NORTH AMERICA

Productivity of Organic Cropping Systems

By T.W. Bruulsema, D.W. Dibb, H.F. Reetz, Jr., and P.E. Fixen

Retail sales of organic food have been growing by about 20% annually since 1990. With the enactment of the USDA Organic Rule in October 2002, media and consumer interest in the topic have also grown. However, organic foods still comprise a small proportion of the total crop area (**Table 1**) and the total retail market (**Table 2**). Sales growth in some of the most intensively organic European countries is slowing. But fast or slow, continued growth raises questions regarding the productivity and sustainability of organic cropping systems.

The productivity of organic cropping systems is considerably lower than that of conventional or integrated cropping systems. Their lower productivity implies that their widespread adoption could potentially lead to less land available for non-farm uses such as wildlife habitat, greater negative impacts on the environment, and reduced sustainability.

Significance

The notion of organic agriculture is more important to the fertilizer industry than its small percentage of land area would imply. Consumers value the concept because of their perception that the food is produced naturally without impairing the environment. The word "organic" itself resonates pleasantly, and is used in disciplines from chemistry through theology. Though its meaning varies, it rarely connotes anything negative.

While consumers may choose organic out of good motives, the practice does not deliver all they perceive. Consumer preference is important in business – "the customer is always right." We strive to manage plant nutrients to produce the healthy food the consumer demands. But we also need to deliver the facts on organic production.

Productivity

Organic cropping systems clearly yield less than those that have all available technologies at their disposal. While individual crop comparisons may show no difference, analysis of the complete system – including land area required to produce organic sources of nutrients – clearly implies dramatically reduced production of harvestable crops.

Because organic production has greater restrictions on inputs, it is more difficult to maintain the same yield levels sustainably. Organic standards minimize or eliminate use of synthetic or manufactured inputs and encourage maximum use of local natural resources. Organic food producers rarely use soluble mineral nutrients. They also exclude some organic sources, such as

TABLE 1. Area of certified organic production has expanded.

Land type	Certified organic land Acres, 1995	Certified organic land Acres, 2001	Proportion of total land area %, 2001	Rate of expansion 1995-2001 %/yr
Cropland	638,500	1,302,000	0.36	13
Pasture & rangeland	276,300	1,039,000	0.23	25

Source: USDA-ERS, 2001
http://www.ers.usda.gov/

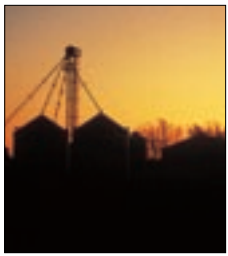
sewage sludge and composts derived from wastes. Thus, they must rely to a greater extent on green manures, crop rotation, and animal manures.

Crops produced organically will not always yield less, but often do. For example, a 21-year study in Switzerland found that yields were 20% less when a rotation including wheat, potato, and forage was managed organically (Mäder *et al.*, 2002). However, the economically most important crop, potato, suffered the greatest yield reduction (38%). Forage crops made up 43% of the rotation, which could imply greater emphasis on animal agriculture than would be justified by local or global demand – not to mention its impact on the environment. As stated by Per Pinstrup-Anderson, leader of the International Food Policy Research Institute (IFPRI), "...yields per unit of total land used for organic farming including the land needed to produce green manure and animal waste are not at a level necessary to avoid encroachment on ecologically fragile soils and still meet future food demands."

Organic systems vary more widely in nutrient availability because of reliance on indigenous soil fertility with high spatial variability. Nutrient input levels in organic farming systems tend to be lower than in conventional systems because the philosophy is aimed at growing crops under more natural conditions. Deficiencies of nitrogen (N), phosphorus (P), and potassium (K) are natural conditions. These deficiencies reduce productivity.

Short-term productivity differences may be smaller than those in the longer term. Sustainable yields depend on the balance of nutrients applied to and removed from the field. Many fertile soils may produce good yields with a deficit in P and K inputs for 10 years or more, but not indefinitely.

External inputs of organic nutrient sources often contain nutrients that were originally supplied in an inorganic form, such as commercial fertilizers. Or they contain nutrients mined from soils external to the farm.



Were organic farming to be more broadly adopted, such practices would lead to extensive soil nutrient depletion. Crops across Canada and the U.S. already remove approximately as much P as, and more K than, that contained in the sum of all recoverable manure plus all commercial fertilizers used.

Across Canada and the U.S., a recent summary of soil tests shows that substantial areas remain deficient in P and K. Of the 2.5 million soil samples submitted for field crops, 47% tested medium or lower in P and about 43% tested in that range for K.

Soil Quality

Productivity depends on soil quality. Soil quality – its structure and its capacity to retain water and nutrients – depends on inputs of organic material to maintain appropriate levels of humus. Nutrient inputs have large impacts on the total quantity of organic material produced and available to build soil humus. When nutrient deficiency limits crop yields, it also limits their contribution of organic material (crop residue) to the soil. Nitrogen has particular importance, since soil humus maintains a carbon (C) to N ratio of 10, and adequate N inputs are necessary to stabilize and build soil C in the long term.

TABLE 2. Organic food markets are growing, but form a small part of total food sales.

Country	Value of total organic sales in 2000 US$, millions	% of total food sales	Expected growth, %/yr
Austria	200-225	1.8-2.0	10-15
Denmark	350-375	2.5-3.0	10-15
France	800-850	0.8-1.0	10-15
Germany	2,100-2,200	1.6-1.8	10-15
Japan	2,000-2,500		
Switzerland	450-475	2.0-2.5	10-15
United Kingdom	1,100-1,200	1.0-2.5	15-20
U.S.	7,500-8,000	1.5-2.0	20

From ITC, 2002. Overview world markets for organic food & beverages (estimates). http://www.intracen.org/mds/sectors/organic/overview.pdf

Organic systems often rely on tillage to incorporate organic materials and control weeds. Tillage increases mineralization (breakdown) of soil organic matter. Today's integrated, conventional cropping systems are reducing or eliminating tillage, allowing crop residues to contribute more to increasing soil organic matter content.

Natural or Synthetic?

It is often implied that nutrients used in organic cropping systems are "natural" as opposed to the "synthetic" or "chemical" sources used in conventional systems. Actually, any effort to differentiate foods from a nutrient source standpoint is of limited use because all nutrients are "chemical"...all are "natural" and exist in nature...and all nutrients are absorbed by the plant almost entirely in the soluble inorganic form whether the source of nutrients is organic or inorganic. The "natural" versus "synthetic" distinctions are not defensible on the basis of science.

Environmental Impact

The inputs allowed as fertilizers in organic production are lower and more variable in nutrient content and plant-availability than commercial fertilizers. To meet all the crop's need using these inputs, they have to be applied at high rates. There is greater likelihood of supplying some nutrients at excess rates, which may lead to increased risk of loss and negative environmental impact. A commentary published recently in the journal *Nature* points out, "Manure breakdown cannot be synchronized with crop canopy growth, as is desirable, but continues throughout the growing season. Plowing in of legume crops (a necessary part of the organic method to build soil fertility) and continued manure breakdown leads to nitrate leaching into aquifers and waterways at identical rates to conventional farms."

When today's producers harvest the North American corn crop, they currently remove an amount of N in the grain equivalent to 75% of the fertilizer applied to the crop. The fate of the remaining N concerns them – some does potentially contaminate water. But they have already made progress. They are recovering 25% more than they did in the 1970s and they strive for continued improvement.

Prudent, scientifically sound use of technology in a site-specific management program is essential to minimizing nutrient impacts on the environment. Improved and adapted genetic materials are a key component. Integrated pest management must be included, using best practices from cultural, biological, and chemical approaches. Conservation tillage and other practices to control erosion, maintain water quality, and reduce herbicide use are often critical.

Productivity is important. Not only for profit, not only to feed the growing world, not only to save land for wildlife habitat, but also for the benefit of the soil. No discussion of organic farming fails to mention the importance of organic matter for sustaining soil productivity. But the original source of organic matter is photosynthesis – plant productivity. Land areas deficient in mineral nutrients will not produce as much vital organic material.

The challenge facing agriculture today is to increase the quantity and quality of food produced, with less detrimental impact on the environment. The ability of organic farming (as currently defined) to meet the challenge is limited by the unscientific restrictions placed on inputs that contribute to productivity. BC

Dr. Bruulsema is PPI Northeast U.S. and Eastern Canada Director, located at Guelph, Ontario; e-mail: tbruulsema@ppi-ppic.org. Dr. Dibb is PPI President, located at Norcross, Georgia. Dr. Reetz is PPI Midwest Director, located at Monticello, Illinois. Dr. Fixen is PPI Senior Vice President, Coordinator of North American Program, and Research Director, located at Brookings, South Dakota.

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