Indian Journal of Agronomy **54**(2): 193–199 (June 2009)

Organic farming: Development and strategies in Indian Perspective

S.K. SAINI* AND SUNITA T. PANDEY**

Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar, U.S. Nagar, Uttarakhand 263 145

ABSTRACT

Increasing awareness about conservation of environment as well as health hazards associated with agro-chemicals and consumers' preference, to safe and hazard-free food are the major factors that lead to the growing interest in alternate forms of agriculture in the world. Organic agriculture is one of the broad spectrum of production methods, being considered in support of the environment and human health. The demand for organic food is steadily increasing both in the developed and developing countries with an annual average growth rate of 20-25%. Organic agriculture, is one of the fastest-growing sectors of agricultural production. However, there are certain issues that need to be addressed before we go for a large-scale conversion to organic agriculture. Some of the important issues are: Can organic farming produce enough food for everybody? Is it possible to meet the nutrient requirements of crops entirely from organic farming? Is the food produced by organic farming superior in taste and quality? Is it economically feasible? This article presents a critical review on these aspects in Indian perspective.

Key words: Agriculture, Organic farming

Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. Organic production systems are based on specific standards precisely formulated for food production and aim at achieving agro-ecosystems, which are socially and ecologically sustainable. It is based on minimizing the use of external inputs through efficient use of on-farm resources compared to industrial agriculture. Thus the use of synthetic fertilizers and pesticides is avoided.

Organic in organic agriculture is a labelling term that denotes products that have been produced in accordance with certain standards during food production, handling, processing and marketing stages, and certified by a duly constituted certification body or authority. The organic label is therefore a process claim rather than a product claim. It should not necessarily be interpreted to mean that the foods produced are healthier, safer or all natural. It simply means that the products follow the defined standard of production and handling, although survey indicates that consumers consider the organic label as an indication of purity and careful handling.

Many definitions have been proposed for organic agriculture. Ethical issues such as fair labour practices and animal ethics have also been included in organic agriculture definitions. To promote organic agriculture and to ensure fair practices in international trade of organic food, the Codex Alimentarius commission, a joint body of FAO/WHO framed certain guidelines for the production, processing, labelling and marketing of organically produced foods, with a view to facilitate trade and prevent misleading claims. The codex Alimentarius Commission defines organic agriculture as a holistic food production management system, which promotes and enhances agro ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of on-farm input, taking into account that regional conditions require locally adapted system. This is accomplished by using, agronomic, biological and or mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system.

**Corresponding author: ***Associate Professor, Department of Agronomy, GBPUA&T, Pantnagar
(E-mail: sk_saini@india.com, sunitatewari_8@yahoo.co.in)

Perspectives of Organic Farming in India

After nearly four decades of globally acclaimed agro-technological revolution termed as 'Green Revolution', Indian agriculture is again at crossroads. On one side of the spectrum are the developed countries with almost a zero growth rate of agriculture and of environmental degradation owing to extensive industrialisation and indiscriminate use of agricultural chemicals. On the other side a developing country, with population growth outstripping agricultural productivity growth, and required to produce more and more food, fibre and fuel from ever-shrinking agricultural land. The post-Green Revolution problems, presently threatening the sustainability of Indian agriculture as a whole and raising a serious concern about national food security include : stagnation or even decline

in production and productivity growth rates of major crops, receding groundwater tables in many agriculturally important areas, deterioration of soil fertility, decline in factor productivity, low diversity of production systems, and increasing production costs, leaving agriculture as an economically non-viable enterprise for resource-poor farmers. It is due to these problems that the echo of sustainable and eco-friendly agriculture became louder. In the name of sustainability and eco-friendliness, various new farming concepts, viz., organic agriculture, natural farming, biodynamic agriculture, eco-farming, do-nothing agriculture, homa-farming etc. collectively known as 'organic farming' have been proposed in recent years, with the essential feature remaining same *i.e.* back to nature.

The primary concern of all organized communities and civilized societies is to meet the food requirements of its people. The cultivated area, required to maintain the present level of food grain production in India without using the fertilizers, reaches more than the total geographical area of the country. At present, there is a gap of nearly 10 m t between annual addition and removal of nutrients by crops which is met by mining nutrients from soil. A negative balance of about 8 mt of NPK is foreseen in 2020, even if we continue to use chemical fertilizers, maintaining present growth rates of production and consumption. The most optimistic estimates at present show that only about 20-30% nutrient needs of Indian agriculture can be met by utilizing various organic sources. On long-term basis, conjoint application of inorganic fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality and soil productivity. The organic sources should be used in integration with chemical fertilizers to narrow down the gap between addition and removal of nutrients by crops as well as to sustain soil quality and to achieve higher crop productivity. The food security demand of the country requires that inorganic fertilizers be used in balanced doses.

Organic farming has the twin objectives of the system being sustainable and environmentally benign. To achieve these two goals, it has developed some rules and standards which must be strictly adhered to. There is a meagre scope for change and flexibility. Organic farming thus, does not require best use of options available but the best use of approved options. These options are usually more complex and less effective than the conventional ones. The Indian farmer should get the advantage of emerging global market on organic farming which is at present around 26 billion US $, and is expected to grow to 102 billion US $ in 2010 (NAAS, 2005). Currently, 130 countries are producing certified organic products. Organic farming as a concept/philosophy is well tested in some of the western countries though the same is not unknown to most of the nations. But in the Indian context, it needs to be looked into more critically seeking answers to the following questions: What level of crop productivity is acceptable? Is it suitable for a country like India with such a large population to feed or can it fit in the niche areas? Are available organic sources of plant nutrients sufficient for organic farming in the form it is advocated? Are organic farming technologies sustainable in the long run? Is there any scope for promotion of organic farming in the export market, without compromising with the national food security that exists in the country?.

Organic farming and crop productivity level

A number of studies showed that under drought conditions, crops in organic agriculture systems produce significantly higher yields than comparable conventional agricultural crops (Pretty 2000; Subba Rao 1999). It has also been established that organic systems have less long-term yield variability. A survey of 208 projects in developing tropical countries, in which contemporary organic practices were introduced, showed average yield increase of 5-10% in irrigated crops and 50-100% in rainfed crops.

The so-called organic transition effect, in which a yield decline in the first 1-4 years of transition to organic agriculture, followed by a yield increase when soils have developed adequate biological activity has not been borne out in some reviews of yield comparison studies. However, it is generally propagated that the organic farming sustains higher yields as compared to conventional farming using inorganic fertilizers and plant-protection chemicals. There are dependable research evidences to show that balanced inorganic fertilisation and integrated nutrient management have sustained crop yields on long-term basis (Diwedi *et al.,* 2002; Nambiar, 1994 and Swarup and Wanjari 2000), but convincing and clinching evidences are still to be found out to show that higher crop yields could be obtained under organic farming systems on long-term basis. Not many experimental evidences on the long-term effect of organic farming are available, since the practice of organic farming in the country is of recent origin. Nevertheless, data from Long Term Fertilizer Experiments (LTFE) established on acid soils of Ranchi showed that supplementation of entire N through farmyard manure sustained crop yields at much lower level. Results of initial 4 years of a long-term experiment on rice-wheat system at Modipuram also go against the myth, as the yields of both rice and wheat remained sizeable low under organic farming compared with conventional farming owing to lesser number of ears i.e. effective tillers and fewer number of grains per ear (Yadav *et al.,* 2002) in the former case (Table 1).

Table 1. Yield and yield - attributes of rice and wheat under conventional and organic crop management during fourth year of cropping in a fixed-plot experiment.

Treatments	Yield (t/ha)		Ears/ m^2	Grain/ ear	Grain weight/ ear (g)
	Grain	Straw			
Rice (2001)					
Unfertilised (Control)	2.34	3.09	196	43	0.62
100% NPK	5.15	6.59	250	94	1.68
Organic farming	3.84	4.69	236	77	1.65
Wheat (2001-2002)					
Unfertilised (control)	2.11	2.91	238	26	1.16
100% NPK	4.82	6.54	375	38	1.70
Organic farming	4.16	5.35	282	35	1.73

Crop production essentially represents extraction of resources from soil. Unless these are replaced, the soil will become depleted and infertile. The question is how fast and in what quantities these are replenished through organic sources? This becomes crucial to meet the demand of food and fibre of ever increasing population. The sustainable yield targets, which are satisfactory today, may not be tenable 10 years hence, best results world over in productivity and economic gains have been obtained with the conjoint use of organic sources and inorganic fertilisers.

Trewaves (2001) pointed out the hazards of relying solely on organic sources for nutrients. Manure breakdown can not be synchronised with crop growth as is desirable, but continues throughout the growing season. Manure is variable in composition and may yield unpredictable nutrition for crop growth. Long-term application of inorganic fertilisers is known to increase organic carbon owing to higher root biomass production**.** Soil organisms are for their role as nutrients recyclers.

At the global level, especially in developing countries with high population pressure, and with the present state of knowledge and technology, organic farming cannot produce enough food for everybody.

Organic farming vs potential of organic manures

Both food and therefore nutrient needs of India are expected to go up consistently in the future without a break. The net cropped area has more or less stabilised at 143 m ha. The population of 1 billion plus is expected to grow by 14 to 15 m each year. Land is limited and shrinking whereas human and animal population are increasing. The land to man ratio has fallen rapidly in the past half century from 0.34 in 1950 to 0.14, and is projected to be 0.10 in 2025. At present, each hectare of net sown area has to support more than 7 persons. This pressure will only increase in the coming years. It is also disquieting that during the 1990s India witnessed depressed rates of growth in yield and production compared to world averages. Keeping in view the conservative population estimate of 1.4 billion by 2025 and minimum caloric requirement of food, the country will need to produce at least 300 mt of foodgrain. For this purpose, it will be necessary to use 30 to 35 mt of NPK from various sources. In addition, according to National Academy of Agricultural Sciences (NAAS, 1997) the experts on horticulture, vegetable, plantation crops, sugarcane, cotton, oilseeds and potato have projected that by 2025, the demand for fertilisers for these high value crops, which also have high export potential and claim fertiliser use on priority basis, will rise to 3.0, 2.0, 3.2, 0.9, 3.1, 1.5 and 1.0 mt, respectively. This adds to the total nutrient needs by another 14 to 15 mt NPK. Thus, the country will be required to arrange for the supply of about 40 to 45 m t of nutrients by 2025.

It is neither possible nor feasible to replace chemical fertilisers completely to sustain present level of crop production. Projections on the availability of plant nutrients from organic sources for agriculture in India during 2000-2025 as worked out by Tandon (1997) are given in the Table 2 and projected plant nutrient (NPK) addition and removal as per Katyal (2001) in the Table 3. These figures apparently reveal that all tappable nutrients form organic sources will be barely able to meet the deficit of nutrients in soil after crop removal at present level of production. Ensuring nutrient supply of 45 m t to produce 300 m t of food grain and other commodities by 2025 would merely be a dream.

Organic agriculture: Scope and area approach

Only 30% of India's total cultivable area is covered with fertilizers where irrigation facilities are available and in the remaining 70% of arable land, which is mainly rainfed, negligible amount of fertilizers is being used. Farmers in these areas often use organic manure as a source of nutrients that are readily available either in their own farm or in their locality. The north-eastern region of India provides considerable opportunity for organic farming due to least utilization of chemical inputs. It is estimated that 18 m ha of such land is available in the N-E, which can be exploited for organic production. With the sizable acreage under naturally organic/default organic cultivation, India has tremendous potential to grow crops organically and emerge as a major supplier of organic products in the world's organic market.

The report of the Task Force on organic farming appointed by the Government of India also observed that in vast areas of the country, where limited amount of chemicals is used and have low productivity, could be exploited as potential areas for organic agriculture. Arresting the

Table 2. Some projections on the availability of organic resources for agriculture in India during 2000-2025.

Items	2000	2010	2025
Generators			
Human population (million)	1,000	1,120	1,300
Livestock population (million)	498	537	596
Food grain production	230	264	315
Nutrients (theoretical potential, mt N + P_2O_5 + K_2O)			
Human excreta	2.00	2.24	2.60
Livestock dung	6.64	7.00	7.54
Crop residues	6.21	7.10	20.27
Nutrient (considered tapable, mt N + P_2O_5 + K_2O)			
Human excreta	1.60	1.80	2.10
Livestock dung	2.00	2.10	2.26
Crop residues	2.05	2.34	3.39
Total	**5.05**	**6.24**	**7.75**

All data pertaining to nutrients in dung and in residues are counted twice to the extent these are fed to the animals.
Tapable = 30% of dung, 80% of excreta, 33% of crop residues.

Table 3. Projected plant nutrient (N + P_2O_5 + K_2O) addition and removal in India[1] (million tonnes)

Items	2000	2020
Addition through fertilisers	18.07	29.60
Crop removal	28.00	37.46
Balance	-10.00	-7.86
Total projected (2025) availability of plant nutrients from tappable organic sources		7.75

decline of soil organic matter is the most potent weapon in fighting against unabated soil degradation and imperilled sustainability of agriculture in tropical regions of India, particularly those under the influence of arid, semi-arid and sub-humid climate. Application of organic manure is the only option to improve the soil organic carbon for sustenance of soil quality and future agricultural productivity.

Studies showed that under drought condition, crops in organic agriculture system produce significantly higher yield than comparable conventional agriculture crops (Stanhill, 1990 and Dormaar *et al.*, 1988) often outyielding conventional crops (Wynen 1994, Lockeretz *et al.*, 1981 and Petersen *et al.*, 1999) by 7-90%. Other have shown that organic systems have less long-term yield variability (Peters 1994; and Smolik *et al.*, 1995). A survey of 208 projects in developing tropical countries in which contemporary organic practice were introduced, showed average yield increase of 5-10% in irrigated crops and 50-100% in rainfed crops (Pretty and Hine, 2001).

For promotion of organic farming, identification of potential areas and crops are crucial. The Government's strategy to promote organic farming for the crops having market potential like fruits, spices oilseeds, pulses, vegetables, wheat, cotton, basmati rice etc. As far as potential areas are concerned, three priority zones have already been identified. Category-I : The top priority areas for promotion of organic farming are the rainfed areas where fertiliser and agro-chemical consumption is already very low. Category-II: Areas are primarily under rainfed farming with little irrigation support and Category-III: The last priority areas are those with moderate to heavy use of fertilisers and pesticides, mostly multiple cropped areas.

Safety, quality and taste of organic food

There is a growing demand for organic foods, driven primarily by the consumer's perceptions of the quality, taste and safety of these foods and to the positive environmental impact of organic agriculture practices. The 'organic' label is not a health claim, it is a process claim. It has been demonstrated that organically produced foods have lower levels of pesticides and veterinary drug residues and in many cases lower nitrate contents. No clear trends have however been established in organoleptic quality differences between organically and conventionally grown foods.

There have been many claims that eating organic foods increases exposure to microbiological contaminants. But studies investigating these claims have no evidence to support them. Organic foods must meet the same quality and safety standards applied to conventional foods. These include the CODEX General Principles of Food Hygiene and Food Safety Programmes based on the Hazard Analysis and Critical Control Point. Analysis of pesticide residues in produce in the US and Europe has shown organic products have significantly lower pesticide residues than conventional products. Nitrates are significant contaminants of foods, generally associated with intensive use of nitrogen fertilizers. Studies that compared nitrate contents of organic and conventional products found significantly higher nitrates in conventional products.

There are also claims that food produced by organic methods tastes better and contains a better balance of vitamins and minerals than conventionally grown food. However, there is no clear scientific evidence, with some studies showing increase in vitamin C, minerals and proteins, more sweeter and less tart apples etc. A crude analysis of the literature, however, favours organic products in this area. A tasting panel convened by the Consumer Association in the United Kingdom did not consistently favour the taste of organic fruits and vegetables. Quality after storage has been reported to be better in organic products relative to conventional products after compara-

tive tests. Reviews of organic vs conventional product sensory analysis studies have reported results that do not clearly substantiate claims of superior organic product tastiness.

The quality of crops is controlled by a complex interaction of factors, including soil type and the ratio of minerals in added compost, manure and fertilizer. So it is difficult to separate the influence of the environment and farming system. There is scope to generate information on the quality of produce generated on organic farms in future studies. As per traditional belief that organic manure promotes quality while mineral fertilisers promote quantity. Regardless of whether the nutrients are from organic or inorganic source, plants absorb the same in form of inorganic ions: ammonium, nitrate, phosphate, potassium etc. Sensors in plant roots, if any, to distinguish between nutrients ions coming from organic or inorganic sources are to be yet discovered. Once absorbed, the nutrients are resynthesised into compounds that determine the quality of produce *e.g.,* flavour, shelf-life etc., which is the function of genetic make-up of the plants (variety). Thus, any difference in taste of modern high-yielding varieties from that of traditional low-yielding ones is due to difference in genetic material of these varieties. There is no scientific evidence presented as yet to show that organically produced food is of better quality and taste, and use of inorganic fertiliser deteriorates it. The better taste of the organically grown food is of psychological nature, and could be attributed to *'Placebo effect'* widely used in drug testing, where harmless sugar pills administered to control groups are known to cure patients of their imaginary ailments, when told of their novelty and wonderful therapeutic properties. More someone pays for it faster is the cure *i.e.* a clear case of *'mind over matter'*.

A general perception propagated in public minds is that organically grown food is more nutritious, healthy and safe. There are no consistent and valid reports of differences in the mineral contents of organic and conventional food. However, N applications generally improve both the protein and bread-making quality. There are many factors, environmental and cultural, that influence the nutritional composition of the produce. There is no difference between the protein content and other quality parameters such as vitamins, nutraceuticals and trace minerals of conventionally and organically grown crops, which at best could be linked to the varietal characteristics. The genetically modified 'golden rice' contains higher vitamin A content over the traditional varieties will continue to have its superior nutritive value, irrespective of organic or inorganic fertilisation. In the field of plant nutrition, the cry of 'only natural' has no justification or scientific basis (Woese *et al.,* 1997). The attitude that organic foods are safe and healthy is based on misconception that hazards in food are mainly derived from agro-chemical additives. In fact, microbes and not chemicals are the major source of foodborne diseases *viz.,* typhoid, gastroenteritis, dysentery, cystecurcosis etc. which contain intestinal bacteria, many of which may present substantial human health threats, can be an effective nutrient source, but the pathogen risk must be seriously considered. Land application of manure is particularly associated with *Salmonella*, *Escherichia coli* and *Taenia soleum*, which can contaminate the soil. These pathogens are known to survive in soil for a long period. They may be carried on edible plant parts coming in direct contact with soil and get into the food chain. They may also be introduced into shallow surface waters as well as ground water polluting potable water supply (Mikkelson and Gillian, 1995).

Organic farming and environment

Organic farming is eco-friendly and keeps the soils healthy without polluting environment. It is well known that nitrate is the main end product of manure decomposition, and it is continuously released from organic matter undergoing decomposition. Since nitrate release is not synchronised with either crop demand or its uptake, it tends to accumulate in excessive amounts in soil and pose environmental risk. Nitrate, thus formed without being taken up by plants may leach polluting groundwater or may denitrify polluting atmosphere. The ions irrespective of their origin whether from organic or inorganic source will behave similarly. There is no evidence that NO_3 ions from organic sources are less mobile or have lower denitrification potential than inorganic fertilizers. Trace elements and heavy metal concentrations in animal wastes (manures) and sewage sludges vary widely, and can be at

Table 4. Total concentration (mg/kg of dry weight) of selected heavy metals and trace elements in fertilisers, manures and biosolids

Sources	As	Cd	Cr	Cu	Pb	Ni	Zn
Cow manure	-	8.1	58	62	16	29	71
Poultry manue	0.35 - 10.5	-	0.6 - 9.6	3.5	-	-	51 - 538
Sewage sludge	3.6	2.3	35	511	65	22	705

nd= not detected

times very high (Table 4) and often exceed concentrations normally found in inorganic fertilizers. Field application of such organic manures which have to be applied in very high quantities to meet the requirement of major plant nutrients may lead to heavy metal accumulation in soil polluting arable land. These will find way into edible plant parts and will get into the food chain becoming health hazard.

The interest in organic agriculture in developing countries is growing because it requires less financial input and places more reliance on the natural and human resources available. Studies to date seem to indicate that organic agriculture offers comparative advantage in areas with less rainfall and relatively low natural and soil fertility levels. Labour is almost non-existent. Organic agriculture does not need costly investments in irrigation, energy and external inputs, but rather organic agricultural policies have the potential to improve local food security, especially in marginal areas.

Possibly, the greatest impact of organic agriculture is on the mindset of people. It uses traditional and indigenous farming knowledge, while introducing selected modern technologies to manage and enhance diversity, to incorporate biological principles and resources into farming systems, and to ecologically intensify agricultural production. Instead of being an obstacle to progress, traditions may become an integral part of it. By adopting organic agriculture, farmers are challenged to take on new knowledge and perspectives, and to innovate. This leads to an increased engagement in farming which can trigger greater opportunities for rural employment and economic upliftment. Thus through greater emphasis on use of local resources and self-reliance, conversion to organic agriculture definitely contributes to the empowerment of farmers and local communities.

The following conclusions can be drawn on important issues regarding organic farming: Large-scale conversion to organic agriculture would result in food shortage with the present state of knowledge and technology, as the yield reduction of organic system relative to conventional agriculture average 10-15%, especially in intensive farming systems. However, in traditional rainfed agriculture, organic farming has the potential to increase the yield since 70% of total cultivable land falls in this category. Mere 5-10% increase in farm production would definitely help achieve the targeted growth rate of 4-5% in agricultural production during X five-year plan.

Organic manure is an alternative renewable source of nutrient supply. A large gap exists between the available potential and utilization of organic wastes. However, it is not possible to meet the nutrient requirements of crops entirely from organic sources, if 100% cultivable land is converted to organic farming.

Organic farming systems can deliver agronomic and environmental benefits both through structural changes and tactical management of farming systems. The benefits of organic farming are relevant both to developed nations (environmental protection, biodiversity enhancement, reduced energy use and CO_2 emission) and to developing countries like India (sustainable resource use, increased crop yield without over-reliance on costly external inputs, environment and biodiversity protection, etc.).

Organic foods are proved superior in health and safety, but there is no scientific evidence to prove their superiority in taste and nutrition, as most of the studies are often inconclusive.

Organic farming is a holistic production system that has the advantage of efficient use and recycling of locally available resources. It is best suited to rainfed areas with scarcity of water and light soils. Some monopoly high value crops of rainfed areas like seed spices have great international demand, if produce organically. Organic production in rainfed areas not only boost the economy of this region but also sustain the productivity of natural resources. The need is to strengthen research on development of processing and marketing infrastructure, and financial as well as technical support for quality organic production.

REFERENCES

Dormaar, J. F., Lindwall, C.W. and Kozub, G.C. 1988. Effectiveness of manure and commercial fertilizer in restoring productivity of an artificially eroded dark brown chernozemic soil under dryland conditions. *Canadian Journal of Soil Science* **68:** 669-697.

Dwivedi, B.S., Shukla, A.K and Singh, V.K. 2002. *Annual Report, 2001-02, PDCSR, Modipuram* pp. 76-80.

Katyal, J.C. 2001. Fertilizer use situation in India. *Journal of Indian Society Soil Science* **49**: 570-582.

Lockeretz, W., Shearer, G. and Kohl, D.H. 1981. Organic farming in the corn belt. *Science* **211:** 540-546.

Mikkelson, R.L. and Gillian, J.N. 1995. (In): *Animal waste and the land-water interface* (K. Steele Ed.), Lewis Publishers, Boca Raton FI., pp. 57-68.

Nambiar, K.K.M. 1994. *Soil fertility and Crop productivity under long-term fertilizer use in India*, ICAR, New Delhi. pp 144.

National Academy of Agricultural Sciences (NAAS) 1997. *Proceedings*. Symposium on "Plant Nutrient Needs, Supply, Efficiency and Policy Issues; 2025 'Summary and Recommendation'.

National Academy of Agricultural Sciences (NAAS) 2005. Policy Paper (30) on organic Farming : Approach and Possibilities in the context of Indian Agriculture.

Peters, S.E. 1994. Conversion to low-input farming systems in Pennsylvania, USA. An evaluation of the Rodal Farming Systems Trial and related economic studies. (In) *Economics of Organic Farming* (Eds Lampkin, N. H. and Padel, S.), CAB, Wallingford, UK, pp. 265-284.

Petersen, C., Drinkwater, L. and Wagoner, P. 1999. *The Rodale Institute Farming System Trail: The first 15 years.* Publisher: The Rodale Institue, Kutztown, PA, pp. 40. www. Rodaleinstitute. org.

Pretty, J. and Hine, R. 2001. Reducing food poverty with sustainable agriculture: A summary of new evidence. SAFE Research Project, University of Essex, Wivenhoe Park, UK, pp. 136.

Pretty, J. 2000. The real costs of modern farming. *Agricultural Systems* **65 :** 113-136.

Smolik, J.D., Dobbs, T.L. and Rickerl, D.H. 1995. The relative sustainability of alternative, conventional and reduced till farming system. *American Journal of Alternative Agriculture* **10** : 25.

Stanhill, G. 1990. The comparative productivity of organic agriculture. *Agriculture Ecosystem and Environment* **30**: 1-26.

Subba Rao, I.V. 1999. Soil and environmental pollution – A threat to sustainable agriculture *Journal of Indian Society of Soil Science* **47 :** 611-633.

Swarup, A. and Wanjari, R.H. 2000. Three decades of All India coordinated Research Project on LTFEs to study changes in soil quality, crop productivity and sustainability IISS, Bhopal, p. 59.

Tandon, H.L.S. 1997. Proceedings. Symposium on Plant Nutrient Need, Supply, Efficiency and Policy issues: 2000-2025 (Eds. Kanwar, J.S. and Katyal, J.C.). National Academy of Agricultural Sciences, New Delhi.

Trewaves, A. 2001. Urban myths of organic farming, *Nature* **410** : 409-410.

Woese, K.D., Lange, C.B. and Bogel, K.W. 1997. A comparison of organically and conventionally grown foods-Results of a review of the relevant literature. *Journal Science Food and Agriculture* **74**: 281-293.

Wynen, E. 1994. Economics of organic farming in Australia. (In) *The Economics of Organic Farming* (Eds Lampkin, N.H. and Padel, S.), CAB, Wallingford, UK, pp. 185-199.

Yadav, R.L., Dwivedi, B.S., Shukla, A.K. and Singh, V.K. 2002. *Annual Report*, 2001-02, PDCSR, Modipuram, pp. 81-84.