Towards Organic Agriculture (2017) : 109-126
Editor : B. Gangwar and N. K. Jat
Today & Tomorrow's Printers and Publishers, New Delhi - 110 002, India

Organic Agriculture in Arid Areas

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In India, approximately 50.8 m ha land (15.8% of the country's geographical area) is arid, 123.4 m ha (37.6%) is semi-arid and 54.1 m ha (16.5%) area is in the dry sub-humid region (MoEF, 2001; NBSS&LUP, 2001). In other words, drylands cover about 228 m ha area (69% of the total geographical area of the country). The hot arid zones experience an annual rainfall between 100 and 500 mm. It comes under the influence of the sub-tropical high pressure belt extending from north-west Africa to Asia. The Indian hot arid zone occupies an area of 0.32 million km^2 forming a continuous stretch in the north western states of Rajasthan, Gujarat, Punjab, Haryana and scattered landmasses in the peninsular states of Maharashtra, Karnataka and Andhra Pradesh. An area of 70,000 km^2 is the cold desert in the country in the Ladakh region of Jammu and Kashmir State. Low and erratic rainfall, extreme temperatures (- 5.7 to 50.0°C), long sunshine duration (6.6-10 hours), low relative humidity (30%-80%) high wind velocity (9-13 kmph) and high evapo-transpiration (1600-1800 mm) are characteristic features of the region. The soils are poor in nutrients, wind erosion occurs on a mammoth scale and paucity of water is a perennial bottleneck.

Despite these hostile conditions, the region supports a large human and livestock population and a variety of flora and fauna. However, the ever increasing human and livestock population and developmental activities exert enormous pressure on the slender natural resource base of the region. A major challenge is desertification due to wind erosion/ deposition, water erosion, water logging and salinity.

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Major part of arid region is by default doing organic agriculture. The fertilizer and pesticide consumption is almost negligible in most of the arid region, which makes this area well suited for organic agriculture. The yearly consumption of NPK fertilizer is 1.34 mt @51.71 kg ha^{-1} in 2012-13 (Anonymous, 2013). Moreover the arid region farmers are doing subsistence farming by using the on-farm resources. Arid regions are full of botanicals and preparations made from these specific plants can be used for managing the pest and disease problems of the plants. A wide base of a variety of plants exist, different parts of which can be utilized in making the botanical preparations/bio-pesticide. A few to list are *Adathoda zeylanica, Agave americana, Allium sativum, Anacardium occidentale, Argemone mexicana, Azadirachta indica, Brassica campestris, Capsicum frutescens, Cassia tora, Cinnamomum verum, Ocimum sanctum, Parthenium bysterophorus, Sesamum indicum* etc. The hot arid zone of Rajasthan distributed in 12 districts of the state has livestock population of 29.08 million, which is about 50% of the total population of the state (Anonymous, 2008). This huge population of animal which is prevalent in arid region make available the organic matter in the form of dung/excreta for improving the soil health in prevalent hot conditions.

Lessons to be learned

- Water scarcity is the most limiting factor for agriculture in the arid and semi-arid tropics.
- Climate is variable and rainfall is unreliable.
- Soils in the arid regions are vulnerable and highly prone to degrade.
- Building up and protecting soil organic matter is crucial for soil fertility.
- Agroforestry has considerable potential. However, it must be carefully adapted to local climatic conditions.
- Ecosystem diversity is an important tool for managing pests and diseases.

Organic agriculture is not a “new” concept. However, it was marginalized against the large-scale chemical based farming practices that have steadily dominated food production over the last 45 years. The difference between organic agriculture and modern conventional agriculture accounts for most of the controversy with claims and counter claims surrounding organic agriculture and organic food. The comparison between organic and conventional agriculture is summarized as follows:

Factor	Organic agriculture	Conventional agriculture
Operational size	Small, marginal and inter-dependent activities	Large scale, monetarily tied to major food production
Approach	No use of external inputs, less mechanization during growing and harvesting process. Use of organic inputs *i.e.* on-farm products, green manure, biofertilizers and various enriched composts	Use of external chemical inputs *i.e.* fertilizers, pesticides and herbicides etc. and rely on mechanized production using special implements and facilities
Technology	Traditional, nature based, ecosystem friendly and sustainable	Chemical based, harmful to environment and biodiversity and nutrient depleting
Products	Nutritious and free from chemicals and heavy metals	May contain toxic residues of chemicals and heavy metals
Market	Farmers local market and through specific wholesalers and retailers and also direct to consumers	Wholesale with products distribution across large areas

Why organic agriculture in arid areas

In present scenario to restore our natural resources, to safeguard our environment and to obtain pesticide residue free vegetables, fruit, cereals, pulses, spices and other commodity. Organic and ecological farming has been observed to be feasible in the long run in term off soil fertility, stability of crop yields and economy. Though labour expenses are high in organic agriculture, the input costs especially from external sources are minimal thus effecting good returns. The population in dryland areas is currently growing at a rate of 2.3% per year which is unable to earn year round livelihood in own village. Since the organic agriculture is labour intensive and relies on local input, it provides food security and ample opportunity for local employment and proper utilization of their precious human. In terms of input supply, the arid areas are very rich in local resources suitable for supporting organic agriculture like neem (*Azadirachta indica*), Karanji (*Pongimia pinnata*), and *Calatropis* spp. are abundantly available in drylands and can be used as best sources of bio-pesticides, (Rajeshwar Rao, 1999). Similarly, minerals like rock phosphate, gypsum and lime are available naturally in large quantity in Rajasthan. These minerals will improve soil conditions and also supply plant nutrients. The Government of India task force on organic farming and several other

reviewers have identified rainfed areas and regions in north east as more suitable for organic farming in view of the low input use (GOI, 2001; Dwivedi 2005; Ramesh *et al.*, 2005).

What is organic agriculture?

As codified in the Codex Alimentarius Commission from the FAO/ WHO: Organic agriculture is a holistic 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 off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system. An organic production system is designed to a) enhance biological diversity within the whole system; b) increase soil biological activity; c) maintain long-term soil fertility; d) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources; e) rely on renewable resources in locally organized agricultural systems; f) promote the healthy use of soil, water, and air, as well as minimize all forms of pollution thereto that may result from agricultural practices (FAO, 1999).

Organic agriculture is not only a specific agricultural production system, it is also a systemic and encompassing approach to sustainable livelihoods in general, where due account is given to relevant factors of influence for sustainable development and vulnerability, be this on physical, economic, or socio-cultural levels (Eyhorn, 2007). Organic agriculture has a long tradition as a farming system and it has been adapted for many climate zones and local conditions; as a result, much and detailed situation-specific information on Organic agriculture is available. Instead of single organic manures farmer can go for combination of organic manures based on location specific availability of these organic inputs. Use of combination of organic manures over a period of time improve the soil organic matter content and soil fertility, there by sustaining the soil health and crop productivity (Ramesh *et al.*, 2009). Continuous addition of organic manures to the organic and integrated management practices resulted in a build-up of soil organic carbon and higher macro and micro-nutrients (Panwar *et al.*, 2010).

Furthermore, Organic agriculture has a recognized potential as a development strategy for rural communities (Eyhorn 2007 and Halberg *et al.*, 2006). There are several approaches of “sustainable agriculture” besides

Organic agriculture (Eyhorn *et al.*, 2003). These capture important aspects such as improved pest or water management, crop rotations, etc. The advantage of Organic agriculture is that it comprises a bundle of mutually adapted and optimized practices and is thus a whole operational farming system with a proven record of good performance. In addition, the certification available for products of Organic agriculture allows realization of higher prices. In organic agriculture use of external inputs is minimized therefore cost of production reduced to great extent. Further, due to quality production organic produce get 10-15% premium price. By these two factors farmers economic conditions improve. This has been proved by a survey of organic farms all over the India, done by Indian Institute of Soil Science, Bhopal (Ramesh *et al.*, 2010).

Presently two types of organic agriculture is prevalent in the country 1) Farmers driven organic agriculture and 2) Market driven organic agriculture.

Farmers driven organic agriculture: Organic agriculture systems can be found operating across the country under diverse climate, especially under tribal regions, hilly areas and rainfed regions where human, animal and crop husbandry are interlinked such that nutrient recycling takes primacy over use of chemicals inputs and entire food production system works satisfactorily without much dependence on external inputs. Agrochemicals use particularly fertilizer consumption is either negligible or less than 10-15 kg ha^{-1} year-1 with almost no use of pesticides in arid regions of country. Most of these organic agriculture works on the principles of diversity and integration to strengthen the eco-system services and utilizes on-farm resources in preference to off-farm inputs for meeting out the nutrient demands of the crop. Productivity levels of such systems are however very low. This is the most potential area for future growth of organic agriculture in arid regions of India.

Market driven organic agriculture: Entrepreneurs cum farmers have taken advantage of market demands for organic food and converted their farm production system from low value high volume to high value low volume. Specific food items produced organically always fetches premium price over conventional food. These farms are either practicing diversified agriculture with components of crop, fruits, vegetables etc. and animal husbandry or utilizing the organic resources available locally farm enterprises like dairy, poultry, mushroom cultivation, fishery etc. Organic agriculture therefore, is highly location specific and economic success depends upon the availability of resources and management.

Recent Trends in Organic Agriculture

Currently, India ranks 10th among the top ten countries in terms of cultivable land under organic certification. The certified area includes 10% cultivable area with 0.50 million hectares and rest 90% (4.71 million ha) is forest and wild area for collection of minor forest produces. The total area under organic certification is 5.21 million hectare (APEDA, 2013). India produced around 1.34 million tonnes of certified organic products which includes all varieties of food products namely Sugarcane, Cotton, Basmati rice, Pulses, Tea, Spices, Coffee, Oil Seeds, Fruits and their value added products. The production is not limited to the edible sector but also produces organic cotton fiber, functional food products etc. (APEDA, 2013). Among all the states, Madhya Pradesh has covered largest area under organic certification followed by Rajasthan and Uttar Pradesh. In India, Madhya Pradesh has highest area under organic agriculture (1.1 million ha or 52%), Maharashtra is at second (0.96 million ha or 33.6%) and Orissa is at third (0.67 million ha or 9.7%).

India is bestowed with lot of potential to produce all varieties of organic products due to its various agro climatic regions. An inherited tradition of organic farming in several states of the country is an added advantage. This holds the promise for organic producers to tap the market which is steadily growing (15 to 25 %) in the domestic market related to the export market. India exported 135 products during (2012-13) with the total volume of 165262 tonnes including 4985 tonnes organic textiles. The organic agri-export realization was around 374 million US $ including 160 US $ organic textiles registering a 4.38% growth over the previous year. Organic products are exported to EU, US, Switzerland, Canada, South-East Asian countries and South Africa. Oil seeds - Soybean (41%) lead among the products exported followed by Cane Sugar (26%), processed food products (14%), Basmati Rice (5%), other cereals and millets (4%), Tea (2%), Spices (1%), Dry fruits (1%) and others.

Concern and urgency to go for organic agriculture

1. Fertilizer consumption will rise to >30 million tones by 2025 AD from the current level of -25.54 mt (128.34 kg ha^{-1} in 2012-13).
2. The demand of pesticide would double from current 0.8 lakh tones
3. Expenditure for purchase of fertilizers and other chemicals will very high which will increase the cost of production.
4. Even with increase in the use of fertilizers and chemicals the rate of food production may not increase.

5. Safe food and residue free fruit and vegetables will not be available.
6. Other harmful and catastrophic effect that follows would degrade our resources lead us to permanent sickness.
7. Leached nitrates, phosphate, heavy metal and other agrochemical reached to our water bodies making them unfit for drinking.
8. Pesticide residues observed in our vegetables and fruits in many instances have reach 10 to 120 ppm.
9. Food chain has been affected by these elements and leads to imbalance to in ecosystem and deformities in man and animals.
10. Biodiversity of flora and fauna facing a threat with intense chemical agri-horti system.

Limitations and difficulties in adopting Organic Agriculture

- Organic agriculture facing the major difficulties in finding alternative to fertilizers and plant protection chemicals and pesticide.
- Pest management in organic farming is preventive only. After acute infestation of pest no alternative bio-pesticide is available.
- Package and practice to be adopted for organic production not readily available.
- Inputs for organic farming especially for disease and pest management promote or involve labour intensive technique.
- There is an immediate need to explore the indigenous traditional knowledge of agriculture and also to develop a ecologically sound system to control pest by harnessing friendly insects and birds.
- A common question asked about the organic movement related to its yield (Trewavas, 2004). “Can organic agriculture feed the world?” in answer to this question, one may ask, is conventional agriculture successfully feeding the world. Even the high input high yielding system is completely dependent on utilization of fossil fuels, which is limited (Woodword, 1996).
- Yield losses during conversion from conventional to organic farming: Conversion from the traditional low external input system of cultivation rarely results in lower yields. However, when switching from external – input – intensive form of agriculture,

the yield may decline significantly at least during the initial years of conversion, until the natural soil tilth and fertility restored. But after that the level may stabilize at a comparable level or even higher levels, depending on the efficacy of organic management and quality of organic fertilizers applied (Kasturi, 2007).

In traditional rainfed farming and in arid region (with low external inputs), the situation is different, yield are significantly lower and thus, the difference in yield between the conventional and conversion period is narrow or even higher, so these areas organic agriculture has shown the potential to increase yields.

Quality of organic products

Moreover, there is a growing demand for organic foods driven primarily by the consumer's perceptions of the quality 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 terms of organoleptic quality differences between organically and conventionally grown foods. There have been many claims that eating organic foods increases exposure to microbiological contaminants (Avery, 1998). But studies investigating these claims have no evidence to support them (Pell, 1997; Jones, 1999). Organic products shows good in quality after storage in comparison to conventional products (Reganold *et al*., 2001). It is a known fact that 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 (Warman and Harvard, 1998). There is scope to generate information on the quality of produce generated on organic farms in future studies. Organic foods are proved superior in terms of health and safety, but there is no scientific evidence to prove their superiority in terms of taste and nutrition, as most of the studies are often inconclusive.

Special benefits of organic agriculture in the arid areas

In turn, organic farming with its central focus on maintaining and improving soil health, its avoidance of pollutants, and its reliance on local inputs and labour, can materially advance the economic and ecological health of the arid regions, as well as people who live there. Semi-arid and

arid dryland soils typically are poor in water-holding capacity as well as organic matter (Sharma, 2000). In some areas, depth of the soil is another limiting factor for agricultural production. Addition of organic matter, a corner stone of organic agriculture practices, will not only improve the physical condition of these dryland soils, but also greatly improve their ability to supply balanced plant nutrients. The success of organic agriculture depends upon development and integration of various activities at farm in a way that availability of organic resources for recycling at farm in a way that availability of organic resources for recycling of nutrients is not a constraint. In drylands, there is over-exploitation of natural resources (Suresh Reddy, 2010) mainly because of inappropriate production-enhancing technologies. For example, use of tractor increases wind erosion and damages natural regeneration of trees and grasses. Over-use or improper use of canal irrigation can cause waterlogging and secondary salinization (not to mention malaria epidemics). Excessive groundwater pumping has decreased the groundwater table drastically in tube-well irrigated areas. In many locations where intensive-input agriculture systems are followed, soil fertility is decreasing and certain severe pests are becoming resistant to synthetic pesticides (Butterworth *et al.*, 2003). These are all indicators of improper land use, leading to desertification; adoption of organic farming practices suitable for drylands can help to ameliorate these conditions. To be sure, many farmers resist implementing organic systems because they fear a drop in productivity and thus income, during the years while synthetic fertilizer/pesticide use is discontinued and the soil is gradually built up by organic means. However, the longest transition periods occur where pesticide use has previously been greatest. And, because of the lack of a reliable water supply, average fertilizer use in the semi-arid, rainfed drylands (67% of India's agricultural area) is already very low (36.4 kg ha^{-1}) compared to the national average of 76.8 kg ha^{-1}. In the actual desert areas, fertilizer use is negligible (FAI, 1998). Pesticide use is also very low. Furthermore, large parts of the drylands are still categorized as "virgin," meaning no synthetic inputs have been used there to date. This makes a quick shift to organic agriculture, with no drop in productivity, much easier.

Due to climatic variability, farming systems in drylands traditionally mix crops, trees, animals, grasses etc. Such diversified systems have been found efficient in nutrient recycling and restoration of soil fertility, the basic aims of organic farming; they minimize pest incidence as well. Furthermore, India's traditional farmers possess a rich body of wisdom, based on long observation and practice, concerning soil fertility management and pest control; this can be drawn on to further strengthen

organic systems (Sharma and Goyal, 2000). These two factors will also aid the quick development of more efficient, more productive organic farming systems in these areas. Arid areas are reported to have relative advantage to go for organic agriculture primarily due to i) low level of input use, ii) shorter conversion period and iii) smaller yield reductions compared to semi-arid and humid areas.

Organic system research in arid regions

One organic system has been developed for the low rainfall areas at Central Arid Zone Research Institute in Jodhpur, and aims at developing an organic production protocol for high value –low water requiring crops (Sharma, 2011). A rotation of four crops including clusterbean and sesame in rainy season (*kharif*) and cumin and psullium in winter (*rabi*) was selected for the study. Some of the important findings are as follows:

Effect of organic treatments on sesame and clusterbean yield: Clusterbean and sesame showed improvement in yield with manure application in combination with neem cake and bio-pesticide spray. Manure application increased yield; effects being more up to 3 t ha^{-1} manure application in case of sesame (Table 1). In protection treatments neem cake application enhanced crop yield partly due to nutrition and protection both, while spray of bio-pesticide purely increased yield by controlling pest. Combination of Neem cake + bio-pesticide + manure gave maximum yield (Anonymous, 2012).

Table 1. Effect of organic treatments on yield of sesame and clusterbean (kg ha^{-1})

Treatment	Sesame				Clusterbean			
	Manure application (t ha^{-1})							
Protection level	0.0	1.5	3.0	4.5	0.0	1.5	3.0	4.5
Control	196	397	452	624	236	268	307	345
Soil application of neem cake (400 kg ha^{-1})	238	433	694	848	258	303	385	404
Biopesticide spray (3% neem oil)	208	399	577	678	320	372	432	498
Soil application of neem cake (400 kg ha^{-1}) + biopesticide (3% neem oil) spray	324	555	896	1015	335	394	460	537

Contribution of diversity for controlling pest in organic system: The perennial components ber (*Ziziphus*), henna, *Calotropis* supported a good diversity and number of beneficial insects during the kharif season. On

henna and ber plants honey bees, syrphid flies, houseflies and yellow jacket wasps, V*aspa* sp. were a major presence, the wasps being avid predators of many lepidopteran pests. Large number of bumble bees was observed on the *Calotropis* plant. Sesame crop supported good diversity of big honey bees and bumble bees during peak flowering time. Sulphur butterflies (*Catopsilia* sp.) were frequent on *Cassia* plants the eggs of these species attract trichogrammatid egg parasitoid to the field. The improvement in biodiversity due to organic system helps in pest control (Anonymous, 2012).

***Organic production system for high value crops*:** Highest cumin (539.2 kg ha^{-1}) and psyllium (803.9 kg ha^{-1}) yields were obtained in rotation with clusterbean and 4.5 t ha^{-1} manure application. Incidence of wilt and blight in cumin was 39 and 32% lower with the use of neem cake and bio-pesticide spray compared to no manure and no pest control treatment. Manuring @ 1.5, 3.0 and 4.5 t ha^{-1} increased clusterbean yield by 49.8, 77.7 and 95.5% respectively over control (Figure 1A). Early withdrawal of monsoon resulted in low sesame yield, particularly at lower level of protection and manuring (Figure 1B). There was 105.5% increase in yield from no manuring to highest level (4.5t ha-1) of manuring. Also the effect of level of pest management was conspicuous as the increase in yield was 29.7, 36.9 and 56.1% with the level of pest management p1, p2 and p3, respectively over control. In first week of September *Jassid empoasca* population was quite high (1-3 nymphs per leaf) in 4.5 t manure plot-1 at p0 i.e. no pest control as compared to p3 (soil application + spray of bio-pesticides) (Anonymous, 2014).

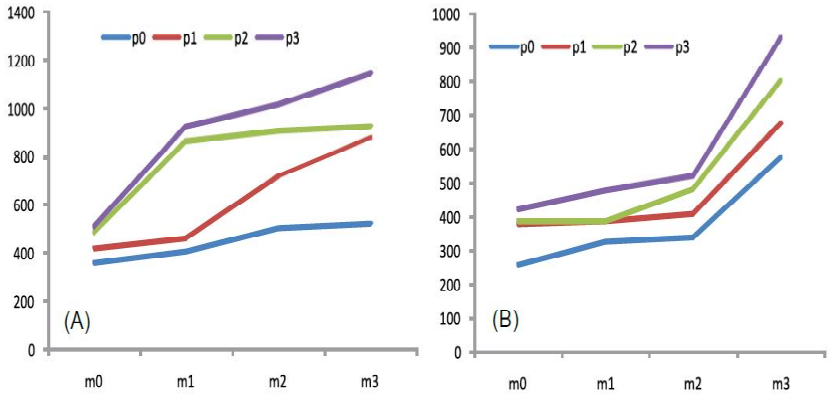

Fig 1. Effect of manuring and protection treatments on clusterbean (A) and sesame (B) seed yields (m_0 = no manure application, m_1 = manure application @1.5 t ha^{-1}, m_2 = manure application @3.0 t ha^{-1}, m_3 = manure application @4.5 t ha^{-1}, p_0 = no pest management, p_1 = soil application of neem cake @400 kg ha^{-1}, p_2 = foliar spray of biopesticide as and when required, $p_3 = p_1 + p_2$)

Improvement in soil properties: Increase in soil moisture retention with the use of organic manure was observed that helped in better growth and yield of crops (Figure 2). Similarly increase in soil organic carbon from 0.23% to 0.29% was reported after three years application of manure @5.0 t ha^{-1} (Sharma, 2011).

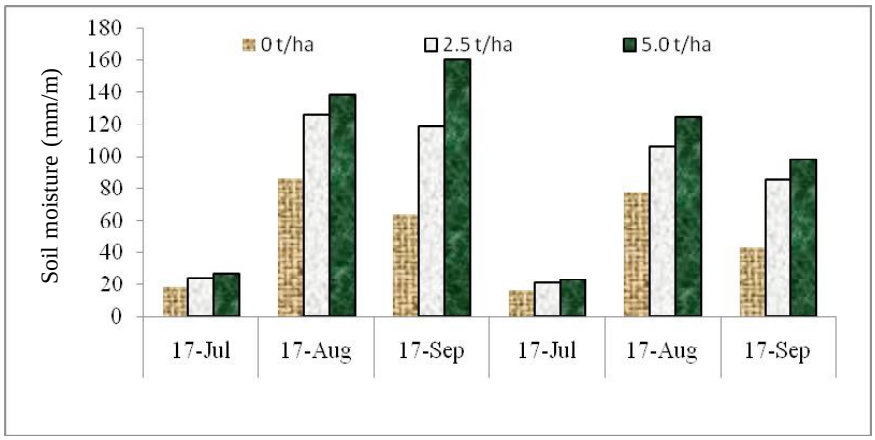

Fig. 2. Soil moisture status in sesame and clusterbean plots

Under a silvipasture system in shallow soil depth at Bhopalgarh, Jodhpur clearly indicated that grass yield increased by 20.9% and 25.2% with the application of 2.5 t ha^{-1} and 5.0 t ha^{-1} manure as compared to control (1787.5 kg ha^{-1}). Only 6.1% mortality in un-manured plants and 2% in manured plants of *Acacia senegal* (kumut) were observed during initial establishment of silvipasture system (Anonymous, 2011).

Challenges for promoting organic agriculture in arid regions.

Organic agriculture has great significance in the dryland areas also. Soil and climatic conditions in India's drylands make them particularly well suited to organic agriculture. Organic agriculture with its central focus on maintaining and improving soil health, its avoidance of pollutants, and its reliance on local inputs and labour, can materially advance the economic and ecological health of the drylands and people habitats.

In India IFOAM has fixed the standards of organic agriculture. Several government agencies and NGOs are working individually to promote and popularize these standards. Basic standard as applicable to Indian condition have been drafted by the National Standard Committee constituted by IFOAM. Indian Council of Agriculture Research have a wealth of information on organic agriculture but are unable to provide

financial support for initiating such programs. Thus, there is need for all related agencies to create integrated programs, linking the storehouses of technologies with financial institutions, in order to effectively promote organic agriculture. Since funding agencies always have the financial upper hand, they must take the lead to ensure sufficient technology backup and marketing of these products. The target-oriented implementation of organic agriculture enables efficient use of locally available resources, which is a central element of adapted technologies. Organic agriculture also presents an opportunity to achieve socioeconomic sustainability, because it is committed to:

1. Participatory technology development
2. Fair trade
3. Autonomy and self-determination.

Nevertheless, there are some critical questions towards organic agriculture from the point of view of development policies which need solutions:

1. "Brussels, Tokyo and Washington" are defining organic agriculture worldwide. Such desk-created standards may create trade barriers for some developing countries (Vogl, *et al*., 2005) particularly in arid and semi-arid regions. How can producers from poor farmers of underdeveloped/developing countries increase their participation in global standards development and how can they define their own locally adapted standards in order to increase sovereignty and identification?
2. Inspection, certification and accreditation are becoming increasingly complex and thus a greater hurdle for small farmers in developing countries. The creation of local, indigenous certification programmes and smallholder group certification, which builds on the presence of an internal control system, are important solutions. How can the standard-setters in government authorities, IFOAM, APEDA and private labelling programmes consider this issue in their discussions on harmonization? How can they include "accreditation" in current discussions on harmonization?
3. Many small farmers in poor countries do not have access to the organic market. How can authorities and market partners from private make the organic market more transparent and improve market access for small and poor farmers? How can they reduce especially non tariff trade barriers such as organic certification?

4. Income and benefits for organic trade are not always equally distributed. How can organic trade guarantee a fair share of consumers' expenditure to all participants in the value chain, especially to producers? Is certified fair trade the right and only answer to this question?

5. Organic agriculture is a know-how-intensive farming method. To be competitive, organic farmers need to experiment with new techniques, and must manage land, labour, capital and innovations quite differently from conventional farmers. How can research and development improve access for small farmers to this know-how and to specific inputs, such as seeds and biological methods of pest control?

6. Does organic agriculture reach the poorest of the poor? Are other models such as "low external input systems" more appropriate for this target-group?

7. Organic agriculture is not advocated to all the areas because of limited local input availability. Still some entrepreneurs cum farmers practicing organic agriculture by utilizing external organic inputs. Some mechanism is required for testing of such products/produce. Local inputs for organic agriculture should be encouraged not only so that local resources can be utilized but also so that village-level employment can be generated. Locally produced inputs are also, pure in their form, much less likely to be adulterated.

8. Chemical inputs are available at subsidized rates to conventional farmers but organic inputs i.e. bio-pesticide formulations, concentrated organic manures and small scale industries were not supported with any subsidy. Indeed, subsidies have been provided for setting up bio-fertilizer and vermicomposting units under NPOF and for setting up export schemes under NPOP. Additional subsidies could be provided for (i) Setting up organic input production units for composting, bio pesticides etc., (ii) Compensating organic farmers during the period of conversion to organic techniques, to compensate for yield reductions if any, (iii) Establishing village-level grading and packaging units for organic produce and (iv) Developing local and regional marketing infrastructure for organic produce in dryland areas, where regional/local food security is more important than crops for export.

9. Does cultivation of every commodity is financially sustainable in organic agriculture? Arid regions of India known for the quality production of several spices (Seed spices and chili) and medicinal plants that are in already in great demand both in national and international market. The organic production of these commodities further increases the demand.

Research gaps

ICAR institutes, State Agriculture Universities, private organization and NGO's have already done much research on various components of organic agriculture such as vermicompost, bio-pesticides, bio-fertilizers, and agro-forestry. However, more research is needed to integrate these efforts and assess their effects. There is an urgent need on all the following aspects of organic agriculture which encompasses all the aspects related to crop husbandry, livestock production, socio-economic aspects, quality, health, food security and environment, simultaneously:

- On-farm research in organic agriculture – to compare the package and practices at organic and conventional farms; to evaluate the total farm productivity and profitability; to monitor the impact on soil properties and to know the indigenous technical knowledge used on-farm for various agricultural operations.
- Soil health and link with plant health in organic and low input farming systems.
- Supporting and facilitating the innovation in the field of novel pesticides suited for organic agriculture.
- Improving the quality, the ecological, technical and economic performance of organic and low-input crop production systems by breeding.
- Use of locally available resources for production of manures and bio-pesticides for on-farm nutrient and pest management.
- Improving husbandry systems which respect to animal welfare.
- Innovation in the field of alternative or complementary medication/ veterinary treatments in organic livestock systems.
- Development of attitudes of different relevant societal groups and actors towards organic agriculture and consequences for future actions.
- Socio-economic analysis of different forms of co-operation between farms.

- Enhancing health promoting properties of organic food and optimising its organoleptic quality parameters.
- Organic/low input farming and biodiversity.
- Organic/low input farming and climate change.

Conclusion

Organic agriculture is a holistic production system run with the efficient use and recycling of locally available resources. Water shortages and vulnerable soils are the most common limiting factors for agriculture in the arid tropics. In regions where irrigation is not feasible, the only production systems that can be sustained are those that improve water efficiency and soil fertility. Due to scarcity of water and light soils areas OA is best suitable and applicable arid areas. High value crops of this region like seed spices are having great international demand if produce organically. Organic productions in arid areas not only boost the economy of this region but also sustain the productivity of natural resources. The need is to do research on crop husbandry (organic plant production), livestock production, socio-economic aspects, quality, health, food security and environment as well as technical support for quality organic production. Organic agriculture has been neglected in the agricultural policy, and therefore there is less government assistance for the promotion of organic agriculture, as it exists for the conventional agriculture in the form of subsidies, agricultural extension services and official research. Given proper encouragement, organic agriculture will progress tremendously in India, especially in the arid regions of the country and also uplift the socio-economic status of famers.

References

Anonymous. 2008. *Census of Livestock 2007*. Goverment of Rajasthan, Jaipur.

Anonymous. 2011. *CAZRI Annual Report 2010-11*. Central Arid Zone Research Institute, Jodhpur (Rajasthan), India, pp. 172.

Anonymous. 2012. *CAZRI Annual Report 2011-12*. Central Arid Zone Research Institute, Jodhpur (Rajasthan), India, pp. 132.

Anonymous. 2013. *Agricultural Statistics at a glance 2013*. Directorate of Economics & Statistics, Ministry of Agriculture, Government of India, New Delhi, pp. 319.

Anonymous. 2014. *CAZRI Annual Report 2013-14*. Central Arid Zone Research Institute, Jodhpur (Rajasthan), India, pp. 146.

APEDA. 2013. *Organic production and current scenario in India*. http://www.apeda.gov.in /apedawebsite/organic/Organic_Products.html.

Avery D. 1998. The hidden dangers of organic food, Hudson Institute. www. hudson.org.

Butterworth J, Adolph B and Suresh Reddy B. 2003. *How Farmers Manage Soil Fertility. A Guide to Support Innovation and Livelihoods*. Andhra Pradesh Rural Livelihoods Programme, Hyderabad, Natural Resources Institute, UK.

Dwivedi V. 2005. *Organic farming: Policy initiatives*. Paper presented at the National Seminar on National Policy on Promoting Organic Farming, 10-11 March, 2005, pp. 58-61.

Eyhorn F, Heeb M and Weidmann G. 2003. *IFOAM Training Manual for Organic Agriculture in the Tropics*. Bonn, Germany: International Federation of Organic Agriculture Movements (IFOAM).

Eyhorn F. 2007. *Organic Farming for Sustainable Livelihoods in Developing Countries: The Case of Cotton in India*. Ph.D. thesis. Department of Philosophy and Science, University of Bonn. http://www.zb.unibe.ch/download/eldiss/06eyhorn_f.pdf.

FAI. 1998. *Fertiliser Statistics 1997-98*. The Fertiliser Association of India, New Delhi.

FAO/WHO (Food and Agriculture Organization/World Health Organization). 1999. *Codex Alimentarius: Guidelines for the Production, Processing, Labeling and Marketing of Organically Produced Foods*. CAC/GL 32. Paris: FAO/WHO. http:// www.codexalimentarius.net/download/standards/360/CXG_032e.pdf.

GOI. 2001. *The report of the working group on organic and biodynamic farming, Planning Commission*, Government of India, pp. 25.

Halberg N, Alroe H F, Knudsen M T and Kristensen E S. 2006. *Global Development of Organic Agriculture: Challenges and Prospects* (eds). CABI Publishing, Wallingford, Oxfordshire, UK.

Jones D L. 1999. Potential health risks associated with the persistence of Escherichia coli O157 in agricultural environments. *Soil Use Management* **15**: 76–83.

Kasturi Das. 2007. Towards a smoother transition to organic farming, *Economic and Political Weekly*, June 16.

Lampkin N. 1990. *Organic Farming*, Farming Press, Ipswich, UK, pp. 715.

MoEF. 2001. India: National Action Programme to Combat Desertification in the Context of United Nations Convention to Combat Desertification (UNCCD). *Volume I: Status of Desertification*. Ministry of Environment & Forests, Government of India, New Delhi, pp, 294.

NBSS&LUP. 2001. *Agro-ecological Sub-regions of India for Planning and Development*. NBSS&LUP Publication, Nagpur.

Panwar N R, Ramesh P, Singh A B and Ramana S. 2010. Influence of organic, chemical and integrated management practices on soil organic carbon and soil nutrient status. *Communications in Soil Science and Plant Analysis* **41**: 1073-1083.

Pell A N. 1997. Manure and microbes: Public and animal health problem? *Journal of Dairy Science* **80**: 2673–2681.

Rajeshwar Rao B R. 1999. Medicinal plants for dry areas. *Sustainable alternate land use systems for drylands* (eds.), Singh R P and Osman M, pp 139-156. Oriental Enterprises, Dehradun (India).

Ramesh P, Mohan Singh and Subba Rao A. 2005. *Organic farming: Its relevance to the Indian context. Current Science* **88**: 561-568.

Ramesh P, Panwar N R, Singh A B, Ramana S and Subba Rao A. 2009. Impact of organic–manure combinations on the productivity and soil quality in different cropping systems in central India. *Journal of Plant Nutrition and Soil Science* **172**: 577–585.

Ramesh P, Panwar N R, Singh A B, Ramana S, Yadav S K, Shrivastava R and Subbarao A. 2010. Status of organic farming in India. *Current Science* **98**:1190-1194.

Reganold J P, Glover J D, Andrews P K and Hinman H R. 2001. Sustainability of three apple production systems. *Nature* **410**: 926–930.

Sharma A K and Goyal R K. 2000. Addition in tradition: Agroforestry in the arid zone of India. *LEISA India* **2**:19-20.

Sharma A K. 2000. Sustainability through simplicity: Rainwater conservation in the arid zone of India. *Indian Water Resources Quarterly* **48**: 5-10.

Sharma A K. 2011. Organic System in low rainfall areas for climate resilience and returns. Organic Farming Newsletter **7**(4): 3-9. NCOF, India. Available at http:// www.orgprints. org/20805.

Suresh Reddy B. 2010. Organic Farming: Status, Issues and Prospects – *A Review. Agricultural Economics Research Review* **23**: 343-358.

Trewavas A. 2004. A critical assessment of organic agriculture and food assertions with particular respect to the UK and the potential environmental benefits of no till agriculture. *Crop Protection* **23**: 757-781.

Vogl C, Kilcher L and Schmidt H. 2005. Are standards and regulations of organic farming moving away from small farmers' knowledge? *Journal of Sustainable Agriculture* **26**: 5-26.

Warman P R and Harvard K A. 1998. Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweetcorn. *Agriculture Ecosystem and Environment* **68**: 207–216.

Woodward L. 1996. Can Organic Farming Feed the World? Elm Farm Research Centre, Newbury, UK.