

Organic farming to achieve resilience and better food quality

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Sustainability of food production systems in India linked with decline in soil health, loss of productivity, soil infertility, desertification, reduced agro-diversity, pesticide pollution and emerging pest-resistance have raised serious concerns about the future of the current chemical and input-intensive model. Problems are bound to grow across the country with the current approach. The climate emergency has further aggravated the farm situation due to increased incidence of crop losses related to extreme weather events. All these assessments highlighted the strong need for major transformation of food production systems and point towards agro-ecology as the solution. The empirical evidences, could prove that the integrated organic management systems underpinning ecological principles are as productive as present conventional systems and even superior under the more fragile and tough environments (rainfed and hilly areas). In India, organic agriculture emerged as more resilient sustainable food production system which promotes agro-ecosystem health, self-reliance and brings more prosperity to our farmer.

Keywords: Agroecology, Food production, Organic agriculture, Sustainability

ORGANIC agriculture is an integrated food production management system, which promotes and enhances agro-eco-system health, including bio-diversity, biological cycles and soil biological activity. It emphasizes the use of natural inputs (mineral and products derived from plants) and management practices in preference to the use of off-farm inputs (synthetic fertilizers and pesticides) taking into account that regional conditions require locally adapted systems. This is accomplished by using, wherever possible, agronomic, biological and mechanical methods. The goal of organic agriculture is to contribute to the enhancement of sustainability and to achieve greater resilience in the agro-ecology.

Organic farming – A self-reliant alternate farming system

Globally, the International Assessment of Agricultural Knowledge, Science and Technology

for Development, United Nations Committee on World Food Security's and High Level Panel of Experts on Food Security and Nutrition and Food and Agriculture Organization highlighted the strong need for major transformation of food systems and point toward agro-ecology as the

solution.

The Central Government has been promoting organic farming through *Paramparagat Krishi Vikas Yojana* and Mission Organic Value Chain Development for North Eastern Region Mission for Integrated Development of Horticulture.



Fig. 1. Dr Babalad gliricidia leaf mulch in cotton.

Karnataka is the first state to bring organic farming policy. Sikkim became India's first 100% organic state. Even though India is being ranked first in the world with respect to number of organic farmers (1.9 million), it has only 2% of net sown area and 1.3% of total holdings are organically farmed. Total area under organic certification process (registered under National Programme for Organic Production) is 4.34 million ha (2020-21) showing increasing trend which is 20%. This includes 2.66 million ha cultivable area (2% of the 140.1 million ha net sown area) and another 1.68 million ha of wild forest collection. India produced around 3.50 million MT (2020-21) of certified organic products which includes all varieties of food products. The production is not limited to the edible sector but also produces organic cotton fibre, functional food products etc. Organic products are exported to USA, European Union, Canada, Great Britain, Korea Republic, Israel, Switzerland, Ecuador, Vietnam, Australia etc. In terms of export value realization, processed foods including soya meal (57%) lead among the products followed by oilseeds (9%), cereals and millets (7%), plantation crop products such as tea and coffee (6%), spices and condiments (5%), medicinal plants (5%), dry fruits (3%), sugar (3%), and others.

Transition from conventional to organic farming

A transition from conventional to organic farming gives more emphasis to soil building practices, increase crop and animal diversity and enhance natural processes on the farm. Organic farming introduces a change in the farming systems and aims at maximum production in the cropping pattern and optimal utilization of resources. Transition can take 2–3 years, depending on the product and government regulations. During this period, organic production methods must be



Fig. 2. Dr. Babalad Gliricidia live hedge row and soybean crop

observed. The transitory products from second year could be sold as organic in-transition. Switch to organic production may be more advantageous for small-scale farmers in developing countries.

Soil regeneration and fertility management

Management of soil fertility is one of the major challenges faced by the organic farmer. Soil fertility needs to consider physical condition, nutrient status and biological 'health' of the soil. Optimizing the soil physical condition by management of soil organic matter and reduced tillage practices benefit by improving soil structure, fertility, root growth, infiltration and reduced erosion. Frequent return of organic matter to the soil (e.g. legumes, manure and crop residues) provides nutrients (particularly N and P) and benefits soil fertility, soil physical condition and biological activity. Intercropping with legumes can introduce N into the soil, whilst deep-rooted plants can make nutrients in the subsoil available. Introduce cover crops and catch crops wherever possible which provide fresh organic matter, can hold mainly nitrogen and other

nutrients that might otherwise be lost by leaching. The soil organic carbon was significantly higher (60%) under organic management (0.64) over initial value of 0.41 and was found to be significantly superior over integrated (0.58) and inorganic (0.51) nutrient management practices in legume based cropping system over a period of 8 years (2004-12) under ICAR-Network Project on Organic Farming (NPOF) at UAS, Dharwad (Table 1).

Crop residues as amendment

There is a substantial potential for local crop residues to be recycled as soil amendments. Crop residue amendments over time improve SOC, soil structure and alleviate negative effects of soil compaction. In semi-arid regions, crop residue mulches can reduce evaporation, increase available water content and improve water-use efficiency. In long term studies under NPOF at UAS, Dharwad, improvement in soil organic carbon, available nutrients and soil structure by *in-situ* incorporation of maize, cotton and pigeonpea residues, application of gliricidia green leaf manure and organic manures were observed (Fig. 1).

Soil organic carbon

Soil organic carbon (SOC) plays a critical role in sustaining organic production systems by enhancing soil fertility and maintaining productivity. SOC improves soil structure and water holding capacity while providing substrates for soil biota. While conventional agricultural

Table 1. Effect of long term organic management on soil available nutrients

Nutrient management	Organic Carbon (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)
100% organic with legume rotation	0.64	283.0	33.3	378.8	24.89
Integrated (INM) with legume rotation	0.58	279.8	28.7	352.4	24.52
100% inorganic with legume rotation	0.51	259.1	24.5	330.4	23.81
Initial (2004-05)	0.40	250.00	23.00	330.0	20.00

practices are known to deplete SOC, strategies to manage organic matter such as residue retention can reduce the severity of carbon losses. Application of farm yard manure, composts, vermicompost and other animal manures improved plant available nitrogen fractions in the soil, due to the release of nitrogen through their decomposition.

Soil biolife and their eco-services

The living organisms in the soil are the core of organic farming. Though earthworms are the most visible soil organisms and perform an important role in organic matter breakdown, it is the other macroscopic and microscopic organisms that are the key players. Most of the activities of soil organisms are beneficial and it should be one of the aims of the organic farmer to stimulate soil biological activity. Soil microorganisms provide better living conditions (good soil structure), food (energy) source (fresh organic matter) and optimum moisture conditions. Dehydrogenase, alkaline phosphatase and microbial biomass carbon were higher in organic soils by 52.3%, 28.4% and 34.4% respectively compared to the conventional farms (Table 2). In the organically managed soils, both



Fig. 3. Dr. Babalad Jeevamruth preparation

macronutrients (N, P and K) and micronutrients (Zn, Cu, Fe, Mn) were available in larger quantities compared to the conventional soils. The long term studies under NPOF at UAS, Dharwad indicated that the soil microflora (bacteria, fungi and actinomycetes) and enzymatic activity (dehydrogenase and phosphatase) were significantly superior under organic management system as compared to inorganic management. The organic carbon content which was found to vary with the management practice is known to influence the microbial population and soil biological activities.

Nitrogen

The nitrogen dynamics in soil is also governed by the soil organic

matter. Application of organic manures and green manures improve plant available nitrogen fraction in soil due to the greater release of nitrogen through the decomposition. Hedge rows of gliricidia, subabul, sesbania, desmenthus etc., and their alleys help in capturing N and prevent it from being leached (Fig. 2). Green manures/legume cover crops those that fix N and provide a boost to soil fertility. Choice is dependent on purpose for instance, some are good at capturing N, and others are good N fixers. Other factors

to consider are the time of year involved, soil type, climate, rate of development, persistence, potential as a subsequent volunteer weed and seed cost. Release of N is, again, an important consideration. The mature the crop is, the slower will be the N release. Develop crop rotations that take account of the nitrogen supply from legumes. Match 'fertility building' and 'fertility depleting' phases of rotations to ensure enough N is available in the rotation to sustain the levels of yield that are anticipated. Crop sequencing in the rotation should aim to match N release and timing to crop uptake demands.

Phosphorus

Soil phosphorus supply relies both on microbial activity to convert

Table 2. Basic parameters of soil and enzymatic activity under organic and conventional systems – a long term study (17 years)

Parameter	Organic farming						Conventional farming					
	Min.	Max.	Med.	SD	CV	Mean (n=24)	Min	Max	Med	SD	CV	Mean (n=24)
pH (1M KCl)	4.52	6.82	6.06	0.53	8.80	6.04	2.65	7.85	4.79	1.32	27.4	4.82
TOC	8.80	36.2	11.4	6.92	48.7	14.2	6.50	24.0	9.70	3.73	36.2	10.3
TN	0.80	3.90	1.10	0.71	5.07	1.42	0.70	2.4	1.00	0.38	34.5	1.10
DEH	0.25	0.66	0.41	0.12	28.6	0.42	0.21	0.48	0.29	0.07	22.6	0.31
CAT	0.05	0.16	0.08	0.03	33.3	0.09	0.03	0.11	0.08	0.02	28.6	0.07
AIP	0.63	2.21	1.01	0.41	36.6	1.12	0.41	1.48	0.71	0.29	37.2	0.78
AcP	1.08	3.46	1.90	0.59	29.9	1.97	0.79	3.22	1.62	0.52	30.8	1.69
EEGRSP	0.41	2.12	1.05	0.341	33.1	1.03	0.42	1.17	0.87	0.247	31.3	0.79
DOC	70.3	138	93.1	18.46	19.0	136	89.9	251	118	42.64	31.3	97.1
DON	19.9	47.1	30.3	7.82	25.1	31.2	17.7	46.9	22.0	7.93	30.5	26.0

TOC, total organic carbon (g/kg); TN, total nitrogen (g/kg); EEGRSP, easily extractable glomalin-related soil protein (g kg⁻¹); DOC, dissolved organic carbon (g/kg); DON, dissolved organic nitrogen (g/kg); DEH, Dehydrogenases (mg TPF/kg/24h); CAT, Catalase (mg H₂O₂/g/min); AIP, alkaline phosphatase and AcP-acid Phosphatase (mMpNP/kg/h); Med-median; SD, standard deviation; CV, coefficient of variation.



Fig. 4. Dr Babalad organic soybean (ICAR, NPOF trial).

(‘mineralise’) organic P sources and on chemical transformations within the soil. The fraction associated with soil organic matter accounts for 30 to 50% of the total P in most soils, with the remainder present as inorganic forms. Most P compounds in soil are either insoluble or poorly soluble. The large reserves of P that have accumulated under conventionally managed fields may act as a source of P when farms are first converted to a less-intensive, organic management. However, the conversion of poorly soluble P compounds into crop available P is dependent on the maintenance of a neutral to slightly acidic pH.

Potassium

Potassium application is an agronomic practice used to increase plant tolerance to temporary water shortages as it assists plants in responding to short-term water deficit. However, increased SOM content has been associated with reduced K fixation and improved K availability attributed to interlayer exchange and organic molecule adsorption sites. Appropriate application of K-rich residues may assist in saturating K-fixing soils. While organic sources of K are capable of increasing solution, exchangeable, and fixed K. Increase in soil exchangeable K ($\times K$) is most commonly reported due to the relevance of XK for changes in plant availability. Careful management of nutrients to replace the large removals of K from cereal cropping

systems is particularly important in organic systems, where there is great reliance on the K recycled by crop residues.

Productivity potential of organic agriculture

Since the advent of organic farming in recent years, there had been concerns on the production potential of the system. The empirical evidences indicated that the effect of organic management practice is significant. During conversion

period, the productive performance of organic crop farms is lower compared to the conventional farms. However, it also suggests that performance gap has decreased over time. The results of long term experiments during last 10-15 years from world over have proved otherwise. In irrigated conditions, organic farming may be yielding 5-12% less than their conventional counterparts but under rain-fed and water deficit conditions, organic system yields 7 to 15% more.

The location specific organic farming practices in different crops and cropping systems are being addressed under NPOF since 2004-05. The long term studies under NPOF centre at UAS, Dharwad centre has made a significant contribution by standardizing the organic farming practices in 17 important crops and cropping systems of this region. The performance of sorghum, maize, rice, rainfed wheat, pearl millet, pigeonpea, greengram, chickpea, groundnut, soybean, chilli and cotton in a cropping system, consistently showed that the organic farming practices on ecological principles are as productive

Table 3. Yield of crops in four sequence cropping systems (2009-2012 pooled)

Farming system	Groundnut	Sorghum	Soybean	Durum wheat	Maize	Chickpea
Organic	3789	1220	2602	1127	4611	1098
Integrated	3587	1194	2311	1038	4486	1013
RPP*	3545	1160	2376	1032	4509	1036
Inorganic	3018	1002	1804	857	3673	849
LSD (0.05)	303	92	269	71	306	101

RPP, Recommended package of practices (ICAR, NPOF, UAS, Dharwad)



Fig. 5. Dr Babalad pigeonpea-green gram inter cropping system under organic farming.



Fig. 6. Dr. Babalad vermicompost unit.

as conventional practices and superior over inorganic alone (Table 3). Similar study conducted under ICAR, Network Project on Organic Farming at different centres, yield levels under organic system were noted lower in the initial years and yields attained comparable outputs by 4th and 5th years.

Institute of Organic Agriculture and the Swiss Federal Research Station for Agroecology and Agriculture found that yields under organic management system were less by about 20% but fertilizer, energy and pesticide use were less by 34%, 53% and 97% respectively as compared to conventional system. A study at Iowa State University assessed the agro-ecosystem performance of farms and found the yield was slightly lower (organic corn and soybean yield averaged 91.8% and 99.6% of conventional respectively) initially in organic plots but in fourth year, organic yield exceeded conventional for both corn and soybean crops. Thirty years of Farming System trial at Rodale Institute of Organic Farming, showed organic corn yields were 31% higher than conventional in years of drought. These yields were remarkable when compared to genetically engineered 'drought tolerant' varieties which saw increases of only 6.7% to 13.3% over conventional (non-drought resistant)

varieties.

Profitability

The difference between organic and conventional systems can be $\pm 10-20\%$. Positive factors for organic production are lower operating costs, premium price and shorter supply chain. NPOF trials indicated that in legume based cropping systems organic and integrated systems produced higher returns than the inorganic system mainly due to higher productivity and on farm recycling of inputs and other resources. With an average price premium 20-25% and lower production costs, the organic systems achieve greater net returns at lower risk. The studies on the impact of organic farming on economics of sugarcane cultivation in Maharashtra showed that the organic farming resulted in 15.63% higher profits than the conventional farming.

Consumers' perception and quality food

The key factors affecting consumer demand for organic food is the health consciousness and often considered to be chemical-free. Moreover, organic food often associated with fair trade labels that embed an ethic of social justice into the production system itself. It should be noted that there are multiple, organic inspired variants like jaivik, biodynamic, regenerative, natural, diversified, etc.,

though some of these systems may lack the heft of formal governmental standards and certification approval.

Various quality parameters like ascorbic acid, beta carotene, titrable acidity, soluble solids, and insoluble solids and colour value were higher for organic tomatoes applied with vermicompost along with other organic sources. In pomegranate juice, the higher pulp weight, dry matter content, ascorbic acid, lycopene content was observed and retained marketable fruits quality up to 30 days after storage grown with organic practices. In banana crop, organic management enhanced quality attributes (TSS – 23.23%, acidity – 0.82%, ascorbic acid – 12.92 mg/100 g, non-reducing and total sugars - 6.06 and 14.92%) and shelf life (14.03 days).

SUMMARY

As food security is not only a component of increased productivity, it also encompasses other issues of policies, trade, prices and environmental and resource use optimization. Organic farming as we see today is not the age-old traditional farming, it is a science based ecological intensification of cropping system with efficient management of on-farm resources, to achieve greater resilience in soil health and with comparable productivity of high quality food. Interdisciplinary research is needed in order to fully understand the likelihood of grower adoption and to support management recommendations that are deliberately tailored to unique agro-ecosystem contexts. With adequate policy support, organic agriculture can play a greater role in furthering the cause of food security and nutritional security in the country.

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