OF SOILS, SUBSIDIES & SURVIVAL

A REPORT ON LIVING SOILS

GREENPEACE
ग्रीनपीस

CONTENTS

Introduction 03

Soils: Indicators of Life and Their Role in Agriculture 06

Soil Health: Role of Organic Matter and Ecological Fertilisation 14

Soil Health: Impact of Chemical Fertilisation 28

Soil Health: Central Government Policies and Schemes 36

Way forward: An Umbrella Policy for Ecological Fertilisation 50

References 54

Appendix 59

Printed on 100% recycled paper

LIVINGSOILS

REPORT PRODUCED BY Greenpeace India Society, February 2011

LEAD AUTHORS

Dr. O P Rupela, Former Scientist
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Andhra Pradesh

Gopikrishna SR, Sustainable Agriculture Campaigner, Greenpeace India

SOCIAL AUDIT TEAM

Coordination:

Rajesh Krishnan, Jai Krishna, Kapil Mishra, Shivani Shah, Sunil Parbhakar, Prarthana Banikya,
Shoumendra Malik, Keshab Hazarika, Bidyamani, and Gopikrishna SR

Stakeholder Survey:

Assam - Tapan Sharma, Lakheswar Nath, Jayanta Saikia and Hitesh Deka
Karnataka - Thara Rao, Suvarna, Sridhar.N, Madhava H.S, H.Dinesh, Pavithra, K.S. Prem Nath and Prabhakar.P
Madhya Pradesh - P.S. Vijay Shankar, Bharat Kumar, Rajaram, Devkaran Chauhan, Mohan, Pappu, Sikdar, Mahendra, Mukesh, Hare Singh
Orissa - Dr G.B. Nath, SharadaKanta Dash, Bikash Palsania, Dasharathi Behera, Kanhu Charan Mahakur
Punjab - Dr. Manpreet Brar, Gurdeep Singh, Jagtar Singh and Sukhvinder Singh.

Data compilation and analysis (National):

Rishi Raj Varma, Xavier Institute of Management, Bhubaneswar (XIMB), Orissa

PROOF READING: Shivani Shah

PHOTOGRAPHY: Vivek M, Ravi Choudhary, Jai Krishna, Jabbar Khan

DESIGN & LAYOUT: Shagun Mitra & Reema Ganguly

ACKNOWLEDGEMENTS:

Assam - Rashtriya Gramin Vikas Nidhi (Guwahati) and Sipachar Diamond Club (Darrang)
Karnataka - Environmental Study Centre (Shimoga), Spandana (Shimoga) and Sustainable Organic Initiatives for Livelihoods, SOIL (Bangalore)
Madhya Pradesh - Samaj Pragati Sahyog (Dewas)
Orissa - Paschim Odisha Krishak Sanghatan Samanvay Samiti (Sambalpur)
Punjab - Kheti Virasat Mission (Bhatinda)

Residents of the villages in which survey, focus group discussions and Jansunvais were organised.
All the stakeholders of agriculture who participated in the Jansunvais in their respective locations and voiced their views.
All participants of the national workshop on Soil Health Management and Support Systems, New Delhi, 13 December, 2010.

FOR MORE INFORMATION, PLEASE CONTACT:

Gopikrishna SR, Sustainable Agriculture Campaigner, Greenpeace India.
Mob: +91 99008 97341 Email: gkrishna@greenpeace.org

INTRODUCTION

Soil is one of the basic natural resources that supports life on Earth. It is an ecosystem, which is home to several living organisms, which makes soil alive and gives it good structure and texture. A living soil ecosystem nurtures and nourishes plants by providing a healthy medium to take roots and through a steady supply of nutrients.

Use of chemical fertilisers disturbs the natural soil ecosystem and its indiscriminate use has resulted in the degradation of soil. Degraded/dead soils lead to poor plant growth and hence reduced productivity of an agricultural system. Chemical fertiliser subsidy policy of successive governments at the Centre from the late 70s has been a major driver that catalysed and is still catalysing indiscriminate use of chemical fertilisers. A total neglect of ecological/organic fertilisation by policy makers, extension officers and farmers during the peak Green Revolution period (70s to 80s) also added to soil health crisis (Roy et al, 2009).

Acknowledging the crisis, the Union Government brought in a new Nutrient Based Subsidy (NBS) policy. But it continues to support chemical fertilisers only. Hence, questions were raised by think tanks and practitioners about its capability to solve the crisis, as it has been widely accepted that organic matter, both in terms of quantity and quality, is critical to rejuvenate the degraded soils. (Mishra et al, 2010) The Government on its part was quite vocal about the schemes that have components to support organic fertilisation, and they believe that NBS along with these schemes that support organic and bio-fertilisers can solve the crisis. (PIB release, 2010)

It is in this context that Greenpeace India launched the “Living Soils” campaign. As part of the campaign social audits on Central Government’s Soil Health Management policies and schemes, were organised in selected districts of Assam, Orissa, Karnataka, Madhya Pradesh and Punjab from July to November 2010. A stakeholder survey interviewing 1000 farmers (200 each from a selected district in each State) was done as a first step to bring out the perceptions and observations of the farmers on soil health and also to understand the impact of soil health management policies in these locations. The social audit team comprised of experts, farmer leaders and civil group representatives from the location. The findings were presented in Jansunvais (public hearings) organised in each location along with local groups, where all the relevant stakeholders in that region participated. The compiled findings and recommendations were presented and were discussed at a national workshop in Delhi on 13th December, 2010.

This report is an effort to create the foundation for the understanding on living soils, which is essential for sustaining agriculture. The inferences have been arrived at by pooling together scientific literature and farmers’ views on this issue. It is a reality that when studying issues related to soil health or while making policies related to it, the farmer, who is the most important stakeholder, is seldom consulted. We have given special attention to rectify this grave inadequacy in our academic processes like the social surveys, public hearings and workshops and in this final report as well. Every section has a component from the existing scientific literature available and another one on what the farmers’ opinion on the same are.

The report, in the first chapter attempts to define a living and healthy soil and tries to list down the vital indicators for that. This is followed by a chapter on the need for ecological fertilisation of soil. The third chapter looks at the current situation of intensive synthetic fertiliser use and assesses the impacts of it in the Indian context. The fourth chapter critically analyses Central Government policies and schemes on soil health management in the light of this understanding. The fifth and final one presents a way forward. This chapter is a compilation of the recommendations from public hearings in the five states where the social audits were conducted and also the recommendations from the National Workshop held in New Delhi on 13th December, 2010.

ONE
DEFINING LIVING SOILS

SOILS: INDICATORS OF LIFE AND THEIR ROLE IN AGRICULTURE

When one looks at the soil, it may seem like lifeless clay, sand and pebbles. But in fact, the soil is very much alive. Many millions of small organisms live in soil. Some of the organisms are large enough to be seen, such as earthworms and small insects[1]. Living roots can also be seen in the soil. But, most living things in the soil are so small that one needs a microscope to be able to see them. These microscopic organisms include nematodes[2], bacteria, actinomycetes and fungi. A majority of soil animals are also microscopic (Coleman and Crossley 1996).

Living components of soil and their role in agriculture:

Living organisms in the soil play a critical role in maintaining soil health and fertility. Some of the beneficial functions are listed below.

a) Breaking down dead leaves and other plant debris, converting them into organic matter and making their nutrients available for the plants.

b) Burrowing in the soil to make small tunnels that increase aeration and water-movement; causing tiny soil particles to stick together, opening up spaces that allow water and air to enter the soil more easily.

c) Protecting plant roots from harmful organisms. Serving as food for predators such as beetles.

Most arthropods and nematodes, inhabiting the soil, are beneficial. Bacterivores and fungivores are beneficial in nutrient recycling. All have important roles in improving soil structure. But interestingly, while much attention and investments in agricultural research has been made on harmful ones and managing (controlling) them with agro-chemicals, there is sparse and miniscule focus on maintaining the beneficial living organisms in the soil.

Majority of the soil micro-organisms (fungi, actinomycetes, bacteria) are agriculturally beneficial, particularly for plant nutrient recycling. Some micro-organisms are endophytes i.e. they live inside the plant system and largely gain entry through roots. For example, rhizobia (a group of soil bacteria that enter plants and help them access nitrogen from air, a process called biological nitrogen fixation - BNF) form special structures on roots of legumes called nodules and can potentially meet 80% of the nitrogen needs of a plant. Rhizobia have also been reported from rice roots and stems, and benefit rice plants (Chi et al. 2005).

Some beneficial fungi infect plant-roots (mycorrhizae and endomycorrhizae) and effectively mobilise nutrients and moisture for plants, and thus help them tolerate drought. Indeed, some micro-organisms are harmful and cause diseases of plants. But these can be managed by some other beneficial micro-organisms and extracts of some plants (botanicals).

A large population of bacteria lives on the surface of plant roots (generally referred to as 'rhizobacteria') and are believed to play important roles in helping plants manage soil pests that can potentially harm them and for accessing nutrients (Ramamoorthy et al. 2001; Sikora 1997).

Several mites, nematodes, insects, arachnids (spiders) inhabiting soils have been reported as predators or parasites of plant pests (Lacey et al. 2001), an area not much explored and applied for agricultural production.

[1]Arthropods - are invertebrate animals having an external skeleton, a segmented body and jointed appendages, and includes insects, arachnids, crustaceans, and others.
[2]Nematodes - roundworms (phylum Nematoda), the most diverse phylum of pseudocoelomates, that have a digestive system that is like a tube with openings at both ends.

It has been estimated that under favourable conditions, one tenth of organic matter in a soil is made up of soil animals. Thus a 10cm of a hectare of soil with 1% organic matter contains roughly 1500 kg of soil fauna (Rao and Patra. 2009).

More than 90% of the planet's genetic biodiversity is found in soils. A gram of soil can contain as many as 10,000 different species. Current estimates for the number of prokaryotes, which include bacteria and Archaea, range from 300,000 to one million species. However less than 1% of the micro organisms have actually been isolated and identified (Rao, 2007). We are not aware of the functions of the vast diversity in the unculturable fraction which presents a challenge for researchers (Keller and Zengler, 2004).

Farmers' Perception

Stakeholder surveys and focus group discussions conducted as part of the Living Soils social audits indicate that farmers believe that soil is an ecosystem that supports different life forms. They are also able to identify the major living organisms in the soil, though their understanding is mostly restricted to the organisms, which can be seen through naked eyes. 88% of the surveyed farmers strongly believed that soil has life (Chart 1.1). 98.5% of the surveyed farmers considered presence of earthworms as an indicator of life in soil. Considerable number of farmers also suggested that they have observed insects, worms, algae etc. (Chart 1.2).

Chart 1.1
Soil has life?

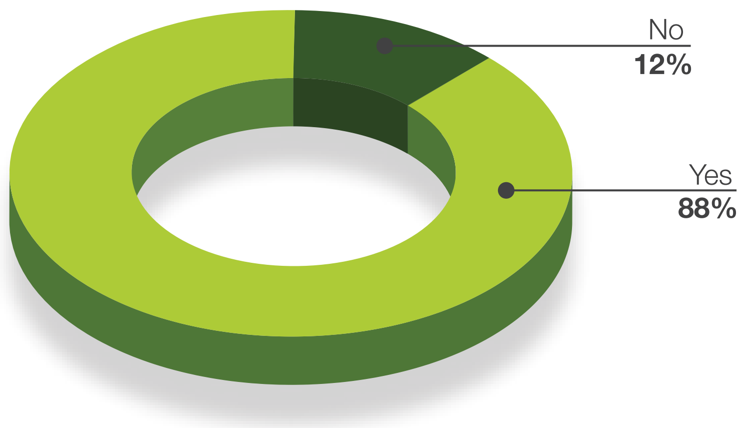


Chart 1.2
Different kinds of living organisms in soil observed by farmers

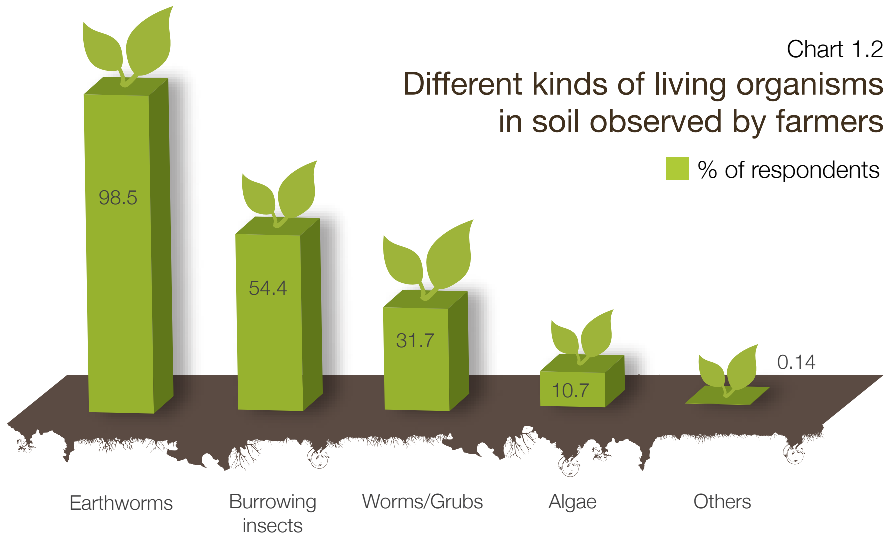


Image: Healthy soil nurtures and nourishes plants.

Image: Healthy soil is rich in organic matter and has living organisms.

Non-living components of soil and their role in agriculture

In addition to living organisms, soil is made up of three non-living things - rock particles (pebbles, sand, silt and clay), water and gases- that make up most of the volume and weight of the soil. The rock particles are derived from the mother-rock below the surface of the soil and are formed over centuries. Chemical properties of a soil are largely determined by the rock beneath. Water is found in three places in the soil:

(i) Stuck to the surfaces of the particles of rock,
(ii) Filling some of the spaces between the particles, and
(iii) Stored in the organic matter as in a sponge.

All the living things in soil, including plant roots, need water to survive. Gases (oxygen, carbon-dioxide, nitrogen and others) are in the spaces between the particles that are not filled by water. Plant roots, and most other living things in the soil, need oxygen to survive. If the soil is flooded, and all the spaces in the soil are filled with water, most plants will die (rice is an exception). Dead organic matter is another important non-living component of the soil (including detritus of plants) and serves as food for micro-organisms and macro-fauna (Alexandra and de Bruyn 1997).

Defining and understanding soil health

Soil health is defined as the capacity of soil to function. Functions of soil include sustaining biological productivity, regulating water flow, storing and cycling nutrients, and filtering, buffering, and transforming organic and inorganic materials. Soil also functions as a habitat and genetic reserve for numerous organisms. Consequently, management strategies that optimise multiple soil-functions have a greater potential for improving soil-health than management strategies that focus on a single function (Doran and Zeiss 2000).

Soil health is not a new concept. Farmers in many countries, including India, were aware of the importance of soil health for agricultural prosperity thousands of years ago, and reflected this awareness in their treatises on farm management. As the science of agriculture developed, plant nutrients were identified as essential components of soil-health, at least with respect to crop productivity. This resulted in a paradigm of plant-nutrition and soil-management that relied heavily on the use of artificial fertilisers and intensive tillage.

But over the years, increasing concern over agriculture's impact on the environment, including soil degradation, and the resultant threat to productivity has created renewed interest in soil health. Efforts to define soil-health in the context of multiple soil-functions began in 1977 (Warkentin and Fletcher, 1977), and were followed by more formalised definitions (Larson and Pierce, 1991; Karlen et al., 1997), selection of indicators (Doran and Parkin, 1994), and specific strategies to enhance soil-health (Doran et al., 1996).

Soil health indicators

The quality of soil is rather dynamic and can affect the sustainability and productivity of land use. It is the end-product of soil degradation or conserving processes and is controlled by chemical, physical, and biological components of soil and their interactions (Papendick and Parr, 1992). Physical and chemical properties are shaped by biological activity which, in turn, is enhanced or limited by chemical and physical condition. (Rao, 2007)

Indicators, however, vary according to the location, and the level of sophistication at which measurements are likely to be made (Riley, 2001). Therefore, it is not possible to develop a single short list which is suitable for all purposes. Also, several authors emphasised the range of likely indicators rather than the use of any single indicator.

Image: Vermicompost is a good source of plant nutrients.

BIOLOGICAL INDICATORS

Identification of biological indicators of soil-quality is reported to be critically important by several authors (Doran and Parkin, 1994; Abawi and Widmer, 2000) because soil-quality is strongly influenced by micro-biological mediated processes (nutrient cycling, nutrient capacity, aggregate stability). Of particular importance is to identify those components that rapidly respond to changes in soil-quality (Romig et al., 1995). Of the several soil biological quality parameters, Rao and Manna (2005) opined that 4 parameters - microbial bio-mass carbon, active (particulate) organic matter, soil respiration and N mineralisation potential - are sufficient to give a reliable picture of soil's biological quality.

CHEMICAL INDICATORS

Chemical indicators include soil organic matter, pH, electrical conductivity and extractable plant nutrients. Soil fertility, nutrient restoring and recycling, and environmental quality issues are directly related with chemical indicators (Rao, 2007).

All types of plant biomass have all the 33 plus elements (3 major nutrients NPK, 12 micro-elements and 18 trace elements – at least) needed for plant growth but largely in 'non-available' form. Their degradation by microorganisms results in organic matter – the storehouse for plant nutrients. Chemical tests like organic carbon percent are soil-quality indicators which provide information on the capacity of soil to supply mineral nutrients. Availability of the different nutrients is also dependent on the soil pH. Soil pH is estimate of the activity of hydrogen ions in the soil solution.

PHYSICAL INDICATORS

Soil's physical properties are estimated from the soil's texture, bulk density (a measure of soil compaction), porosity, water-holding capacity (Hillel, 1982). The presence or absence of hard pans usually presents barriers to rooting depth. These properties are all improved through additions of organic matter to soils. (Refer Chapter 2 for detailed discussions) Therefore, the suitability of soil for sustaining plant growth and biological activity is a function of its physical properties (porosity, water holding capacity, structure, and tilth).

Table 1.1
Soil health indicators used to assess soil functions

Indicator	Soil-function
Soil organic matter (SOM)	Soil structure, stability, nutrient retention; soil-erosion (Carter, 2002).
Physical: soil aggregate stability, infiltration and bulk density	Retention and mobility of water and nutrients; habitat for macro and micro fauna (Bengtsson, 1998; Swift et al., 2004).
Chemical: pH, extractable soil nutrients, N-P-K and base cations Ca Mg & K	Soil-biological and chemical activity thresholds; plant- available nutrients and potential for N and P as well as loss of Ca, Mg & K (Doran and Jones, 1996; Drinkwater et al.1996).
Biological: microbial biomass C and N; potentially mineralisable N	Microbial catalytic potential and repository for C and N; soil productivity and N supplying potential (Cadisch and Giller, 1997; Doran and Jones, 1996)

There are several criteria to consider while selecting soil health and soil quality indicators.

In much of the literature, it is postulated that basic soil quality indicators should reflect criteria which are relevant to existing soil databases (Doran and Parkin, 1994). Based on these propositions a list of basic soil-properties that should be indicative of soil quality was established. This list has been included in the minimum data set (MDS) by Larson and Pierce (1994), and expanded with a few biological aspects of soil quality, namely microbial biomass C and N, and soil respiration by Doran and Parkin (1994). Identification of indicators that could be used by farmers/field workers will also be a good idea. Few such parameters can be the population of macrofauna such as earthworm in a given volume of top 15cm soil, soil-texture by feel method, soil-smells, soil taste – acidic, basic etc. (provided it is free of harmful pesticides).

Farmers' Perception

Farmers have their own ways of understanding soil health. 71.4% of the surveyed farmers believe that if living organisms are present in the soil, the soil is healthy. Presence of decaying organic matter, water holding capacity of the soil, nutrient availability for plants and soil texture are some of the other parameters that the farmers consider as important (Chart 1.3). The social audit team has also observed that farmers can recognise the health condition of the soil by viewing, feeling and tasting. Many of the farmers opined that they feel reassured if earthworms are present in their fields.

Chart 1.3
Parameters that decide soil health

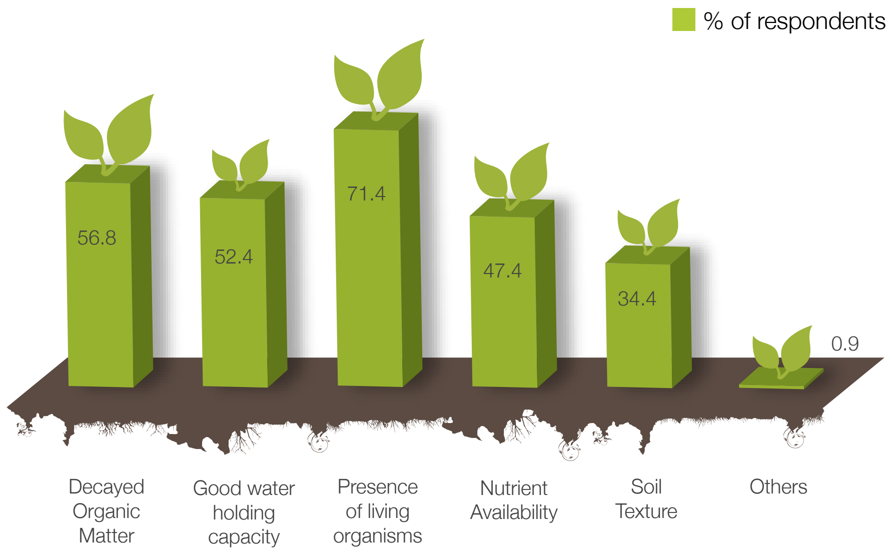



Image: Farmer applying dried groundnut leaves in soil.

Soil health in future

While much has been accomplished in the area of soil-health, much more needs to be done. Research efforts to monitor and index indicators of soil-health need to be balanced with efforts to clearly define relationships between the status of indicators and specific soil-functions. In doing so, there is a need to consider the simultaneity of diverse and occasionally conflicting soil-functions and their soil-property requirements (Sojka and Upchurch, 1999). Greater relevance to these efforts may be achieved by adopting a broader perspective on soil-health; a perspective that establishes strategies for agricultural and natural resource sustainability upfront, and then uses indicators encompassing all aspects of agro-ecosystem performance, including productivity.

Ecological agriculture is one that, over the long-term, enhances environmental quality and the resource-base on which agriculture depends, provides for basic human food and fibre needs, is economically viable, and enhances the quality of life of farmers and society as a whole (Schaller, 1990) and is sustainable. This definition, and others like it, can be used as a starting point to develop specific strategies for agricultural and natural resource sustainability. To make these strategies amenable for assessment, however, they need to be organised into measurable categories, as there is no single, summary indicator for sustainability.

The performance of every farm can be expressed through economic, environmental, and social indicators. Indicators chosen from these categories should be a reflection of producer success and natural-resource conservation. Indicators should also be relatively easy to measure and simple to interpret. Examples of indicators meeting these criteria include crop yield, profit, risk of crop failure, soil organic matter content, soil depth, percent soil cover, leachable salts (especially NO_3-N), and energy use.

General management strategies considered to enhance agricultural and natural resource sustainability include crop rotation (for tighter cycling of nutrients), reduction in soil disturbance (to maintain soil organic matter and reduce erosion), and use of renewable biological resources (to reduce auxiliary energy requirements). For these management strategies to be successful, however, it will likely be necessary to make better use of the diversity and resilience of the biological community in soil.

In future:

- Awareness about the concept of soil health has to increase among agricultural scientists, particularly on the importance of soil in maintaining plant productivity and environmental quality over the long-term.
- There is a need to better understand relationships between the status of soil-health indicators and soil functions, and to consider the occasionally conflicting nature of soil functions and their soil-property requirements.
- The best application of soil-health may be under a broader context that first defines strategies to enhance agricultural and natural resource sustainability, and then uses indicators encompassing all aspects of agro-ecosystem performance.

TWO
ECOLOGICAL FERTILISATION

SOIL HEALTH: ROLE OF ORGANIC MATTER AND ECOLOGICAL FERTILISATION

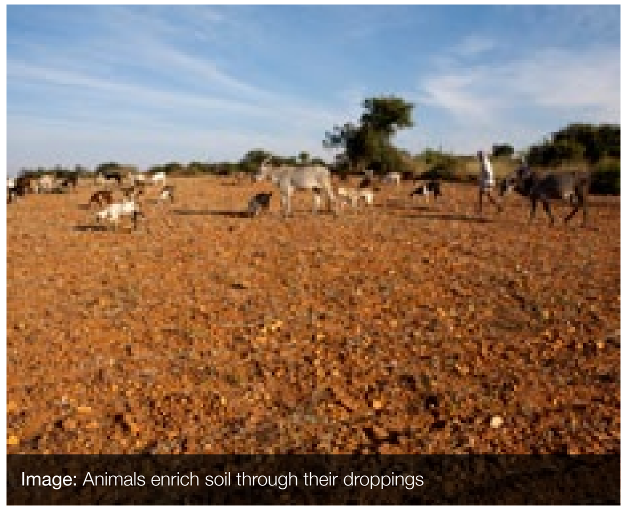


Image: Animals enrich soil through their droppings

Organic matter: Lifeline of Soil

The organic matter in soil derives from plants and animals. In a forest, for example, leaf litter and woody material falls to the forest floor. This is referred to as organic material. When it decays to the point at which it is no longer recognizable, it is called soil-organic matter (SOM). When the organic matter has broken down into stable humic substances that resist further decomposition, it is called humus. Thus soil-organic matter (SOM) comprises of all the organic matter in the soil exclusive of the material that has not decayed.

Soil organic matter plays a key role in soil-function, determining soil quality, water holding capacity and susceptibility of soil to degradation (Giller and Cadisch, 1997; Feller et al. 2001). In addition, soil organic matter may serve as a source or sink to atmospheric CO_2 (Lal, 1998). An increase in the soil carbon content is indicated by a higher microbial biomass and elevated respiration (Sparling et al. 2003). It is also the principal reserve of nutrients such as N in the soil, and some tropical soils may contain large quantities of mineral N in the top two metre depth (Havlin et al. 2005).

Ecological fertilisation for organic matter build-up and better crop yields

Most cultivated fields in tropics (particularly arid and semi-arid soils) usually have much less amount of SOM in the top 15 to 30 cm (generally <1%) than those in the temperate climates (generally 2% and more). Some of the agro practices that have been reported to enhance SOM are reduced tillage, crop residue recycling, green manuring, compost application, soil surface mulching, poly cropping (Hepperly et al. 2007), inclusion of legumes in cropping sequence (Drinkwater et al. 1998) and integration of trees (modified alley cropping) on cropped lands (Young et al. 1986, Rupela et al. 2006b). And all these natural resource conservation practices on their own or in combinations have been reported to increase crop yield (Hepperly et al. 2006), and treatment receiving such inputs has been reported more resilient in an extreme climate year (Lotter et al. 2003).

Some of the most common ecological/organic fertilisation practices and their benefits as reported by scientists are presented in this chapter.

Image: Farm Yard Manure helps build-up of organic matter in soil.

Image: Cattle provide both draught power as well as good manure. They have to be an integral component of a sustainable farm.

Farm Yard Manure (FYM):

Long term experiments on different fertiliser levels and FYM in alfisols at Bangalore (Karnataka), Palampur (Himachal Pradesh) and Ranchi (Jharkhand) indicated that, incorporation of FYM resulted in build up in Soil Organic Carbon. (Singh, 2007) A build up of organic carbon in the soil due to continuous application of manure and crop residues has also been reported by several scientists (Gattani et al. 1976, Sinha et al 1983 and Patiram and Singh 1993).

Application of FYM alone or with fertilisers has improved physical, chemical and biological properties of soil (Gajanan et al. 2005). Application of FYM has improved soil physical conditions viz., stable soil aggregates, density, soil moisture holding capacity and soil air movement.

FYM application also has a positive influence on the nutrient availability. Available nitrogen content has a direct relationship with organic carbon content of the soil (Black, 1993). Gajanan et al (2005) observed an increase in available nitrogen with application of FYM, and also observed improved nitrogen use efficiency. They also observed build up of available P_2O_5 in plots applied with FYM. The decomposition of FYM releases certain compounds which help in enhanced dissolution of native P compounds. The build-up of available P_2O_5 is attributed to this process. FYM application also has a positive influence on available potassium. FYM is not only a direct and ready source but helps in minimising the leaching loss of K by retaining K ions on exchange sites (Bansal, 1992).

Availability of major secondary and micro nutrients such as Calcium, Magnesium, Sulphur, Zinc, Copper, Manganese and Iron increased in fields applied with FYM (Gajanan et al. 2005).

In addition to all these, the beneficial microbial population and enzyme activities were enhanced significantly on application of FYM (Vasuki et al. 2009).

Legume crop rotations

Beside N-fixation, legumes also help in solubilisation of P (release of piscidic acid by roots of pigeonpea - Ae et al. 1990), increase in soil microbial activity, organic matter restoration and improvement of the physical health of soil (Acharya and Bandyopadhyay, 2002). Results from the All India Co-ordinated Research Project on Cropping Systems showed consistently better productivity from rice-pulse than rice-wheat systems (Hegde, 1992). The benefits of legumes in rotation are not solely due to biological nitrogen fixation, but result from improved soil structure, reduced disease incidence and increased mycorrhizal colonisation (Wani et al., 1995).

In addition, recent global meta-analysis has also shown that cover crops such as legumes can provide enough nitrogen to substitute the amount of synthetic nitrogen used worldwide while maintaining the same food production (Badgley et al. 2007).

Image: Panchagavya is prepared mainly using the five products of the cow - milk, curd, ghee, urine and dung.

Image: Panchagavya is a rich source of beneficial microorganisms.

Green Leaf Manure (GLM)

Improvement in soil porosity and maximum water holding capacity (MWHC) was recorded with Green Manure application in vertisols. (Pathak and Sarkar, 1997) Reduction in bulk density and improvement in aggregate stability, extractable carbon, sugar and microbial biomass was recorded (Prabhakar et al. 2002). With green manuring population of N_2 fixers and phosphate solubilisers increased considerably (Kute and Mann, 1969). Another study recorded a significant increase in the bacterial population and microbial biomass of N in the soil amended with green manures (Azam et al. 1985). Growing of legume as green manure (Sesbania aculeate L.) helped to save 60 kg nitrogen for the succeeding paddy crop (Kolar and Grewal, 1988).

Liquid manures

Use of traditional knowledge based liquid manures viz., Panchagavya, Jeevamrutha, Beejamrutha Amritpaani and biofertilisers in paddy with and without compost indicated that, paddy yield obtained under organic farming was equal to research station yield. Application of Panchagavya and Jeevamrutha to paddy at monthly interval has resulted in lush green colour of the crop and the crop was fairly free from pest and diseases. Further, the microbial population viz., N fixers, P solublisers and actinomycets were very high compared to control plots (Devakumar et.al, 2008).

Cowdung is rich in agriculturally beneficial microorganisms. Organic farmers in India widely prepare and use a traditional knowledge product Amrit Paani (1kg dung, 1l urine, 50g jaggery made to 10l with water, stirred every day 4-5 times, ready for use as soil applicant on day 4) and was found having high population (more than 0.1 million per ml) of these bacteria. Their population was at par or more than some of the inoculants manufactured by bioproducts industry and sold in the market (See Appendix 1 for details).

Manure from weeds

Weeds produce substantial quantities of biomass which can be used either as compost or as green manure. Use of weeds as compost in finger millet and groundnut have shown that yield has substantially increased to a larger extent and was superior to or equal to FYM application. (Ramachandra et al. 2005). Therefore removing weeds manually or mechanically would highly likely be more cost effective and environment friendly than use of herbicides that kill soil life along with the weeds.

Image: Multiple cropping involving different crops helps to improve soil health.

Niranjana Maru and Ashok Bang (2007) reported considerable improvement in soil health through ecological fertilisation practices (Table 2.1)

Table 2.1
Soil Health Improvement over a period of 5 years

Parameters	Comparative Improvement		
	Control level	Improved level	Improved level compared with control (in percent)
Organic matter (Humus) %	1.25	4.60	368%
Cation Exchange capacity (CEC)	35.16	44.91	128%
Total Nitrogen, N %	0.073	0.267	378%
Available Phosphorous (Kilogram/hectare) %	22.45	50.43	225%
Available K (Kilogram/hectare) %	100.00	435.00	435%
Porosity %	39.23	47.16	120%
Available water holding capacity AWC w/w%	14.46	19.59	135%

Source: Niranjana Maru & Ashok Bang, 2007, Soil health and fertility improvement in their model of sustainable, self-reliant organic, biodiverse, eco-agriculture. Presented in The National Workshop on New Paradigm for Rainfed Farming "From Impoverishment to Empowerment: With Productivity, Profitability & Sustainability for Farmers and Farming" Sept 2007, at ICAR, New Delhi.

Farmers' Speak

Stakeholder survey revealed that farmers were not only aware about the ecological/organic fertilisation, but also believed that ecological fertilisation can maintain soil health. 98% of the surveyed farmers were aware of organic fertilisers (Chart 2.1). 64.4% of the surveyed farmers were aware of the Farm Yard Manure and 69.3% knew about value of compost. Farmers were also aware of the importance of Green Leaf Manuring and Biofertilisers (Chart 2.2).

94% of the surveyed farmers believed that organic fertilisers can maintain soil health. 4% believed that a mix of organic and chemical fertilisation is better, and only 2% opined that chemical fertilisation practices were good for soil health (Chart 2.3).

Chart 2.1
Awareness of organic fertilisers

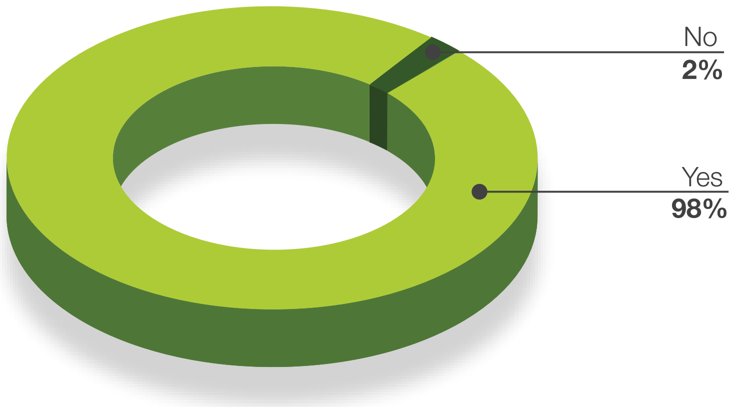


Chart 2.2
Different types of organic fertilisers

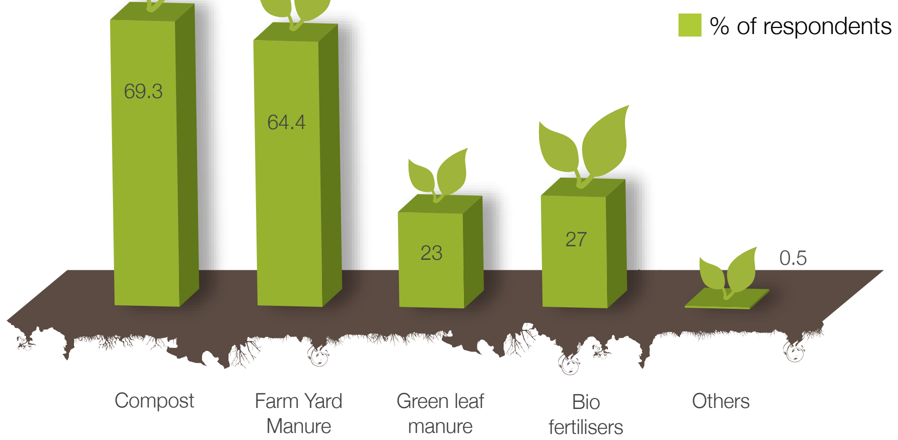
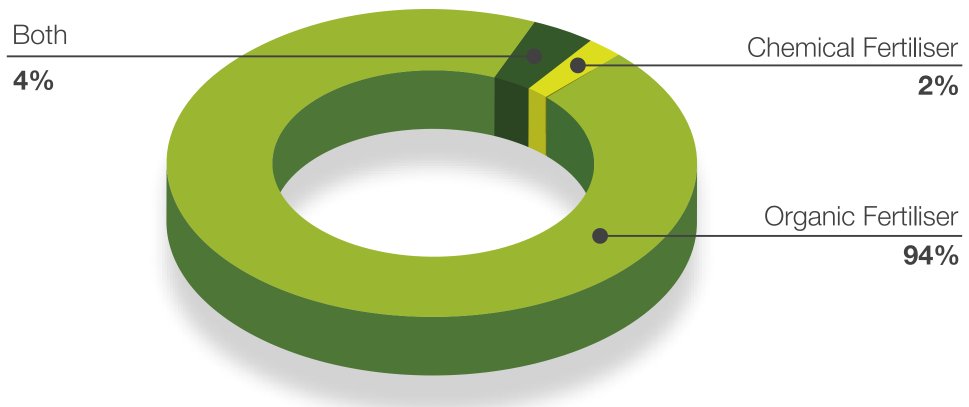


Chart 2.3
Awareness regarding the kind of fertiliser conducive for better soil health and sustained production



Farmers using organic fertilisers confirmed that they use it because, it provides higher productivity. 83.5% of the respondents endorsed this view point (Chart 2.4). Farmers who are not using organic fertilisers were concerned about the unavailability of the same (Chart 2.5). Source of organic fertilisers which was mainly Farm Yard Manure or Compost was generally prepared by farmers in their own fields (Chart 2.6).

Chart 2.4
Reasons for using organic fertilisers

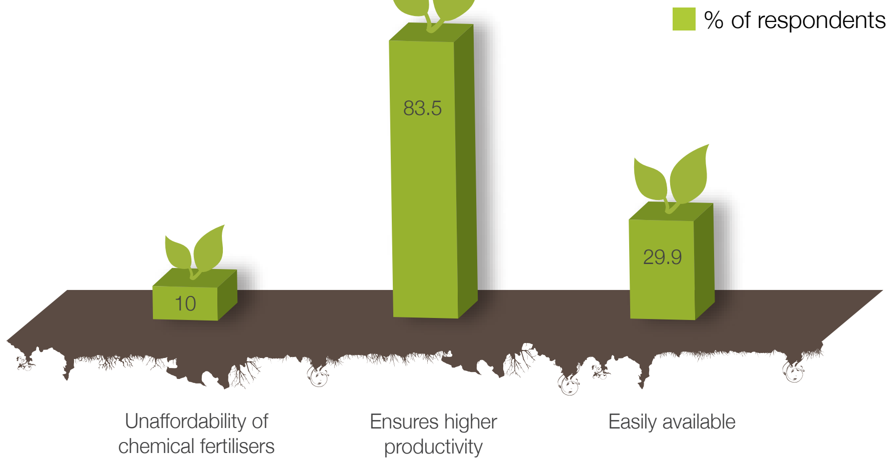


Chart 2.5
Reasons for not using organic fertilisers

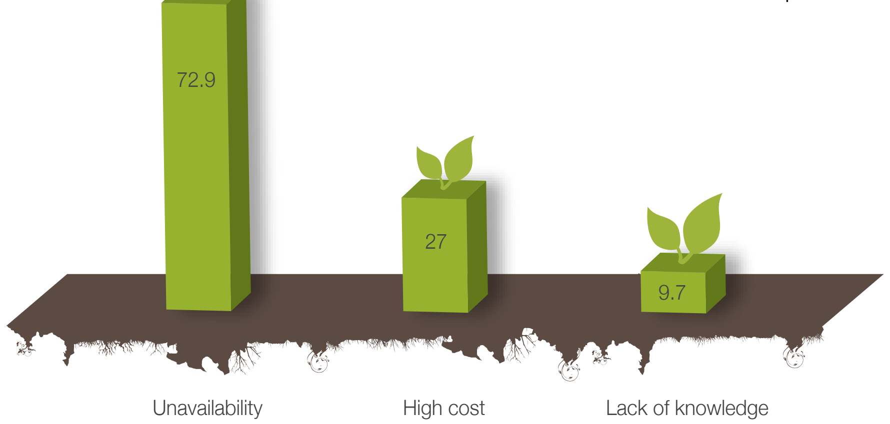


Chart 2.6
Source of organic fertilisers

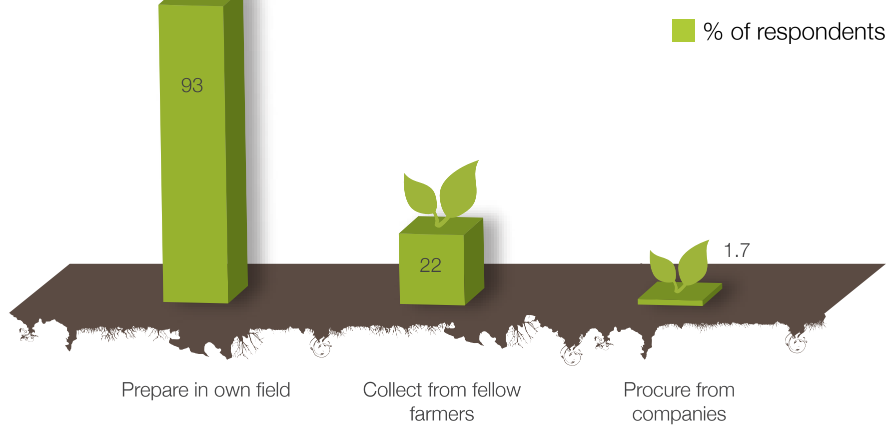


Image: A tomato crop in a mixed crop farm.

The stakeholder survey revealed that farmers were aware of the nitrogen fixing capacity of leguminous crops like pulses. 79% of the surveyed conveyed their knowledge about pulse crops (Chart 2.7). An analysis of the responses from the social audit states revealed that out of five states, Madhya Pradesh had the maximum number of farmers cultivating pulses (54%) at least in one season. In Punjab only 1% of the surveyed farmers were cultivating pulses and none in Orissa (Chart 2.8).

Chart 2.7

Awareness of the fact that leguminous plants like pulses can fix atmospheric nitrogen

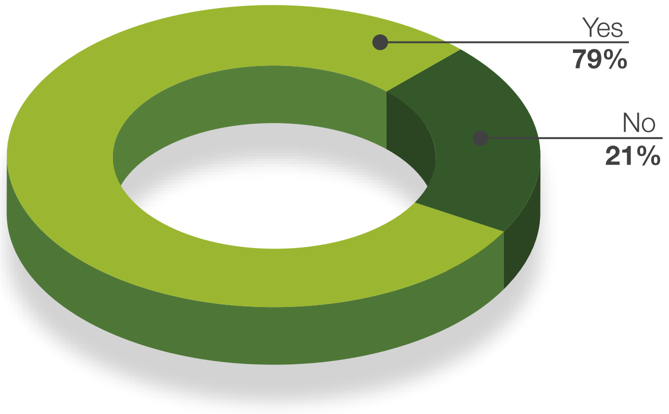
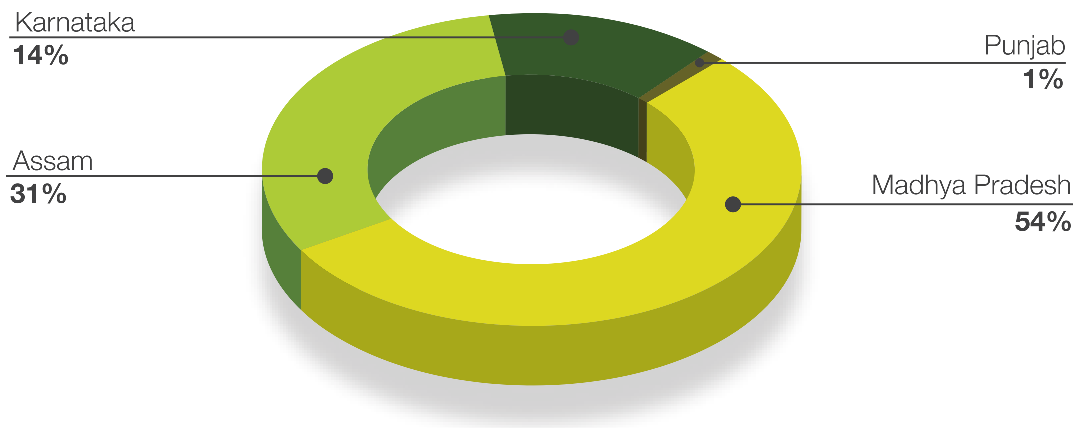


Chart 2.8

Cultivation of pulses



64% of the surveyed farmers either grew some green manure crops to be incorporated into the field or apply Green leaf manures (Chart 2.9). Among the social audit states, Madhya Pradesh and Assam had maximum number of respondents applying green manures and none from Orissa (Chart 2.10).

Chart 2.9

Do you cultivate Green Manure Crops?

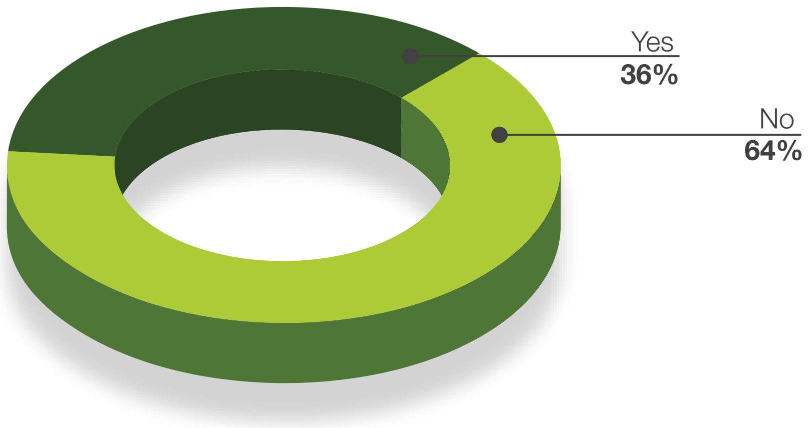
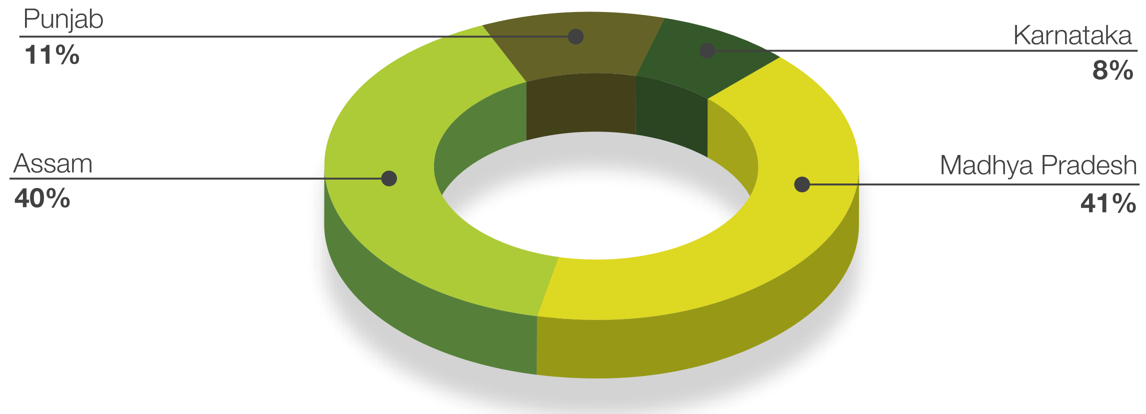


Chart 2.10

Cultivation of green manure crops



Regarding the recommendations that the farmers followed on kind of fertiliser and the quantity, most of the farmers (63.3%) decided by themselves (Chart 2.11). 95% of the surveyed farmers who were using organic fertilisers now, used these for long – traditional habit. This indicated that the role of extension systems and civil society organisations were very minimal in promoting ecological fertilisation (Chart 2.12).

Chart 2.11

Whose recommendations farmers follow regarding use of fertiliser or manure?

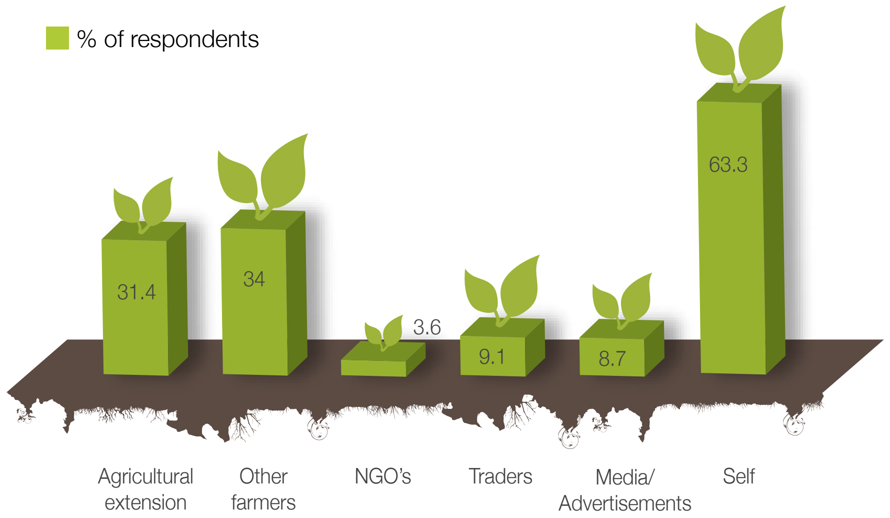


Chart 2.12

Introduction to organic fertilisation

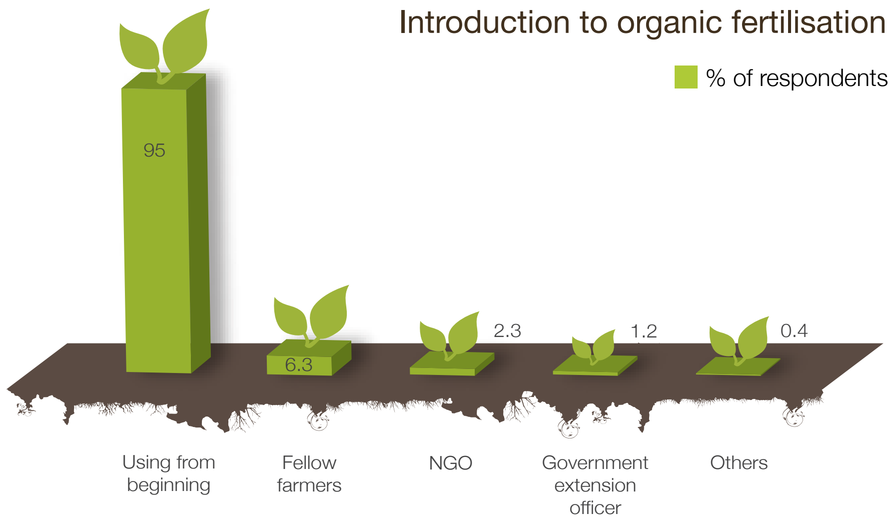


Image: Crop residues after harvest can be applied to the soil after composting (in situ and ex situ). If the crop residues are fed to the cattle, the Farm Yard Manure can be brought back to soil.

Image: Cultivation of legume crops can bring down the dependence on synthetic nitrogen fertilisers. They are also a good source of protein and help contribute to nutritional security.

Biomass availability: Myths & reality

Many of the objections made against ecological fertilisation have confused science with pragmatics. While there is an argument that there is probably not enough bio-mass currently available to support a fully 'non-synthetic fertiliser' strategy of crop nutrition, and that labour costs presently constitute a barrier to such practices, there is plenty of evidence that such nutrition can give superior results. A limiting factor is that few resources have been invested thus far in evaluating species, in improving cultural practices, and in devising appropriate implements for growing and harnessing plant biomass. Many practices associated with agro-ecological practice are currently labour-intensive. But little thought has gone into developing this labour intensive nature of ecological fertilisation as an opportunity to generate rural employment opportunities.

Even though there were no coordinated strategies developed to generate biomass, there were studies by scientists which showed that sufficient biomass can be generated through a combination of practices, some of which are discussed above. Livestock being a critical source of manure, needs to be promoted as an integral component of the farm.

Krishnappa et al (1996) reported that growing of glyricidia as green manure crop on bunds at 2m distance can yield biomass of 6t/ha and it would be around 8t/ha/year in garden land. Similarly, production of green biomass on road sides' avenue plantation and along the railway tracks will yield large amount of green biomass.

In addition to developing strategies for generating biomass, we also need to ensure that plant biomass is not burnt and are brought back into the field.

In the Indo-Gangetic plain (traverses four countries- India, Pakistan, Nepal and Bangladesh), rice-wheat is the most exhaustive cropping system, depending heavily on soil nutrients and water, one of the most serious issue here is the burning of crop residues instead of their recycling. Punjab of India alone has been reported to burn about 12 million t of rice-wheat residues and with this emits about 23 million t of carbon dioxide and burns about 18 million $ worth of urea (Sidhu et al. 1998). These crop residues, and even the weeds or any other plant biomass can be composted or better used as surface mulch (Rupela et al. 2006) and thus be harnessed to generate the needed crop nutrients for high yield.

The soil nutrients are mined and transferred to urban areas through the process of crop production and food trade. So it is highly essential to return the nutrients from the waste materials generated in urban areas be ploughed back to the Agricultural land to sustain the soil fertility. Recycling of decomposable materials through composting or surface mulch is important. Several methods of composting have been evolved for treatment of urban wastes. With the advancement of eco sanitation concept, the human excreta and waste water from the household are recognised as a resource. It has been estimated that the cost of such Eco-sanitation systems implemented on a global scale, could be offset by the commercial value of the phosphorus and nitrogen they yield (Stockholm Environment Institute, 2005).

Thus, we can see that there is a plethora of ways through which plant biomass can be generated and recycled. What is needed is suitable strategies and support systems.

THREE

CHEMICAL FERTILISATION

SOIL HEALTH: IMPACT OF CHEMICAL FERTILISATION

A crop needs more than 33 elements [of which 3 – nitrogen (N), phosphorus (P), potash (K) are widely termed as major elements, 12 as micro or vital elements and 18 as trace elements] for good growth and yield (Bourguignon, 1998). All soils have all these elements but much of the concentration of each of these elements is in non-available form and plants cannot use them as crop nutrients unless solubilised by micro-organisms inhabiting soils.

> Although much of the concentration of every element is insoluble, a small percentage (ranging 0.1 to 7.7%) in this case is soluble. Because the total quantity of the insoluble form is large (29.7 ppm for Boron to 40442 ppm for iron), solubilisation of a small percentage is substantial enough to meet crop needs (See Appendix 2 for details).

On the other hand, elements in different synthetic fertilisers are in soluble form and when applied to soils, are readily taken up by crops. And indeed there is lot of data reporting yield increase due to application of these synthetic fertilisers. But one can buy fertilisers of only three elements – N, P, K from the market. Fertilisers of some micro and trace elements can also be purchased but these are less widely available. Most farmers, over the years, have found them to be very convenient inputs as it is less expensive (owing to the huge amount of subsidy – Refer Chapter 4), and ease of use. The farmers have been bought into these systems (through policies and industry forces) to the extent that their non-availability or less availability in the market has resulted in protests and agitation by them, particularly in the recent past[3].

However, there are reports which point to the fact that chemical fertilisers can adversely affect some of the critical soil functions.

Indicators of good soil fertility like microbial biomass, enzymatic activity and water-holding capacity are all drastically reduced under chemical fertilisation practices especially indiscriminate use of nitrogenous fertilisers (Masto et al., 2008).

Another common detrimental effect of the excess use of nitrogen fertiliser on soil health is acidification, and the impact it has on soil living organisms, crucial also for natural nutrient cycling (Darilek et al., 2009, Kibblewhite et al., 2008). When Ammoniacal fertilisers are applied, the pH decreases mainly due to the release of H+ ions after mineralisation (Suresh Lal and Mathur, 1988 and Gajanan et al, 1999)

Heavy dependence on chemical fertilisers can also lead to decreased nutrient availability. Gajanan et al (2005) observed lower available nitrogen in only chemical fertiliser applied plots and reported that it could be due to low biomass production and lower rate of mineralisation.

The enzymatic activity in the soil is also seriously impaired by chemical fertiliser usage (Rupela et al. 2006a). The acid phosphatase activity decreases with the application of synthetic fertilisers. The reason behind this is that the readily available phosphorous in the soil hinders the activity of microorganism responsible for this (Juma and Tabatabai, 1978).

Excessive usage of chemical fertilisers has already degraded soils in the intensive chemical fertiliser using regions and has resulted in yield stagnation. In one cycle of rice-wheat, nutrients (N, P_2O_5, K_2O) removal is about 502 kg/ha to

Image: Excessive tillage can affect soil health.

[3]http://timesofindia.indiatimes.com/city/bangalore/Fertilizer-fury-spreads/articleshow/3118530.cms

produce 4 to 5 tonnes of rice. Despite intensive use of inputs (both fertilisers and water), yields have stagnated and responsiveness to agro-inputs has decreased over the years (Chand and Haque, 1998). Soil degradation, mainly the decline in soil organic matter both in quality and quantity, is one of the major reasons linked to stagnation and decline in yields (Dawe et al., 2000; Yadav et al., 2000; Ladha et al., 2003).

Research also suggests that use of synthetic fertilisers adversely affects proper functioning of at least some of the eco-friendly agro-practices. Nitrogen fertiliser has been reported to suppress nitrogen fixation (ability of plants to access nitrogen from air) (Streeter 1988) and even kill soil biota. It is argued that these dead biota serve as source of nutrients and result in enhanced yield but eventually, over the years, result in reduced SOM. These issues have been more pronounced in intensively cropped areas where fertiliser use is intense.

The most common problems noted in these areas are given below even though these are not exclusively due to chemical fertilisers:

- Deficiencies of micro or trace elements in the soil.
- Depletion of water resources in areas of good quality underground water.
- Salinity and sodicity build-up in canal irrigated areas.
- Hard pan formation and reduced organic matter content in the soil.
- Increased use and reliance on inorganic fertilisers and chemicals.
- Increased cost of cultivation, especially tillage cost.
- Late sowing of rabi crops.
- Degradation of eco-system.

Farmers' Speak

Farmers were aware of the harmful impact of chemical fertilisers on soil. 96% of the respondents opined that use of chemical fertilisers leads to soil degradation (Chart3.1). Even with this understanding farmers continued to use chemical fertilisers as there was no other option (Chart 3.2).

Chart 3.1

Use of chemical fertilisers lead to soil degradation?

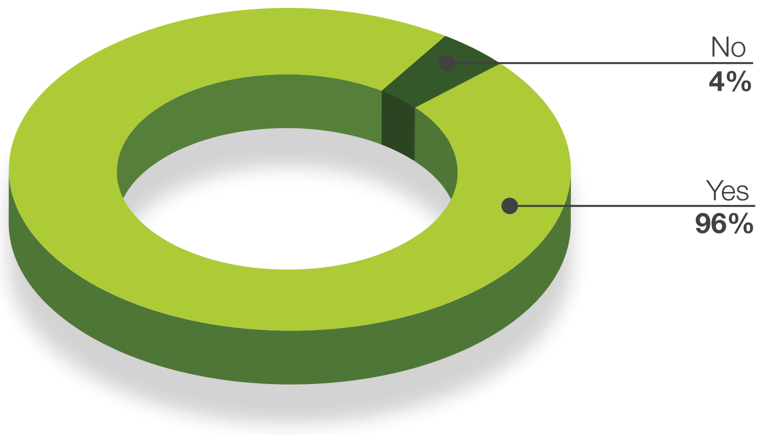
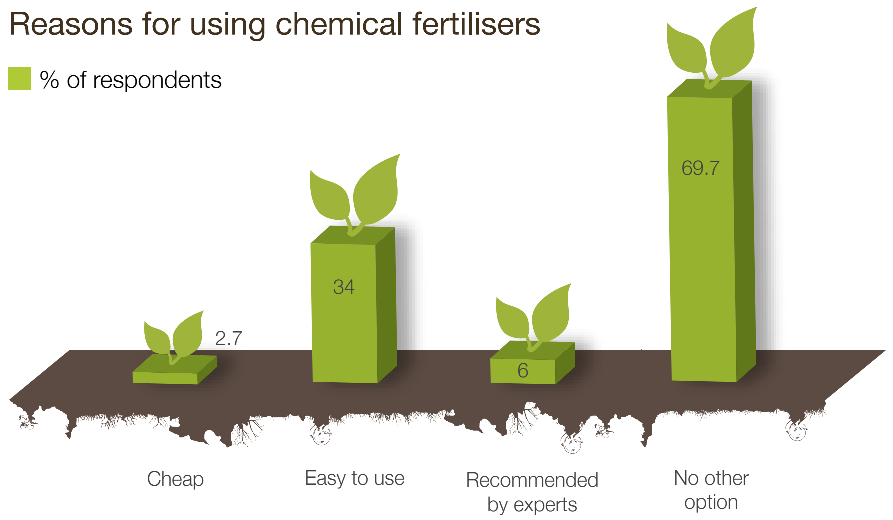


Chart 3.2

Reasons for using chemical fertilisers



Farmers have their own criteria to measure soil degradation. Disappearance of living organisms, reduction in water holding capacity, which is a measure of increased frequency of irrigation (in irrigated regions) or wilting of plants in rainfed regions were some of the indicators for them. They also related soil problems to chemical intensive mode of farming.

All the respondents (100%) who have confirmed that they have stopped observing living organisms as of now, have observed the same before 1980. 81% of the respondents last observed living organisms in 2000. So for majority of the respondents who have stopped observing living organisms, they had last observed them in this decade (Chart 3.3), which indicates that living organisms were slowly disappearing and completely vanished by the end of the last decade.

Majority of the farmers (88.8%) attributed the loss of living organisms from their soils to chemical intensive mode of farming, basically application of chemical fertilisers and pesticides. (Chart 3.4).

Chart 3.3
Time period of observations of living organisms last time

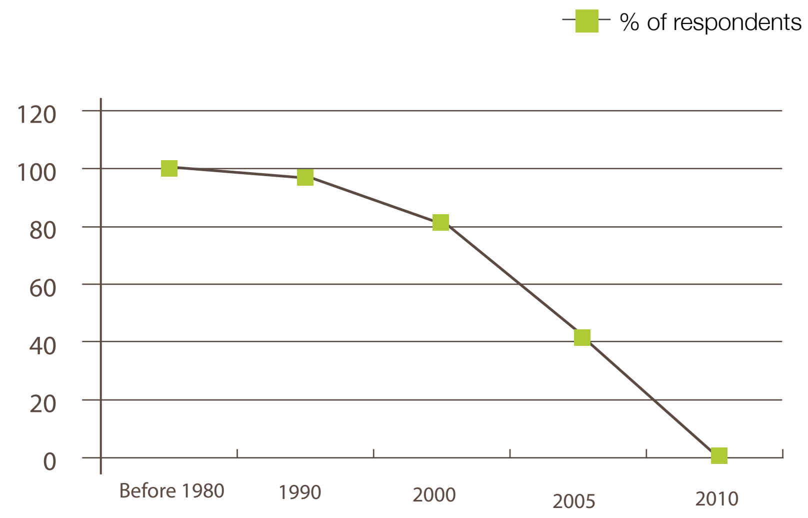
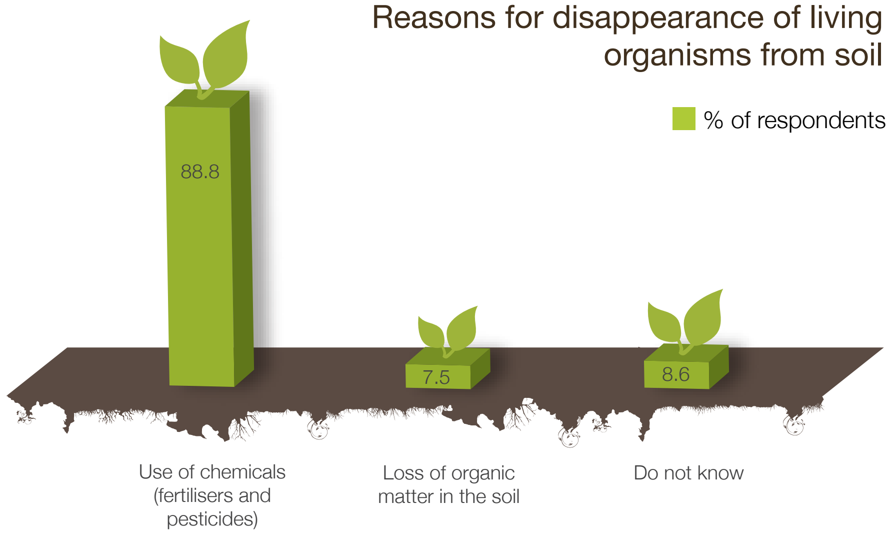


Chart 3.4
Reasons for disappearance of living organisms from soil



56% of the respondents observed change in the water holding capacity of their soil, and out of this share of farmers who have observed a change in water holding capacity, 93% have observed a decline (Charts 3.5 and 3.6).

Farmers also confirmed that the major changes in water holding capacity have taken place in the last two decades (1990-2010) (Chart 3.7).

Chart 3.5
Change in soil's water holding capacity

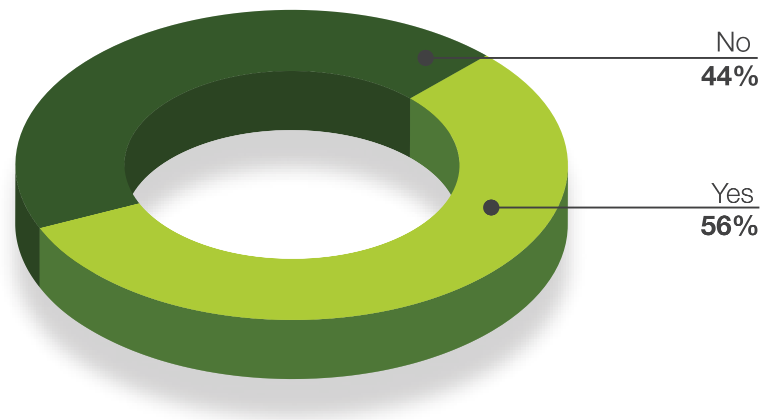


Chart 3.6
Nature of change in water holding capacity

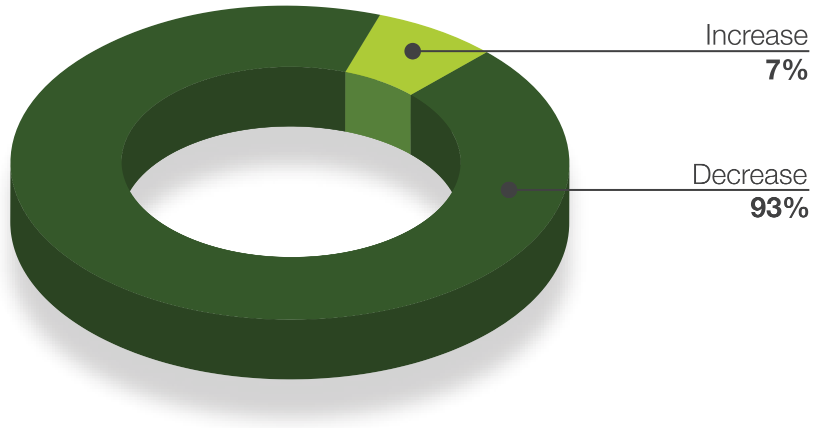


Chart 3.7
Time period when changes in soil's water holding capacity started to happen

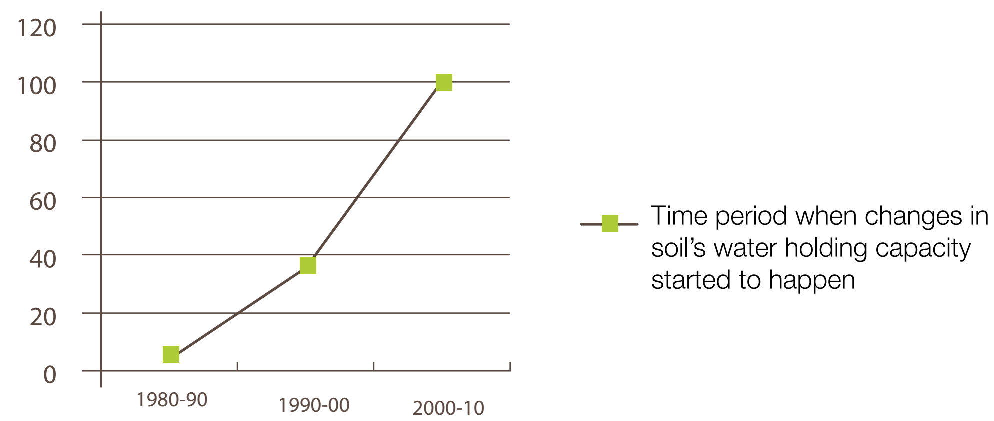


Image: Extensive monocropping adversely affects soil health.

Some of the other major factors that need to be considered while taking call on chemical fertiliser based soil health management:

Fossil fuel dependent soil management: Recipe for disaster

Present day agriculture is extremely dependent on fossil energy. However, according to some estimates fossil fuel production peaked in 1960 (Ivanhoe 1995), i.e. oil extraction is no longer capable of keeping pace with the increasing demand. This situation may trigger an unprecedented increase in fossil energy prices, which makes the entire food production-distribution system highly vulnerable (Günther 2000).

Production of chemical fertilisers is highly dependent on fossil fuels. Natural gas, the main fuel and feedstock, accounts for 62% of the energy used in synthetic N fertiliser production. Less efficient and more polluting fuels such as naphtha and fuel oil also represent a high share, 15 and 9% respectively, of the energy used in fertiliser manufacture (values as of 2006/07, FAI 2007). In addition to emissions from manufacture, N fertilisers when applied to farm soils result in emissions of N_2O. The concern over N_2O emissions arises from its long atmospheric life (166 ± 16 years) and its higher global warming potential (296 times that of CO_2) The total emissions from the manufacture and use of synthetic nitrogen fertilisers in India represent 6% (3% from manufacture and 3% from usage) of India's total emissions, comparable to sectors like cement or iron and steel industries, and to emissions from the entire road transport system (Tirado et al. 2010).

Dwindling phosphate reserves

There is a growing consensus on the reality of peak phosphorus, although the exact year is of course not known as it depends on a variety of factors. Latest studies indicate that the peak in global phosphorus production could occur by 2033 (Cordell et al, 2009).

FAO has been highlighting the issue of phosphate scarcity. (FAO, 2008). A paper at FAO expert meeting on how to feed the world in 2050 highlighted that phosphorus is a major non-renewable resource where scarcity could significantly affect crop yields by 2050 (Fischer, 2009).

The geopolitical realities associated with the phosphate reserves add another dimension to this dwindling resource. For known phosphate reserves, 87% are found in just five countries. By far the biggest is in the Western Sahara and Morocco (35%) followed by China, (23%), Jordan (9%), South Africa (9%) and the USA (7%) (Soil Association, 2010). The uneven distribution of reserves led to an article in Scientific American to declare phosphorus "a geostrategic ticking time bomb" (Vaccarit, 2009).

Image: Nitrogen fertilisers contaminate groundwater and pose a threat to human health.

The USA stopped exporting any phosphate rock in 2004 and since the early 1990s has significantly increased the quantity it imports. China has already begun to safeguard its own supplies by imposing a 135% tariff on exports from 2008 (Soil Association, 2010).

Price volatility is another significant factor that needs to be taken into account while depending on the external phosphate reserve. In 2007/08, the phosphate rock commodity price increased by 800%, and the reason for which is attributed to several factors including the rise in the price of oil (Soil Association, 2010).

Pollution due to chemical fertilisation and the environmental consequences

A recent study by Greenpeace India in the Malwa region of Punjab which has shown that drinking water was heavily contaminated with nitrates. 20% of all sampled wells had nitrate levels above the safety limit of 50 mg per litre as established by the World Health Organisation (WHO). The source of the pollution was nitrogenous fertiliser, especially urea (Tirado, 2009).

Production of every tonne of Phosphatic fertilisers by dissolving phosphate rock in sulphuric acid yields 5 tonnes of phospho gypsum as by-product, and due to the presence of naturally occurring uranium and radium in the phosphate ore, this is toxic and radioactive. (Rosemarin etal, 2009). Cadmium inputs to soil from rock phosphate fertiliser production has also been a concern with long-term implications for soil fertility and human health. (Smith, 2007). Phosphorus bound to soil particles can enter watercourses and can cause Eutrophication (Defra, 2010).

Socio-economic factors

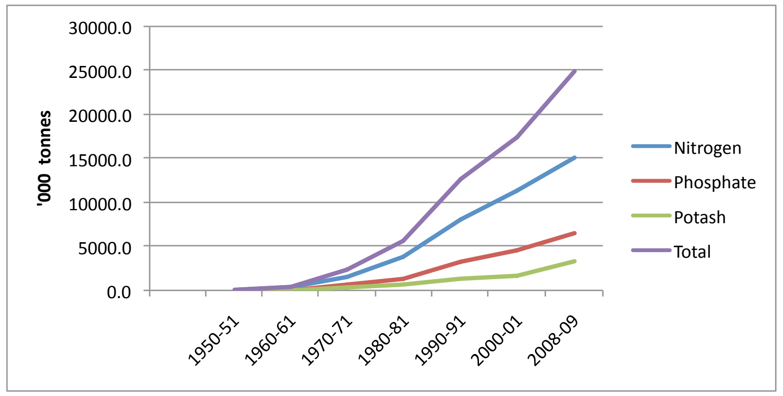
The dryland farmers and the farmers adopting ecological farming practices are often kept out of the subsidy benefits. It is to be noted that the irrigated area, which accounts for 40% of the total agricultural area in India, receives 60% of the fertiliser applied. (Roy et.al, 2009) Also, even in a system where subsidies exist, the chemical fertilisers are proving to be unaffordable to the farmers.

FOUR
POLICIES & SUPPORT SYSTEMS

SOIL HEALTH: CENTRAL GOVERNMENT POLICIES AND SCHEMES

The chemical and synthetic fertilisers, particularly Nitrogen, Phosphorous and Potassium (NPK), are highly subsidised. The amount of subsidy on this has grown exponentially during the last three decades from a mere Rs. 60 crore during 1976-77 to an astronomical Rs. 40,338 crore during 2007-08. In 2008-09, it shot up to Rs 96,606 crores; The budget allocation for 2009-10 for fertiliser subsidies was Rs 49,980 crores and has a similar estimate for 2010-11[4]. This huge rise in subsidy is attributed to inflation, and subsequent price fluctuations in the international fertiliser market. On a real term basis also, the fertiliser subsidy allocation has been showing a rising trend. Huge amounts of subsidy allocations provided directly to the industry have led to indiscriminate production and availability while neglecting the locally available knowledge on soil nutrient management. Widespread usage of such fertilisers has resulted in the degradation of soil (as discussed in Chapter 3).

Chart 4.1
Chemical Fertiliser Consumption in India



Nutrient Based Subsidy (NBS) for Chemical fertilisers

Following the acknowledgement of the issues associated with the old fertiliser subsidy model, the Union Government introduced NBS system for fertilisers with effect from 1st April 2010. NBS is a nutrient centric subsidy model, wherein Government fixes subsidy for each nutrient. With this new model, the fertiliser prices are completely decontrolled.

Decline in soil organic matter and deficiency of secondary and micro-nutrients was a major issue which has led to soil degradation. The new policy doesn't address these concerns. The NBS is applicable only for the three macro nutrients – nitrogen (N), phosphorous (P) and potassium (K), one secondary nutrient – sulphur (S) – and only two micro nutrients – zinc (Zn) and boron (B). Urea is being treated separately and is not brought under the NBS, though there are talks about bringing it also under the NBS regime this year. Organic fertilisers are not eligible for subsidy under NBS.

[4]Budget documents, Government of India – relevant years

Image: Farmer and farm-centric eco-friendly policies need to be promoted.

The per hectare chemical fertiliser consumption data used here is based on Gross Cropped Area (GCA). GCA is calculated by adding land area as many times as it is cultivated in a year. Counting cultivated land more than once raises the total sown area and hence the average consumption appears low. It is to be noted that the same piece of land receives the fertilisers when it is cultivated twice or thrice, and hence the area is not divisible by the number of crops employed in that piece of land.

Fertiliser consumed per hectare of Net Sown Area (NSA) would be a better indicator while formulating soil health policies. NSA represents the total sown area with crops and orchards, and in this case area sown more than once in the same year is counted only once. This gives a better understanding of the amount of fertilisers applied per unit of land area.

From the table 4.1, it is also clear that there is considerable difference between the two indicators.

In short, NBS is meant for supporting the same old chemical fertilisers. This does not seem to address the concerns of ills of chemical fertilisers as envisaged. It does not encourage alternative eco-friendly, farmer and farm centric methods of supplying nutrients as well as enriching the biomass which are vital for improving soil health. It also does not undo the injustice created by the earlier policy which does not benefit the rainfed farmers who use very little or no chemical fertilisers.

Are we referring to the right indicators while formulating soil health policies?

The Planning Commission's Economic survey 2009-10 says *"The per hectare consumption of fertilisers in nutrients terms increased from 105.5 kg in 2005-06 to 128.6 kg in 2008-09. However, improving the marginal productivity of soil still remains a challenge. This requires increased NPK application and application of proper nutrients, based on soil analysis."* [5]

Image: All indicators of soil health need to be considered while formulating soil health policies.

Table 4.1.
Fertiliser applied per unit land area – comparison between per hectare of GCA and NSA

Year	Net Sown Area ('000 ha)	Gross Cropped Area ('000 ha)	Fertiliser consumption ('000 tonnes)	Fertiliser consumption kg per hectare of GCA	Fertiliser consumption kg per hectare of NSA	Difference in per hectare consumption (kg)
2005-06	141490	193050	20340	105.36	143.75	38.39
2006-07	139950	193230	21651	112.04	154.70	42.66
2007-08	140860	195830	22570	115.25	160.23	44.98

Source: Department of Agriculture and Cooperation

[5] http://indiabudget.nic.in/es2009-10/chapt2010/chapter08.pdf

Image: The land and the soil remain the same even if cultivated twice or thrice.

The difference is even more pronounced when you go to the State level data. Table 4.2 represents the data from Punjab, a high fertiliser consuming state and Orissa, a moderate consumer of fertilisers. In 2007-08 in Punjab, the NPK per hectare of Net Sown Area was 189% higher than NPK per hectare of GCA, and in Orissa it was 162% higher in 2008-09.

Table 4.2
Per hectare fertiliser consumption in States

	Punjab (2007-08)	Orissa (2008-09)
Net sown area ('000 ha)	4174	5604
Area sown more than once ('000 ha)	3695	3467
Total Cropped Area / Gross Cropped Area ('000 ha)	7869	9071
NPK ('000 tonnes)	1698	534.87
NPK per hectare of Gross Cropped Area (kg/ha)	215.8	58.96
NPK per hectare of Net Sown Area (kg/ha)	406.8	95.44
Percentage difference between the per unit consumption figures	**189%**	**162%**

Data Sources:

1) Annual Administrative Report , 2008-09, Department of Agriculture, Punjab
2) Orissa Agriculture Statistics 2008-09, Directorate of Agriculture & Food Production, Orissa

Based on this misleading indicator (per hectare of GCA), our policy makers recommend increased consumption of chemical fertilisers. These indicators are also compared with international ones. In this context, it is to be noted that internationally the per hectare consumption is calculated based on Arable land[6]. As per FAO definition the double cropped area is counted only once while measuring Arable land. Arable land is comparable with NSA, and hence it is not fair to compare an indicator based on GCA with this.

It is very important to critically choose the indicators while designing policies for resources management. Also, it is important to consider the fertiliser consumption pattern and averages at state and even district, taluk & village levels before mindlessly formulating policies to promote chemical fertilisers.

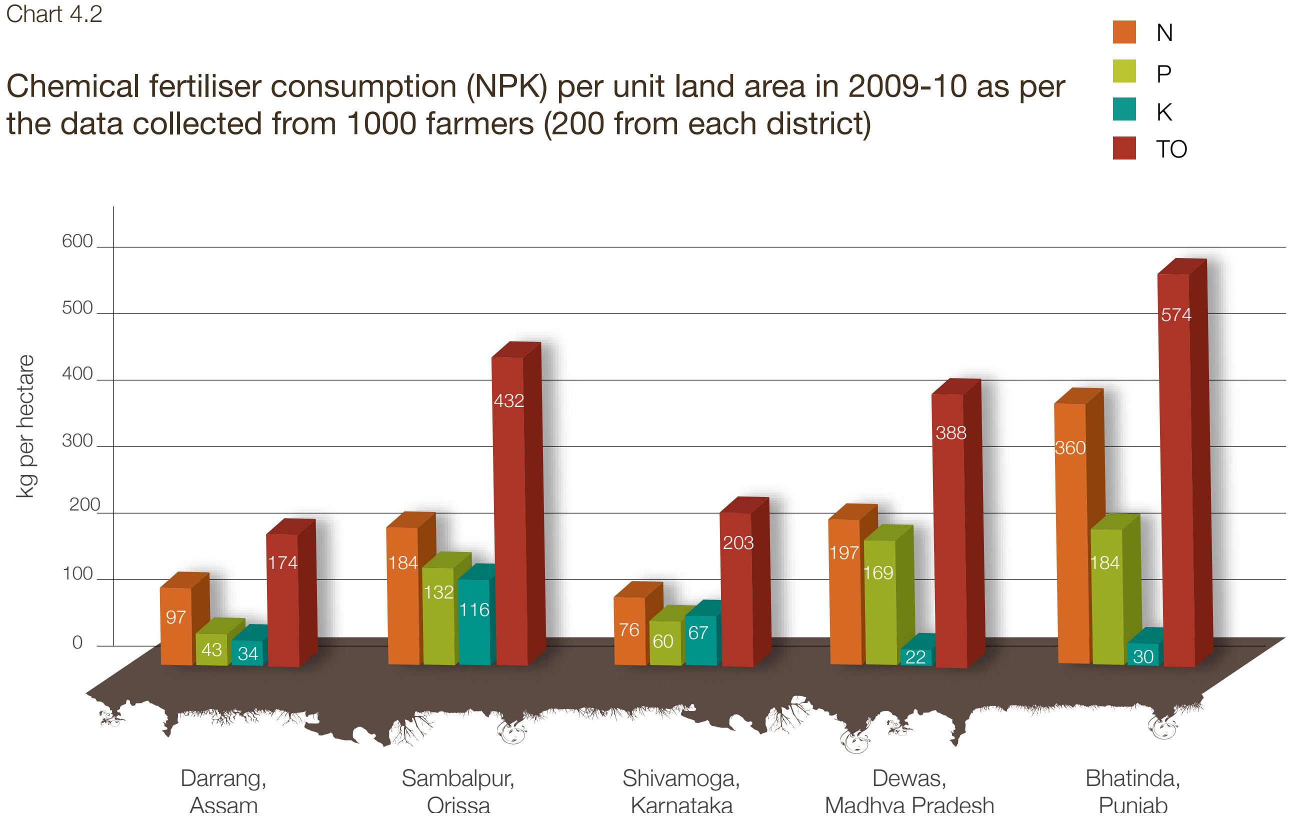
Fertiliser consumption in the social audit districts:

The data from stakeholder survey reveals that the chemical nutrients applied per unit of land area is reaching alarming levels in the social audit districts. It is touching 574kg/ha in Bhatinda, Punjab, 432kg/ha in Sambalpur, Orissa, and 388kg/ha in Dewas, Madhya Pradesh. It may be noted from the discussions in Chapter 3 that indiscriminate use of these chemical nutrients have very adverse effects on the physical, biological and chemical properties of the soil. This leads to deterioration of the soil heath on all fronts and hence can affect Agricultural production.

Image: Crop rotation with pulses needs to be promoted for better soil health and nutritional security.

Chart 4.2

Chemical fertiliser consumption (NPK) per unit land area in 2009-10 as per the data collected from 1000 farmers (200 from each district)



[6]http://www.fao.org/waicent/faostat/agricult/landuse-e.htm

Central Government support systems for organic fertilisers

An analysis (Table 4.3) of the major Government schemes which have components for soil health management reveals that the Government spent Rs 49,980 crores during 2009-10 for promoting chemical fertilisers, whereas the total amount spent on other four schemes taken together is Rs 5,375 crores, almost one tenth of the amount spent on chemical fertilisers. Considering the fact that ecological/organic fertilisation is only a component in these schemes, the support for the same is negligible.

In short, the Central Government policies are highly skewed towards chemical fertilisers!

Table 4.3
Soil Health components and total outlay for the major Central Government Policies and Schemes

Policy /Scheme	Components	2008-09	2009-10
		Allocation - Rupees (crores)	
Chemical Fertiliser Subsidy	Support only for Chemical fertilisers	96,606	49,980
National Project on Management of Soil Health and Fertility (NPMSF)	Three main components – Organic manuring only a subcomponent of INM component.	47	47
National Project on Organic Farming (NPOF)	Seven components of which, of which one provides support for organic fertiliser production	30	30
Rashtriya Krishi Vikas Yojana (RKVY)	Seventeen components aimed at overall development of Agriculture, of which two are linked to soil health, and one linked to promotion of organic fertilisers	3165.67	3806.74
National Food Security Mission (NFSM – Rice, Wheat and Pulses)	15 components for rice, 14 for wheat and 8 for pulses of which one component each is related to Integrated nutrient management or micronutrient addition	1167.31	1490.98

Ref: (1) Union Budget documents, relevant years, (2) Compendium of Plan Schemes in DAC (http://agricoop.nic.in/progs.htm), (3) http://rkvy.nic.in , (4) http://nfsm.gov.in

Further analysis of money spent on each component of RKVY, indicates that only 2.64% of the total amount spent under this scheme in 28 states in 2009-10 was earmarked for organic farming/biofertiliser component. Again, this money is not exclusively for ecological fertilisation but for promoting all aspects of organic farming and biofertilisers.

Table 4.4.
Amount spent on organic farming/ biofertilisers under RKVY in 28 States of India
(Excluding Union Territories and money allocated for institutions)

Year	Total amount allotted under RKVY in (lakh rupees)	Amount spent on Organic farming/biofertilisers (lakh rupees)	Percentage of money spent on organic fertiliser component
2007-2008	116738.45	2369.36	2.03
2008-2009	304206.14	6099.50	2.01
2009-2010 (P)	362005.93	9565.87	2.64

Source: Earmarking of Funds under different Components under Stream I Projects of the Rashtriya Krishi Vikas Yojana (RKVY), Dept of Agriculture & Coperation, GOI

A perusal of the RKVY spending during the last three years in the social audit states (Table 4.5) revealed that, there is no consistent spending every year on organic/biofertiliser component. States like Punjab, which is suffering from indiscriminate chemical fertiliser usage has not even spent a single rupee on this component.

Thus we can conclude that there is hardly any support for ecological/organic fertilisation!

Table 4.5.
Amount spent under RKVY for organic farming /biofertilisers in the five social audit states

State	2007-08		2008-09		2009-2010	
	Total allocation (Lakh rupees)	Amount for organic fert (Lakh rupees)	Total allocation (Lakh rupees)	Amount for organic fert (Lakh rupees)	Total allocation (Lakh rupees)	Amount for organic fert (Lakh rupees)
Assam	0	0	14262	0	8001	129.25
Orissa	2872.34	203.36	6964.82	0	9051.25	104.44
Karnataka	11000	700	31414	0	31892	763.00
Madhya Pradesh	7902.32	0	17205.01	400	15747.25	0
Punjab	5834.00	0	10459.09	0	5703.50	0

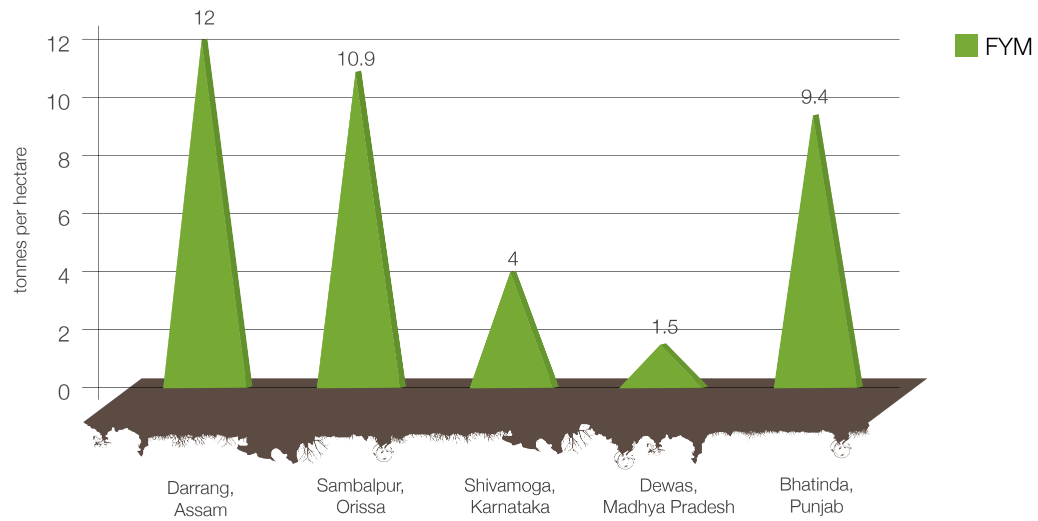
Source : Earmarking of Funds under different Components under Stream I Projects of the Rashtriya Krishi Vikas Yojana (RKVY), Dept of Agriculture & Coperation, GOI

Image: Promotion of cattle as an integral component of farm not only helps improve soil health but also contributes to livelihood security of the small farmers.

Organic fertiliser consumption in the social audit districts

The survey revealed that farmers have been using organic manures, even though they were not receiving any kind of support for the same. But it is mainly restricted to Farm Yard Manure application and there was a direct link between the number of cattle owned and organic manure addition. Even though majority of the farmers are aware of the different modes of ecological fertilisation (as discussed in Chapter 2), they were not practicing any of those mainly due to lack of support and labour intensive nature of these operations.

Chart 4.3
Application of Farm Yard Manure in social audit districts



Farmers' Speak

The discussions in this chapter show that even on paper, the Central Government policies are highly skewed towards chemical fertilisers and there is hardly any support for ecological/ organic fertilisation. The situation is even worse as we go down to the real beneficiaries at the grass roots. There is hardly any awareness about these policies, and the benefits are also not reaching them.

The survey revealed that only 34% of the surveyed farmers knew that the chemical fertilisers are subsidised (Chart 4.4). Out of the aware farmers, only 7% knew that a new subsidy system (NBS) was introduced by the Government. (Chart4.5). Even at the subsidised rate, 94% of the farmers thought that chemical fertilisers were unaffordable and not economical (Chart 4.6).

Chart 4.4
Awareness regarding Central Government subsidy for chemical fertilisers

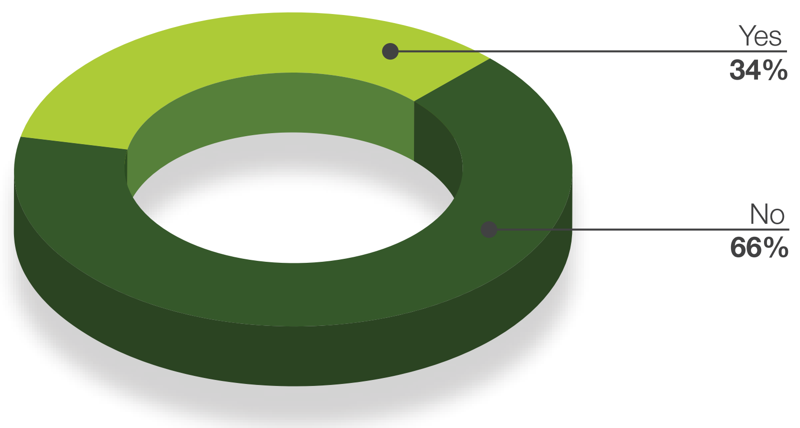


Chart 4.5
Awareness regarding Nutrient Based Subsidy system

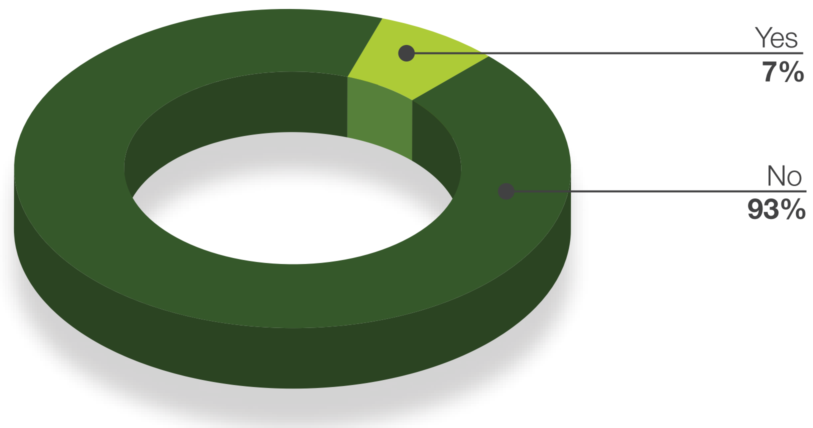
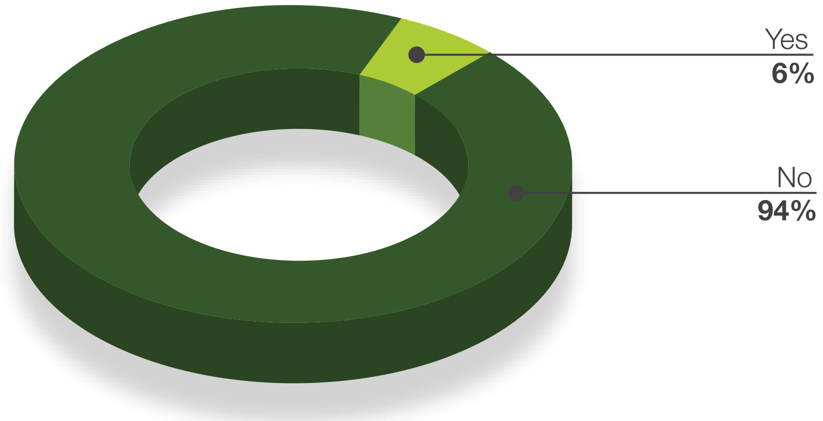


Chart 4.6
Affordability and economic viability of chemical fertilisers at present market rates



Out of the 1000 farmers surveyed, only 1% of the farmers received any kind of support for production and use of organic fertilisers (Chart 4.7). 98% of the surveyed farmers were ready to use organic fertilisers if they were subsidised and easily available (Chart 4.8). Regarding the delivery mechanism, 72.2% of the farmers opted for direct subsidy to farmers, and a considerable number of farmers (49.4%) emphasise on the need for involvement of Panchayats and local administration in coordinating the subsidy delivery and organic fertiliser production (Chart 4.9).

Chart 4.7

Support for production and use of organic fertilisers

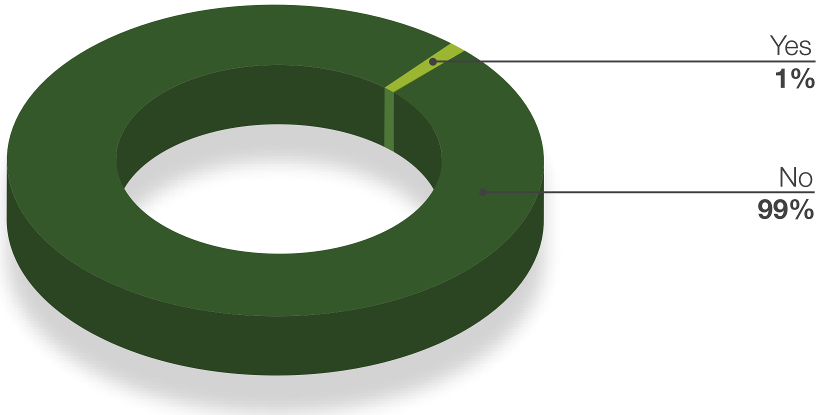


Chart 4.8

Willingness to use organic fertilisers if they are subsidised and made easily available

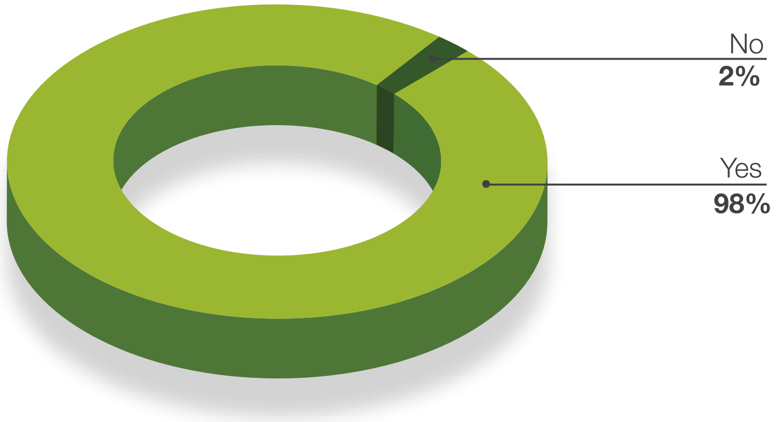


Chart 4.9

Expectations regarding support from government for organic fertilisers

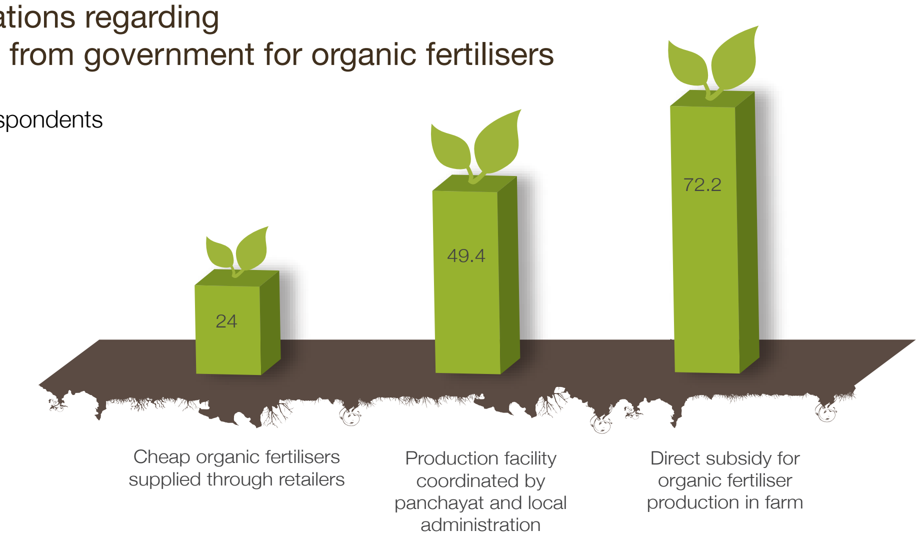


Image: A forward looking ecological fertilisation policy can bring back life in soils and smiles on the farmers' faces.

To sum up:

- The Central Government schemes are highly skewed towards chemical fertilisers and there is hardly any support for ecological fertilisation. At the grass roots, the situation is even worse.
- The policy makers should be careful in selecting the right indicators while developing soil health management policies. Misleading indicators like kilogram per hectare of GCA should be avoided.
- The amount of chemical nutrients applied per unit of cultivated area per year is alarmingly high in social audit districts, and there is an urgent need to check this considering the soil health condition as well as the socio-economic impacts of the same.
- Though an ecosystem approach through all modes of ecological fertilisation practices is essential to maintain the physical, biological and chemical properties of the soil, now the practices are mostly restricted to application of Farm Yard Manure only.
- Farmers are concerned about the soil health situation and are ready to adopt ecological fertilisation practices, provided there is support for the same.

FIVE

WAY FORWARD

WAY FORWARD: AN UMBRELLA POLICY FOR ECOLOGICAL FERTILISATION

The ecological fertilisation and natural resource conservation practices discussed in Chapter 2 have a strong potential for building resilient food production systems in the face of uncertainties, through farm-diversification and building soil-fertility. Also, in the interest of sustainability of livelihoods of people through agriculture, eco-friendly agro-techniques need to be proactively promoted. It is worth noting that all the 33 elements, needed for crop growth are found in every plant (including weeds and crop residues which farmers discard out of fields or even burn – Sidhu et al. 1998) and each of its parts. Most of these elements, with the exception of some like potash (K), are in bound-form and much of these solubilise as they decompose due to micro-organisms inhabiting soils. Composting of animal excrements and plant biomass is possible and has potential to generate rural employment. Large quantities of plant bio-mass can be generated, even in rainfed areas, on the fields where crops are grown to meet the recommended levels of fertilisers for dryland crops (about 80kg N and 10kg P per ha). These when used as surface mulch, can meet crop-nutrient needs (Rupela et al. 2006a). And thus obviate the need to depend on synthetic fertilisers.

Additionally, these practices offer alternatives to energy-intensive production inputs such as synthetic fertilisers which are likely to be further limited due to rising energy prices. These practices are therefore likely to achieve equal or even higher yields, as compared to the current conventional practices, which translate into a potentially important option for food security and sustainable livelihoods in rural areas in times of climate change.

Recommendations from Jansunvais and the National workshop

As part of the Living Soils social audit Jansunvais (public hearings) were organized in the entire social audit districts in which all stakeholders of Agriculture participated. The recommendations that came out of the public hearing were compiled and presented at a National workshop in New Delhi in which experts, policy makers, civil society representatives and practitioners participated.

From the deliberations, it was clear that the farmers as well as other stakeholders of agriculture are equally concerned about the state of soil in the country. Everyone agreed to the fact that indiscriminate usage of chemical fertilisers are leading to the present soil health crisis, however the farmers were left without any choice in the absence of adequate support systems.

There were talks about developing strategies for generation of biomass through a variety of means. The discussions also pointed to the need for convergence of policies at the grassroots so as to enable a better soil health, increased productivity and sustainable livelihoods.

The consensus that came out in all these deliberations was there is a need for an umbrella policy for Ecological fertilisation and a mission mode approach to support and promote all components of ecological fertilisation to be taken by the Government. Thus emerged the concept of an ecological fertilisation mission.

The Ecological Fertilisation Mission (EFM)

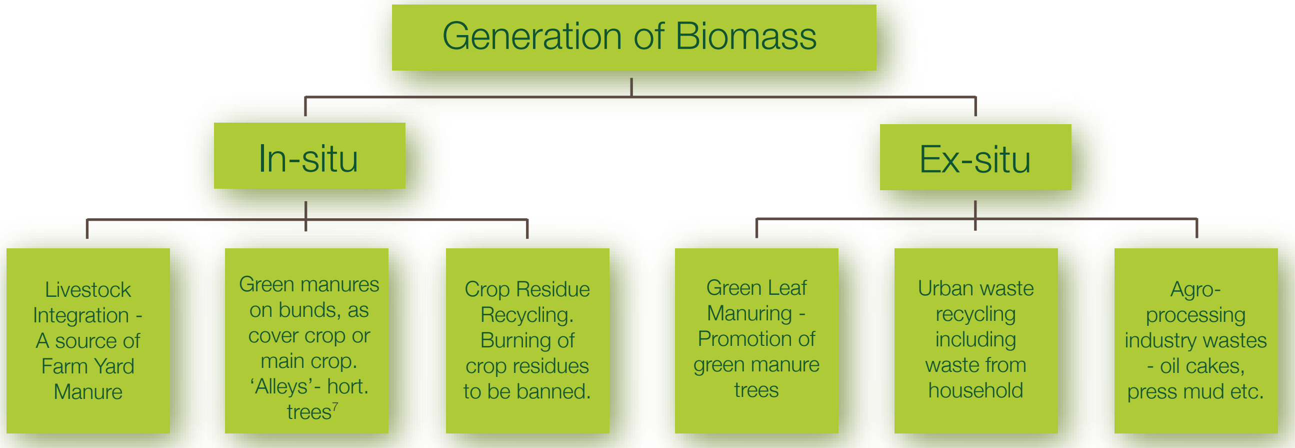
From the discussions in Chapter 4 it is quite clear that the present support systems for ecological fertilisation are scattered, in accessible and in adequate. At the same time, a mission mode approach is needed to generate and add large quantities of biomass in soil. The Central Government should initiate an Ecological Fertilisation Mission with enough financial outlay to restore and maintain soil health. This should have provisions for checking indiscriminate use of chemical fertilisers and promotion of eco-friendly nutrient supplying systems.

What needs to be supported under EFM?

All components of ecological fertilisation practices need to be supported under this new mission. These can be broadly classified into:

a) Generation of Biomass

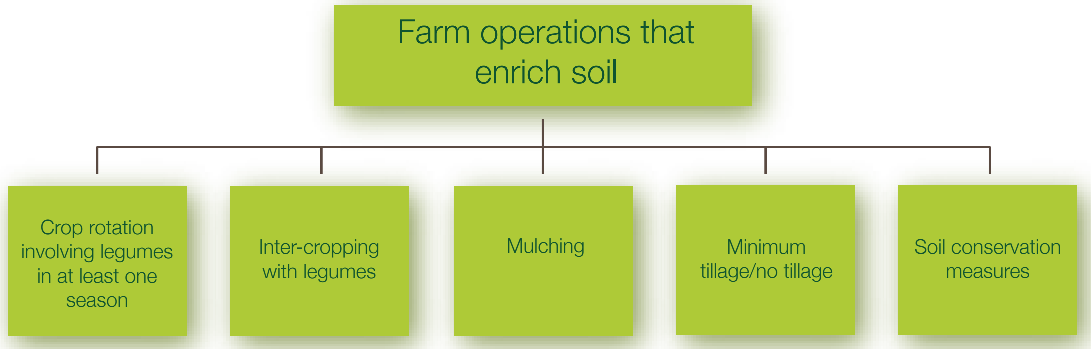
This includes both in situ (on farm) and ex situ (outside farm) methods of biomass generation



b) Composting

On-farm and off farm composting techniques need to be supported. This includes community managed composting pits, and also facilities managed by the farmers themselves. The different methods of composting suited for the locations and the residue available need to be identified and promoted.

c) Farm operations



d) Bio-fertilisers and farm made liquid manures

Bio-fertilisers are substances that contain agriculturally beneficial micro organisms which when applied to the soil can form mutually beneficial relationships with plants and can assist nutrient availability. The mission should ensure that there should be availability of good quality bio-fertilisers suited for specific locations and crops, at minimal or no cost to the farmers.

In addition to this, indigenously developed bio-fertilisers such as Panchagavya, Amrit Paani, Jeevamrutha etc., popularly known as liquid manures, produced by the farmers in their fields, using locally available resource, need to be supported.

e) Eco-bonus for maintaining soil health

Farmers maintaining proper soil health in their fields should be rewarded by initiating an "eco-bonus" system. The soil should be assessed based on the physical, chemical and biological properties of the soil.

[7] Including horticultural trees on cropped land as 5 feet wide 'Alleys' running East-West can also help in biomass generation. This will not cause shading to crops except in the 5 feet belt, and the trees can be lopped for biomass generation.

Institutional mechanism:

The Indian farmers who are largely small and marginal need institutional support for ensuring soil health. A successful model for this is the one being coordinated by the Society for Elimination of Rural Poverty (SERP) of Andhra Pradesh, an agency working under the government of Andhra Pradesh. SERP, through a federation of Self Help Groups [SHGs] has successfully taken up Non Pesticide Management [NPM, innovated and developed by Centre for Sustainable Agriculture, an NGO] in all crops in a very large scale. The NPM over time graduated to Community Managed Sustainable Agriculture (CMSA) and is presently followed on about 28 lakh acres. This kind of a model needs to be worked out for ecological fertilization practices which can be scaled up. Government needs to develop a broad based institutional mechanism involving Gram Panchayats, Krishi Vigyan Kendras, Farmer co-operatives, civil society, rural industry, Self Help Groups (SHGs) and line departments operating at the grass root level with a national coordination system for supporting ecological fertilization practices. At the national level, this mission can be driven by the Ministry of Agriculture and Cooperation and Ministry of Rural Development. The mission should also find synergy with flagship rural development programmes such as National Rural Livelihood Mission (NRLM) and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS).

Budgetary allocation for EFM:

The Mission should have a separate budgetary allocation in the Union budget. Even though the mission should find synergy with other schemes, the mission fund should not be created by diverting funds from any other organic farming/ bio-fertiliser/compost promotion programmes. Instead the money should be shifted from the allocation for chemical fertiliser subsidy.

Regarding the delivery mechanism, the mission should adopt a mix of direct cash transfers and subsidy system. Subsidy may be given for community based programmes and can be delivered through an institutional mechanism created for the purpose.

The Government should organise a series of consultations involving all stakeholders to finalise the organisational structure, delivery mechanism and also the practices that needs to be supported, before the actual mission kicks in.

REFERENCES

Abawi, G.S., and Widmer, T.L., 2000. Impact of soil health management practices on soil borne pathogens, nematodes and root diseases of vegetables crops. Applied Soil Ecology 15, 37–47.

Acharya, C.L. and Bandyopadhyay. 2002. Efficient input management for sustainable agriculture production. Indian Farming 52(8): 42-49.

Ae N, Arihara J, Okada K, Yoshihara T and Johansen C. 1990. Phosphorus uptake by pigeonpea and its role in cropping systems of the Indian subcontinent. Science 248, 477–480.

Alexandra, L. and de Bruyn, L. 1997. The status of soil macrofauna as indicators of soil health to monitor the sustainability of Australian agricultural soils. Ecological Economics 23(2): 167-178.

Azam F., Mallik K.A. and Sajjad M.I., 1985, Transformation in soils and availability of plants of 15N applied as inorganic fertiliser and legume residues, Plant and Soil, Vol. 86, pp. 3-13.

Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, M. J., Avilés-Vázquez, K., Samulon, A. and Perfecto, I. 2007. Organic agriculture and the global food supply. Renewable Agriculture and Food Systems 22: 86-108.

Bansal, K.N.1992. Potassium balancein multiple cropping system in vertisol of Jabalpur. Journal of Potassium Res.85: p52-58

Bengtsson, J. 1998. Which species? What kind of diversity? Which ecosystem function? Some problems in studies of relations between biodiversity and ecosystem function. Appl. Soil. Ecol. 10, 191–199.

Black, C.A, 1993. Soil fertility evaluation and control, Lewis publication, London

Bourguignon C. 1998. Regenerating the Soil. Other India Press, Mapusa, Goa, India.

Cadisch, G. & Giller, K.E. 1997. Driven by Nature, Plant Litter Quality and Decomposition. CAB International, Wallingford

Carter, M.R. 2002. Soil quality for sustainable land management: Organic matter and aggregation interactions that maintain soil functions. Agron J 94: 38-47

Chand R. and Haque T. 1998. “Rice-wheat cropping system in Indo-Gangetic region – issues concerning sustainability.” Economic and Political Weekly 33(26): A 108-112.

Chi F, Shen SH, Cheng HP, Jing YX, Yanni YG and Dazzo FB. 2005. Ascending migration of endophytic rhizobia, from roots to leaves, inside rice plants and assessment of benefits to rice growth physiology. Applied and Environmental Microbiology 71:7271–7278.

Coleman, DC, and DA. Crossley, Jr. 1996. Fundamentals of Soil Ecology. Elsevier Academic Press.

Cordell et al 2009 (p289): “This analysis of peak phosphorus is based on estimated P7 content in remaining world phosphate rock reserves (approximately 2358 MTP8) and cumulative production between 1900 and 2007 (totaling 882MT P) based on US Geological survey data (Buckingham and Jasinski, 2006; Jaisinski, 2007, 2008), data from the European Fertiliser Manufacturers Association (2000), and the International Fertiliser Industry Association (2006)”

Darilek, J. L., Huang, B., Wang, Z., Qi, Y., Zhao, Y., Sun, W., Gu, Z. and Shi, X., 2009 Changes in soil fertility parameters and the environmental effects in a rapidly developing region of China. Agriculture, Ecosystems & Environment 129: 286-292.

Dawe, D., Dobermann, A., Ladha, J. K., Yadav, R. L., Bao, L., Gupta, R. K., Lal, P., Panaullah, G., Sariam, O., Singh, Y., Swarup, A. and Zhen, Q. X. (2003) Do organic amendments improve yield trends and profitability in intensive rice systems? Field Crops Research 83: 191-213

Defra (2010), ‘Diffuse water pollution: phosphorus’ www.defra.gov.uk/environment/quality/water/waterquality/diffuse/nitrate/phosphorus.htm

Devakumar N., Rao G.G.E., Nagaraj S., Shubha S., Khan ,Imran and Goudar S.B., 2008. Organic farming and activities of Organic Farming Research Centre. A bulletin by UAS, Bangalore. pp 18-27.

Doran, J.W. and Zeiss, M.R. 2000. Soil health and sustainability: managing the biotic component of soil quality. Applied Soil Ecology 15(1): 3-11.

Doran, J.W., and T.B. Parkin. 1994. Defining and assessing soil quality. p. 3-21. In J.W. Doran et al. (ed.) Defining soil quality for a sustainable environment. SSSA Spec. Publ. 35. SSSA, Madison, WI.

Doran, J.W., Jones, A.J. (Eds.). 1996a. Methods for Assessing Soil Quality. Soil Science Society of America Special Publication, vol. 49. Soil Science Society of America, Madison, Wisconsin.

Doran, J.W., M. Sarrantonio, and M.A. Liebig. 1996. Soil health and sustainability. Advances in Agronomy. 56:1-54.

Drinkwater, L.E., Cambardella, C.A., Reeder, J.D., Rice, C.W. 1996. Potentially mineralizable nitrogen as an indicator of biologically active soil nitrogen. In: Doran, J.W., Jones, A.J. (Eds.), Methods for Assessing Soil Quality. Soil Science Society of America, Special Publication 49, Madison, WI, pp. 217–229.

Drinkwater, L.E., Wagoner, P. and M. Sarrantonio. 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. Nature 396:262-265.

FAO (2008), ‘Efficiency of soil and fertiliser phosphorus use: Reconciling changing concepts of soils phosphorus behaviour with agronomic information’, Fertiliser and Plant Nutrition Bulletin, 18,Rome (ftp://ftp.fao.org/docrep/fao/010/a1595e/a1595e00.pdf);

Feller C., Balesdent J, Nicolardot B and Cerri C. 2001. Approaching functional soil organic matter pools through particle-size fractionation, examples for tropical soils. In Lal R, Kimble KM & Follet RF(eds) Assessment methods for soil carbon. Advances in Soil Science, pp 53-67 CRC

Fertiliser Statistics (several volumes), Fertiliser Association of India.

Fischer RA, Byerlee D and Edmeades GO (2009), ‘Can technology deliver on the yield challenge to 2050?’

Gajanan, G.N., Ganapathi and Shankar, M.A, 2005, Relevance of organic matter for sustainable crop production in dryland – A success story for 25 years. (Report of AICRP on dryland Agriculture)

Gajanan, G.N., Hedge, B.R., Ganapathi, Panduranga, Somashekara, 1999, Research Nulletin, AICRP on Dryland Agriculture, UAS, GKVK, Bangalore – 560 065

Gattani, D.D., Jain, S.V., and Seth, S.P. 1976. Effect of continuous use of chemical fertilizers and manures on soil physical and chemical properties, Journal of Indian Society of Soil Sciences, 24: p 284-289

Giller K. E and Cadisch G. 1997. Driven by nature: a sense of arrival or departure. In: Cadisch G. and Giller K. E (eds), Driven by nature: Plant Litter Quality and Decomposition. CAB International, Wallingford, UK pp 393-399

Günther, F. 2000. Vulnerability in agriculture: Energy use, structure and energy futures. INES conference, KTH, Stockholm, 15 June 2000. Department of Systems Ecology, Stockholm University.

Havlin, J.L., J.D. Beaton, S.L. Tisdale, and W.L. Nelson. 2005. Soil fertility and nutrient management: An introduction to nutrient management. 7th Edition. 515 p. Pearson/Prentice Hall. Upper Saddle River, NJ.

Hegde, D.M. 1992. Cropping Systems Research Highlights. Modipuram. Project Directorate for Cropping System Research, Modipuram.

Hepperly, P., Douds, D., and R. Seidel. 2006. The Rodale Institute Farming Systems Trial 1981 to 2005: Long term analysis of organic and conventional maize and soybean cropping systems. Pages 15-31 in Long Term Field Experiments in Organic Farming. J. Raupp, C. Pekrun, M. Oltmanns, and U. Kopke eds. ISO¬FAR, Verlag Dr. Koster, Berlin 198 p.

Hepperly, P., Seidel, R., Pimentel, D., Hanson, J., and D. Douds, Jr. 2007. Organic farming enhances soil carbon and its benefits. Pages 129-153 in Soil Carbon Management: Economic, Environmental, and Soci¬etal Benefits, J. Kimble, C. Rice, D. Reed, S. Mooney, R. Follet, and R. Lal eds. CRC Press, Boca Raton, 268 p.

Hillel, D. 1982. Introduction to soil physics. Academic Press, San Diego, CA. http://soilhealth.cals.cornell.edu/

Ivanhoe, L. F. 1995. Future world oil supplies: There is a finite limit; World Oil, October 1995, p. 77-88.

Jumma, N.G and Tabatabai, M.A.,1978, Distribution of phosphomonoesterases in soils. Soil Scie., 126:101-108

Karlen, D.L., M.J. Mausbach, J.W. Doran, R.G. Cline, R.F. Harris, and G.E. Shuman. 1997. Soil quality: A concept, definition, and framework for evaluation (A guest editorial). Soil Sci. Soc. Am. J. 61:4-10.

Keller, M. and Zengler, K. 2004. Tapping into microbial diversity. Nature Reviews: Microbiology 2, 141-150

Kibblewhite, M. G., Ritz, K. and Swift, M. J. (2008) Soil health in agricultural systems. Philosophical Transactions of the Royal Society B: Biological Sciences 363: 685-701.

Kolar, J.S. and Grewal, H.S. 1988. Green manure to sustain productivity and save nitrogen for rice in a rice-wheat cropping system. International Rice Research Newsletter. 13: 29.

Krishnappa, A. M., Ramana gowda, P. and Arunkumar, Y.S., 1996. Sugmentation of biomass production for organic farming. In Organic farming and sustainable agriculture proceedings of national seminar held at UAS, Bangalore 9-11 Oct., 1996 pp: 33-45

Kute, S. B. , and Mann H.S., 1969, Effect of green manuring on the composition of soil and wheat crop and balance of major plant nutrient in soil after the crop, Journal of Agricultural Sciences, Vol.39, pp. 10-17.

Lacey, L.A., Frutos, R., Kaya, H.K. and Vail, P. 2001. Insect pathogens as biological control agents: Do they have a future? Biological Control 21(3): 230-248.

Ladha, J. K., Dawe, D., Pathak, H., Padre, A. T., Yadav, R. L., Singh, B., Singh, Y., Singh, Y., Singh, P., Kundu, A. L., Sakal, R., Ram, N., Regmi, A. P., Gami, S. K., Bhandari, A. L., Amin, R., Yadav, C. R., Bhattarai, E. M., Das, S., Aggarwal, H. P., Gupta, R. K. and Hobbs, P. R. (2003) How extensive are yield declines in long-term rice-wheat experiments in Asia? Field Crops Research 81: 159-180.

Lal, R. 1998. Basic concepts and global issues: soil quality and agricultural sustainability. In: Lal, R (Ed.), Soil Quality and Agricultural Sustainability. Ann Arbor Science, Chelsea, MI, USA, pp. 3–12.

Larson, W. E. and Pierce, F. J. 1994. The dynamics of soil quality as a measure of sustainable mangement. Pages 37 - 51 in J. W. Doran, D. C. Coleman, D. F. Bezdicek and B. A. Stewart, eds. Defining soil quality for a sustainable environment. SSSA- Special Publication 35. Soil Science Society of America, Madison , WI, USA.

Larson, W.E., and F.J. Pierce. 1991. Conservation and enhancement of soil quality. In Evaluation for sustainable land management in the developing world. Vol. 2. IBSRAM Proc. 12(2). Bangkok, Thailand. Int. Board for Soil Res. and Management.

Lotter, D., Seidel, R., and W. Liebhardt. 2003. The performance of organic and conventional cropping systems in an extreme climate year. American Journal of Alternative Agriculture 18(2):1-9.

Masto, R., Chhonkar, P., Singh, D. and Patra, A. 2008 Alternative soil quality indices for evaluating the effect of intensive cropping, fertilisation and manuring for 31 years in the semi-arid soils of India. Environmental Monitoring and Assessment 136: 419-435.

Mishra, Srijit and Gopikrishna, S.R. 2010. Nutrient Based Subsidy and Support Systems for Ecological Fertilization, Greenpeace India Policy Brief.

Papendick, R.I., Parr, J. 1992. Soil quality — the key to a sustainable agriculture. Am. J.Altern. Agric. 7, 2–3.

Pathak, H and Sarkar M.C., 1997. Nitrogen supplementation with rice straw in an ustocherept. Journal of the Indian Society of Soil Science, Vol. 45 , pp. 103-106

Patiram and Singh K./A. 1993. Effect of continuous application of manures and fertilizers on some properties of acid inceptisoll, Journal of Indian Society of Soil Sciences, 41: p 430-433

PIB release, 2010. http://pib.nic.in/release/release.asp?relid=65368

Prabhakar M., Hebbar S.S. and Prasannakumar, 2002. Green manuring in rainfed vegetable and fruit production systems, in: Potentials of green manuring in rainfed agriculture, pp. 79-88.

Ramachandra Prasad T.V., Channabasavegowda R. and Kirankumar V.K., 2005, Some complements for sustainable farming systems. In proceedings of symposium on sustainable agriculture for drylands on the Deccan Plateau, held at UAS, Bangalore. pp. 300-308

Ramamoorthy, V., Viswanathan, R., Raguchander, T., Prakasam, V. and Samiyappan, R. 2001. Induction of systemic resistance by plant growth promoting rhizobacteria in crop plants against pests and diseases. Crop Protection 20 (1): 1-11.

Rao, D.L.N. 2007. Microbial Diversity, Soil Health and Sustainability, Journal of Indian Society of Soil Science, Vol 55, No.4, pp 392-403

Rao, D.L.N. and Manna, M.C. 2005. An Appraisal of Soil Quality Assessment Indicators In: Conservation Agriculture-Status and Prospects. Proceedings of National Conference on Conservation Agriculture: Conserving Resources-Enhancing productivity. Eds. (I,P, Abrol, R.K. Gupta and R.K. Malik), CASA, New Delhi , pp 210-217.

Rao, D.L.N., and Patra, A.K. 2009. Soil Microbial Diversity and Sustainable Agriculture, Journal of the Indian Society of Soil Science, Vol 57, No.4, pp 513-530.

Riley, J. 2001. The indicator explosion: local needs and international challenges. Agriculture, Ecosystems, and Environment 87: 119-120.

Romig, D.E., Garlynd, M.J., Harris, R.F., McSweeney, K. 1995. How farmers assess soil health and quality. Journal of Soil and Water Conservation 50, 229–236.

Rosemarin A, de Bruijne G and Caldwell I (2009), 'The next inconvenient truth: peak phosphorus'; Cordell et al (2009) 'The storyof phosphorus'.

Roy, B.C. , Chattopadhyay G.N. and Tirado R. 2009. Subsidising food crisis: synthetic fertilizers lead to poor soil and less food, Greenpeace India report.

Rupela, O.P., Gowda, C.L.L., Wani, S.P. and Hameeda Bee. 2006(a). Evaluation of crop production systems based on locally available biological inputs. Pages 501-515 in Biological Approaches to Sustainable Soil Systems (N. Uphoff et al. eds.), CRC Taylor & Francis, Boca Raton, Florida, USA.

Rupela, O.P., Humayun, P., Venkateswarlu, B. and Yadav, A.K. 2006. Comparing conventional and organic farming crop production systems: Inputs, minimal treatments and data needs. Organic Farming Newsletter, Vol 2: 3-17

Sanchez, P., M. P. Gichuru, and L. B. Katz. 1982. Organic matter in major soils of the tropical and tem¬perate regions. Proc. Int. Soc. Soil Sci. Cong. 1:99-114.
Schaller, N. 1990. Mainstreaming low-input agriculture. J. Soil and Water Conserv. 45:9-12.

Sidhu, B.S., Rupela, O.P., Beri, V. and Joshi, P.K. 1998. Sustainability implications of burning rice- and wheat-straw in Punjab. Economic and Political Weekly, Sep 1998: A-163-168.

Sikora, R.A. 1997. Biological system management in the rhizosphere: an inside-out/outside-in perspective. Mededelingen - Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen Universiteit Gent 62(2a): 105-112.

Singh ,Muneshwar 2007, Proceedings of soil organic carbon stocks and soil organic matter management in relation to soil quality and climate change,L-17 P 1-8.

Sinha, B.K, Sarkar A.K., and Srivaastava 1983. Effect of continuous application of manure and fertilizer as difficult tons of aluminium in acid soil, Journal of Indian Society of Soil Sciences, 31: p 632-634.

Smith SR, (2007), 'Recycling biosolids to land' in Hislop H The Nutrient Cycle: Closing the Loop, Green Alliance.

Soil Association, 2010, A rock and hard place- Peak phosphorus and threat to our food security.

Sojka, R.E., and D.R. Upchurch. 1999. Reservations regarding the soil quality concept. Soil Sci. Soc. Am. J. 63:1039-1054. USDA-NRCS Soil Quality Institute. 1999. Soil quality card design guide: A guide to develop locally adapted conservation tools. http://www.statlab.iastate.edu/survey/SQI/

Sparling, G., Parfitt, R. L., Hewitt, A. E., Schipper, L. A. 2003. Three approaches to define desired soil organic matter contents. J Environ Qual 32: 760-766

Stockholm Environment Institute (2005), 'Sustainable pathways to attain the millennium development goals – assessing the role of water, energy and sanitation', for the UN World Summit September 2005, Stockholm.

Streeter J. 1988. Inhibition of legume nodule formation and nitrogen fixation by nitrate. CRC Critical reviews in Plant Science 7:1–23.

Suresh lal and Mathur, B.S, 1988. Effect of long term application of fertilizers, manures and lime on crop yields and some soil physical and chemical properties. Journal of Indian Society of Soil Sciences., 38:p 21-26

Swift, M.J., A. Izac, and M. Van Noordwijk. 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? Agriculture, Ecosystems and Environment 104(1): 113-134.
Tirado, R (2009), Chemical fertilizers in our water: an analysis of nitrates in the groundwater in Punjab, Greenpeace report

Tirado, R., Gopikrishna, S.R., Krishnan, R. and Smith, P. 2010. Greenhouse gas emissions and mitigation potential from fertilizer manufacture and application in India. International Journal of Agriculture Sustainability 8(3): 176–185, doi:10.3763/ijas.2009.0422.

Vaccarit DA (2009), 'Phosphorus famine: the threat to our food supply' (www.scientificamerican.com/article.cfm?id=phosphorus-a-loomingcrisis).

Vasuki,N., Yogananda,S.B., Preethu,D.C., Sudhir,K., Jayaprakash S.M, 2009. Impact of long term fertiliser application on soil quality, crop productivity and sustainability – two decades experience

Wani, S.P., Rupela, O.P. and Lee, K.K. 1995. Sustainable agriculture in the semi-arid tropics through biological nitrogen fixation in grain legume. Plant and Soil 174: 29-49.

Warkentin, B.P., and H.R. Fletcher. 1977. Soil quality for intensive agriculture. p.594-598. In Proceedings of the International Seminar on Soil Environment and Fertility Management in Intensive Agriculture. Society of Science of Soil and Manure. Japan.

Yadav, R. L., Dwivedi, B. S. and Pandey, P. S. (2000). Rice-wheat cropping system: assessment of sustainability under green manuring and chemical fertiliser inputs. Field Crops Research 65: 15.

Young, A., R.J. Cheatle and P. Muraya. 1986. The potential of agroforestry for soil conservation. Part III. Soil Changes under Agroforestry (SCUAF): A predictive model. ICRAF Working Paper 44. Nairobi: ICRAF.

APPENDIX

Appendix 1

Population (log10 per g or per ml of material) of agriculturally beneficial bacteria in cattle dung, its products (compost, Amrit Paani) and bio-fertilisers sold in Indian markets.

Material	Beneficial group of bacteria			
	Siderophore	Growth without N	P-solubilisers	*Pseudomonas fluorescens*
Compost from fields of 7 farmers	6.07-8.11	ND*	<2.0 - 7.85	<3 - 6.89
Market Inoculants (range)∞	**NR**	**3.30-7.45**	**5.08-6.62**	**<2-6.81**
Cattle dung	5.82-8.26	6.64-6.76	<2.0	<3.0
Amrit Paani#	6.00	5.0	5.85	5.41
Compost prepared at ICRISAT	6.14	6.7	6.17	6.46

* ND = Not determined
∞ Duplicate samples of at least four companies were collected and studied within the expiry period stated on the products. Each data point is mean of the duplicate samples.
A traditional knowledge product widely used by organic farmers.

Source: O.P. Rupela, unpublished

Appendix 2

The data below is from the field of a farmer (Deepak Suchade, mobile: 9329570960) who cultivated only 10 Gunta [¼ of one acre (=40 Gunta or 43560 sft)] and claimed to produce enough for a family of four. Sowing is generally done by dibbling seeds on a heap containing 'Amrit Matti' – a kind of high quality compost. Heaps (about 45 cm diameter and about 30cm high) were covered with about 10 cm thick plant biomass (foliage or grass) dipped in Amrit Paani. Watering was done by rose cans or hose pipe. Soil sampling was done in Sept 2007 from top 15 cm profile using a 40mm soil corer. Samples from uncultivated part of the same field was used as control.

It may be noted that the control soil had large quantity of total form of each nutrient. Only <0.1% (in case of iron) to 7.7 % (in case of sulfur) were in the available form. However, concentration of the available nutrients below the heaps was 1.3 to 7.6 times more than that in the control plots. The increased concentration were now more than the critical limits of each of the six nutrients. It seems that the biological activity in the heap and below it was converting the non-available form to available form. This also means that addition of compost and use of biomass as surface mulch has the potential to meet nutrient needs without using bag fertilisers. More studies are needed to confirm this phenomenon.

Concentration (ppm) of available form of five different nutrients in the soil samples collected from the field of a farmer growing crops by 'Heap Method#' without chemical fertilizers.

Nutrient (critical minimum limits, ppm)	Spot of soil sampling			
	Control∞	Between heaps	Heaps	Below heaps
Phosphorus (5)	17.1 (329)	20.5	33.1	247.7
Potash (50)	284 (ND)#	315	424	770
Boron (0.58)	0.3 (29.7)	0.3	0.3	2.3
Sulfur (8-10)	7.2 (93)	7.0	7.6	18.9
Iron (2)	15.6 (40442)	11.7	9.1	21.0
Zinc (0.75)	0.8 (133)	1.1	1.0	6.1

∞ Data in parentheses are total concentration (non-available form) of the same nutrient.
ND = Not Determined

'Living Soils', a nationwide campaign launched by Greenpeace India critically reviewed the soil health management support systems of Central Government through a participatory approach using social audit as a tool. The campaign organised in selected districts of Assam, Orissa, Karnataka, Madhya Pradesh and Punjab between July and November 2010, proved to be a celebration of soils. Farmers came in large numbers to organise demonstrations and events to highlight the issues related to soil health and solutions.

LIVINGSOILS

Greenpeace is a global organisation that uses non-violent direct action to tackle the most crucial threats to our planet's biodiversity and environment. Greenpeace is a non-profit organisation, present in 40 countries across Europe, The Americas, Asia and the Pacific.

It speaks for 2.8 million supporters worldwide, and inspires many millions more to take action every day. To maintain its independence, Greenpeace does not accept donations from governments or corporations but relies on contributions from individual supporters and foundation grants.

Greenpeace has been campaigning against environmental degradation since 1971 when a small boat of volunteers and journalists sailed into Amchitka, an area north of Alaska, where the US Government was conducting underground nuclear tests.This tradition of 'bearing witness' in a non-violent manner continues today, and ships are an important part of all its campaign work.

Greenpeace India Society

Head Office - Bengaluru
60, Wellington Street,
Richmond Town
Bengaluru 560 025, India
T: +91 80 41154861,
F: + 91 80 41154862

Regional Office - New Delhi
T-95A, First Floor ,C L House
Gautam Nagar, Gujar Dairy
New Delhi 110 049, India
T: +91 11 46495000
F: +91 11 46495010

Toll Free No : 1800 425 0374
E: supporter.services.in@greenpeace.org
www.greenpeaceindia.org

GREENPEACE
ग्रीनपीस