulate parameters that indicate water and nutritional status on a real-time basis. And if that were possible, we could play management, or "What if?" games. We could approach in-season quantification of the benefits of irrigation or fertilization in particular. My dream of 1959 just might be realizable. We might be able to figuratively ask, "Tell me, crop, how are you?" and receive an answer that allowed us to improve its environment if need be.

In inspirational working retreats on crop simulation, at Herb Stapleton's place in Tucson, Arizona, I met Don Baker, USDA cotton physiologist, who spent the year 1973-74 with me at Clemson. We were able to put together, in FORTRAN, the rudiments of a cotton crop simulator, which we named GOSSYM, for GOSsypium SYMulator (sic). Don took responsibility for code development above ground; I took responsibility for describing activities below ground, including temperature behavior; Ben Alexander kept us both straight by improving, tightening and modularizing our code. Across the ground level interface we transferred water, carbohydrates and nitrogen.

When Don returned to his Starkville, MS home, soil physicist Frank Whisler joined the development and testing crew. Over the next few years we punched and ran hundreds of batches of hundreds of IBM punched cards that held our Fortran code until dial-up terminals to mainframes

became available. By 1976 we were simulating cotton crop behavior well enough to be invited by GOSPLAN to talk about our results (we were not required to share the details of how) in Moscow, Riga and Kishinev.

Naturally lighted growth chambers (SPAR - Soil, Plant, Atmosphere Research - units) were built in Florence, SC and Starkville, MS with the aid of Claude Phene and James McKinion and used to refine rate equations for various physiological processes. Field tests were confirming state variables and serving to improve other rate equations. James was recently returned from a PhD program at Tulane in Expert Systems and took the lead to install GOSSYM as the response generator in a cotton management expert system, which we named COMAX, for COtton MAnagement eXpert.

Together, we finally had a system that could at least partially answer the question, "Tell me crop, how are you?" And armed with the answers, we could make the crop "more comfortable" by feeding, watering, or even understanding it.

By 1982 news of our endeavors had reached Andy Jordan of National Cotton Council and A J Dye of USDA-Extension Service. Andy began to twist our arms to test our models on real farms. We argued that we were still in the research mode, and not ready to risk being wrong in advising farmers how to treat their crops. Andy's response was, "It's better than the seat-of-the-pants methods now being used to manage," to which we had no counter argument.

GOSSYM-COMAX included near 4,000 FORTRAN statements and was running on mainframes. To operate the models from a farmer's environment was infeasible. Fortunately the IBM-PC had just become commercially available. Therefore we requested of NCC and USDA funds to convert the software from mainframe configuration to the PC (personal computer). While they were considering our requests, I walked across the street to Clemson's Computer Science Department and asked the chairman to please identify the brightest undergraduate in the department. I gave him (now a medical doctor) access to the mainframe source location and asked him to please download the files and configure them for the PC. A week later, he phoned me and said, "Come and see."

All input data were still in card image format -- a holdover from mainframe configuration. NCC and USDA funds were used to improve the input format to make it useable by farmers. Those funds also provided a PC and weather station for each of two evaluating farms.

Baker, Dye, Jordan and I selected for initial 1984 evaluation one farm in South Carolina (Sam and Billy McCoy in Sumter County, in cooperation with Clemson Cotton Extension Specialist Lawrence Harvey) and one in Mississippi (Frank Mitchener in Tallahatchie County, in cooperation with Mississippi Cotton Extension Specialist George Mullendore). Each farm was provided a PC and networked weather station together with the required hand holding and guidance. At year's end all parties involved were pleased enough with the results to repeat the improved process in 1985.

That winter several Mississippi cotton farmers requested to be part of the continuing evaluation. Sixteen farmers were trained to use the simulation models to assist in crop management during the 1986 crop season.

An early experience in the benefits of GOSSYM-COMAX came on the Mississippi Mitchener farm. [For those unfamiliar, cotton is by nature a perennial, and would continue vegetative growth, after fruiting, until frost. To rid the plant of green leaves (which stain the pretty white lint terribly during the mechanical picking), the crop is chemically defoliated. But defoliation stops carbohydrate production, and therefore boll growth, stopping yield increase. Too early defoliation decreases yield; too late risks wintry weather damage to the crop before it can be harvested, maybe under muddy conditions. So "when do I defoliate?" is a very typical, critical decision.] Mitchener, in 1986 or 1987, I forget which, argued with GOSSYM-COMAX prediction that 1 September, if my memory is correct, was the day to defoliate. "But my father never defoliated that early, I've never defoliated that early, and I'm leaving in three days on vacation." He waited until his return to defoliate, two weeks later began picking, but was rained out by a hurricane. "Had I followed GOSSYM-COMAX recommendation," he related to the Cotton Production Conference, "I would be a million dollars ahead today." That statement got a lot of people's attention.

Several Mississippi Extension administrators realized the potential of GOSSYM-COMAX as both a management tool and an educational tool. Management of the growing crop could be improved by quantification of "What if?" questions, e.g. variety selection, planting date, irrigation scheduling, nitrogen scheduling and defoliation scheduling. "What if I delay planting a week?" "What if I split nitrogen application in consideration of forecast rainfall?" "When can I defoliate my crop without significantly and economically decreasing yield?" "Should I apply PIX?" The economics of such decisions could now be quantified, and not left to guess, as had been the previous case. A sharper decision-making tool was available.

Largely as a result of George Mullendore's cultivation of Mississippi Extension administration, their Computer Specialist John Giesman began training farmers how to run GOSSYM-COMAX, supported by Baker, Whisler and McKinion with respect to the physiology described by the model, required input data, and interpretation of output. As the experiences of Mississippi farmers became known across the US cotton belt, farmers began coming to the Mississippi facility for training.

As farmer adoption of computer simulation of crop growth increased, both in numbers and in geographic distribution, the team realized the need for several efforts. The model had been based on very few varieties, on a limited climatic data base, on limited soil classes, and on "good" but not "best" management practices. Research and extension workers across the cotton belt were enlisted to field verify the model. Use of the model to integrate much of the traditional cotton research was promoted, especially at the annual Cotton Production Conference. Classroom use of the model to teach cotton physiology was implemented in several universities. Several agronomists realized the potential to utilize GOSSYM-COMAX in their research programs, including Israeli Avi Marani who is today still working in Rehovot to improve the model, after his retirement; I visited him there in May 2004.

When it became obvious to the National Cotton Council and to USDA Extension Service that GOSSYM-COMAX was a worthwhile contribution to the cotton industry, the two organizations chose to establish a center to lead, promote and facilitate the technology. Jordan and Dye asked if I would move to Starkville, MS to direct such a center, reasoning that Baker's lab there was the center of GOSSYM-COMAX research and that more Mississippi farmers were adopting the technology than other states. I begged off for a few months until they accepted my counter proposal to rent space and hire agronomists and programmers in Starkville, but to commute from Clemson, 420 miles away, to direct the center. They and Bud Webb, my Clemson Extension director, further agreed that no one would ever complain about my travel budget.

In 1988, with National Cotton Council seed money, we rented space in Starkville, hired agronomist Dave Albers and programmer Phillip Baulch and began writing documentation, training, supporting in real time, and traveling to promote and facilitate the technology. Later, soil scientist Gene Stevens, agronomist Holly Jackson and programmer Kelli McCarter were added to the group. I bought a Cessna 182 airplane, which had enough load capacity for four of us together with our luggage, books, and boots. From Albequerque, NM to Washington, DC I landed on dirt strips, spray plane fields and Washington National airport, carrying and promoting the GOSSYM-COMAX, crop simulation, and information technologies. We carried training and support throughout the cotton belt into several states.

I'll always be grateful to Andy Jordan of NCC and to A J Dye of USDA-ES for their vision of what could be, and for their guts to act on that vision with faith in the crop simulation technology. Without their leadership, GOSSYM-COMAX would not have been made available to the cotton farmers. Without their leadership, our research efforts would never have received the financial support we realized. They exemplify the adage, "Where there is no man, be that man." They worked hand-in-hand to educate USDA and congressional leaders that it was a viable, modern tool that would improve the economics and environment of cotton production. As a result, from 1989 to 1994, we received line item funding from the US Congress through USDA-ES for our efforts to extend the technology to any farmer who would accept it. We formed the GOSSYM-COMAX Information Unit (GCIU) with the primary focus of writing and delivering documentation, training, on-site consultation, and feedback to the researchers.

In 1987 GOSSYM was used at approximately 65 locations, and in 1988, at close to 150 locations throughout the cotton belt. At that point we lost accurate count because of the neighbor-helping-neighbor effect, because of extension agents taking it to their clients without our knowledge, and simply because we couldn't keep track of all the locations. We estimated 300 farmers used the system in 1989, but then quit even trying to estimate the usage.

What did farmers gain from GOSSYM-COMAX technology? In a nutshell, not intended to be trivial – education. "I spent about two months last winter running GOSSYM-COMAX under every scenario I could imagine – my various soils, extreme weather patterns, varieties, nitrogen scheduling, etc. – broadening, and consolidating, what I thought I knew about managing a crop." "I always wondered why that field was later than my others. Now GOSSYM-COMAX has helped me understand why." "I learned that I can defoliate at least 10 days earlier than my father told me I could, without decreasing my yield." "I've learned more about growing cotton from my computer than my classroom teacher or my extension advisor taught me."

What did we learn from our training experience? Much! First, whatever is intuitively obvious is not. Humorist Will Rogers wrote in the 31 August 1924 New York Times, "You know everybody is ignorant, only on different subjects." Life experiences teach cotton farmers different subjects than agronomists, programmers or agricultural engineers. Clarity of assumptions, simplicity of screen input layout, lucidity of output results, and repetition of necessary oral instructions cannot be over emphasized. Repeatedly, when ridiculous results occurred during training, misunderstanding or miscommunication was at fault. The ability to think like a farmer is priceless while designing computer screens, writing documentation, developing training materials, and addressing a group of farmers in front of a computer – unlike any tool to which they have been previously accustomed. If a screen, statement or diagram can be misunderstood, it will be.

Further, providing farmers with technology that improves their life – physically, emotionally, economically – is rewarding. They appreciate our efforts to help them. And they said so, with kind words, with bountiful meals (even if illegal), with referrals, with suggestions for improvement, with continuing friendships.

After 7+ years of continually increasing numbers, the farmers who wanted GOSSYM-COMAX training began tapering off. Why? Several reasons: We approached saturation of those farmers who desired to improve their management techniques, their education and their economics sufficiently to invest their time and resources into something new. We had successfully educated dozens of farmers to the point that they could continue use of GOSSYM-COMAX on their own, or that they could refer back to knowledge they had gained from a few years of experience with the model. The GOSSYM-COMAX system was complex enough that it required a commitment that many farmers were unwilling to make. They had farmed cotton for years, had raised a family doing so, were approaching retirement, and were therefore satisfied with their established practices and methods.

From an Extension standpoint, and from a Congressional funding standpoint, GOSSYM-COMAX came to have been around for "several years." We all know that new technologies, new research, new potentials always attract more attention than do older. Such behavior among state funding considerations and Congress' 5-year funding cycle finally forced the demise of our public funding.

Toward the end of our public funding, realizing that such funding was drawing to a close, privatization of GOSSYM-COMAX was discussed at length. At the request of, and with the cooperation of, the four major public organizations involved (USDA-ES, NCC, Mississippi Extension Service and South Carolina Extension Service), I agreed to transfer (after verifying the legality of doing so) the equipment, intellectual property and personnel into AgBit, Inc. (AGricultural Business Information Technology), which I incorporated and owned in South Carolina. Our goal was to deliver the software and support it, continuing to receive research support from the several agencies. However, while farmers understood our financial position, we were unable to generate sufficient revenue stream to stay alive. In the end I gave all AgBit resources to Phillip Baulch, who lives near Starkville and who continued to operate the company as a part-time business for a few months.

Was GOSSYM-COMAX successful? Absolutely! The explicit and implicit knowledge that derived from the effort and activities is immeasurable. In the face of efforts to put an economic value on every research, extension, and educational action, we cannot always do that. However, farmer after farmer told us he made money using the technology. Student after student told us he had benefited from reading the physiological philosophy of the model, reading the code to see how rate processes were defined, and realizing the necessary integration of all factors affecting crop growth. Researcher after researcher told us how the model had clarified both laboratory and field studies that could both improve the model and contribute to the usual academic literature. I define that as success.

What did I learn from the GOSSYM-COMAX experience? Much! Cooperation is much more effective when conceived, initiated and executed at the working man's level than when begun in a boardroom or behind an executive desk. Researchers, extension workers, teachers and farmers get along well together, usually have no turf issues to contend with, and can get the job done. The best administrators I've known have realized these facts and have been committed to enabling their professionals to proceed with all vigor. I've also learned that better mousetraps don't always result in well beaten paths to the door. They must be sold, or the customer must be educated that mice are undesirable.

What would I do differently if I had it to do over? I would have solicited more farmer and extension agent input into development of the user interface, even though we did get a lot. I would have enlisted a public relations professional to better tell the story as farmers reaped the rewards. I would have argued with the team more to simplify the output, to make the system easier to implement. But I would have still enjoyed tremendously the farm visits just the same.

Following reduction of GOSSYM-COMAX to an unprofitable private enterprise, and following changes in Clemson administration that made it less desirable to profess there, I retired and am now doing commercial and residential construction, using insulated concrete forms, growing muscadines and chestnuts and studying Hebraic roots of Christianity. Don Baker had retired earlier, into on-farm consultation using GOSSYM-COMAX. Frank Whisler continues to teach agronomy at Mississippi State. James McKinion directs the (redirected) USDA laboratory in Starkville. Youngster Phillip Baulch has adapted his programming skills into financial management software.

Thanks for listening. Come and see us.

Dr. Jerry R Lambert *is Professor Emeritus of Agricultural Engineering at Clemson University in South Carolina (USA) since 1997. He began teaching and research at Clemson in 1964 after study at North Carolina State University and University of Florida. Sabbatical study and teaching leaves include Landbouwhogeschool at Wageningen, Holland (1970) and Technion in Haifa, Israel (1981) His research interests comprised crop-water relations, decision practices and agricultural meteorology. He taught courses in soil and water conservation, hydrology, crop simulation and personal computer basics. In addition, as director of an extension center he developed, promoted, and supported a model for practical decision making for cotton farmers. He also led academic, research and extension implementation of personal computers and networking throughout South Carolina, and developed CUFAN (Clemson University Forestry and Agriculture Network),*

consisting of data network, software and training.

Since retirement Dr Lambert has completely changed pace to work as a licensed general contractor in residential and commercial construction, using another new technology -- insulated concrete forms -- to provide tremendous benefit to his clients. See www.maxxbilt.com for examples. His late mentor Kees Dewit proposed that no one should complete a lifetime in one profession, and executed that philosophy. Dr Lambert grows and ferments muscadines (a southern US grape) and chestnuts, being restored from the American chestnut blight