Fast Breaking Papers - 2010

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Graeme L. Hammer talks with *ScienceWatch.com* and answers a few questions about this month's Fast Breaking Paper in the field of Agricultural Sciences.

Article Title: Can Changes in Canopy and/or Root System Architecture Explain Historical Maize Yield Trends in the US Corn Belt?

Authors: **Hammer, GL**;Dong, ZS;McLean, G;Doherty, A;Messina, C;Schusler, J;Zinselmeier, C;Paszkiewicz, S;Cooper, M

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(addresses have been truncated.)

SW: Why do you think your paper is highly cited?

The paper addresses a salient, unresolved issue in agriculture, i.e., what mechanisms have underpinned the continuous historical increase in maize yield in the US Corn Belt? It provides some interesting insights on this question and identifies a likely mechanism, which had previously not been widely attributed.

There have been few detailed relevant physiological studies, some good studies on trait associations with yield advance, and no shortage of firmly held opinions, but no previous attempt to put this into a quantitative framework to test the various assertions.

This paper used a model-based hypothesis-testing approach to investigate the relative importance of the effects of changes in leaf and/or root factors. The approach involved the use of virtual plant computer simulation technologies.

An advanced crop model was modified to take into account known effects on crop growth associated with varying leaf erectness and/or root system architecture and the likely consequences on yield were simulated for representative sites.

The study revealed that the historical corn yield trend and its association with higher plant density was

more likely related to change in root system architecture than to change in leaf erectness.

While more erect leaf types could contribute to the effect in some high-yielding situations, changes in root systems to enhance capture of soil water at depth had the dominating effect.

Results for simulations conducted for hypothetical hybrids that varied in root system characteristics were found to be consistent with a set of field experiments that reported yield response to density for hybrids released over the past 20 years.

"The work has general relevance to the need to continue to increase crop productivity for global food security. While the context of the study was the US corn belt, the findings have far more general implications."

Does it describe a new discovery, methodology, or synthesis of knowledge?

This paper is an integrating synthesis of knowledge that has generated new insights.

The use of dynamic crop models helped us to look beyond the clearly visible differences among hybrids in this time series of yield advance. It enabled us to focus on the driving processes of crop growth that must be responsible for these effects.

Prior to this work the dominant opinion was that improvements in light-use efficiency associated with leaf erectness underpinned the long-term yield improvement of maize. However, this had not been evaluated quantitatively in comparison to other possibilities or as a component of a more integrated framework.

The work reported in this paper demonstrated that a more plausible explanation for yield improvement is access to additional water through enhancements in root system architecture.

The improvements in light-use efficiency via changes in canopy architecture made a smaller but important contribution and thus had a secondary role. The changes in leaf angle were readily observable, so working on these trait phenotypes was easier.

Tackling the root question is now more firmly justified than was the case prior to this work. It does not make the work any easier, but it certainly more strongly motivates work on the root system.

Would you summarize the significance of your paper in layman's terms?

The paper suggests that improvements in the ability of maize crops to capture additional water from the soil via changes in root system architecture is more likely to explain the historical yield advance in the US corn belt than the more readily observed changes in canopy architecture (such as leaf erectness) and any associated effects they may have on enhanced efficiency of use of light energy. This provides valuable insight as to potential avenues for future crop improvement.

How did you become involved in this research, and were there any problems along the way?

I became involved in this research through a long-standing research collaboration with scientists at Pioneer Hi-Bred International that aimed at developing and evaluating modelling capability to underpin novel approaches to crop improvement by identifying critical adaptive traits, particularly for the efficient use of water.

There were no major problems along the way, but we navigated many "dry gullies" as ideas were developed and tested over the years of this collaborative relationship.

Where do you see your research leading in the future?

It is clear that, as we move forward, we need to look much harder at root systems and how they capture water. In our study, the extra amount of water required for the 6t/ha historical yield increase was

estimated as about 270mm.

Further research is required to determine whether this has now positioned the corn crop near the limit of water resource availability or whether there remains opportunity for yield advance by further improvement in water capture.

Beyond the specific issue, we have developed confidence and the modelling tools required for the more general use of model-based analyses in interfacing with plant breeding. Developing and applying this capability offers many opportunities and will be a major theme into the future.

Do you foresee any social or political implications for your research?

This work has general relevance to the need to continue to increase crop productivity for global food security. While the context of the study was the US Corn Belt, the findings have far more widespread implications.

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RADIATION USE EFFICIENCY; ANTHESIS-SILKING INTERVAL; DIFFERENT WATER REGIMES; GRAIN-YIELD; DROUGHT TOLERANCE; KERNEL KEYWORDS: NUMBER; TROPICAL MAIZE; LEAF NITROGEN; PLANT-DENSITY; STAY-GREEN.

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