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# New vistas in organic agriculture – prospects for the future

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Organic agriculture plays an important and growing role in Indian agriculture. Emerging research in organic agriculture is showing that organic agricultural systems provide a comprehensive strategy for mitigating and facilitating the effects of climate change. Organic agriculture has opened new vistas in research field of soil fertility management with more impetus to soil biodiversity studies, management of weeds, insects and diseases by following minimum tillage practices, crop rotation principles and cover crops, biological methods of weeds, insects and disease management besides breeding and genetics aspects.The main impact benefits of organic production systems make organic agriculture an effective vehicle for achieving national economic and environmental goals. By this way organic agriculture presents a catalogue of new vistas in organic research, so that the research will help organic farmers to improve the agricultural, environmental and economic performance of their production systems.

Organic Farming is gaining more popularity on the global arena with increase in health and environmental awareness due to the ill effects left behind on soil and health by practicing conventional farming. Today's world knows the benefits embedded in this system are multiple and manifold, addressing the ecological, economic and social sustainability. Although the term 'organic farming' is getting popularity in recent times, but it was initiated in 10,000 years back when our ancient forefathers started cultivation depending on natural sources only (Bhattacharyya and Chakraborty, 2005). Organic farming has great linkage with sustainability in agriculture as organic farming is one of the several approaches found to meet the objectives of sustainable agriculture (Narayanan, 2005) and organic agriculture claims to be sustainable in long run (IFOAM, 2002, 2004).

Organic agriculture is defined in India's National Programme for Organic Production (NPOP) as "a system of farm design and management to create an ecosystem, which can achieve sustainable productivity without the use of artificial external inputs such as chemical fertilizers and pesticides". Lack of full fledged scientific cultivation practices is the main bottleneck for whole farm conversion of conventional to organic farm. In this article, the new vistas abundant in organic agriculture are reviewed and the research needs in organic farming are pointed for future prospects and sustainability of organic agriculture.

## Current relevance of organic agriculture in India:

India's advantage is its diverse agro-climatic zones, where the rainfed and hilly regions of the country are practicing subsistent agriculture for a long period. These areas are organic by default. With the launching of National Programme on Organic Production (NPOP) by the Ministry of Commerce during 2001 and National Project on Organic Farming (NPOF) by the Ministry of Agriculture under Department of Agriculture and Cooperation were the two important interventions by the Indian government. During the last five years, organic agriculture has grown many folds and large numbers of farmers have adopted this low cost on-farm resource based agriculture. From 76,000 ha of organic farm land certified in 2005, it has increased to 1.2 m ha as on march 2009 under certification process (Yadav, 2009). Twelve states have defined organic policies and two states Uttaranchal and Sikkim have declared their states as organic. Karnataka has typical composition of the most of the Agro-Climatic conditions in the country. State has brought out Agriculture Policy of Karnataka 2006 which has addressed the main issues related to Karnataka agriculture especially organic farming. Recently on 26$^{th}$ January 2009, Government had set up the Karnataka Organic Agriculture Mission and drawn an ambitious plan to promote organic agriculture with impetus on value

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addition to high value and marketable crops for domestic and international market. Organic farming has so far captured only about 0.85% of the total cultivable land. From 1.20 million ha area, India's main organic products were, spices, tea, coffee and organic cotton.

Organic agriculture as a tool for second green revolution in the country are recommended in 11th plan document on organic sector and National Commission on Farmers, in particular for agro-ecozones comprising rain fed areas, hilly areas and areas experiencing ecological backlash of green revolution.

For quality assurance the country has internationally acclaimed certification process in place for export, import and domestic markets. 16 accredited certification agencies are looking after the requirement of certification process and the products certified by them are accepted in many countries including European Union, USA and Japan (Yadav, 2009).

**Glimpses of on going research project in organic agriculture at UAS, G.K.V.K., Bangalore:**

– The University of Agricultural Sciences has pioneered in research and development work on organic farming in tune with state's policy on organic farming.

– A premier Research Institute on Organic Farming has been established at GKVK campus functioning as a nodal centre to promote multidisciplinary research on organic farming including integrated farming system.

– An Organic Agriculture Research Station at Nagenahalli has converted the entire farm into organic with establishing composting units, bio-digesters, recycling of farm residues in crop production.

– Organic Farming Research Centre, Navile, Shimoga is validating the existing organic practices, analysis of nutrient and microbial status of liquid manures, conservation of local seed material in paddy and ragi.

– Establishment of Bio-fuel park at Madenur, Hassan

– Model organic farms at Chinthamani, Balajigapade, Hiriyur and Navile were established with financial support of NCOF, GOI. Also field trails are being carried out on organic farming in all the research stations under UAS (B)

– Recycling of cattle urine in crop production as top dressing is carried out at Operational Research Project, Pavagada. Yield of paddy, marigold, chillies, bittergourd, arecanut, betelvine and groundnut was increased by the use of cattle urine (Reddy, 2008)

– Apart from PG research in organic farming, value addition of organic products, nutrition status and market status are being investigated at UAS, Bangalore.

The issues surrounding "scale of organic operations" ebb and flow like the tides on the shore. So an intriguing question that remains relevant today is "under what specific circumstances and conditions can organic farming systems produce a significant portion of our food and fiber needs?" With new vistas in organic agriculture concrete research objectives were needed in these areas.

– Organic research should be conducted under certified organic conditions

– Organic research should involve organic producers as active team members.

– Organic research should emphasize multidisciplinary systems approaches, rather than input-substitution approaches in managing pest problems and fertility needs.

– Research trials should be set up for long-term studies of organic systems(Jane sooby *et al.*, 2007).

**New vistas in organic agriculture:**

Soil - fertility management (Microbial life and soil quality):

– Determine relationships between crop nutrient content and soil quality

– Nutrient budgeting tools such as look up tables for the nutrients contributed to soils by specific crops and inputs to be developed.

– Develop low –cost, farmer-friendly soil testing methods and kits to assess soil quality and fertility status.

– Investigate plant soil microbial community response to crop rotations that feature green manures, cover crops, crop rotations.

– Determine how organic farming can conserve soil organic matter, build soil quality and contribute to carbon sequestration under normal tillage practices.

– Determine the timing of nutrient release by various organic fertility amendments.

– To test the efficacy of products marketed to organic farmers as microbial stimulants, humic acids, humates, fulvates and mycorrhizal stimulants.

– Documenting the role of compost in building soil and plant health.

**Fertility management:**

It is well established scientifically that specific and measurable changes take place in cropped fields that undergoes a transition from chemical to organic management. Such changes have been documented in long-term studies comparing organic and conventional farming systems, which show distinct changes over time in the biological, chemical and physical properties of the organically managed soils (Drinkwater *et al.*, 1998; Clark *et al.,* 1998; Reganold *et al.,* 2001; Kramer *et al.,* 2006).

This is a complex and challenging area of scientific study as it involves multiple interactions underlying soil microbial ecology and their management implications in crop production (Burger *et al.*, 2005).Goldstein (2003) emphasizes the active role of corn roots in seeking out N and suggests that corn roots have the ability to stimulate mineralization in order to meet the plant's nitrogen needs. More work is needed to determine the respective roles of plants and soil microbial communities in nutrient cycling and to develop practical management recommendations to optimize these roles.

Evidences suggest that soils in organic cropping systems are sensitive to the sources of carbon and nitrogen that they receive. More work is needed to determine the changes that occur in microbial communities under long term application of organic amendments, and to develop management recommendations for organic agro-ecosystems.

**Soil organic matter:**

Microbial life in organically managed soils has significant qualitative impacts on soil organic matter and consequently, on soil fertility. Biologically active light fraction organic matter is a functionally important pool of soil organic matter and assays of particulate residues comprising this fraction is the best way to characterize the quality and quantity of soil organic matter

Phelan (1997,2004) has developed the concept of biological buffering, which states that sustained influx of soil organic matter in organically manages soils provides the resource base for the soil community, whose interactions then attenuate or buffer the impact of changes in the soil environment. He also puts forth the mineral balance hypothesis, which maintains that plants with an optimal mineral balance show lower susceptibility to pests. This indicates that the relationship of soil microbial life to soil fertility in organically managed systems is not merely governed by a formulaic input of quantifiable nutrients, but rather by maintenance of a subterranean soil habitat conducive to microbial functioning and associated plant health. It reveals surmountable organic farming research challenge: how to define and measure the quality of soil organic matter in organically managed systems and how to relate organic matter quality to management practices used to grow specific crops in defined rotations. So testing methods be developed to detect biologically significant soil parameters such as N mineralization potential and active soil carbon levels. This requires a paradigm shift from crop-focused agronomic approach to soil-focused whole farm husbandry.

**Root-microbe associations:**

Plant roots form symbioses with a variety of microorganisms that strongly impact crop production. The relationship that microorganisms have plant roots (*Rhizobium* spp., *Mycorrhizae* etc.,) are important in organic nutrient cycling. These relationships require further study to elucidate their roles in crop nutrient acquisition and maintenance of crop health and to determine management practices that support these functions.

**Ammonium: Nitrate ratio:**

Many studies have characterized that organic soils are having a larger $NH_4^+$: $NO_3^-$ ratio than in conventionally managed soils (Drinkwater *et al.,* 1995, Burger and Jackson, 2003). Studies to know the actual extent of the $NH_4^+$: $NO_3^-$ ratio in organically managed soils, determining how it is influenced by organic fertility inputs and delineating its significance holds promise in developing management practices that will optimize soil N and C cycling in organic agro ecosystems.

**Nutrient budgeting:**

More work is needed to develop nutrient budgets for a wide variety of cropping sequences under different climatic and soil conditions. Researchers have begun to develop nutrient budgeting tools that estimate nutrient inputs and losses from biologically managed systems. Goldstein (2003) developed a nutrient budgeting tool for corn production that can estimate nitrate in the soil at harvest and the amount of surplus N lost or immobilized during the growing season. On similar lines Drinkwater *et al.* (2005) has developed nutrient budgets for organic cropping systems based on "mass balancing". This system analyzes nutrient inputs and harvested outputs over a period of years to determine net losses or accumulations of nutrients.

**Crop rotation and cover crops:**

More work is needed to better understand their effects on soil microbial life, soil fertility and disease resistance in organic cropping systems. The studies conducted by Karlen *et al.* (2006) have shown that crop rotations that include forages improve soil quality, whereas continuous crop rotation with corn had the lowest soil quality index.

**Soil quality and soil health:**

The concept of soil quality and soil health has increasingly marked scientific discussions about sustainable soil management. The characterization of soil quality provides a framework for defining soil health. Commonly identified soil quality indicator properties include the soil's physical traits of soil texture, topsoil and rooting depth, bulk density, water infiltration rate, water-holding capacity, and aggregate stability and the soil's chemical properties of pH, electrical conductivity, cation-exchange capacity, organic matter levels, exchangeable potassium, and exchangeable calcium (Doran and Parkin 1996). The soil's biological properties that indicate soil quality are to date less well characterized. These properties include mineralizable nitrogen, microbial biomass carbon and nitrogen, microbial activity measurements, earthworm populations, enzymes, and disease suppressive ness (Mitchell *et al.,* 2000; Doran and Parkin, 1996).

Ferris *et al*. (2001) have developed nematode faunal analysis as a useful and easily derived indicator of soil quality, based on the fact that nematode populations fall into distinct indicator guilds depending on the structure and function of the soil food web. Such integrative measurements can be useful to organic farmers, particularly if straightforward field tests or inexpensive soil testing services can be offered.

**Systemic management of plant pests: weeds, insects, and diseases:**

Weeds:

– Refine cover crop and green manure systems to suppress weeds and enhance soil fertility, including the use of multi-species cover crops and inter planting covers into standing crops.

– Evaluate the effectiveness of various crop rotation strategies in suppressing annual and perennial weeds.

– Identify effective control methods favoring system wide approaches for specific difficult-to-control annual and perennial weeds.

– Determine how to manage nitrogen applications to optimize crop yields and minimize weed growth.

– Determine the effects of different methods and timing of cover crop take down, seedbed preparation, pre- and post-emergence crop cultivation, and post-harvest tillage on weed seed germination, seed destruction by predators, and resurgent growth of perennials.

– Identify the impacts of native pathogens on weed seeds and weed growth through classical and bio-herbicide (augmentation) biocontrol methods

– Develop reduced- and no-tillage organic systems, and design new machinery to implement these systems.

– Compare the efficacy of specific tillage implements in controlling weeds with respect to such factors as timing of operations, ability to handle surface organic matter residues, soil moisture conditions, driving speed, and number of passes.

– Develop weed flaming protocols and safety standards.

– Determine the role of single and multi-species grazing of pastures, fallow fields, and crop residues for weed suppression.

Pests:

– Develop cultural practices to activate induced systemic resistance in crops.

– Develop composts and compost teas to stimulate plant immune response by manipulating feed stocks, preparation methods, or microbial composition of the finished product.

– Evaluate the effectiveness and impact on whole farm ecology of using botanical and other insecticides compliant with the organic standards.

– Identify effective control methods favoring system wide approaches for hard-to- control insects such as flea beetle, codling moth, aphids, thrips, stinkbug, yellow margin leaf beetle, corn borer, soybean aphid and other virus vectors (such as white flies and aphids).

– Optimize plant species mixes and planting strategies for hedgerows and buffers to provide habitat for natural enemies of crop pests.

– Develop importation strategies and habitat manipulations to maximize the effect of competitors, predators, parasites, and pathogens as biocontrol agents.

– Determine long-term soil and human health effects of applying pesticides that are compliant with the organic standards, such as sulfurs, petroleum oils, copper fungicides and botanicals.

Diseases:

– Explore how to manage soil microbial dynamics to enhance nutrient cycling and to develop disease-suppressive soils.

– Develop systems to produce healthy seedlings for transplanting.

– Evaluate biological seed treatments and conditioners for fungus control.

– Develop effective control methods for difficult to control diseases such as Asian soybean rust, powdery mildew, late blight (*Phytophthora*), blight, early blight (*Alternaria*) and mildew.

– Develop alternatives to copper and sulfur fungicides in organic production.

– Evaluate the effect of compost and compost extracts on plant growth, yield and disease suppression.

Recent research is addressing ways to manage aboveground biodiversity to regulate pest populations, including use of beetle banks to control crop-damaging larvae (Prasad *et al.,* 2002), attracting wild birds to control insect pests (Jones and Sieving, 2003) and utilizing vegetational corridors and flowering hedgerows to attract beneficial insects (Nicholls and Altieri, 2004)

The ability of crops to resist insect and disease attacks may arise from activity in the rhizosphere mediated by soil organic matter. The nature of signaling mechanisms is likely to be complex. Substrate-dependent disease suppression has been thoroughly reviewed recently. However, the active role of organic matter in these interactions needs much more investigation. Clearer characterization of organic matter fractions and their functions is also needed.

There is a growing body of evidence that bacterial and fungal biocontrol agents can play significant roles in suppressing weeds within organic farming systems (Yandoc *et al.,* 2004). While research is needed to determine which types of beneficial bacteria and fungi are most effective for biocontrol under specific soil, climate, and crop management conditions, scientists and producers should resist the temptation to investigate these tools within an input-substitution model of organic crop management. One perspective is that "what is lacking is not biocontrol organisms but the environment that supports high populations and activities related to biological control" (Stone *et al.,* 2004).

**Breeding and genetics :**

Organic growers and livestock producers require breeding programs that produce crops and animals which meet the unique needs and conditions of organic farming systems.

**Research needs:**

Plants:

– In general, breed crops for disease and insect resistance, good yield in a biologically diverse system, ability to compete with weeds, compatibility with intercrops, and good response to organic fertility sources.

– Breed crops suited for specific regions, climates, and soil types.

– Develop guidelines by which growers can select and save their own seed for their specific growing conditions.

– Conduct breeding work on minor crops that fill niche markets.

– Develop mechanisms for preventing or eradicating genetic contamination, such as breeding non-compatibility genes into organic crop varieties that would prevent them from accepting pollen from genetically modified (GM) hybrids

– Develop methods to breed out GM traits.

– Breed for horizontal resistance to pests.

– Work with older heirloom varieties and landraces as well as modern cultivars to identify and preserve useful traits.

– Work with wild relatives of crop plants to identify useful traits and to preserve diversity.

– Develop perennial organic agricultural systems by breeding perennial grain varieties.

– Develop organic crop varieties that are well-suited for grazing (e.g., short-statured, small-eared corn) and otherwise suited for integration with livestock production.

– Develop varieties of soil-building crops, and develop uses and markets for such crops, so that organic farmers will have more options to comply with soil-building crop rotation requirements.

**Animals:**

– In general, select for healthy, adaptable animals with desirable behavioral traits and consistent production.

– Breed and select livestock and poultry for foraging ability and efficient use of pasture.

– Breed specifically for good performance under organic management.

– Preserve traditional livestock varieties.

– Identify non-production traits for which to breed, such as resistance to diseases and internal parasites, longevity of the animal's productive life, or durability in harsh climates.

Availability of organic seed is a critical issue for organic growers. Strong demand for organic seed is a relatively recent development that accompanied full implementation of the National Organic Standards, which requires that certified organic growers use certified organic seed when the seed is "commercially available." The organic seed requirement for organically certified crops, combined with increasing risk of organic crop contamination by GM gene sequences, has led to increased interest in organic variety development and seed production on the part of organic farmers. Organic growers are also very interested in seeing horizontal resistance developed in varieties bred for organic systems.

**Other issues:**

All major food crops have been developed from wild, weedy relatives. Many recently "discovered" minor or alternative crops (e.g., amaranth) also arose from the breeding of wild relatives. Continued development of such crops and markets for them can benefit organic farmers by providing more options for diversity in the field and in marketing. These results support the hypothesis that varieties for organic agriculture should be selected within an organic production system to achieve maximum yield potential (Murphy and Jones, 2005). Organic breeding be done under certified organic conditions, both on-farm and on-station. Broad organic animal breeding goals include selecting for healthy, adaptable animals with desirable behavioral traits and consistent production (Idel, 2006). The dearth of information on organically-adapted animal breeds is a significant problem that can be addressed by establishing publicly funded organic animal breeding programs.

## Conclusion:

Organic agriculture plays an important and growing role in Indian agriculture. Relatively modest investments in organic research and education can significantly increase the economic benefits and environmental services provided by organic farming systems and the organic products sector. Emerging research in organic agriculture is showing that organic agricultural systems provide a comprehensive strategy for mitigating the effects of climate change and facilitating the adaptation to climate change. Organic agriculture has opened new vistas in research field of soil fertility management with more impetus to soil biodiversity studies, management of weeds, insects and diseases by following minimum tillage practices, crop rotation principles and cover crops, biological methods of weeds, insects and disease management. Breeding and genetics is the new tool which will boost the organic farming revolution with timely availability of organically certified and grown seeds, new breeds tailored for organic environment, conservation of local seed material, develop methods to breed out GM traits and organic growers are also very interested in seeing horizontal resistance developed in varieties bred for organic systems.

Organic agriculture also reduces the use of non-renewable sources of energy such as fossil fuels. The multiple benefits of organic production systems make organic agriculture an effective vehicle for achieving national economic and environmental goals.

The biggest challenge currently for organic growers is that they don't get the same support as conventional growers. Government policies should be aimed at alleviating these concerns of organic growers by providing availability of organic inputs and low cost certification process. The demand from farmers for a separate standard and certification for domestic market has to be validated and proper guidelines framed in this matter. Market development for the organic products and value addition of organic products are to be promoted. By this way organic agriculture presents a catalogue of new vistas in organic research, so that the research will help organic farmers improve the agricultural, environmental and economic performance of their production systems.

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