STRATEGIES FOR SUSTAINABLE INCREASE IN FOOD PRODUCTION

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Introduction

The major constraints to food security are found in social, economic and political conditions rather than in production methods themselves. Most prominent reasons for lack of food security are: poverty, inequality and discrimination (on grounds of class, age, sex etc) – lack of money to buy food or lack of access to resources to produce food such as access to land, access to inputs and water and access to credits. Other factors are lack of labour or lack of distribution capacity and bad infrastructure. Women in India are major producers of food in terms of value, volume and hours worked. Yet their contribution to farming is insufficiently recognized and there is a growing imbalance between women's access to land, labour, capital, services and facilities on the one hand and their role in production on the other. Furthermore, food insecurity, less varied diet, decreasing nutritional value and deterioration of diets affects the women the worst. While it is clear that the main solutions to food security will have to be found in social, economic and political improvement, nevertheless, demand for food will increase in the future so there are reasons why production issues have to be addressed and a number of production related factors need to be considered seriously.

The development of high-yielding varieties of crops has greatly benefited some segments of society, but not without attendant risks. The Green Revolution brought a trend towards genetically more uniform agriculture in areas suited to the high-yielding, high-input modern varieties. Whereas traditional mixed farming systems produce reliable yields, planting a single modern crop variety over a large area can result in high yields but the crop may be extremely vulnerable to pests, disease and severe weather. The Irish famine in 1846 due to the potato blight Phytophthera infestans is well known. In 1970, the U.S. corn crop suffered a 15 percent reduction in yield and losses worth roughly $ 1 billion when a leaf fungus (Helminthosporim *maydis*) spread rapidly through the genetically uniform crop. The loss of a large portion of the Soviet wheat crop to cold weather in 1972, and the citrus canker outbreak in Florida in 1984 all stemmed from reduction in genetic diversity.

The Value of Genetic Diversity in Agriculture

Newer strategies for stabilizing production involve the use of varietal blends (a mix of strains sharing similar traits but based on different parents) or multilines (varieties containing several different sources of resistance). In each case, the crop represents a genetically diverse array that can better withstand disease and pets. Despite these efforts, genetic uniformity still places some crops at risk of disease outbreaks and in some regions that risk is considerable. Some 62 percent of rice varieties in Bangladesh, 74 percent in Indonesia, and 75 percent in Sri Lanka are derived from one maternal parent.

It is now well established that the traditional practice of maintaining genetic diversity in the field is the key to long-term sustainable food production. In agriculture and forestry, genetic diversity can enhance production in all agricultural and ecosystem zones. Several varieties can be planted in the same field to minimize crop failure, and new varieties can be bred to maximize production or adapt to adverse or changing conditions.

In the United States form 1930 to 1980, the use of genetic diversity by plant breeders, accounted for at least half of the doubling in yields of rice, barley, soybeans, wheat, cotton, and sugarcane; a threefold increase in tomato yields; and a fourfold increase in yields of corn, sorghum, and potato.

As important as genetic diversity is to increasing yields, it is at least as important in maintaining existing productivity. Introducing genetic resistance to certain insect pests can increase crop yields, but since natural selection often helps insects quickly overcome this resistance, new genetic resistance has to be periodically introduced into the crop just to sustain the higher productivity. Pesticides are also overcome by evolution, so another important agricultural use of genetic diversity is to offset productivity losses from pesticide resistance.

Wild relatives of crops have contributed significantly to agriculture, particularly in disease resistance. Thanks to wild wheat varieties, domesticated wheat now resists fungal diseases, drought, winter cold, and heat. Rice gets its resistance to two of Asia's four main rice diseases from a single sample of rice from central India, Oryza *nivara*.

Genetic Diversity and Livestock Breeding

Genetic diversity is becoming increasingly important in forestry and fisheries, and the use of genetic resources in livestock breeding has markedly increased yields. The average milk yield of cows in the United States has doubled over the past 30 years, and genetic improvement accounts for more than 25 percent of this gain in at least one breed. Although not as dramatic, Asia has also seen a rise in milk output due to the improved genetic stock of dairy cattle.

For a variety of reasons, genetic diversity has been less useful in livestock breeding than in crop breeding. Whereas one major use of the genetic diversity of crops has been in the development of strains resistant to specific pests and diseases, livestock husbandry has relied largely on vaccines since animals (unlike plants) can develop immunity to disease. Second, maintaining livestock germplasm is tougher logistically than maintaining the genetic material of plants: since animals do not produce anything comparable to plant seeds that can be stored easily. An additional problem is that many of the closest relatives of domesticated animals are extinct, endangered, or rare, and thus unavailable for breeding. This should be a priority area for germplasm conservation.

Genetic Improvement of Forest Species

Genetic improvement of forest species has also received less attention than crop improvement. Until recently, most timber was harvested from the wild and little attention was paid to breeding programs. In addition, because trees are so long-lived, the rate of genetic improvement of tree species is quite slow. Tests and measurements of growth characteristics have been made for some 500 species (primarily conifers) over the years, but less than 40 tree species are being bred. Yet, impressive gains have been made with these species. In intensive breeding programs, a 15 to 25 percent gain in productivity per generation has been attained for trees growing on high-quality sites without inputs of fertilizer, water, or pesticides.

Aquaculture

Fish breeding has not been widely utilized to enhance yields because most of the fish eaten is caught from the wild. An exception is aquaculture. In one case, the domestic carp *(Cyprinus carpio)* was bred with a wild carp in the Soviet Union to enhance the cold resistance of the domestic species and allow a range extension to the north.

Maintaining Soil Biodiversity for increased agricultural production.

Improvement in agricultural sustainability will require the optimal use and management of soil fertility and soil physical properties. Both rely on soil biological process and soil biodiversity. This implies management practices that enhance soil biological activity and thereby build up long-term soil productivity and health. Such practices are of major importance in marginal lands to avoid degradation, and in degraded lands in need of restoration.

Integrated Soil Management and Soil Biodiversity

Over the last few years, the concept of Integrated Soil Management (ISM) and Integrated Plant Nutrient Management (IPNM) has been gaining acceptance. It advocates the careful management of nutrient stocks and flows in a way that leads to profitable and sustained production. ISM emphasises the management of nutrient flows, but does not ignore other important aspects of the soil complex, such as maintaining organic matter content, soil structure and soil biodiversity.

Soil biodiversity reflects the mix and populations of diverse living organisms in the soil- the myriad of invisible microbes to the more familiar macro-fauna such as earthworms and termites. These organisms interact with one another and with plants and animals forming a web of biological activity. Environmental factors, including temperature, moisture, acidity and several chemical components of the soil affect soil biological activity. Clearly, for a productive sustainable agriculture, the complex interaction among these factors must be understood so that they can be managed as an integrated system.

Soil health can be defined as the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity and maintain their water quality as well as plant, animal, and human health. The concept of soil health includes the ecological attributes of the soil, which have implications beyond its quality or capacity to produce a particular crop. These attributes are chiefly those associated with the soil biota; its diversity, its food web structure, its activity ad the range of functions it performs. For example, soil biodiversity per se may not be a soil property that is critical for the production of a given crop, but it is a property that may be vital for the continued capacity of the soil to produce that crop.

Biological populations and processes influence soil fertility and structure in a variety of ways, each of which can have an ameliorating effect on the main soil-based constraints to productivity:

- Symbionts such as rhizobia and mycorrhiza increase the efficiency of nutrient acquisition by plants;
- A wide range of fungi, bacteria, and animals participate in the process of decomposition, mineralization, and nutrient immobilisation and therefore influence the efficiency of nutrient cycles;

- Soil organisms mediate bot the synthesis and decomposition of soil organic matter and therefore influence cation exchange capacity, the soil N, S, and P reserve, soil acidity and toxicity; and soil water holding capacity;
- The burrowing and particle transport activities of soil fauna, and the aggregation of soil particles by fungi and bacteria, influence soil structure and soil water regime.

Enhancing soil biological activity

Certain ecological principles are needed to enhance soil biological activity and thereby increase agricultural production

- Supply of organic matter
  Most soil organisms rely on organic matter for food. Each type of soil organism occupies a different niche in the web of life and favours a different substrate and nutrient source. Thus a rich supply and varied source of organic matter will generally support a wider variety of organisms.

- Increasing the number of plant varieties
  Crops should be mixed and their spatial-temporal distribution varied to create a greater diversity of niches and resources that stimulate soil biodiversity.
  * Create a diverse landscape – Diverse habitats support complex mixes of soil organisms;
  * Rotate crops – Crop rotation allows nutrient demand and rooting depth to be varied, thus reducing nutrient mining and hardpans. This encourages the presence of awider variety of organisms, improves nutrient cycling and improves natural processes of pest and disease control.

- Protecting the habitat of soil organisms
  Stimulate soil biodiversity by improving soil living conditions: such as aeration, temperature, moisture, and nutrients quantity and quality.
    - Reduce tillage;
    - Minimise compaction;
    - Minimise the use of pesticides, herbicides and fertilizers;
    - Improve water drainage
    - Maximise soil cover.

- Farming practices to change soil life
  Direct: - methods of intervening in the production system aim to alter the abundance or activity of specific groups of organisms (inoculation and direct manipulation of soil biota).
  Indirect: - interventions are means of managing soil biotic processes by manipulating the factors that control biotic activity (habitat structure, microclimate, nutrients and energy resources) rather than the organisms themselves.

  Common constraints to the use of different soil biological management practices include the labour and time costs, monetary cost, availability of inputs e.g. planting material/inoculants and capacities, as well as social acceptability.

Table 1 : Farmer's Management Practices for Influencing Soil Fertility Through Manipulation of Biological Processes

Management Practices	Biological processes influenced	Soil fertility effects

Biological Inputs • Inoculation with nitrogen-fixing bacteria, mycorrhizas, etc • Introduce bacteria, nematodes, or insects that are predators of pest organism	• Nitrogen fixation • Facilitate nutrient uptake • Fauna burrowing • Decomposition	• Increase nutrient acquisition and H^2O uptake; • Increased heavy metals tolerance • Improve soil structure and porosity • Stimulation of nutrient release
Organic matter inputs • Crop residues • Root residues • Weed residues (without seeds) • Tree litters/ pruning • Green manure • Farmyard manure • Precomposting • Others	• Decomposition • SOM synthesis • Soil fauna and microflora growth	• Increased nutrient availability • Increased nutrient storage/ exchange • Soil physical structure improved • Soil water regimes improved • Increase soil buffer capacity toxicity diminished • Macropore formation improved (macrofauna) • Soil aggregation improved (microfauna)
Inorganic fertiliser inputs	• Mycorrhiza function inhibited (at high P levels) • N-fixation inhibited (at high N levels) • Mineralization / immobilisation balace changed	• Direct transfer of nutrient to plant increased • Nutrient losses increased risk • Acidification risk • Increased nutrient availability
Tillage	• Decomposition stimulated by OM incorporation • SOM decay stimulated by aeration and particle size reduction • Faunal and microbial population diminished	• Short-term nutrient availability increased • Root growth in tilled layer promoted • Nutrient losses increased • Long-term nutrient storage diminished
Pesticides	In general non target organism populations diminished or	• Destabilisation of nutrient cycles

	eradicated	• Loss of soil structure

Source: *http://www.fao.org/agAGL/agll/soilbiod/default.htm*

Policy requirements for sustainable agriculture through diversification of crop production and broader diversity in crops

In order to increase agricultural production in the long term, the incorporation of a broader range of crops including non-food crops is a necessity. Innovative approaches in plant breeding for the purposes of domesticating new crops, bringing in as yet underutilized crops into the mainstream, the development of new plant varieties promoting genetic diversity on farms, such as planting mixtures of adapted varieties, are now recognized as a means for adding stability in agricultural systems and promoting agricultural production and food security.

- Governments, intergovernmental organizations, research institutions, extension agencies, the private sector, farmers organizations and NGOs, should
  - develop programs to monitor genetic uniformity and assess vulnerability in crops;
  - review policies which may affect the level of diversity in agricultural systems, and specifically the degree of genetic uniformity and vulnerability of major crops
  - increase heterogeneity by planting mixtures of adapted varieties and species as appropriate.

- Funding agencies should be encouraged to support international agricultural centres, national agricultural research systems, and other relevant research bodies and NGOs, for work aimed at enhancing levels of genetic diversity in agricultural systems. The release by the international centers of unfinished varieties to national programmes for further development, including on-farm improvement and the selection of high yielding landraces/farmers varieties are measures which could bring higher levels of diversity, adaptability and stability to crops.

- Research systems should
  - increase their capacity to develop and use multilines, mixtures and synthetic varieties;
  - increase their capacity to use integrated pest management strategies, including the use of race-non-specific (horizontal) resistances, the pyramiding of race-specific resistances, and the strategic deployment of resistance genes;
  - encourage the strategic use of a broad range of varieties;
  - use participatory plant breeding strategies to develop plant varieties specifically adapted to local environments;
  - support efforts to identify those activities used in plant breeding, plant research and farming systems that foster on-farm diversity. Such research might include a review of non-homogenous farming systems such as those based on intercropping, polycropping, integrated pest management, and integrated nutrient management, for their possible wider applicability, as well as research to develop appropriate plant breeding methodologies.

- At the national and international levels, systems should be put in place for
  - Developing monitoring and early warning systems for loss of plant genetic resources for food and agriculture

- Supporting on-farm management and improvement of plant genetic resources for food and agriculture
- Increasing genetic enhancement and base-broadening efforts
- Developing new markets for local varieties and diversity-rich products.

Organic Agriculture

Organic agriculture includes all agricultural systems that promote the environmentally, socially and economically sound production of food and fibers. These systems take local soil fertility as a key to successful production. By respecting the natural capacity of plants, animals and the landscape, it aims to optimize quality in all aspects of agriculture and the environment. Organic agriculture dramatically reduces external inputs by refraining from the use of chemo- synthetic fertilizers, pesticides, and pharmaceuticals. Instead it allows the powerful laws of nature to increase both agricultural yields and disease resistance.

Organic agriculture offers the most comprehensive response to the sustainability problems facing agriculture and our food production system. Organic agriculture adopts farming practices minus the use of chemical fertilizers and pesticides. Also in relation to food security, organic agriculture is an appropriate response. Organic production has the potential to produce sufficient quantities and high quality nutritious food. In addition, organic agriculture is particularly well suited for those rural communities that are currently most exposed to food shortages. Also organic agriculture practices are most suited to arid and semi- areas and mountainous areas that are most degraded and account for highly fragile agro- ecosystems. The solutions delivered by organic agriculture should not be seen as isolated technologies but the result of the implementation of a whole farming and food system. One of the main features of organic agriculture is how well it integrates a number of important issues. Even if there are other solutions to each individual problem, there is no other solution that to such a large extent addresses most of the current problems facing rural communities.

Can organic agriculture help augment national food security?

The answer to the question whether organic agriculture can provide and how it will deliver food security is complex. Apart from being the most appropriate tool for reversing ecological degradation, organic agriculture contributes to food security by a combination of many features. The main relevance of organic agriculture is that:

- Organic agriculture can increase productivity, especially in those situations where farmers are most prone to food shortages.
- Organic agriculture can produce safe food and supports a varied diet
- Organic agriculture can increase income and/ or return on labour
- Organic agriculture can reduce costs of production
- The diversification of production that follows reduces both the risk of crop failures and their effects
- Organic agriculture recognises the value of traditional and indigenous knowledge and integrates this in its production methods
- Organic agriculture is sustainable in the long term

Organic agriculture can increase farm productivity

Will production increase or decrease when farms are converted to organic agriculture?

It is not possible to make simple statements about production levels and potentials. However, an overview of how a conversion to organic agriculture will affect yields indicates the following:

- In conventional agriculture practised in most rich countries, conversion to organic agriculture normally leads to yield reduction, often in the range of 5-20 %
- In Green Revolution agriculture (irrigated lands) conversion to organic agriculture may lead to equal yields
- In 'traditional' agriculture in rain-fed areas, organic farming normally leads to increased yield. On marginal soils it often surmounts conventional yields.

The increased productivity associated with conversion to organic production arises from one or more of the following mechanisms:

- Increase diversity in the agricultural system through crop rotation, intercropping and poly-cultures
- The use of green manure crops either separately or intercropped
- Improved on farm recycling of nutrients by utilisation of crop residues as mulch or through composting and non burning
- Integration of livestock and crops, leading to improved nutrient management
- Better use of natural resources, especially water (by mulching, eater harvesting and through the increase in soil organic matter)

Greater crop diversity not only has the added benefit of more varied diet for farm families and farm workers, more importantly it reduces the risk of harvest failure. Comparing both methods economically- for instance net income and risk of production- organic farming is often better compared to conventional agriculture.

The major critique raised against organic farming is that it is not sustainable in the long term when it comes to nutrient management, i.e. that chemical fertilisers are needed to replace the nutrient that are taken away from the soil. In theory this argument may have some merit, but in practice, the long term-experience of organic farms is contradicting this. There is no evidence that soils are depleted of nutrients on farms that have been organically managed for decades (up to 70 years), on the contrary they normally show an increase in soil organic matter, available nutrients and fertility.

Organic agriculture is a means to increase income

The mechanisms whereby organic farming can improve income, profitability and return to labour are:

- By removing and reducing the need for purchased inputs
- By diversification and optimising productivity
- By maintenance or improvement of on farm and off – farm bio- diversity
- By sales on a premium market

- By setting up processing units close to the farms, organic agriculture can generate rural employment

Maintenance or improvement of on farm and off farm bio-diversity

Organic farms exhibit greater biodiversity with more trees, a wider diversity of crops and many different natural predators that control pests and help prevent disease. Bio-diverse systems are 2-3 times more productive than mono- cultures and are also less prone to weeds. Such biodiversity is vital for ensuring long- term food security. The maintenance of a wide range of crops provides food security throughout the year, an overwhelming important consideration for small farmers, who are intuitively aware of the dangers of mono cropping. Apart from food, biodiversity also provides for the needs of fuel wood and fodder of the rural poor.

By protecting or improving on – farm biodiversity and surrounding natural areas, organic farmers are able to utilise and/ or market " wild " or non- cultivated crops such as medicinal herbs, mushrooms, fruits, etc. those products may also provide an income opportunity for the landless rural poor. In addition they can contribute to the diet.

Organic agriculture provides a varied and safe diet

The increase in production incurred by increased use of fertilisers coupled with new varieties specially developed for a more intensive system has lead to a dilution of essential microelements, reduction of protein quality. A change in diet caused by the comparative advantage of Green Revolution crops and varieties over traditional crops and varieties also contributes to reduced nutrient density of food. In addition monocultures that are a result of the new technologies are leading to a less varied diet, causing malnutrition.

Organic farming adopts farming practices minus the use of toxic inputs such as chemical herbicides or pesticides that are damaging to the environment and human health. Thus organic farming provides safe food. Rresearch of corn, strawberries, fruits grown organically show significantly higher levels of cancer-fighting antioxidants than conventionally grown foods. Organically grown food shows general improvement in taste and nutritional content.

Diversification

The diversification that is often linked to a conversion to organic agriculture can itself leads to increased income (or reduced expenses). Typical examples are:

- Addition of an extra single component of the farm system (with little change to the rest of the farm) such as a home garden production, introduction of fish ponds or a dairy cow
- Addition of a new productive element to the farm system, such as duck or fish in rice paddy fields, or fruit trees planted on the boundaries that provide a boost to total farm food production, without necessarily affecting cereal productivity.
- Addition of products derived from green manure crops, shade trees or other components typically associated with organic farming

Market opportunities

No monetary income and production at a basic level of self-sufficiency is a very risky portion for a rural household. Sudden illness, adverse weather conditions, etc. can push the family into starvation. Therefore, the possibility to sell organic products for a premium price can be very relevant.

In addition to its advantage as means of producing food for farming communities themselves, organic agriculture also has a substantial potential to offer increased income in the production of premium priced crops for a demand driven market.

Exports of organic spices, tea, coffee, basmati rice, sesame and cotton have increased farmers income by 20-30 %. While the income opportunities from export are generally appreciated, we should also be alert that there is a danger for small holders to be left out of the picture. Active government support to inspection and certification and market- oriented services are necessary to provide equal opportunities for small and marginal landholders. Otherwise the export of certified organic products risks becoming a business that only large farmers, or highly organized groups of small holders can afford.

Also, export production should not compete with the production of food for local markets, but there is not always a contradiction between export marketing and local food production. Many of these crops are also grown in rotation with other food crops (cotton with corn, millet, beans, etc) or a system of intercropping with food crops (coffee with bananas, other fruits, etc.) In this way organic farming can both improve income and safeguard local consumption.

Organic agriculture integrates traditional and indigenous farming knowledge

Rural indigenous knowledge and tradition, both agricultural and non- agricultural, is invariably connected to agriculture and agricultural systems. Agricultural systems that rely exclusively on natural methods of building soil fertility and combating pests and disease fall into two categories: certified organic production, which has been inspected and is verified as "organically produced", and *de facto* organic production. Certified organic production forms the basis of what is now a phenomenally rapidly growing market. This however represents just the tip of the iceberg in terms of land that is managed according to organic precepts but is not certified as such. Such *de facto* organic farming appears to be particularly prevalent in resource poor and/or agriculturally marginal regions where local populations have a limited engagement with the cash economy. In such situations, sophisticated systems of crop rotation, soil management and pest and disease control have evolved solely on the basis of traditional knowledge.

Indian farmers are farmers for forty centuries who have a wealth of indigenous agricultural knowledge: This knowledge system is locally bound, culture and context – specific, long standing non- formal knowledge system, which is indigenous to specific areas, orally transmitted, dynamic and adaptive, holistic in nature and closely related to survival and subsistence for many people, specially in the dry land and mountainous regions. Organic agriculture connects to traditional and indigenous farming knowledge while introducing selected modern technologies to manage and enhance diversity, to incorporate biological principles and resources into farming systems and to ecologically intensify agricultural production.

Present status

Organic production is organized by individual farmers, farmers' and women's' organizations, trading companies and a wide variety of NGOs. There are different motivations noticeable amongst farmers for changing to the organic farming system. Organic production is practiced to improve soil fertility, to increase and sustain production, to overcome dependency on external inputs and more frequently, farmers switch to organic agriculture in order to secure market premiums, which are usually found in the more lucrative export markets.

India produces primary organic products. The certified organic area under cultivation is 2.50 lakh hectares, 1.32 per cent of the total agriculture area. Processed food is limited. Certified organic products are predominantly exported, mainly to Europe. Domestic market is virtually non-existent. The Ministry of Agriculture has formulated the National Project on Organic Farming with an outlay of Rs.1000 million for ensuring production, promotion, market development and regulation of organic agriculture in the country. Ministry of Commerce has launched the National Programme for Organic Farming (NPOF) and set up National Steering Committee (NSC). The national accreditation and certification system is in place and regulation is enforced for export. The states of Sikkim, Mizoram, Uttaranchal, Madhya Pradesh and Kerala have announced programmes and made budgetary allocations for promotion of organic agriculture.

Challenges

The most important challenges relate to:

- Government policy initiatives and assistance to conversion processes.
- Access to technical assistance, certification and reasonable forms of credit.
- Extension services and training for farmers
- Training/capacity building for OA by setting up demonstration farms and organic Farmers Field Schools
- Organic Agricultural faculties in a number of prominent Agricultural Universities.
- Increased investment and research in OA. The approach should be land to lab and not lab to land
- Scientific validation of traditional agricultural practices that have proved efficient in increasing the productivity and sustaining resources. Also scientific studies of organic farms that report higher yield than conventional farms.
- Production and supply of organic seeds, organic manure, organic bio-fertilizers and bio- pesticides
- Increase in the number and variety of processed products
- Create consumer awareness about safe and environmentally friendly production of food
- Development of a local Indian market, to supplement the growing export
- Adding organic information to the existing oversees reports on markets.
- Creating awareness among farmers of the importance of certification, as it provides organic guarantee to the consumers and helps in value addition.
- Government support to farmers associations, cooperative or NGOs to facilitate Smallholder Group Certification
- Adequate infrastructure for transport, storage, processing and market.

Policy recommendations

It is recommended that:

- The Ministry of Agriculture should introduce favorable government policies and strategies for promotion of organic agriculture.
- The Government of India to initiate a program of assistance to farmers for conversion
- To promote training and capacity building for organic agriculture by setting up organic Farmers Field Schools that take farmers' knowledge of traditional agriculture practices as the basis and improve on it.
- The Indian Council of Agriculture Research, ICAR, to initiate immediately the set up of an Organic faculty in 5 agriculture Universities
- To increase investment and reorient research in organic agriculture and scale up projects that have already proved successful thereby generating a meaningful impact on income, food security and environmental well being of the poor farmers. Initiate research aimed at scientific validation of the Vedic and traditional agricultural practices that have been for centuries organic and convert this knowledge into advantage. Initiate comparative research on costs of production, productivity and other benefits accruing from organic farming as compared to conventional agriculture.
- To strengthen links and cooperation between government and NGO's from organic sector at national level.
- Government assistance in providing facilities for soil, water testing and pesticide residue testing of organic products.
- Government assistance in micro credit and micro enterprise to self-help groups of landless agricultural families, particularly women, for organic seed preparation, organic compost, bio-pesticides and bio-fertilizers (accessing usufruct rights of common property resources like waste lands exclusively for resource poor).
- The recognition that most rural women are farmers necessitates a reorientation of research, development and extension. Women's access to resources needs to be strengthened as well. Training activities need to be made more relevant to their needs, the crops they produce, the livestock they raise and the farming systems and time constraints within which they work. The credit to be provided and repayment terms have to be adapted to the type of activities women undertake.
- The Dept. of Cooperatives and the Khadi & Village Boards to take up processing of organic products, close to the production areas. This will provide increased employment opportunities to the rural poor.
- To find private or public promoters willing to invest in or take up awareness campaigns, to educate farmers and consumers that by choosing organic agriculture products they are not only getting safe products but are contributing to environmental protection.
- The USAID already sponsors the FICCI, AIC reports, through their ACE Project. It should be investigated whether organic products could be added to their overseas reports, without too many additional costs.
- Farmers' organizations and cooperatives, NGOs to be encouraged to organize internal control systems for small farmers group certification.
- To investigate the possibilities for funding of studies on food security and income generation in the main areas of organic production in India. To select suitable institutions/organizations with renowned experience to carry out these studies.

- To create monthly information bulletin for organic farmers on local prices of the most common food items. Funding for 3 years initially, after which this service would be paid for by subscriptions. The same bulletin could cover information about the preferable mix of crops for own consumption and for the market, relating to specific agro-ecological zones and market demand.

The System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) is a cultivation methodology that shows stunning increases in the productivity of rice. Given the importance of this cereal to global food production, the contribution of SRI to an evergreen revolution should not be underestimated. SRI was developed in Madagascar under the guidance of a Jesuit priest , Fr. Henri de Laulanie, who had been trained in agriculture. SRI enables small farmers to significantly increase yields by changing the ways that plants, soil, water and nutrients are managed in farmers' fields**.** Rice yields in Madagascar have shown an increase from 2-2.5 t/ha yields, on poor soils, to an average yield of 8 t/ha, and sometimes more. Similar results are being obtained with SRI methods in more than a dozen other countries around the world, so it appears that SRI can be beneficial to farmers in a variety of agricultural situations.

To get yield improvements with SRI, it is not necessary to use new varieties of rice or increase the use of agrochemicals. The recommended changes in management practices bring out the productive potential that exists in the rice germplasm but that is inhibited by the practices being used in rice cultivation. SRI appears to work by changing the standard practices that farmers follow, such as planting fairly mature seedlings, (3-4 weeks old), planting the seedlings densely, keeping the fields flooded during the growing season, and using chemical fertilizers. These traditional practices have been followed to save labor and apparently reduce risk as well as to get more production, but they limit rice yield potential by inhibiting root growth and constraining the abundance and diversity of microorganisms in the soil that are crucial for supporting plant growth.
SRI methods, by changing the ways in which rice plants, soil, water and nutrients are managed, have usually been able to double rice yields, to an average of 7-8 tons/hectare (t/ha), compared with the present world average of 3.8 t/ha. With proper and sustained use of these methods, yields can even go beyond 15 t/ha, which has been thought by researchers to represent a kind of 'yield ceiling' of rice. A summary of SRI production levels in a diverse set of countries is presented in Table 2, comparing average and maximum SRI yields with those obtained by usual production methods under similar conditions.

Table 2. Average and Maximum SRI Yields vs. Comparison Yields, in tons per hectare, from Ten Countries

Country	No. of farmers (farms and experimental station)	Average Comparison Yield (t/ha)	Average SRI Yield (t/ha)	Average Max. SRI Yield (t/ha)
Bangladesh	4 -farm (261) 6-station	**4.9** (4.4-5.0)	**6.3** (5.25-7.5)	**7.1** (5.6-9.5)
Cambodia	3 on-farm (427)	**2.7** (2.0-4.0)	**4.8** (3.4-6.0)	**12.9** (10.0-14.0)
China	7 on-station w/	**10.9**	**12.4**	**13.5**

	hybrid varieties	(10.0-11.8)	(9.7-15.8)	(10.5-17.5
Cuba	3 on farm	**6.2** (5.8-6.6)	**9.8** (8.8-11.0)	**13.3** (12.0-14.0)
Gambia	1 on-farm (10) 1 on-station)	**2.3** (2.0-2.5)	**7.1** (6.8-7.4)	**8.8** (8.3-9.4)
Indonesia	2 on-farm 5 on-station	**5.0** (4.1-6.7)	**7.4** (6.2-8.4)	**9.0** (7.0-10.3)
Madagascar	11 on-farm (3,025) 3 on-station	**2.6** (1.5-3.6)	**7.2** (4.2-10.35)	**13.9** (5.6-21.0)
Philippines	4 on- farm (47) 1 on –station	**3.0** (2.0-3.6)	**6.0** (4.95-7.6)	**7.4** (7.3-7.6)
Sierra Leone	8 on-farm (160)	**2.5** (1.9-3.2)	**5.3** (4.9-7.4)	**7.4**
Sri Lanka	6 on-farm (275) 2 on-station	**3.6** (2.7-4.2)	**7.8** (7-13.0)	**14.3** (11.4-17.0)

Source: Country reports in Uphoff et al. (2002).

These increases are achieved at relatively low cost without having to use new services. While high-yield varieties and hybrids produce the highest yields with SRI, all varieties, traditional and local landraces, have responded positively without using agrochemicals, with reduced water use and only10 % as much seed as commonly used.

Farmers using the System of Rice Intensification can lower their costs of production, as they are less dependent on purchased external inputs, which raise their profits and income. They also increase their overall productivity**,** by raising the productivity of their land, labor, capital and water all at the same time. The SRI approach supports changes (a) in the *plants,* particularly greater root growth, and (b) in the *soil,* with a greater abundance, diversity and activity of bacteria, fungi and other microbes as well as the services of soil macrofauna such as earthworms.

Plants generally share some of the sugars, amino acids and other growth-supporting molecules that they create in their canopies, through photosynthesis and by other biochemical processes, with soil microorganisms that support the plant's growth in a symbiotic manner. In return for the carbon and other substances that they receive from plants through root exudation, microbes reciprocate by enhancing soil nutrient availability and uptake (Neumann and Romheld 2001). The roots of SRI plant s are several times larger than those of rice plants grown with conventional practices, particularly under the anaerobic conditions of continuous flooding.

The Role of GM crops in increasing food supply

Will GM technology feed the world or increase food supply as the Ag-biotech industry claims? There is little evidence today to suggest that this might be the case. Although the technology has the potential to create crops that could be more relevant to the needs of the small farmers and the poor, it is not doing so at present. The main crops on offer are soya, cotton, corn and canola and the two predominant traits are herbicide tolerance and insect resistance. Soya is principally meant for animal feed and the corn is yellow corn that is used for animal feed and for making High Fructose Corn Syrup, a sugar substitute,. GM research is not targeted at the white maize, which is a staple food in Africa and which is very susceptible to disease. To reduce hunger and poverty, GM technology would need to address food crops like millets and pulses and traits like drought tolerance and better nutrient uptake.

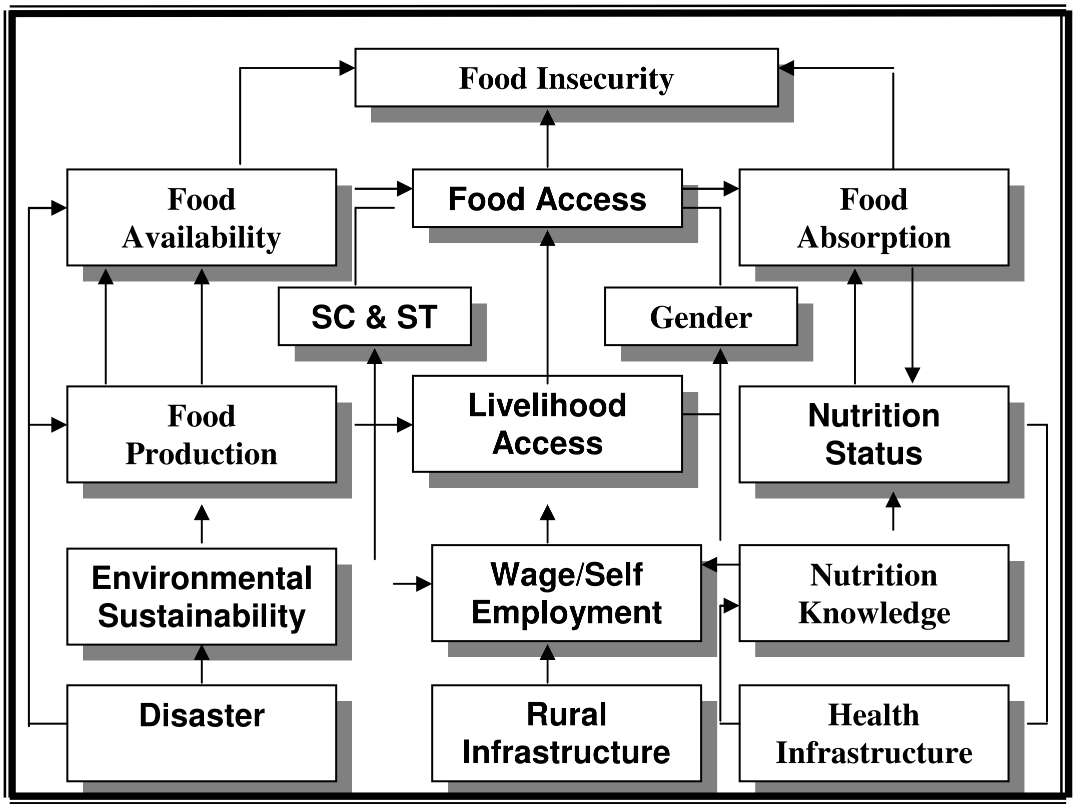
If GM technology were to address a real problem related to agriculture, food and nutrition, there is perhaps no better target than *Lathyrus sativus*, popularly known as *khesari daal.* This is a highly nutritious legume that can grow in the poorest soils and is available to the poor . It is a valuable source of protein but it contains a toxin. Therefore consumption of *khesari daal* over time leads to a form of paralysis because of the toxin but sometimes it's the only food available and is eaten despite the known effects. If GM technology could knock off the toxin gene and produce a safe version of *Lathyrus sativus*, that would be a genuine contribution to agricultural productivity but there is no research being done on Lathyrus or crops needed by the poor. Most of the research is geared to the needs of large scale , industrial agriculture.

Safe and meaningful GM technology may one day play a role in alleviating hunger but other factors will remain overwhelmingly important. A dispassionate appraisal of existing varieties in the field will indicate that almost all crop varieties that are important for food security are still emerging from conventional breeding. Comparing investments in the two technologies, it is clear that conventional breeding has been more effective and productive and has offered greater number of varieties of both food and cash crop compared to GM technology. If the same amount of money and resources that have been invested in GM technology were to be invested in conventional breeding and in crops and traits of importance to developing countries, then it is very likely that we would see problems in agriculture being solved more readily and more quickly.

It needs to be kept in mind that genetic improvement either through the transgenic or the conventional route will not result in better crops unless there are accompanying skills in farm management and optimal management of resources, which are often scarce in developing countries. This over expectation from any one agent of change, genetic, biological or chemical, is unlikely to solve agricultural problems and could end up being a recipe for disaster.

Apart from that, hunger is a complex issue. It is not just about food production, it is also about international trade policies, access to water, soil quality, the size of land holdings, the nature and extent of agricultural subsidies, the availability of easy credit, the availability of good quality agricultural inputs and so on. The multiple, interwoven factors resulting in rural food insecurity are shown in a diagram below (Figure 1)

Figure 1: Factors associated with Food Insecurity in Rural India



Source: *Food Insecurity Atlas of Rural India,* MS Swaminathan Research Foundation and World Food Program, Chennai, 2001, .5.

The Role of Intellectual Property Rights in promoting agricultural production / productivity.

Intellectual Property Rights have become a feature of agricultural research and seed production after the Uruguay GATT Round that introduced the concept of Trade Related Intellectual Property Rights (TRIPS). TRIPS has introduced a regime for the protection of new plant varieties (seeds) which all member states have to follow in one of two forms, a patent or a Plant Breeders' Right (PBR). It is widely accepted that patents on seeds would be against the interest of small farmers since they would restrict access to seed. Farmers, who are accustomed to saving seed from their harvest for the next crop, would be compelled to buy seed for every sowing, if they wanted to buy the patented new seed. This would be an additional financial burden which small farmers could ill afford.

Patents are also iniquitous because they ignore the contribution of farming communities to the development of a crop variety. All new varieties are based on older varieties or on land races developed by farmers. The IPR accorded must reflect the fact that farmer innovations constitute the major steps in developing a plant variety. A patent grants complete rights to the agency that provides the last changes in a crop variety, ignoring the many innovations contributed by the farming communities.

Developing countries must create IPR laws that balance the rights of farmers and breeders. In order to ensure that farmers can access seed easily, an IPR regime must have strong farmers rights, rights for researchers to carry on innovation and breeding with plant germplasm and clauses like compulsory licensing to protect the interest of the farming community if the seed provided by the breeder becomes too expensive or too scarce. The Indian law on plant varieties is a novel legislation that has moved away from the UPOV (Union for the Protection New Varieties of Plants) model and incorporated the enabling elements of the Convention on Biological Diversity.

The Indian law recognizes the farmer not just as a cultivator but also as a conserver of the agricultural gene pool and a breeder who has bred several successful varieties. A path breaking feature in the Farmers' Rights of the Indian law, (the Protection of Plant Varieties and Farmers' Rights Act , 2001), is the right granted to the farmer to sell the seed of even a protected variety, after the second generation but without using the registered name and only for local (not commercial) use.

In this way, both Farmers and Breeders rights are protected. The Breeder is rewarded for his innovation by having control of the commercial market place but without being able to threaten the farmers' ability to be independent and self reliant in agriculture.

<u>Importance of Farmer's Right to Sell Seed</u>

The pivotal importance of the farmer having the right to sell (not save, not exchange, but sell) seed has to be seen in the context of seed production in India. In India, the farming community is the largest seed producer, providing about 85% of the country's annual requirement of over 60 lakh tons. If the farmer were to be denied the right to sell, it would result in a substantial loss of income for him. But far more importantly, such a step would displace the farming community as the country's major seed provider. Their only replacement if this happens, will be the large Life Science corporations since budget cuts have seriously weakened the capacity and output of the other player, the public research institutions.

It is important to understand the political economy of seed production and seed sale in India and in the world, to understand why it was absolutely crucial for food security for the farmer to retain the right to sell. In India, the farming community is the largest producer of seed, supplying the bulk of India's seed requirement. The Agro-Chemical giants turned Life -Science Corporations have emerged as the largest seed producers in the industrialised nations. In Europe and the US, as also in Canada, Australia, New Zealand, Japan and to a lesser extent, Korea and some Latin American countries, seed production is now in the hands of the large corporations. Control over the seed sector was established by the simple expediency of buying up the smaller seed companies. In India, such a strategy can not work because the situation is different.

In India, a strategy to control seed production would have to rely on legally taking away the farmers' right to sell seed. If the farmer can be stopped by law from selling seed (and by implication, producing seed) , the market automatically becomes available to the next alternative, the MNC. Weak Farmers Rights will allow seed corporations to dominate the seed market. Strong Farmers Rights keeps the farming community alive and well as viable competitors and an effective deterrent to a take over of the seed market by the corporate sector. Control over seed production is central to self-reliance in agricultural production and food and nutritional security.

The Indian law further strengthens the farmers' right to access to seed, by forbidding the Gene Use Restricting Technology (GURT) or terminator technology which would shift control over seed from farmers to plant breeders

Researchers rights

IPR regimes must have provisions for Researchers Rights, which allow scientists and breeders to have free access to registered varieties for research. The registered variety should be free for the purpose of creating other, new varieties so that a breeder can not stop other breeders from using the protected variety to breed new crop varieties suited to local conditions.

Protection of public interest

Public interest clauses, like exclusion of certain varieties from protection and the grant of Compulsory Licensing should be important features of an IPR regime on plant varieties. Exclusionary clauses must be protective of human, animal and plant life and health and the environment.

Is UPOV a suitable IPR platform for developing countries?

The International Union for the Protection of New Varieties of Plants (UPOV) is an inter-governmental organization that regulates the implementation of Plant Breeders' Rights.
UPOV has no concept of farmers' rights, acknowledging only one right, the breeders' right. In the UPOV system, the farmer would not have the right to sell seed or other rights like compulsory licensing and being protected from the terminator technology. UPOV was developed for agriculture in developed countries where investment in breeding and seed production is largely done by the private sector and farmers are heavily subsidised. UPOV is not suited to developing countries because its working is totally alien to the conditions of agriculture prevailing in the countries of the south and its focus is not increasing agriculture production but protecting the intellectual property of the breeder. IPR regimes in developing countries must be designed to strengthen the farmer and the breeder in a way that both contribute to enhancing agricultural production without establishing any monopolies.

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