Published online June 5, 2007

Dynamic Cropping Systems: Increasing Adaptability Amid an Uncertain Future

J. D. Hanson,* M. A. Liebig, S. D. Merrill, D. L. Tanaka, J. M. Krupinsky, and D. E. Stott

ABSTRACT

Future trends in population growth, energy use, climate change, and globalization will challenge agriculturists to develop innovative production systems that are highly productive and environmentally sound. Furthermore, future agricultural production systems must possess an inherent capacity to adapt to change to be sustainable. Given this context, adoption of dynamic cropping systems is proposed to meet multiple agronomic and environmental objectives through the enhancement of management adaptability to externalities. Dynamic cropping systems are a form of agricultural production that relies on an annual strategy to optimize the outcome of (i) production, (ii) economic, and (iii) resource conservation goals using ecologically-based management principles. Dynamic cropping systems are inherently complex, possessing larger crop portfolios and greater crop diversity and sequencing flexibility as compared with monoculture and fixed-sequence cropping systems. Greater crop diversity and sequencing flexibility within dynamic cropping systems may result in reduced weed and disease infestations, greater nutrient- and precipitation-use efficiency, decreased requirements of exogenous inputs, and lower production risk. The multiple interactions among management components of dynamic cropping systems demand greater management intensity than monoculture and fixed-sequence cropping systems. Further development of dynamic cropping systems is important for managing crop production systems in a sustainable manner. These systems can ultimately assist land managers to develop new and improved land-use strategies to the benefit of generations to come.

The sustainability of agriculture is facing significant challenges as we enter the 21st century. Major challenges include (i) human population growth and the increased demand for agricultural land and resources, (ii) overdependence on fossil energy and the increased monetary and environmental costs of nonrenewable resources, (iii) global climate change (Brown, 2006; Diamond, 2005), and (iv) globalization. These dominate issues are challenging agriculturists to develop more sustainable management systems like no other time in history. To meet the food and nutritional needs of a growing population, agriculture will need to move beyond the past emphasis on productivity to encompass improved public health, social well being, and a sound environment (Doran, 2005; Hanson et al., 2007).

Several statistics highlight the challenges facing the global agricultural community. The human population was ≈6.5 billion in late 2005, and is projected to rise to 7.6 billion by 2020 and 9.1 billion by 2050 (United Nations Population Division, 2006). To meet the demand for food, agriculture will need to produce as much food in the next 25 yr as it has produced in the last 10 000 yr (Mountain, 2006). Increasing food production to this extent will have significant ramifications on resource use. From 1961 to 1996, the doubling of agricultural food production was associated with a 6.9-fold increase in N fertilization, a 3.5-fold increase in P fertilization, a 1.7-fold increase of irrigated cropland, and a 1.1-fold increase of land under cultivation (Tilman, 1999). On the basis of linear extrapolation, the anticipated next doubling of global food production would be associated with an approximate threefold increase in N and P fertilization, a doubling of irrigated land area, and an 18% increase in land under cultivation. Given these projections, agriculture appears to be on a trajectory to become more resource intensive in the future.

Energy derived from fossil fuels (e.g., oil, coal, and natural gas) occupies a central role in agricultural production throughout the world. Utilization of fossil energy in the production of food, feed, and fiber has significantly increased food production and improved standards of living (Dalgaard et al., 2001; Cleveland, 1995; Tilman et al., 2002). However, there are numerous environmental and socioeconomic problems associated with the use of fossil energy. Global climate change, acidic deposition, groundwater contamination, and human health effects are just some of the social costs associated with the use of fossil energy; costs not reflected in its market price (McLaughlin et al., 2002). Increased awareness of the social costs of fossil energy dependence and the realization of potential limitations in oil supplies have underscored the need to reduce energy inputs in agricultural production, as well as develop alternate energy sources for the future (Pimentel and Patzek, 2005).

Of the four major threats to agricultural sustainability, global climate change is perhaps the most disconcerting given the uncertainty surrounding its future impact on agroecosystems. Elevated concentrations of greenhouse gases in the earth's atmosphere are expected to increase mean global temperatures by 1.5 to 4.5°C (Mahlman, 1997). The actual outcome of global environmental changes is largely unknown, but the interactions between factors such as elevated CO_2, temperature, and soil moisture are the critical criteria for determining crop yield (Lobell and Asner, 2003; Morison and Lawlor, 1999; Nonhebel, 1993; Rogers and Dahlman, 1994; Wheeler et al., 1996). However, increased temperatures are projected to decrease yields of major crops on a global basis (Lobell and Asner, 2003; Shaobing et al., 2004), making it increasingly difficult to meet future demand for food and fiber. Coupled with the direct effects

J.D. Hanson, M.A. Liebig, S.D. Merrill, D.L. Tanaka, and J.M. Krupinsky, USDA-ARS, Northern Great Plains Research Lab., P.O. Box 459, Mandan, ND 58554; and D.E. Stott, USDA-ARS National Soil Erosion Research Lab., 275 S. Russell St., West Lafayette, IN 47907-2077. The U.S. Department of Agriculture, Agricultural Research Service is an equal opportunity/affirmative action employer and all agency services are available without discrimination. Received 26 Apr. 2006. *Corresponding author (Jon.Hanson@ars.usda.gov).

Published in Agron. J. 99:939–943 (2007).
Symposium Papers
doi:10.2134/agronj2006.0133

of temperature on crop yield are the strong possibility of shifts in vegetation zones toward the poles (or disappearing entirely, due to sea level rise) and a more vigorous hydrological cycle (Rosenzweig and Hillel, 1998). The latter projection does not portend well for agriculture, as an increased frequency of severe weather events is a likely outcome, raising concerns regarding the resilience of current agroecosystems to withstand increased susceptibility to soil erosion (Nearing et al., 2004).

In addition, agricultural producers in the USA are competing in an increasingly global marketplace. Compared to producers in the USA, producers in other countries may be able to produce agricultural commodities cheaper. For example, foreign soybean production has recently exceeded that of the USA (Ash, 2001). Even though agricultural exports remain strong and imports are increasing, the overall U.S. agricultural trade balance has decreased since 2001. The expansion of trade and faster information flow through the internet are converging to alter the worldwide farm and food system. To remain competitive in this market, increased diversity of systems will be required to minimize inputs and improve economic margins. This new farm era is driven by at least five major issues (Thiermann, 2001): (i) increased democratization throughout the world, (ii) improved information dissemination, (iii) increased desire for improvements in standard of living, (iv) reductions in government bureaucracy, and (v) increased international trade.

Adapting to future trends in population growth, energy use, climate change, and globalization will require agriculturists to develop new and innovative production systems that are highly productive, effectively utilize renewable resources, and minimize damage to the environment. These multiple goals are complicated by the fact that agroecosystems function in a context of continuous socioeconomic and environmental flux. This last point makes development of more sustainable agricultural systems exceedingly difficult, as it implies future management strategies for increasing sustainability must incorporate a dynamic component so as to provide producers multiple options to adapt to changing conditions. Given this context, the following discussion will address potential opportunities within cropping systems. The integration of animals and annual and perennial crops into dynamic–integrated agricultural systems is expanded in an alternative venue (Hanson et al., 2007; Hendrickson et al., 2007).

DYNAMIC CROPPING SYSTEMS: A TOOL TO INCREASE MANAGEMENT ADAPTABILITY

Addressing the challenges outlined above requires the development of inherently flexible management strategies appropriate to different regions. In the Great Plains of North America, adoption of dynamic cropping systems is one strategy proposed to increase the sustainability of dryland crop production systems through the enhancement of management adaptability to externalities (Tanaka et al., 2002). Dynamic cropping systems are a form of agricultural production that relies on a long-term strategy of annual crop sequencing to optimize the outcome of production, economic, and resource conservation goals using ecologically based management principles. In the northern Great Plains, dynamic cropping systems could be implemented by moving from the traditional wheat–fallow system to a dynamic system involving a portfolio of crops including, for example, spring wheat (*Triticum aestivum* L.), corn (*Zea mays* L.), sunflower (*Helianthus annuus* L.), canola (*Brassica napus* L.), chickpea (*Cicer arietinum* L.), dry pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.), and buckwheat (*Fagopyrum esculentum* Moench) (Krupinsky et al., 2006).

The concept of dynamic cropping systems is in many ways a return to the past. Subsistence agriculture forced the inclusion of multiple crops and animals in a production system. As technology improved and populations grew, a need arose for more food of high quality. Government programs also helped to accelerate the movement from historically diverse agroecosystems toward monoculture agriculture. Now the need has been recognized to regain the sustainability found in more diverse agricultural systems by incorporating ecological principles into the management of natural resources (Altieri, 2002). The application of ecological principles within agroecosystems requires the adaptation of management to meet the unique conditions of a specific site and an increased level of plant and animal biodiversity (Altieri, 1999). Dynamic cropping systems subsequently evolved from the application of agroecology to farming enterprises within the context of the global community.

The suitability of dynamic cropping system concepts to annual crop selection seems appropriate in the northern Great Plains given the region's highly variable weather and recent cropping practices, which have stressed the importance of increased crop diversity for improving economic viability (Tanaka et al., 2005). Improvements in the sustainability of crop production systems in the Great Plains requires extensive knowledge of crop management effects on soil and water conservation due to limited precipitation, high evapotranspiration, and high potential for erosion (Merrill et al., 2006; Zheng et al., 2004). Furthermore, conservation tillage methods, crop sequences, cultivar selection, nutrient management, and weed and disease control represent management components requiring integration into practical, efficient, and cost-effective cropping systems are required to stabilize yields while conserving natural resources. The presence of multiple management components along with highly variable weather in the Great Plains underscores the importance of using an approach to annual crop selection that is inherently adaptable.

Pragmatically, dynamic cropping systems effectively address the *what to grow*, *when to grow it*, and *how to grow it* considerations of annual crop production in the context of optimizing multiple goals (Sadras et al., 2003). Decisions that lead to a crop choice and its subsequent management should be based, at least in part, on a thorough understanding of short-term crop sequencing synergisms and antagonisms that affect agronomic and environmental attributes. Dynamic cropping systems use crop sequencing to manage crop residues (Krupinsky et al., 2007a), reduce the impact of leaf spot diseases in spring wheat (Krupinsky et al., 2007b), increase the water-use efficiency of the cropping system (Merrill et al., 2007), and make the farming system more sustainable (Tanaka et al., 2007). Key factors guiding decision making in the context of dynamic agricultural systems include diversity, adaptability, reduced input costs, multiple enterprise systems, and environmental and informational awareness (Tanaka et al., 2002). Knowledge of these attributes for multiple sequencing combinations within a given crop portfolio make dynamic cropping systems inherently complex. Thus, farmers and farm advisors will need enhanced understanding of the biology involved in agroecosystems, particularly regarding the interaction of biological and ecological factors. When contrasted with monoculture and fixed-sequence cropping systems, dynamic cropping systems have larger crop portfolios, greater crop diversity, and inherently greater sequencing flexibility (Table 1). Correspondingly, dynamic cropping systems possess a greater degree of management complexity as compared with fixed-sequence and monoculture cropping systems, requiring more knowledgeable managers.

Potential benefits of dynamic cropping systems are significant relative to fixed-sequence and monoculture cropping systems (Fig. 1). Benefits from dynamic cropping systems will likely be realized through increased crop diversity and greater sequencing flexibility across time. Dynamic cropping systems can even provide alternatives for including perennial crops in the sequence. This would allow producers to provide lignocellulosic and perennial feedstocks for the production of ethanol. In the northern Great Plains, the land base for biofuel production will come from marginal lands capable of supporting a perennial crop and existing cropland. Previous studies documenting agroecosystem attributes under different crop sequence treatments provide a glimpse of what may be possible if a dynamic cropping systems approach is used.

Increasing cropping system diversity can vary selection pressure to reduce weed infestations (Derksen et al., 2002) and plant diseases (Krupinsky et al., 2002, 2007b). In contrast, monoculture and short-term (2- to 3-yr) fixed-sequence cropping systems can lead to significant weed and disease problems resulting in reduced crop yield (Anderson et al., 1998; Petrie, 1994). These issues are of considerable concern in organic farming systems. Thus, dynamic cropping systems could be a valuable tool for these crop management systems.

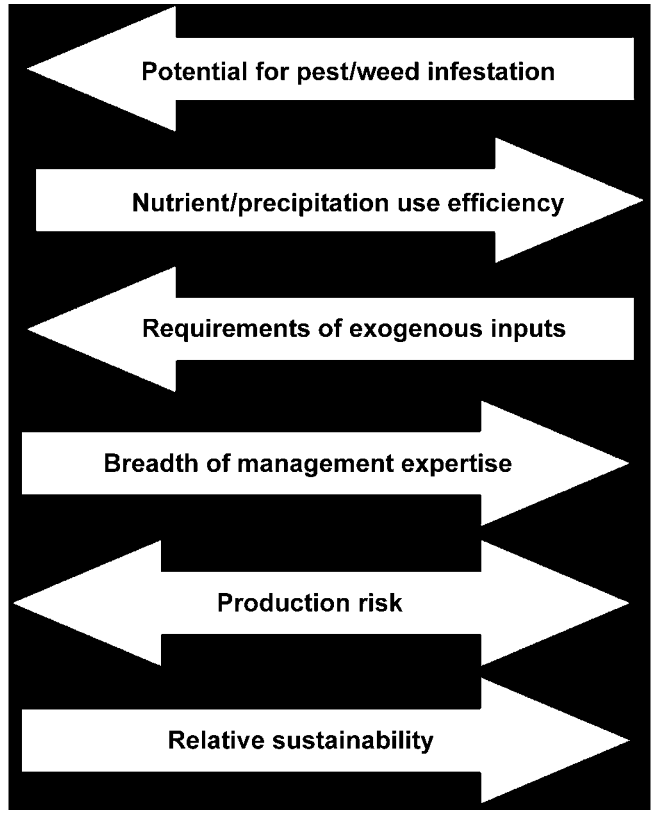

Fig. 1. Continuum of attributes among monoculture, fixed-sequence, and dynamic cropping systems. Arrows point in the direction of increasing values.

Nutrient- and precipitation-use efficiency may be improved under dynamic cropping systems if studies in the northern and central Great Plains are any indication (Merrill et al., 2007; Tanaka et al., 2007). Rotational benefits have been realized by sequencing crop species with different resource demands (Grant et al., 2002;

Table 1. Comparison of monoculture, fixed-sequence, and dynamic cropping systems.

	Cropping system		
Attribute	Monoculture	Fixed-sequence	Dynamic
Crop portfolio	Single crop	Multiple crops; number dependent on regionally adapted species, economics, farmer knowledge, infrastructure.	Multiple crops; number dependent on regionally adapted species, economics, farmer knowledge, and infrastructure.
Crop diversity	N/A†	Diversity dependent on length of fixed sequence.	Diversity inherently high due to annual variation in growing conditions and marketing opportunities, as well as changes in producer goals.
Crop sequencing flexibility	N/A	None, although fixed-sequence cropping systems that incorporate opportunity crops increase flexibility.	High. All crops, in essence, are opportunity crops.
Biological and ecological knowledge	Basic knowledge of agronomy	Some knowledge of crop interactions is necessary.	Extended knowledge of complex, multiyear crop and crop × environment interactions.
Management complexity	Generally low, though variable depending on crop type	Complexity variable depending on length of fixed sequence and diversity of crops grown.	Complexity inherently high due to annual variation in growing conditions, markets, and producer goals.

† N/A, not applicable.

Yamoah et al., 1998), which has led to decreased requirements of exogenous nutrients. Annual legumes, in particular, have been reported to increase productivity of succeeding crops with minimal supplementation of fertilizer N (Miller et al., 2003).

Decreasing the frequency of fallow has been shown to increase the precipitation-use efficiency in dryland cropping systems (Farahani et al., 1998). In annually cropped systems, difference in water use among crops can provide producers with options to select crops based on soil water status at planting, thereby increasing the likelihood that available water will be efficiently used for crop production (Merrill et al., 2004, 2007). Rotating crops with different water use patterns can also increase total nutrient removal and improve nutrient-use efficiency (Grant et al., 2002).

Sequencing crops in a manner to take advantage of available water and nutrients while disrupting weed and disease cycles should decrease requirements for fertilizer and pesticides. Consequently, fewer exogenous inputs should be required in dynamic cropping systems as compared with fixed-sequence and monoculture cropping systems. Managing multiple interactions among management components in a dynamic context would, as expected, require much greater management intensity relative to fixed-sequence and monoculture cropping systems. Finally, production risk among cropping systems would be variable, depending on producer involvement in price support programs for particular crops.

CONCLUSIONS

Collectively, adoption of dynamic cropping systems would be expected to result in more sustainable crop production systems over time. The inherent adaptability ascribed to this crop sequencing approach allows producers to take full advantage of environmental and/or market conditions that would otherwise be limiting under less flexible sequencing approaches. Furthermore, given the significant challenges facing agriculture in the future, flexible cropping systems will be necessary to adapt to increasingly uncertain conditions.

Dynamic cropping systems can potentially make better use of water and soil nutrient requirements and enhance soil–crop production system resilience in the face of climatic risk. By considering producer goals and the externalities influencing agriculture, dynamic cropping systems can be developed to optimize such issues as crop yield and quality; net enterprise return; pest (both insect and plant) management; soil, water, and air quality; and resource conservation. Such systems may lead to the development of dynamic agricultural systems that are economically viable, socially acceptable, and environmentally sustainable.

REFERENCES

Altieri, M. 1999. The ecological role of biodiversity in agroecosystems. Agric. Ecosyst. Environ. 74:19–31.

Altieri, M. 2002. Agroecology: The science of natural resource management for poor farmers in marginal environments. Agric. Ecosyst. Environ. 93:1–24.

Anderson, R.L., D.L. Tanaka, A.L. Black, and E.E. Schweizer. 1998. Weed community and species response to crop rotation, tillage, and nitrogen fertility. Weed Technol. 12:531–536.

Ash, M. 2001. Soybeans: Background and issues for farm legislation. Publ. OCS-0701-01. Economic Research Service, USDA, Washington, DC.

Brown, L.R. 2006. Plan B 2.0: Rescuing a planet under stress and a civilization in trouble. W.W. Norton & Company, New York.

Cleveland, C.J. 1995. The direct and indirect use of fossil fuels and electricity in USA agriculture, 1910–1990. Agric. Ecosyst. Environ. 55:111–121.

Dalgaard, T., N. Halberg, and J.R. Porter. 2001. A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. Agric. Ecosyst. Environ. 87:51–65.

Derksen, D.A., R.L. Anderson, R.E. Blackshaw, and B. Maxwell. 2002. Weed dynamics and management strategies for cropping systems in the northern Great Plains. Agron. J. 94:174–185.

Diamond, J. 2005. Collapse: How societies choose to fail or succeed. Penguin Books, New York.

Doran, J.W. 2005. Overview of soil quality for sustaining earth and its people. Internal publication for outreach purposes. USDA-ARS, Lincoln, NE.

Farahani, H.J., G.A. Peterson, and D.G. Westfall. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Adv. Agron. 64:197–223.

Grant, C.A., G.A. Peterson, and C.A. Campbell. 2002. Nutrient considerations for diversified cropping systems in the northern Great Plains. Agron. J. 94:186–198.

Hanson, J.D., J.R. Hendrickson, and D. Archer. 2007. Challenges for maintaining sustainable agricultural systems. Renew. Agric. Food Syst. (in press).

Hendrickson, J.R., J.D. Hanson, D.L. Tanaka, and G. Sassenrath. 2007. Principles of integrated agricultural systems: Introduction to processes and definition. Renew. Agric. Food Syst. (in press).

Krupinsky, J.M., K.L. Bailey, M.P. McMullen, B.D. Gossen, and T.K. Turkington. 2002. Managing plant disease risk in diversified cropping systems. Agron. J. 94:198–209.

Krupinsky, J.M., S.D. Merrill, D.L. Tanaka, M.A. Liebig, M.T. Lares, and J.D. Hanson. 2007a. Crop residue coverage of soil influenced by crop sequence in a no-till system. Agron. J. 99:921–930 (this issue).

Krupinsky, J.M., D.L. Tanaka, S.D. Merrill, M.A. Liebig, and J.D. Hanson. 2006. Crop sequence effects of ten crops in the northern Great Plains. Agric. Syst. 88:227–254.

Krupinsky, J.M., D.L. Tanaka, S.D. Merrill, M.A. Liebig, M.T. Lares, and J.D. Hanson. 2007b. Crop sequence effects on leaf spot diseases of no-till spring wheat. Agron. J. 99:912–920 (this issue).

Lobell, D.B., and G.P. Asner. 2003. Climate and management contributions to recent trends in U.S. agricultural yields. Science (Washington, DC) 299:1032.

Mahlman, J.D. 1997. Uncertainties in projections of human-caused climate warming. Science 278:1416–1417.

McLaughlin, S.B., D.G. De La Torre Ugarte, C.T. Garten Jr, L.R. Lynd, M.A. Sanderson, V.R. Tolbert, and D.D. Wolf. 2002. High-value renewable energy from prairie grasses. Environ. Sci. Technol. 36:2122–2129.

Merrill, S.D., J.M. Krupinsky, D.L. Tanaka, and R.L. Anderson. 2006. Soil water depletion and recharge under ten crop species and applications to the principles of dynamic cropping systems. J. Soil Water Conserv. 61(1):7–13.

Merrill, S.D., D.L. Tanaka, J.M. Krupinsky, M.A. Liebig, and J.D. Hanson. 2007. Soil water depletion and recharge under ten crop species and applications to the principles of dynamic cropping systems. Agron. J. 99:931–938 (this issue).

Merrill, S.D., D.L. Tanaka, J.M. Krupinsky, and R.E. Ries. 2004. Water use and depletion by diverse crop species on Haplustoll soil in the Northern Great Plains. J. Soil Water Conserv. 59:176–183.

Miller, P.R., Y. Gan, B.G. McConkey, and C.L. McDonald. 2003. Pulse crops for the northern Great Plains: II. Cropping sequence effects on cereal, oilseed, and pulse crops. Agron. J. 95:980–986.

Morison, J.I.L., and D.W. Lawlor. 1999. Interactions between increasing CO_2 concentrations and temperature on plant growth. Plant Cell Environ. 22:659–682.

Mountain, C. 2006. Future agricultural & food challenges. Available at www.intstudy.com/articles/ec186a05.htm [accessed 25 Apr. 2006; verified 28 Mar. 2007]. Thames Digital Media, London.

Nearing, M.A., F.F. Pruski, and M.R. O'Neal. 2004. Expected climate change impacts on soil erosion rates: A review. J. Soil Water Conserv. 59:43–50.

Petrie, G.A. 1994. Effects of temperature and moisture on the number, size and septation of ascospores produced by *Leptosphaeria maculans* (blackleg) on rapeseed stubble. Can. Plant Dis. Survey. 74:141–151.

Pimentel, D., and T.W. Patzek. 2005. Ethanol production using corn, switchgrass, and wood: Biodiesel production using soybean and sunflower. Nat. Resour. Res. 14:65–76.

Nonhebel, S. 1993. Effects of changes in temperature and CO_2 concentration on simulated spring wheat yields in the Netherlands. Clim. Change 24:311–329.

Rogers, H.H., and R.C. Dahlman. 1994. Ecophysiological and ecosystem responses: Effects of CO_2 enrichment on growth and production. Plant Ecol. 104:117–131.

Rosenzweig, C., and D. Hillel. 1998. Climate change and the global harvest: Potential impacts of the greenhouse effect on agriculture. Oxford Univ. Press, Oxford, UK.

Sadras, V., D. Roget, and M. Krause. 2003. Dynamic cropping strategies for risk management in dry-land framing systems. Agric. Syst. 76:920–948.

Shaobing, P., J. Huang, J.E. Sheehy, R.C. Laza, R.M. Visperas, X. Zhong, G.S. Centeno, G.S. Khush, and K.G. Cassman. 2004. Rice yields decline with higher night temperature from global warming. Proc. Natl. Acad. Sci. USA 101:9971–9975.

Tanaka, D.L., R.L. Anderson, and S.C. Rao. 2005. Crop sequencing to improve use of precipitation and synergize crop growth. Agron. J. 97:385–390.

Tanaka, D.L., J.M. Krupinsky, M.A. Liebig, S.D. Merrill, R.E. Ries, J.R. Hendrickson, H.A. Johnson, and J.D. Hanson. 2002. Dynamic cropping systems: An adaptable approach to crop production in the Great Plains. Agron. J. 94:957–961.

Tanaka, D.L., J.M. Krupinsky, S.D. Merrill, M.A. Liebig, and J.D. Hanson. 2007. Dynamic cropping systems for sustainable crop production in the Northern Great Plains. Agron. J. 99:904–911 (this issue).

Thiermann, A.B. 2001. Current rules and future challenges. Available at http://agriculture.de/acms1/conf6/ws9rules.htm [Accessed 18 Sept. 2006; verified 28 Mar. 2007]. Research Consortium Sustainable Animal Production, Germany.

Tilman, D. 1999. Global environmental impacts of agricultural expansion: The need for sustainable and efficient practices. Proc. Natl. Acad. Sci. USA 96:5995–6000.

Tilman, D., K.G. Cassman, P.A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. Nature 418:671–677.

United Nations Population Division. 2006. World population prospects: The 2004 revision and world urbanization prospects. Available at www.un.org/esa/population/unpop.htm [accessed 18 Sept. 2006; verified 28 Mar. 2007]. UN Dep. of Economic and Social Affairs, New York.

Yamoah, C.F., G.E. Varvel, W.J. Waltman, and C.A. Francis. 1998. Long-term nitrogen use and nitrogen-removal index in continuous crops and rotations. Field Crops Res. 57:15–27.

Wheeler, T.R., T.D. Hong, R.H. Ellis, G.R. Batts, J.I.L. Morison, and P. Hadley. 1996. The duration and rate of grain growth, and harvest index, of wheat (*Triticum aestivum* L.) in response to temperature and CO_2. J. Exp. Bot. 47:623–630.

Zheng, F., S.D. Merrill, C. Huang, D.L. Tanaka, F. Darboux, M.A. Liebig, and A.D. Halvorson. 2004. Runoff, soil erosion, and erodibility of Conservation Reserve Program lands under crop and hay production. Soil Sci. Soc. Am. J. 68:1332–1341.