# Health Per Acre
## Organic Solutions to Hunger and Malnutrition

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Navdanya

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# Foreword

## Health Per Acre

## Organic Solutions to Hunger and Malnutrition

India faces a dual crisis related to food and agriculture. First is the malnutrition and hunger crisis. Every 4th Indian is hungry (Ref : Navdanya, "Why is Every 4th Indian Hungry?"). Every third women is severely malnourished. Every second child is "wasted". This is not "Shinning India" but "Starving India". The second aspect of the crisis is the agrarian crisis, tragically highlighted by 250,000 farmers suicides in the last one and a half decades, driven by debt which is largely caused by high cost chemical inputs. The agrarian crisis and the food and nutrition crisis are really connected.

Taking note of the hunger and malnutrition crisis, the Government is trying to put together a Food Security Act. However, there are two serious limitations to the proposed Act. Firstly, it leaves out nutrition. Without nutrition there can be no right to food or health. Malnutrition is leading to a public health crisis, of hunger on the one hand, and obesity, diabetes etc. on the other. Secondly, it leaves out agriculture, food producers and food production systems. Without agriculture and nutrition, there can be no food security.

Both aspects of the food crisis, the agrarian crisis on the one hand and the malnutrition crisis on the other, are related to the fact that food production has become chemical intensive and is focused on "Yield per Acre". However, yield per acre ignores the loss of nutrition which is leading to the malnutrition crisis. It also ignores the increase in costs of chemical inputs which trap farmers in debt and are leading to suicides. "Yield per Acre" measures a part one crop grown in a monoculture. This ignores the lost nutrition in the displaced biodiversity. Thus the Green Revolution led to increase of rice and wheat with chemical intensive, capital intensive and water intensive inputs, but it displaced pulses, oil seeds, millets, greens, vegetables, fruits from the field and from the diet.

Navdanya's "Health per Acre" shows that a shift to biodiverse organic farming and ecological intensification increases output of nutrition while reducing input costs. When agriculture output is measured in terms of "Health per Acre" and "Nutrition per Acre" instead of "Yield per Acre", biodiverse ecological systems have a much higher output. This should be the strategy for protecting the livelihoods of farmers as well the right to food and right to health of all our people.

The paradigm shift we propose is a shift from monocultures to diversity, from chemical intensive agriculture to ecologically intensive, biodiversity intensive agriculture, from external inputs to internal inputs, from capital intensive production to low cost, zero cost production, from yield per acre to health and nutrition per acre, from food as a commodity to food as nourishment and nutrition. This shift addresses the multiple crises related to food systems. It shows how we can protect the environment, while protecting our farmers and our health. And we can do this while lowering costs of food production and distribution. By maximizing health per acre, we can ensure that every child, woman and man in India has access to healthy, nutritious, safe and good food.

**Dr. Vandana Shiva**

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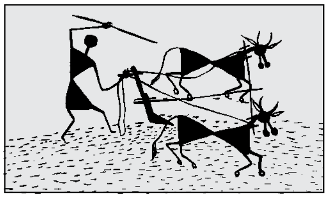
# Introduction

Food, nutrition, health, prosperity, future, and growth, and hunger, disease, poverty, hopelessness, and nation's downfall are much debated topics that, intuitively, are not only correlated but also have a causal connection. Agriculture, one of the oldest and time tested professions of the world, is no longer an economically viable endeavor for most, as demonstrated by the suicides committed by thousands of farmers across India in the past two decades. However, the question to be answered is whether our farmer is committing suicide or our nation. The primary objective of a nation's agriculture is to promote health and feed the people, and to propagate a diet that provides all the necessary nutrients. However, profit maximization has been promoted as the objective of agriculture. Tragically, the more profit oriented agriculture becomes, the higher the farmers indebtedness and farmers suicides, and the deeper the food and nutrition crisis. The irony is that, despite all the claims, maximization of profit for farmers is still far away from realization[1], but the nation has been paying the enormous cost. Most proponents of conventional agriculture claim that the pesticides, one of the many chemicals used in agriculture, have insignificant implication on the human health. Nevertheless, millions of tons of pesticides pumped into the environment every year in the name of high yield agriculture, somehow, manage to reach the human body, as well as the water bodies, fishes, birds, and other animals; this is evident by the fact that quantifiable levels of a number of pesticides have been detected in human milk which puts the infants feeding on the milk at probable risk[2]- risk that is not negligible but rather uncertain. The alarming level of chemicals in the honey sold in Indian market triggered much discussion recently. Science and technology was established to benefit human beings. On the contrary, science and technology, in agriculture, is benefitting the human greed. Because of the need of intensive irrigation by conventional agriculture, some perennial rivers of the world do not reach the sea, but instead dry up in their course midway. A major contributor to global warming, conventional form of agriculture has negative health impacts as well. We shall limit our discussion in this article to the effects of conventional agriculture on the health of the population and of the individuals. This report compares the nutritional and health aspects of food grown organically and food grown conventionally. The scope of the article ranges from nutrition produced per acre farmland by the two systems of agriculture to disease trends observed in the population and how such trends may be related to the food we consume. Conventional agriculture measures "yield" per acre while externalizing costs of chemical inputs, and the environmental and health costs of chemicals. "Yield" measures monoculture outputs, while what we need to assess is diverse outputs of a farming system. Yield also fails to tell us about the nutrition of food. With a focus on health and nutrition we measure health per acre instead of yield per acre.



# What is Health?

Over centuries, the human health has attracted the attention of many. The health of individuals, families, and populations has shaped societies, cultures, countries, and history. Health holds such relevance at all levels of societal organization that ignoring it can not only prove to be futile but also appear to be politically and socially irresponsible. Ancient civilizations realized the importance of health both at individual and community level. Various mythologies around the globe had mentioned deities who blessed their followers with health. Apollo of Greek and Roman mythology and Dhanvantri of Hindu mythology are associated with health and healing- the fact reveals that the concept of health has been an ancient one. Health neither is a new realization of humanity, nor has it gained importance recently.

Although the concept of health is debatable, there are a few accepted definitions. According to Ayurveda, a system of traditional medicine native to the Indian subcontinent, health is defined as," "Samadoshah Samagnischa Samadhatumala kriyaha, Prasanna Atmendria Manaha Swastha Ityabhidheeyate." This definition of health, coined by Vagbhat, means that the person who always eats wholesome food, enjoys a regular lifestyle, remains unattached to the objects of the senses, gives and forgives, loves truth, and serves others, is in good health- it is only when a person is in harmony at physical, mental, psychological, and emotional level that he or she is in good health. Patanjali, the founder of the philosophy and practice of Yoga, states that disease and bad health can hinder the eight fold path to Samadhi- a feeling of bliss also called oneness with the almighty.

Biblical principles- especially the old testament- mentions nutrition and health. Ezekiel was instructed to make nutritious multigrain bread. Health laws given to Moses by God did not emphasize upon disease treatment, but rather endorsed health promotion by disease prevention. Moses recognized the effectiveness of disease prevention over disease cure and propagated the idea of pure food, pure water, pure air, pure bodies, and pure dwellings. Biblical principles are timeless and are as valid today as they were when discovered. According to the Bible, God treats the illness at its source, not the symptoms. The Biblical concept of health is very holistic and includes all aspects of a person- physical, mental, spiritual, and social. Biblically, there is more to health than being only disease-free. There is a sense of well-being, wholeness, integrity, completeness, peace, and prosperity. It is centered in being rightly related to God, and therefore rightly related to everything and everyone else. It is being equipped for God's calling and purposes.

Muslims look at good health as Allah's gift that ensures salvation in the life hereafter and that ensures pleasure in the life in this world. The Quran explicitly mentions," Eat and drink and be not prodigal" (7:31). This directive mandates the followers of Quran to eat or drink the right food in the right quantity. It also forbids excessive eating as it is not conducive to good health. Buddha perceives health to be the greatest gift, a gift without which life is not life but rather a state of suffering and an image of death. According to Buddha, to keep the body in good health is a duty failing which it would become difficult to keep the mind strong and clear. The Buddhist understanding of good health stresses upon the balanced interaction between mind and body as well as between life and its environment; illness tends to arise when this delicate equilibrium is disturbed.

The importance of health does not require quotations from ancient scriptures. We have all seen diseases and deaths around us. The pain and suffering that follows bad health is all the more evident. The World Health Organization defines health as follows ”Health is a state of complete physical, mental, and social well being and not just the absence of diseases or infirmity”. The bibliographic citation for this definition is : Preamble to the constitution of the World Health Organization as adopted by the International Health Conference, New York, 19th June to 22nd July, 1946; it was signed by the representatives of 61 States and entered into force on 7th April, 1948. This definition has been expanded in recent years to include the ability to lead a “socially and economically productive life”. Over years, we have acquired a new philosophy of health, which may be stated as below[3]:

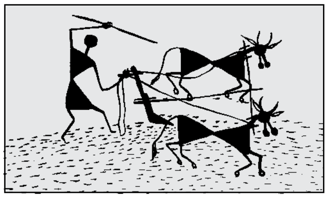
1) Health is a fundamental human right
2) Health is the essence of productive life, and not the result of ever increasing expenditure on medical care
3) Health is intersectoral
4) Health is an integral part of development
5) Health is central to the concept of quality of life
6) Health involves individuals, state, and international responsibility
7) Health and its maintenance is a major social investment
8) Health is a worldwide social goal

There is a legal perspective of health. The Constitution of India, Part 4, mandates, “The state shall regard the raising of level of nutrition and standard of living of its people and the improvement of public health as among its primary duties.”

Based on the citations above, we can safely conclude that overall health can be achieved through a combination of physical, mental, and social wellbeing; together, these factors are referred to as Health Triangle. Philosophically, a spiritual component can be added, making it a Health Quadrilateral. Now, we can be sure that social wellbeing is as important to achieving good health as is a disease free body and mind. Modern man is giving special attention to this whole new genre of scientifically modified fashionable food that is gripping individual and community health. Are we really sure of the food we are consuming? Is the nutrition, and the health offered by that nutrition, in harmony with the dream of Patanjali, Jesus, Mohammed, and Buddha? Are we really propagating health?

As the June 24, 1996, cover story of TIME magazine observed: “Western medicine is at its best in a crisis-battling acute infection, repairing the wounds of war, replacing a broken-down kidney or heart. But increasingly, what ails America and other prosperous societies are chronic illnesses, such as high blood pressure, backaches . . . and acute illnesses that become chronic, such as cancer and AIDS. In most of these, stress and life-style play a part.” Stress has always been and will always be associated to human lives. That the current level of stress in a human life is at an all time high is rather controversial. Because of the scientific accomplishments, life, in general, has become so convenient. The convenience seems to have not penetrated the mind which is in distress. Why are we responding to stress so adversely? Are we confident that our modified style of eating is not leading to high levels of stress? Moreover, lifestyle related diseases can also be referred to as “FOOD STYLE RELATED DISEASES”.

The subsequent chapters will throw light upon the nutritional value of the food that is mostly consumed by modern man and will also compare it with that of food that should ideally be consumed. The food dilemma is so obvious with the advent of fabricated success stories by mega-institutions in Agro business, institutions that act by greed and megalo-mania rather than by compassion and promise to solve the global food crisis.



# What is Nutrition

Nutrition may be defined as the science of food and its relationship to health[3]. It is primarily related to the role played by nutrients in body growth, development, and maintenance. Good nutrition means "maintaining a nutritional status that enables us to grow well and enjoy good health". Nutrients are organic and inorganic complexes contained in food. Each nutrient has specific function in the body. Nutrients may be classified as below:

1) **Macronutrients:** they form the main bulk of food. These are protein, carbohydrates, and fat
2) **Micronutrients:** they are required in small amounts. These are vitamins and minerals.

These days, food is looked at very differently from being just a source of the above mentioned nutrients. There are several bioactive compounds in plant food- several health benefits are attributed to the presence of such compounds in diet. Studies have shown that individuals with increased consumption of fruits and vegetables showed lower incidence of chronic non-communicable diseases such as cancer, cardiovascular diseases, diabetes, and age related decline in cognition[4]. Scientists agreed upon the health benefits of consumption of fruit and vegetable. American Heart Association and American Cancer Society recommends daily intake of generous amounts of fruits and vegetables. Earlier it was thought that the health benefits of fruits and vegetables could be due to the anti-oxidant effects of various micronutrients present in high quantity in them.

This further called for the need for more research to isolate such protective compounds in plant food for therapeutic purposes. Scientists studied the incidence of different chronic diseases in individuals who consumed vitamin, mineral, and antioxidant supplements. Incidentally, these individuals were no better than the normal population in terms of incidence of various cancers, heart diseases, and other chronic diseases. Researchers were compelled to think out of the box. There was something extra in plant food that was unknown. Finally, such compounds as phytochemicals, phenols, flavonoids, etc., in plants were recognized as health promoting chemicals[4,5,6,7,8]. Studies have shown the link between these bioactive compounds and prevention of chronic

| Essential Micronutrients | | | | |
|---|---|---|---|---|
| Vitamin A | Pantothenic Acid (?) | Iodine | Manganese | Thiamin |
| Vitamin D | Vitamin B 12 | Zinc | Iron | Riboflavin |
| Vitamin K | Ascorbic Acid | Copper | Chromium | Nicotinic Acid |
| Vitamin E | Essential Fatty Acids (n6 & n3) | Selenium | Cobalt | Pyridoxine |
| Folic Acid | Biotin (?) | | | |

| Micro Nutrient Rice Foods | |
|---|---|
| Vegetables | Rape Leaves, Cauliflower Greens, Amaranth, Curry Leaves, Garden Cress, Drumstick (Leaves), Fenugreek seeds, Beet Greens, Purslane, Mint, Carrot, Lotus Stem, Tapioca Chips, Colocasia, Radish, Sweet Potato, Yam, Ivy Gourd, Lettuce, Mint, Agathi, Radish Leaves |
| Condiments & Spices | Poppy, Cumin, Coriander, Oregano, Green Chillies (Fresh/Dry), Turmeric, Ginger, Fenugreek, Pepper, Garlic, Mango Powder |
| Nuts & Oilseeds | Cocoanut (Deoiled/Dry/Milk), Groundnut, Cashewnut, Pistachionut, Gingelly Seeds, Garden Cress Seeds, Safflower Seeds, Mustard Seeds, Niger Seeds |
| Fruits | Indian Gooseverry, Watermelon, Custard Apple, Wood Apple, Tomato, Guava, Mango, Pineaple, Orange, Papaya, Grapes, Bael, Pomegranate, Gooseberry, Apricot |

non-communicable diseases[7,8]. These compounds contribute significantly to the total antioxidant activity of fruits and vegetables. These compounds deliver an electron to Reactive oxygen species (ROS- produced in the body as a result of stress, smoking, disease, etc.,) and render them ineffective. ROS are highly reactive and damage cellular macromolecules (protein, membrane, DNA, RNA, etc.). ROS are thought to cause cancers, cardiovascular diseases, diabetes, and other chronic diseases in the long run.

| Major Phytonutrients | Foods Sources of Phytonutrients |
|---|---|
| Carotenoids (Lycopene, Xanthophylls) | Cruciferous Vegetables (Eg Broccoli) |
| Lutein, and Carotene (Cryptoxanthine, Zeaxanthine | Allium Vegetables (Eg Onion) |
| Flavonoids (Quercetin, Myricetin, Quercetagatin, Gossypetin Anthocyanins | Coloured Fruits |
| Isoflavons | Citrus Fruits |
| Phenolic Compounds (Catechin | Soyabean and Other Legumes |
| Indoles n-3 Fatty Acids | Vegetable Oils, Nuts and Seeds |

Additionally, reports from WHO and Food and Agriculture Organization of the United Nations point towards a link between food and nutrition and prevention of non-communicable diseases and also between phytochemicals and prevention of heart disease and cancer. A lot of these phytochemicals used to be present in the traditional Indian diets (predominantly vegetarian with Indian spices), a fact that may explain low percentage of Indian population suffering from cancer compared to developed nations. Many aspects of nutrition are still unknown to us. To act safe, it is still recommended that we derive our nutrition from a variety of sources[8.10]. Hence, the concept of balanced diet is as wise today as it were ever. The following is extracted from a report published by the Planning Commission, Govt. of India[11].

"The three basic approaches for combating micronutrient deficiencies are: medicinal supplementation, food fortification and dietary enrichment through diversification and increased intake of micronutrient-dense foods. The first two approaches can take care of only one or two nutrients. For long-term sustainability, and ensuring adequate intakes of less recognised but deficient nutrients and phytochemicals as well, dietary diversification is the most sensible and sustainable option. Besides its implementation can be in the hands of the community and it can be linked to income generation, particularly for the rural women."

**Summary of Recommended Daily Allowance for Indians[3]**

| Group | Particulars | Body Wt. kg | Net energy Kcal/d | Protein g/d | Fat g/d | Cal-cium mg/d | Iron | Vit. A μg/d Retin-ol | β-caro-fene | Thiamin mg/d | Riboflavin mg/d | Nicotinic acid mg/d | Pyri-dox-ine mg/d | Ascor-bic Acid mg/d | Folic acid mg/d | Vit. B-12 mg/d |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Man | Sedentary work | | 2425 | | | | | | | 1.2 | 1.4 | 16 | | | | |
| | Moderate work | 60 | 2878 | 60 | 20 | 400 | 28 | 600 | 2400 | 1.4 | 1.6 | 18 | 2.0 | 40 | 100 | 1 |
| | Heavy work | | 3800 | | | | | | | 1.6 | 1.9 | 21 | | | | |
| Woman | Sedentary work | | 1875 | | | | | | | 0.9 | 1.1 | 12 | | | | |
| | Moderate work | 50 | 2225 | 50 | 20 | 400 | 30 | 600 | 2400 | 1.1 | 1.3 | 14 | 2.0 | 40 | 100 | 1 |
| | Heavy work | | 2925 | | | | | | | 1.2 | 1.5 | 16 | | | | |
| | Pregnant woman | 50 | +300 | +15 | 30 | 1000 | 38 | 600 | 2400 | +0.2 | +0.2 | +2 | 2.4 | 40 | 400 | 1 |
| | Lactation 0-6 months | 50 | +550 | +25 | 45 | 1000 | 30 | 950 | 3800 | +0.3 | +3 | +4 | | | | |
| | 6-12 months | | +400 | +18 | | | | | | +0.2 | +0.2 | +3 | 2.5 | 80 | 150 | 1.5 |
| Infants | 0-6 months | 5.4 | 108/kg | 2.05/kg | | 500 | | 350 | 1200 | 55μg/kg | 65μg/kg | 710μg/kg | 0.1 | 25 | 25 | 0.2 |
| | 6-12 months | 8.6 | 98/kg | 1.65/kg | | | | | | 55μg/kg | 60μg/kg | 650μg/kg | 0.4 | | | |
| Children | 1-3 years | 12.2 | 1240 | 22 | 25 | 400 | 12 | 400 | | 0.6 | 0.7 | 8 | | 40 | 30 | 0.2-1.0 |
| | 4-6 years | 19.0 | 1690 | 30 | | | 18 | 400 | 1600 | 0.9 | 1.0 | 11 | 0.9 | | 40 | |
| | 7-9 years | 26.9 | 1950 | 41 | | | 26 | 600 | 2400 | 1.0 | 1.2 | 13 | 1.6 | | 60 | |
| Boys | 10-12 years | 35.4 | 2190 | 54 | 22 | 600 | 34 | 600 | 2400 | 1.1 | 1.3 | 15 | 1.6 | 40 | 70 | 0.2-1.0 |
| Girls | 10-12 years | 31.5 | 1970 | 57 | | | 19 | | | 1.0 | 1.2 | 13 | | | | |
| Boys | 13-15 years | 47.8 | 2450 | 70 | 22 | 600 | 41 | 600 | 2400 | 1.2 | 1.5 | 16 | 2.0 | 40 | 100 | 0.2-1.0 |
| Girls | 13-15 years | 46.7 | 2060 | 65 | | | 28 | | | 1.0 | 1.2 | 14 | | | | |
| Boys | 16-18 years | 57.1 | 2640 | 78 | 22 | 500 | 50 | 600 | 2400 | 1.3 | 1.6 | 17 | 2.0 | 40 | 100 | 0.2-1.0 |
| Girls | 16-18 years | 49.9 | 2060 | 63 | | | 30 | | | 1.0 | 1.2 | 14 | | | | |

Underneath, we present a brief description of some of the major nutrients[3].

## Proteins

Proteins are of greatest importance in human nutrition. They are complex organic nitrogenous compounds. Proteins are made up of smaller units called amino acids. Human body needs about 24 amino acids of which 9 are essential because they cannot be synthesized by human body in adequate amounts. Hence, these nine amino acids must be derived from dietary proteins. The essential amino acids are leucine, isoleucine, lysine, methionine, phenylalanine, threonine, valine, tryptophan, and histidine. A protein is said to be biologically complete if it contains all the essential amino acids. Proteins are required for body building, maintenance of vital functions, repair, maintenance of osmotic pressure, and synthesis of antibodies, plasma proteins, haemoglobin, enzymes, hormones, and coagulation factors. Cereals and pulses are the main sources of dietary protein in India. Daily human requirement of protein is 1 g of protein per kg of lean body weight. 1 g of protein produces 4 kcal of energy. Inadequate intake of food or malnutrition leads to Protein Energy Malnutrition that manifests in two clinical forms- kwashiorkor and marasmus. The incidence of protein energy malnutrition in preschool children in India is about 1-2%. Proper nutrition is especially important in the first five years of life- childhood malnutrition affects the mental and physical development of a child, sometimes leaving permanent residual disability. Such malnutrition usually leads to syndrome of deficiency disorders, multiple nutritional deficiencies in a single patient.

**Nutritional Status of Indian Children**

| State | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| India | 24.5 | 46.3 | 55.8 | 38.4 | 19 | 45.9 |
| Andhra Pradesh | 24.6 | 62.7 | 63.7 | 33.9 | 13 | 36.5 |
| Arunachal Pradesh | 58.6 | 60 | 77.6 | 34.2 | 17 | 36.9 |
| Assam | 50.9 | 63.1 | 59.6 | 34.8 | 13 | 40.4 |
| Bihar | 3.7 | 27.9 | 57.3 | 42.3 | 28 | 58.4 |
| Chhatisgarh | 25 | 82 | 54.5 | 45.4 | 18 | 52.1 |
| Goa | 59.4 | 17.7 | 69.8 | 21.3 | 12 | 29.3 |
| Gujarat | 27.8 | 47.8 | 57.1 | 42.4 | 17 | 47.4 |
| Haryana | 22.1 | 16.9 | 44.8 | 35.9 | 17 | 41.9 |
| Himachal Pradesh | 45.4 | 27.1 | 66 | 26.6 | 19 | 36.2 |
| Jammu & Kashmir | 31.6 | 42.3 | 58.3 | 27.6 | 15 | 29.4 |
| Jharkhand | 10.7 | 47.8 | 65.3 | 41 | 31 | 59.2 |
| Karnataka | 35.7 | 58 | 72.5 | 38 | 18 | 41.1 |
| Kerala | 56.5 | 56.2 | 93.6 | 21.1 | 16 | 28.8 |
| Madhya Pradesh | 15.9 | 21.6 | 51.9 | 39.9 | 33 | 60.3 |
| Maharashtra | 52 | 53 | 47.8 | 37.9 | 15 | 39.7 |
| Manipur | 57.8 | 61.7 | 78.1 | 24.7 | 8.3 | 23.8 |
| Meghalaya | 57.8 | 26.3 | 76.3 | 41.7 | 28 | 46.3 |
| Mizoram | 66.4 | 46.1 | 84.6 | 30.1 | 9.2 | 21.6 |
| Nagaland | 54.2 | 29.2 | 71 | 30.3 | 15 | 29.7 |
| Orissa | 54.8 | 50.2 | 67.5 | 38.3 | 19 | 44 |
| Punjab | 12.7 | 36 | 50 | 27.9 | 9 | 27 |
| Rajasthan | 14.1 | 33.2 | 38.7 | 33.7 | 20 | 44 |
| Sikkim | 42.9 | 37.2 | 89.6 | 28.9 | 13 | 22.6 |

| State | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Tamil Nadu | 58.8 | 33.3 | 77.9 | 25.1 | 22 | 33.2 |
| Tripura | 34.6 | 36.1 | 59.8 | 30 | 20 | 39 |
| Uttar Pradesh | 7.3 | 51.3 | 45.5 | 46 | 14 | 47.3 |
| Uttarakhand | 33.5 | 31.2 | 51.6 | 31.9 | 16 | 38 |
| West Bengal | 23.5 | 58.6 | 55.9 | 33 | 19 | 43.5 |
| A & N Islands | " | " | " | " | " | " |
| Chandigarh | " | " | " | " | " | " |
| D & N Haveli | " | " | " | " | " | " |
| Daman & Diu | " | " | " | " | " | " |
| Delhi | 21 | 34.5 | 59.8 | 35.4 | 16 | 33.1 |
| Lakshadweep | " | " | " | " | " | " |
| Puducherry | " | " | " | " | " | " |

1. Percentage of children who are breast fed within one hour of birth
2. Percentage of children of age 0-5 months who are exclusively breastfed
3. Percentage of children of age 6-9 months who receive semisolid food with breast milk
4. Percentage of children under three years of age who are stunted
5. Percentage of children under three years of age who are wasted
6. Percentage of children under three years of age who are underweight

Source: http://www.medindia.net/health_statistics/diseases/children-breastfed.asp

## Fats

Fats are solid at 20 degree centigrade. They are called oils if they are liquid at that temperature. Fats and oils are concentrated sources of energy. They are classified as:

A) Simple lipids- triglycerides

B) Compound lipids- phospholipids

C) Derived lipids- cholesterol.

The human body can synthesize triglycerides and cholesterol endogenously. 99% of body fat in adipose tissue is in the form of triglycerides. Fats yield fatty acid and glycerol on hydrolysis. Fatty acids are classified as saturated fatty acids and unsaturated fatty acids which are further divided into monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA). Polyunsaturated fatty acids are found in vegetable oils and saturated fatty acids are found mainly in animal fats except fish. Essential fatty acids are those that cannot be synthesized by human body- linoleic acid, linolenic acid, and arachidonic acid. 1 g of fat produces 9 kcal of energy. By supplying energy, fats spare protein from being used for energy. Fat serve as vehicles for for fat soluble vitamins (Vit. A,D,E, & K). Fat supports the viscera and insulates the body against cold. Essential fatty acids (EFA) are needed for growth, for structural integrity of cell membranes, and for decreased platelet adhesiveness. Diets rich in EFA reduce serum cholesterol and low density lipoprotein. PUFA are precursors of prostaglandins- local hormones. Cholesterol is an essential component of membranes and nervous tissue and is a precursor for synthesis steroid hormones and bile acids. Deficiency of essential fatty acid can cause phrenoderma or toad skin and skin lesions. High intake of dietary fat causes obesity, coronary heart disease, and cancer (particularly colon cancer from high amount of animal fat in diet).

**Nutritional Status of men and woman in India**

| State | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| India | 35.6 | 34.2 | 12.6 | 9.3 |
| Andhra Pradesh | 33.5 | 30.8 | 15.6 | 13.6 |
| Arunachal Pradesh | 16.4 | 15.2 | 8.8 | 7.1 |
| Assam | 36.5 | 35.6 | 7.8 | 5 |
| Bihar | 45.1 | 35.3 | 4.6 | 6.3 |
| Chhatisgarh | 43.4 | 38.5 | 5.6 | 4.9 |
| Goa | 27.9 | 24.6 | 20.2 | 15.4 |
| Gujarat | 36.3 | 36.1 | 16.7 | 11.3 |
| Haryana | 31.3 | 30.9 | 17.4 | 10.8 |
| Himachal Pradesh | 29.9 | 29.7 | 13.5 | 10.6 |
| Jammu & Kashmir | 24.6 | 28 | 16.7 | 6.2 |
| Jharkhand | 43 | 38.6 | 5.4 | 4.9 |
| Karnataka | 33.5 | 33.9 | 15.3 | 10.9 |
| Kerala | 18 | 21.5 | 28.1 | 17.8 |
| Madhya Pradesh | 41.7 | 41.6 | 7.6 | 4.3 |
| Maharashtra | 36.2 | 33.5 | 14.5 | 11.9 |
| Manipur | 14.8 | 16.3 | 13.3 | 9.2 |
| Meghalaya | 14.6 | 14.1 | 5.3 | 5.9 |
| Mizoram | 14 | 9.2 | 10.6 | 11.4 |
| Nagaland | 17.4 | 14.2 | 6.4 | 5.7 |
| Orissa | 41.4 | 35.7 | 6.6 | 6 |
| Punjab | 18.9 | 20.6 | 29.9 | 22.2 |
| Rajasthan | 36.7 | 40.5 | 8.9 | 6.2 |
| Sikkim | 11.2 | 12.2 | 15.4 | 11.9 |
| Tamil Nadu | 28.4 | 27.1 | 20.9 | 14.5 |
| Tripura | 36.9 | 41.7 | 7.1 | 4.8 |
| Uttar Pradesh | 36 | 38.3 | 9.2 | 7.3 |
| Uttarakhand | 30 | 28.4 | 12.8 | 7.9 |
| West Bengal | 39.1 | 35.2 | 11.4 | 5.5 |
| A & N Islands | " | " | " | " |
| Chandigarh | " | " | " | " |
| D & N Haveli | " | " | " | " |
| Daman & Diu | " | " | " | " |
| Delhi | 14.8 | 15.7 | 26.4 | 16.8 |
| Lakshadweep | " | " | " | " |
| Puducherry | " | " | " | " |

1. Percentage of woman whose body mass index (BMI) is below normal
2. Percentage of men whose body mass index is below normal
3. Percentage of woman who are overweight or obese
4. Percentage of men who are overweight or obese

SOURCE: http://www.medindia.net/health_statistics/diseases/nutritional-status.asp

## Carbohydrate

Carbohydrate is the main source of energy. 1 g of carbohydrate produces 4 kcal of energy. There are three main sources of carbohydrate- starch, sugar, and cellulose. Cellulose is the indigestible component that contributes to dietary fibre. Starch or complex carbohydrate is digested slowly and helps keep body fat low. Simple carbohydrate or sugars trigger insulin secretion and are quickly assimilated into fat.

## Vitamin A

Vitamin A is required for normal vision, for maintaining the integrity and normal functioning of glandular and epithelial tissue, for skeletal growth, for maintenance of immunity, and for protection against certain cancers such as bronchial cancer. Deficiency of vitamin A causes Xerophthalmia which includes ocular (eye) manifestations such as night blindness, conjunctival xerosis, Bitot's spot, Corneal Xerosis, and Keratomalacia. Deficiency of vitamin A also causes follicular hyperkeratosis, anorexia, growth retardation, respiratory and intestinal infections, and child mortality. Malnutrition and vitamin A deficiency are a major cause of blindness in children.

**Estimated Prevalence of Blindness Per 1000 Population**

| State | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| India | 6396 | 57565 | 2068087 | 1002063 | 1129985 | 2132048 |
| Andhra Pradesh | 453 | 4075 | 146404 | 70938 | 79994 | 150932 |
| Arunachal Pradesh | 8 | 72 | 2574 | 1247 | 1407 | 2654 |
| Assam | 165 | 1486 | 53399 | 25874 | 29177 | 55050 |
| Bihar | 438 | 3946 | 141750 | 68683 | 77451 | 146134 |
| Chhatisgarh | 175 | 1571 | 56450 | 27352 | 30844 | 58196 |
| Goa | 11 | 95 | 3430 | 1662 | 1874 | 3536 |
| Gujarat | 306 | 2757 | 99058 | 47997 | 54125 | 102122 |
| Haryana | 126 | 1134 | 40740 | 19740 | 22260 | 42000 |
| Himachal Pradesh | 44 | 393 | 14104 | 6834 | 7706 | 14540 |
| Jammu & Kashmir | 64 | 579 | 20789 | 10073 | 11359 | 21432 |
| Jharkhand | 206 | 1857 | 66705 | 32321 | 36447 | 68768 |
| Karnataka | 328 | 2953 | 106104 | 514111 | 57975 | 109386 |
| Kerala | 200 | 1802 | 64728 | 31363 | 35367 | 66730 |
| Madhya Pradesh | 339 | 3050 | 109577 | 53094 | 59872 | 112966 |
| Maharashtra | 569 | 5121 | 183993 | 89151 | 100533 | 189684 |
| Manipur | 17 | 151 | 5428 | 2630 | 2966 | 55596 |
| Meghalaya | 16 | 146 | 5248 | 2543 | 2867 | 5410 |
| Mizoram | 6 | 57 | 2058 | 997 | 11125 | 2122 |
| Nagaland | 11 | 102 | 3655 | 1771 | 1997 | 3768 |
| Orissa | 223 | 2003 | 71957 | 34866 | 39316 | 74182 |
| Punjab | 147 | 1325 | 47600 | 23064 | 26008 | 49072 |
| Rajasthan | 345 | 3103 | 111480 | 54016 | 6912 | 111928 |
| Sikkim | 4 | 34 | 1207 | 558 | 659 | 1244 |
| Tamil Nadu | 383 | 3443 | 123689 | 59932 | 67582 | 1275144 |

| State | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Tripura | 25 | 227 | 8152 | 3950 | 4454 | 8404 |
| Uttar Pradesh | 1118 | 10060 | 361416 | 175119 | 197475 | 372594 |
| Uttarakhand | 56 | 503 | 18069 | 8755 | 9873 | 18628 |
| West Bengal | 498 | 4486 | 161177 | 78096 | 88066 | 166162 |
| A & N Islands | 3 | 23 | 832 | 403 | 455 | 858 |
| Chandigarh | 6 | 53 | 1921 | 931 | 1049 | 1980 |
| D & N Haveli | 1 | 11 | 411 | 199 | 225 | 424 |
| Daman & Diu | 1 | 8 | 301 | 146 | 164 | 310 |
| Delhi | 96 | 866 | 31129 | 15083 | 17009 | 32092 |
| Lakshadweep | 0 | 4 | 153 | 74 | 84 | 158 |
| Puducherry | 7 | 67 | 2398 | 1162 | 1310 | 2472 |

1. 0-14 YEARS
2. 15-49 YEARS
3. 50+ YEARS
4. MALE
5. FEMALE
6. ALL AGES

SOURCE: http://www.medindia.net/health_statistics/diseases/prevalence-of-blindness-2004.asp

### Vitamin E

It is also called tocopherol. It acts as an antioxidant in lipid (fat) medium.

### Vitamin K

There are two forms of Vitamin K- $K_1$ and $K_2$. The role of vitamin K is to stimulate the production and the release of certain blood coagulation factors.

### Thiamine ($B_1$)

It is essential for the utilization of carbohydrates- direct oxidative pathway for glucose. Thiamine is readily lost from rice during the process of milling. Deficiency of thiamine causes beriberi and Wernick's encephalopathy. These diseases are also seen in excessive alcohol consumption.

### Riboflavin ($B_2$)

It has a fundamental role in cellular oxidation, it plays an important role in maintaining the integrity of mucocutaneous structures, and it is a cofactor in a number of enzymes involved with energy metabolism.

### Niacin ($B_3$)

It is essential for metabolism of protein, fat, and carbohydrate. It is also essential for the normal functioning of the skin and intestinal and nervous systems. Deficiency of Niacin causes pellagra, a disease characterized by diarrhea, dermatitis, and dementia.

### $B_6$ (Pyridoxine)

It is essential in the metabolism of amino acids, fats, and carbohydrate. Deficiency of $B_6$ is associated with peripheral neuritis. Anti-tubercular drug INH causes impaired utilization of $B_6$.

## Folic acid

Folic acid plays a role in the synthesis of nucleic acids (chromosome). Deficiency of folic acid causes megaloblastic anemia, glossitis, cheilosis, gastrointestinal disturbance, infertility, and sterility. It is also required for the normal development of blood cells in the marrow.

## Vitamin C

It is a potent antioxidant in the aqueous (water) medium. It has an important function in tissue oxidation and is needed for formation of collagen. It has an important role in healing and scar formation. Deficiency of Vitamin C causes scurvy. Scurvy, which was once an important deficiency disease, is no longer a disease of global importance.

## Vitamin $B_{12}$

Vitamin $B_{12}$ is a complex organo-metallic compound with a cobolt atom. It, along with folic acid, facilitates the synthesis of DNA. Milk is a good source of this vitamin. The deficiency of Vitamin $B_{12}$ is associated with megaloblastic anemia, demyelinating neurological lesions in the spinal cord, and infertility.

## Calcium

Ionized calcium in plasma has many vital functions- formation of bones and teeth, coagulation of blood, contraction of muscles, keeping membranes intact, metabolism of enzymes and hormones, and cardiac actions. Milk and milk products are good sources of calcium.

## Iron

Iron is necessary for many vital functions in the body including formation of haemoglobin, brain development and function, regulation of body temperature, muscle activity, and catecholamine metabolism. Lack of iron directly affects the immune system- diminishes the number of T-cells and the production of antibodies. Deficiency of iron in diet leads to Iron deficiency anemia.

**Incidence of Anemia in India**

| State | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| India | 69.5 | 55.3 | 57.8 | 24.2 |
| Andhra Pradesh | 70.8 | 62.9 | 56.4 | 23.3 |
| Arunachal Pradesh | 56.9 | 50.6 | 49.2 | 28 |
| Assam | 69.6 | 69.5 | 72 | 39.6 |
| Bihar | 78 | 67.4 | 60.2 | 34.3 |
| Chhattisgarh | 71.2 | 57.5 | 63.1 | 27 |
| Goa | 38.2 | 38 | 36.9 | 10.4 |
| Gujarat | 67.7 | 55.3 | 60.8 | 22.2 |
| Haryana | 72.3 | 56.1 | 69.7 | 19.2 |
| Himachal Pradesh | 54.7 | 43.3 | 37 | 18.9 |
| Jammu & Kashmir | 58.6 | 53.1 | 54 | 19.5 |
| Jharkhand | 70.3 | 69.5 | 68.4 | 36.5 |
| Karnataka | 70.4 | 51.5 | 59.5 | 19.1 |
| Kerala | 44.5 | 32.8 | 33.1 | 8 |

| State | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Madhya Pradesh | 74.1 | 56 | 57.9 | 25.6 |
| Maharashtra | 63.4 | 48.4 | 57.8 | 16.8 |
| Manipur | 41.1 | 35.7 | 36.4 | 11.4 |
| Meghalaya | 64.4 | 47.2 | 56.1 | 36.7 |
| Mizoram | 44.2 | 38.6 | 49.3 | 19.4 |
| Nagaland | " | " | " | " |
| Orissa | 65 | 61.2 | 68.1 | 33.9 |
| Punjab | 66.4 | 38 | 41.6 | 13.6 |
| Rajasthan | 69.7 | 53.1 | 61.2 | 23.6 |
| Sikkim | 59.2 | 60 | 53.1 | 25 |
| Tamil Nadu | 64.2 | 53.2 | 53.3 | 16.5 |
| Tripura | 62.9 | 65.1 | 57.6 | 35.5 |
| Uttar Pradesh | 73.9 | 40.9 | 51.6 | 24.3 |
| Uttarakhand | 61.4 | 55.2 | 45.2 | 29.2 |
| West Bengal | 61 | 63.2 | 62.6 | 32.3 |
| A & N Islands | " | " | " | " |
| Chandigarh | " | " | " | " |
| D & N Haveli | " | " | " | " |
| Daman & Diu | " | " | " | " |
| Delhi | 57 | 44.3 | 29.9 | 17.8 |
| Lakshadweep | " | " | " | " |
| Puducherry | " | " | " | " |

1. Percentage of Children of age 6-59 months who are anemic
2. Percentage of ever married woman of age 15-49 years who are anemic
3. Percentage of pregnant woman of age 15-49 years who are anemic
4. Percentage of ever married men of age 15-49 years who are anemic

Source: http://www.medindia.net/health_statistics/diseases/Anaemia.asp

## Iodine

Iodine is an essential micronutrient. It is required for the synthesis of thyroid hormones. Deficiency of Iodine leads to goiter.

## Zinc

Zinc is a component of more than 300 enzymes in human body. It is active in metabolism of protein and is required for synthesis of insulin and maintenance of immunity. Deficiency of Zinc results in growth failure and sexual infantilism in adolescents. It also causes loss of taste and delayed wound healing. Zinc deficiency in pregnant mothers leads to spontaneous abortion and congenital malformation. Zinc also acts as an antioxidant. Milk is a dependable source of zinc.

## Cobalt

It is a part of Vitamin $B_{12}$. Recently, cobalt deficiency and cobalt iodine ratio in soil have shown to produce goiter in humans. It is suggested that cobalt may be necessary for the first stage of hormone production, that is, capture of iodine by the gland- cobalt may interact with iodine and affect its utilization.

## Chromium

It is suggested that chromium plays a role in carbohydrate and insulin function.

## Molybdenum

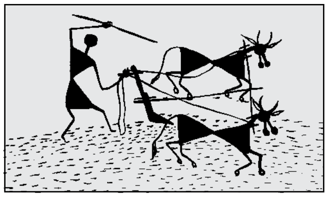
Deficiency of molybdenum is associated with mouth and oesophageal cancer.

## Food, Health and Nutrition

Common sense indicates that disease state of an individual and their dietary patterns are related. We have enough empirical evidence to reveal a causal connection between the two. Diseases are broadly classified into two groups- communicable and non-communicable. Both these types of diseases are either directly or indirectly related to nutrition.

The human body is a delicate and magnificent creation of nature. It is dynamic in its functions and sensitive in its interactions. It is a careful balance between life and matter and it is a sensitive equilibrium of biological forces of nature. Modern medicine was, once upon a time, criticized for treating human body as a machine; a deranged function would lead to fixation of a specific part and the machine starts functioning again, requiring fixed inputs and delivering constant outputs at a particular efficiency quotient. However, this is not the case with human body. Science is still trying to decipher all the inputs (macro as well as micro) that a human body needs. Human body is highly complex and there is a collective consensus that the equilibrium, if disturbed, leads to abnormal physiologic functions and eventually diseases. A major part of this delicate and sensitive equilibrium depends upon the air we breathe, the water we drink, and the food we consume. A large proportion of consumers have lost faith in the food they consume, in the agencies that certify such foods as safe, and in the policies that maintain the supply chain. The change in consumer's perception is a matter of concern.

A topic that is much debated globally is, "WHICH FOOD IS BETTER FOR US TO CONSUME- ORGANIC OR CONVENTIONAL?" The exact answer to this question requires further enormous research. Nevertheless, we have compelling evidence in favor of food grown organically. There are many myths and assumptions that need to be addressed, which is one of the objectives of this report. We shall discuss these assumptions one by one and provide evidence to question them. In course of the report, the reader shall have a clear perspective of organic farming compared to conventional, taking factors like yield, nutrition, health effects, and opinion of scientific community into consideration.

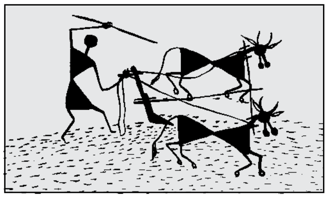


# Nutrition Per Acre

Proponents of conventional chemical agriculture boast of the high yield achieved through this farming practice. According to them, conventional agriculture is the solution to the global food crisis. Surprisingly, comparable yields have been produced by organic farming practices too[1]. "Organic versus Conventional"- the difference originates in the philosophy of the two farming practices, in the intention. On one hand, organic farming methods promote independence, and on the other hand, conventional dictates absolute dependency. The chief foci of organic farming practice are sustainability, ecological consideration, little input, generous gains, and enormous profit to the farmer. The chief foci of conventional farming practice are non-sustainability, adverse environmental impact, large inputs, comparatively moderate gains, and large profit to the corporations. The debate also depends upon how we look at agriculture. Are we concerned more with profit generation rather than food security? Are we growing food to feed humans or are we growing crops to maximize profit at the commodity trade desk? Proponents of conventional agriculture assume that it is the only way to ensure food security. This commitment to food security comes at a time when approximately 40% of world food grains are fed to livestock to be slaughtered on the due date and when a large proportion of global population is suffering from nutritional deficiencies. Probably, we do not have enough food grains to make steak burgers out of them. We have, probably, entered an era in which we have to think more like global citizens rather than like Indian, American, or European.

In this section, we compared the nutrition produced per acre of farmland through organic and conventional agriculture. Initially, we used the data on yields[1], obtained through two farming practices, collected by Navdanya in four states of India- Sikkim, Rajasthan, Kerala, and Uttaranchal. We also used the yield data of 3 case studies conducted at Navdanya farms. We then used the data on nutrition[12] in each food type by referring to "Nutritive value of Indian Foods" published by National Institute of Nutrition, Indian Council of Medical Research, Hyderabad. Throughout this report, the following abbreviation is used for minerals.

| Mineral | Abbreviation | Mineral | Abbreviation |
|---|---|---|---|
| Calcium | Ca | Copper | Cu |
| Iron | Fe | Manganese | Mn |
| Phosphorous | P | Molybdenum | Mo |
| Magnesium | Mg | Zinc | Zn |
| Sodium | Na | Chromium | Cr |
| Potassium | K | Sulphur | S |
| Chlorine | Cl | | |



# Sikkim

## Case Study 1

**Table 1: Analysis of the yield from organic mixed cropping versus the yield from conventional mono cropping in Kharif season in Sikkim.**

**Table S-1: Yield produced per acre-Mixed cropping versus mono cropping.**

| Mixed cropping (yield/acre) | Mono cropping (yield/acre) |
|---|---|
| Maize = 4 Qt | Maize = 5 Qt. |
| Radish = 2 Qt | |
| Mustard leaves (saag) = 100 bundles | |
| Peas = 2 Qt | |
| Total = 9 Qt. | Total = 5 Qt |

Source: Navdanya.

**Table S-2: Analysis of macronutrients produced per acre in the two system of farming integrating the ICMR data into the above table.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Energy (kcal) |
|---|---|---|---|---|
| **Mixed Cropping** | | | | |
| Maize (4 Qt) | 44.4 | 264.8 | 14.4 | 13,68,000 |
| Radish (2 Qt) | 1.4 | 6.8 | 0.2 | 34,000 |
| Mustard leaves (saag) (1qt) | 4.0 | 0.6 | 2.4 | 34,000 |
| Peas (2 Qt) | 14.4 | 31.8 | 0.2 | 1,86,000 |
| Total (9 Qt.) | 64.2 | 304.0 | 17.2 | 16,22,000 |
| **Mono Cropping** | | | | |
| Maize (5 Qt.) | 55.5 | 331.0 | 18.0 | 1,710,000 |
| Total | 55.5 | 331.0 | 18.0 | 1,710,000 |

Source: 1) Navdanya, 2) Nutritive value of Indian foods, ICMR.
Percentage of calories from protein in mixed organic cropping = 17.81%
Percentage of calories from protein in mono cropping = 14.61%

**Table S-3: Analysis of vitamins produced per acre- organic mixed cropping vs. conventional mono cropping**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | B6 (mg) | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | | |
| Maize (4 Qt.) | 360 | 1,680 | 400 | 7,200 | - | 80 | 0 | - |
| Radish (2 Qt.) | 6 | 120 | 40 | 1,000 | - | - | 30,000 | 1,26,000 |
| Mustard leaves (1 Qt.) | 2,622 | 30 | - | - | - | - | 33,000 | - |
| Peas (2 Qt.) | 166 | 500 | 20 | 1,600 | - | - | 18,000 | 40,000 |
| Total (9 Qt.) | 3,154 | 2,330 | 460 | 9,800 | | 80 | 81,000 | 1,66,000 |
| **Mono cropping** | | | | | | | | |
| Maize (5 Qt.) | 450 | 2,100 | 500 | 9,000 | - | 100 | 0 | - |
| Total (5 Qt.) | 450 | 2,100 | 500 | 9,000 | - | 100 | 0 | 0 |

Source: 1) Navdanya, 2) Nutritive value of Indian foods, ICMR.
Total amount of vitamins in milligram produced per acre of farmland in mixed cropping = 2,62,824 mg
Total amount of vitamins in milligram produced per acre of farmland in mono cropping = 12,150 mg

Organic mixed farming produces 21.6 times as much vitamin per acre of farmland in Sikkim as conventional mono cropping does.

**Table S-4: Analysis of major mineral produced per acre of farmland- organic mixed cropping vs. conventional mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | |
| Maize (4 Qt.) | 40 | 9.2 | 1392 | 556 | 63.6 | 1544 | 132 |
| Radish (2 Qt.) | 70 | 0.8 | 44 | - | 66.0 | 176 | - |
| Mustard leaves (1 Qt.) | 155 | 16.3 | 26 | 22 | - | - | - |
| Peas (2 Qt.) | 40 | 3.0 | 278 | 68 | 15.6 | 158 | 40 |
| Total (9 Qt.) | 305 | 29.3 | 1740 | 626 | 145.2 | 1878 | 172 |
| **Mono cropping** | | | | | | | |
| Maize (5 Qt.) | 50 | 11.5 | 1740 | 695 | 79.5 | 1430 | 165 |
| Total (5 Qt.) | 50 | 11.5 | 1740 | 695 | 79.5 | 1430 | 165 |

Source: 1) Navdanya, 2) Nutritive value of Indian foods, ICMR.
Total minerals produced per acre (organic) = 4895.5 g
Total minerals produced per acre (conventional) = 4161 g

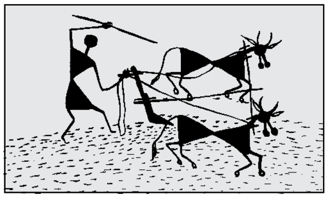
Nutritional anemia is a public health problem in India. It is largely caused by deficiency of iron in diet. Except for calcium and iron, deficiency of other major minerals is not so relevant from the Indian public health perspective[3]. Organic mixed cropping produces 2.6 times as much dietary iron per acre of farmland in Sikkim as conventional mono cropping does.

**Table S-5: Analysis of trace elements produced per acre farmland- organic mixed cropping versus conventional mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | |
| Maize (4 Qt.) | 1,640 | 1,920 | 152 | 11,200 | 16 | 4,56,000 |
| Radish (2 Qt.) | 800 | - | - | - | - | - |
| Mustard leaves (1 Qt.) | 2,690 | 530 | - | 740 | - | - |
| Peas (2 Qt.) | 1,290 | 580 | 638 | 2,300 | 32 | 1,89,000 |
| Total (9 Qt.) | 6,420 | 3,030 | 790 | 14,240 | 48 | 6,45,000 |
| **Mono cropping** | | | | | | |
| Maize (5 Qt.) | 2,050 | 2,400 | 190 | 14,000 | 20 | 5,70,000 |
| Total (5 Qt.) | 2,050 | 2,400 | 190 | 14,000 | 20 | 5,70,000 |

Source: 1) Navdanya, 2) Nutritive value of Indian foods, ICMR.
Total amount of trace minerals per acre (organic) = 6,69,528 mg.
Total amount of trace minerals per acre (conventional) = 5,88,660

Indian diet has been becoming increasingly deficient of trace elements. These trace elements are required in minute quantity, but are required for maintenance of good health. Protective effects of such trace elements in prevention of cancer, cardiovascular disease and other chronic diseases have been noticed. Organic mixed farming produces 3.13 times as much copper, 1.26 times as much manganese, 4.16 times as much molybdenum, equal amount of zinc, 2.4 times as much chromium, and 1.13 times as much sulfur, per acre of farmland, in Sikkim as conventional mono cropping does.



# Rajasthan

Three case studies were conducted by Navdanya in the Jodhpur area of Rajasthan that compared conventional mono cropping and mixed cropping using less pesticides. We shall take each study one by one and shall compare the nutrition produced per unit area of farmland in the two cropping systems.

## Case Study 1:

**Table R-A-1: Comparative study on macronutrients produced in mono cropping (pearl millet) versus mixed cropping (pearl millet, moth, sesame) per unit land**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed cropping** | | | | |
| Pearl Millet (9 qtl.) | 104.4 | 607.5 | 4.5 | 32,49,000 |
| Moth (3.5 qtl.) | 82.6 | 197.75 | 3.85 | 11,55,000 |
| Sesame (0.4 qtl.) | 7.32 | 10.0 | 17.32 | 2,25,200 |
| Total = 12.9 qtl. | 194.32 | 815.25 | 25.67 | 46,29,200 |
| **Mono cropping** | | | | |
| Pearl Millet (12 qtl.) | 139.2 | 810.0 | 6.0 | 43,32,000 |
| Total = 12 qtl. | 139.2 | 810.0 | 6.0 | 43,32,000 |

Source: 1) Navdanya, 2) Nutritive value of Indian foods, ICMR.

Mono cropping produces 71.63% of the protein produced by mixed cropping, a difference that is very critical in an arid region like Rajasthan where vagaries of nature put a limitation on agriculture.

**Table R-A-2: Comparative study on vitamins produced per unit farmland in mono cropping versus mixed cropping.**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | B6 (mg) | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | | |
| Pearl Millet (9 qtl.) | 1,188 | 2,970 | 2,250 | 20,700 | - | 409.5 | 0 | 0 |
| Moth (3.5 qtl.) | 31.5 | 1,575 | 315 | 5,250 | - | - | 7000 | - |
| Sesame ( 0.4 qtl.) | 24 | 404 | 136 | 1,760 | - | 53.6 | 0 | - |
| Total = 12.9 qtl. | 1243.5 | 4,949 | 2701 | 27,710 | 0 | 463.1 | 7000 | 0 |
| **Mono cropping** | | | | | | | | |
| Pearl Millet (12 qtl.) | 1,584 | 3,960 | 3,000 | 27,600 | - | 546 | 0 | 0 |
| Total = 12 qtl. | 1,584 | 3,960 | 3,000 | 27,600 | - | 546 | 0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Sum of all vitamins produced by mono cropping was 83.26% of the sum of all vitamins produced by mixed farming. To put more simply, if mixed cropping produced 100 mg of different vitamins per unit farmland, then mono cropping produces only 83.26 mg of different vitamins in the same unit of farmland; we assume the remaining conditions to be similar.

**Table R-A-3: Comparative study on major minerals produced per unit farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | |
| Pearl Millet (9 qtl.) | 378 | 72 | 2,664 | 1,233 | 98.1 | 2,763 | 351 |
| Moth (3.5 qtl.) | 707 | 33.25 | 805 | 787.5 | 103.25 | 3,836 | 31.5 |
| Sesame ( 0.4 qtl.) | 580 | 3.72 | 228 | - | - | - | - |
| Total = 12.9 qtl. | 1665 | 108.97 | 3,697 | 2020.5 | 201.35 | 6,599 | 382.5 |
| **Mono cropping** | | | | | | | |
| Pearl Millet (12 qtl.) | 504 | 96 | 3,552 | 1,644 | 130.8 | 3,684 | 468 |
| Total = 12 qtl. | 504 | 96 | 3,552 | 1,644 | 130.8 | 3,684 | 468 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals per unit farmland (mixed cropping) = 14,674.32 g.
Total amount of major minerals per unit farmland ( mono cropping) = 10,078.80 g.

Iron produced per unit farmland in mono cropping is 88.10% of the iron produced per unit farmland in mixed cropping.

**Table R-A-4: Comparative study on trace elements produced per unit farmland in mono cropping versus mixed cropping**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | |
| Pearl Millet (9 qtl.) | 9,540 | 10,350 | 621 | 27,900 | 207 | 13,23,000 |
| Moth (3.5 qtl.) | 2,975 | - | - | - | - | 6,30,000 |
| Sesame ( 0.4 qtl.) | 916 | 528 | 81.6 | 4,880 | 34.8 | - |
| Total = 12.9 qtl. | 13,431 | 10,878 | 702.6 | 32,780 | 241.8 | 19,53,000 |
| **Mono cropping** | | | | | | |
| Pearl Millet (12 qtl.) | 12,720 | 13,800 | 828 | 37,200 | 276 | 17,64,000 |
| Total = 12 qtl. | 12,720 | 13,800 | 828 | 37,200 | 276 | 17,64,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

In this case study we observed that trace minerals produced by two system of cropping are comparable.

## Case Study: 2

In this study, mono cropping in an acre farmland was associated with a yield of 10.5 qt. of pearl millet, where as mixed farming in an acre of land was associated with a yield of 10.4 qt. of pearl millet and1.5 qt. of mungbean.

**Table R-B-1: Comparative study of macronutrients produced per acre of farmland- mixed cropping versus mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed Cropping** | | | | |
| Pearl Millet = 10.4 qt. | 120.64 | 702.00 | 52.00 | 37,54,400 |
| Mungbean = 1.5 qt. | 36.00 | 85.05 | 1.95 | 5,01,000 |
| Total = 11.9 qt. | 156.64 | 787.05 | 53.95 | 42,55,400 |
| **Mono Cropping** | | | | |
| Pearl millet = 10.5 qt. | 121.80 | 708.75 | 52.50 | 37,90,500 |
| Total = 10.5 qt. | 121.80 | 708.75 | 52.50 | 37,90,500 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Protein produced by mono cropping per acre of farmland is 77.76% of the protein produced by mixed cropping per acre of farmland. In other words, mixed cropping produced 28.6% more protein than mono cropping per acre farmland.

**Table R-B-2: Comparative study of vitamins produced per acre of farmland- mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | | | |
| Pearl Millet = 10.4 qt. | 1372.8 | 3432.0 | 2600.0 | 23920 | - | 473.2 | 0 | 0 |
| Mungbean = 1.5 qt. | 141.0 | 705.0 | 405.0 | 3150 | - | - | 0 | 250500 |
| Total = 11.9 qt. | 1513.8 | 4137.0 | 3005.0 | 27070 | | 473.2 | 0 | 250500 |
| **Mono Cropping** | | | | | | | | |
| Pearl millet = 10.5 qt. | 1386.0 | 3465.0 | 2625.0 | 24150 | - | 477.8 | 0 | 0 |
| Total = 10.5 qt. | 1386.0 | 3465.0 | 2625.0 | 24150 | - | 477.8 | 0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total vitamin produced per acre farmland (mixed cropping) = 2,86,699 mg
Total vitamin produced per acre farmland ( mono cropping) = 32,104 mg

Vitamins produced by mono cropping is 11.20% of the vitamins produced by mixed cropping per acre of farmland. To put more simply, mixed farming produced 793% more vitamins than that produced by mono cropping per acre of farmland.

**Table R-B-3: Comparative study of major minerals produced per acre of farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | | |
| Pearl Millet = 10.4 qt. | 436.8 | 83.2 | 3078.4 | 1424.8 | 113.4 | 3192.8 | 405.6 |
| Mungbean = 1.5 qt. | 186.0 | 6.6 | 489.0 | 190.5 | 42.0 | 1264.5 | 18.0 |
| Total = 11.9 qt. | 622.8 | 89.8 | 3567.4 | 1615.3 | 155.4 | 4457.3 | 423.6 |
| **Mono Cropping** | | | | | | | |
| Pearl millet = 10.5 qt. | 441.0 | 84.0 | 3108.0 | 1438.5 | 114.5 | 3223.5 | 409.5 |
| Total = 10.5 qt. | 441.0 | 84.0 | 3108.0 | 1438.5 | 114.5 | 3223.5 | 409.5 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals per acre farmland ( mixed cropping) = 10,932 g.
Total amount of major minerals per acre farmland ( mono cropping) = 8,819 g.

Mixed cropping produced 6.9% more iron per acre farmland than that produced by mono cropping per acre farmland.

**Table R-B-4: Comparative study of the trace minerals produced per acre of farmland- mixed cropping versus mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | |
| Pearl Millet = 10.4 qt. | 11,024.0 | 11,960 | 717.6 | 32,240 | 239.2 | 15,28,800 |
| Mungbean = 1.5 qt. | 585.0 | 3,705.0 | 456.0 | 4500 | 21 | 2,82,000 |
| Total = 11.9 qt. | 11,609.0 | 15,665 | 1,173.6 | 36,740.0 | 260.2 | 18,10,800 |
| **Mono Cropping** | | | | | | |
| Pearl millet = 10.5 qt. | 11,130.0 | 12,075 | 724.5 | 32,550 | 241.5 | 15,43,500 |
| Total = 10.5 qt. | 11,130.0 | 12,075 | 724.5 | 32,550 | 241.5 | 15,43,500 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland (mixed cropping) = 1876.25 g
Total amount of trace minerals produced per acre farmland (mono cropping) = 1600.22 g

Mixed cropping produced 17.25% more trace minerals than mono cropping.

## Case Study 3

In a third study conducted at Rajathan, 14 qt. of Maize was produced per acre of farmland in mono cropping whereas mixed farming observed a total yield of 11 qt. of Maize and 2.5 qt. of cowpea per acre of farmland.

**Table R-C-1: Comparative study of macronutrients produced per acre farmland- mixed cropping versus mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed cropping** | | | | |
| Maize = 11 qt. | 122.1 | 728.2 | 39.6 | 37,62,000 |
| Cowpea = 2.5 qt. | 60.3 | 136.3 | 2.5 | 8,07,500 |
| Total = 13.5 qt. | 182.4 | 864.5 | 42.1 | 45,69,500 |
| **Mono cropping** | | | | |
| Maize = 14 qt. | 155.4 | 926.8 | 50.4 | 47,88,000 |
| Total = 14 qt. | 155.4 | 926.8 | 50.4 | 47,88,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Mixed cropping produced 17.37% more protein than that produced by mono cropping per acre farmland.

**Table R-C-2: Comparative study of vitamins produced per acre farmland- mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | | |
| Maize = 11 qt. | 990.0 | 4,620.0 | 1,100.0 | 19,800 | - | 220.0 | 0 | - |
| Cowpea = 2.5 qt. | 30.0 | 1,275.0 | 500.0 | 3,250 | - | 332.5 | 0 | 5,05,000 |
| Total = 13.5 qt. | 1020.0 | 5895.0 | 1,600.0 | 23,050 | 0 | 552.5 | 0 | 5,05,000 |
| **Mono cropping** | | | | | | | | |
| Maize = 14 qt. | 1,260 | 5,880 | 1,400 | 25,200 | - | 280 | 0 | - |
| Total = 14 qt. | 1,260 | 5,880 | 1,400 | 25,200 | - | 280 | 0 | - |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of vitamin produced per acre farmland (mixed cropping) = 537118mg
Total amount of vitamin produced per acre farmland (mono cropping) = 34,020 mg

Mixed cropping produced 1479% more vitamin per acre farmland than that produced by mono cropping per acre farmland.

**Table R-C-3: Comparative study of major minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | |
| Maize = 11 qt. | 110.0 | 25.3 | 3,828.0 | 1,529.0 | 174.9 | 3146.0 | 363.0 |
| Cowpea = 2.5 qt. | 192.5 | 21.5 | 1,035.0 | 525.0 | 58.0 | 2827.5 | 25.0 |
| Total = 13.5 qt. | 302.5 | 46.8 | 4,863.0 | 2,054.0 | 232.9 | 5973.5 | 388.0 |
| **Mono cropping** | | | | | | | |
| Maize = 14 qt. | 140.0 | 32.2 | 4,872.0 | 1,946.0 | 222.6 | 4004.0 | 462.0 |
| Total = 14 qt. | 140.0 | 32.2 | 4,872.0 | 1,946.0 | 222.6 | 4004.0 | 462.0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals produced per acre farmland (mixed cropping) = 13.86 kg.
Total amount of major minerals produced per acre farmland (mono cropping) = 11.68 kg.

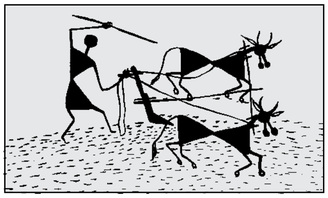
Mixed cropping produces 45.34% more iron than that produced by mono cropping in an acre of farmland.

**Table R-C-4: Comparative study of trace minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | |
| Maize = 11 qt. | 4,510.0 | 5,280.0 | 418.0 | 30,800.0 | 44.0 | 12,54,000.0 |
| Cowpea = 2.5 qt. | 2,175.0 | 3,350.0 | 4,725.0 | 11,500.0 | 72.5 | 4,12,500.0 |
| Total = 13.5 qt. | 6,685.0 | 8,630.0 | 5,143.0 | 42,300.0 | 116.5 | 1,666,500. |
| **Mono cropping** | | | | | | |
| Maize = 14 qt. | 5,740.0 | 6,720.0 | 532.0 | 39,200.0 | 56.0 | 15,96,000.0 |
| Total = 14 qt. | 5,740.0 | 6,720.0 | 532.0 | 39,200.0 | 56.0 | 15,96,000.0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland (mixed cropping) = 1729.38 g.
Total amount of trace minerals produced per acre farmland (mono cropping) = 1648.25 g.

Mixed cropping produced 4.92% more trace minerals than that produced by mono cropping per acre farmland.



# Uttaranchal

Navdanya conducted a study in which 10 farmers were chosen. 7 of these 10 farmers practised organic farming in mixed cropping systems and the remaining three practised mono cropping. We compared the nutrition produced per acre in the two cropping systems in 5 different case studies. We shall take each case study one by one.

## Case Study 1:

Under mono cropping of Paddy, a yield of 12 qt. per acre was observed, whereas under mixed cropping a production of 3 qt. of Mandua (Ragi), 2 qt. of Jhangora (Sanwa millet), 4 qt. of Gahat (Horsegram), and 5 qt. of Bhatt ( Black bean or Rajmah) was realized.

**Table: U-A-1: Comparative study of macronutrients produced per acre farmland- mixed cropping versus mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed Cropping** | | | | |
| Mandua = 3qt. | 21.9 | 216.0 | 3.9 | 9,84,000 |
| Jhangora = 2 qt. | 12.4 | 131.0 | 4.4 | 6,14,000 |
| Gahat = 4 qt. | 88.0 | 228.8 | 2.0 | 12,84,000 |
| Bhatt = 5 qt. | 216.0 | 104.5 | 97.5 | 21,60,000 |
| Total = 14 qt | 338.3 | 680.3 | 107.8 | 50,42,000 |
| **Mono Cropping** | | | | |
| Paddy = 12 qt. | 90.0 | 920.4 | 12.0 | 41,52,000 |
| Total = 12 qt. | 90.0 | 920.4 | 12.0 | 41,52,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic Mixed Farming produced 276% more protein per acre farmland than that produced by conventional mono cropping.

**Table: U-A-2: Comparative study of vitamins produced per acre farmland- mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | | | |
| Mandua = 3qt. | 126 | 1260 | 570 | 3300 | 0 | 54.9 | 0 | 0 |
| Jhangora = 2 qt. | 0 | 660 | 200 | 8400 | 0 | 0 | 0 | 0 |
| Gahat = 4 qt. | 284 | 1680 | 800 | 6000 | 0 | 0 | 400 | 0 |
| Bhatt = 5 qt. | 2130 | 3650 | 1950 | 16000 | - | 500 | - | - |
| Total = 14 qt | 2540.0 | 7250.0 | 3520.0 | 33700 | 0 | 554.9 | 400 | 0 |
| **Mono Cropping** | | | | | | | | |
| Paddy = 12 qt. | 24 | 2520 | 1,920 | 46800 | 0 | 0 | 0 | 924000 |
| Total = 12 qt. | 24 | 2520 | 1,920 | 46800 | 0 | 0 | 0 | 924000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 10483% more carotene, 188% more thiamine, and 83% more riboflavin per acre farmland than those produced by conventional mono cropping per acre farmland.

Organic mixed cropping produced generous amounts of vitamin $B_6$, folic acid, and vitamin C that conventional mono cropping did not produce.

However, conventional mono cropping produced 39% more Niacin per acre farmland than that produced by organic mixed farming per acre farmland. The increase in production of niacin and choline is attributed to the fact that paddy is a rich source of these vitamins and 12 qt. of paddy was produced.

**Table U-A-3: Comparative study of major minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | | |
| Mandua = 3qt. | 1032.0 | 11.7 | 849.0 | 411.0 | 33.0 | 1224.0 | 132.0 |
| Jhangora = 2 qt. | 40.0 | 10.0 | 560.0 | 164.0 | 0 | 0 | 0 |
| Gahat = 4 qt. | 1,148.0 | 27.1 | 1,244.0 | 624.0 | 46.0 | 3,048.0 | 32.0 |
| Bhatt = 5 qt. | 1200.0 | 52.0 | 3450.0 | 1190.0 | - | - | - |
| Total = 14 qt | 3420.0 | 100.8 | 6103.0 | 2389.0 | 79.0 | 4272.0 | 164.0 |
| **Mono Cropping** | | | | | | | |
| Paddy = 12 qt. | 120.0 | 38.4 | 2,280.0 | 1,884.0 | 0 | 0 | 0 |
| Total = 12 qt. | 120.0 | 38.4 | 2,280.0 | 1,884.0 | 0 | 0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals produced per acre farmland (organic mixed cropping) = 16527.8 g
Total amount of major minerals produced per acre farmland (conventional mono cropping) = 4,322 g

Organic mixed cropping produced 282% more major minerals per acre farmland than those produced by conventional mono cropping per acre farmland. Moreover, organic mixed cropping produced 163% iron per acre farmland than that produced by conventional mono cropping.

**Table U-A-4: Comparative study of trace minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | |
| Mandua = 3qt. | 1,410.0 | 16,470.0 | 306.0 | 6,900.0 | 84.0 | 4,80,000.0 |
| Jhangora = 2 qt. | 1,200.0 | 1,920.0 | 0 | 6,000.0 | 180.0 | 0 |
| Gahat = 4 qt. | 7,240.0 | 6,280.0 | 2,996.0 | 11,200.0 | 96.0 | 7,24,000.0 |
| Bhatt = 5 qt. | 5600.0 | 10550.0 | - | 17000 | 140.0 | - |
| Total = 14 qt | 15450.0 | 35220.0 | 3302.0 | 41100.0 | 500.0 | 1204000.0 |
| **Mono Cropping** | | | | | | |
| Paddy = 12 qt. | 2,880.0 | 13,200.0 | 936.0 | 16,800.0 | 108.0 | 0 |
| Total = 12 qt. | 2,880.0 | 13,200.0 | 936.0 | 16,800.0 | 108.0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland (organic mixed cropping) = 1299572 mg.
Total amount of trace minerals produced per acre farmland (conventional mono cropping) = 33,924 mg.

Organic mixed copping producd 3731% more trace minerals than those produced by conventional mono cropping, per acre farmland.

## Case Study 2:

**Table U-B-1: Comparative study of major macronutrients produced per acre farmland- mixed cropping versus mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed Cropping** | | | | |
| Mandua = 6 qt. | 43.8 | 432.0 | 7.8 | 19,68,000 |
| Foxtail millet = 3 qt. | 36.9 | 182.7 | 12.9 | 9,93,000 |
| French beans = 3 qt. | 5.1 | 13.5 | 0.3 | 78,000 |
| Amaranth = 2 qt. | 28.0 | 130.0 | 14.0 | 7,42,000 |
| Total = 14 qt. | 113.8 | 758.2 | 35.0 | 37,81,000 |
| **Mono cropping** | | | | |
| Paddy = 12 qt. | 90.0 | 920.4 | 12.0 | 41,52,000 |
| Total = 12 qt. | 90.0 | 920.4 | 12.0 | 41,52,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 26% more protein than that produced by conventional mono cropping, per acre farmland.

**Table: U-B-2: Comparative study of vitamins produced per acre farmland- mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Ribofla-vin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | | | |
| Mandua = 6 qt. | 252 | 2520 | 1140 | 6600 | 0 | 109.8 | 0 | 0 |
| Foxtail millet = 3 qt. | 96 | 1770 | 330 | 9600 | 0 | 45 | 0 | 0 |
| French beans = 3 qt. | 396 | 240 | 180 | 900 | 0 | 136.5 | 72000 | 0 |
| Amaranth = 2 qt. | - | 200 | 400 | 1800 | 1200 | 164 | 6000 | - |
| Total = 14 qt. | 744 | 4730 | 2050 | 18900 | 1200 | 455.3 | 78000 | 0 |
| **Mono cropping** | | | | | | | | |
| Paddy = 12 qt. | 24 | 2520 | 1,920.0 | 46800 | 0 | 0 | 0 | 924000 |
| Total = 12 qt. | 24 | 2520 | 1,920.0 | 46800 | 0 | 0 | 0 | 924000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 3000% carotene and 88% more thiamine than those produced by conventional mono cropping. Moreover, organic mixed cropping produced folic acid, vitamin $B_6$, and vitamin C that conventional mono cropping did not produce. However, mono cropping produced more more niacin and choline because paddy is a rich source of these vitamins.

**Table U-B-3: Comparative study of major minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | | |
| Mandua = 6 qt. | 2064.0 | 23.4 | 1698.0 | 822.0 | 66.0 | 2,448.0 | 264.0 |
| Foxtail millet = 3 qt. | 93.0 | 8.4 | 870.0 | 243.0 | 13.8 | 750.0 | 111.0 |
| French beans = 3 qt. | 150.0 | 1.83 | 84.0 | 114.0 | 12.9 | 360.0 | 30.0 |
| Amaranth = 2 qt. | 318.0 | 15.2 | 1114.0 | 6.8 | - | 1016.0 | - |
| Total = 14 qt. | 2625.0 | 48.8 | 3766.0 | 1185.8 | 92.7 | 4574.0 | 405.0 |
| **Mono cropping** | | | | | | | |
| Paddy = 12 qt. | 120.0 | 38.4 | 2,280.0 | 1,884.0 | 0 | 0 | 0 |
| Total = 12 qt. | 120.0 | 38.4 | 2,280.0 | 1,884.0 | 0 | 0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of minerals produced per acre farmland (organic mixed cropping) = 12,696 g.
Total amount of minerals produced per acre farmland (conventional mono cropping) = 4,322 g.

Organic mixed cropping produced 194% more minerals than those produced by conventional mono cropping, per acre farmland. Moreover, organic mixed cropping produced 27% more iron than that produced conventional mono cropping, per acre farmland.

**Table U-B-4: Comparative study of trace minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed Cropping** | | | | | | |
| Mandua = 6 qt. | 2,820.0 | 32,940.0 | 612.0 | 13,800.0 | 168.0 | 9,60,000 |
| Foxtail millet = 3 qt. | 4,200.0 | 1,800.0 | 210.0 | 7,200.0 | 90 | 5,13,000 |
| French beans = 3 qt. | 180.0 | 360.0 | 60.0 | 1,260.0 | 18.0 | 11,000 |
| Amaranth = 2 qt. | 1,600.0 | 6,800.0 | - | 5,800.0 | - | - |
| Total = 14 qt. | 8,800.0 | 41,900.0 | 882.0 | 28,060.0 | 276.0 | 1484000 |
| **Mono cropping** | | | | | | |
| Paddy = 12 qt. | 2,880.0 | 13,200.0 | 936.0 | 16,800.0 | 108.0 | 0 |
| Total = 12 qt. | 2,880.0 | 13,200.0 | 936.0 | 16,800.0 | 108.0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland (organic mixed cropping) = 15,63,918 mg.
Total amount of trace minerals produced per acre farmland (conventional mono cropping) = 33,924 mg.

Organic mixed cropping produced 4510% more trace minerals than those produced by conventional mono cropping, per acre farmland.

## Case Study 3:

**Table U-C-1: Comparative study of major macronutrients produced per acre farmland- mixed cropping versus mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed cropping** | | | | |
| Barnyard millet = 2 qt. | 12.4 | 131.0 | 4.4 | 6,14,000 |
| Black gram = 6 qt. | 144.0 | 357.6 | 8.4 | 20,82,000 |
| Horse gram = 4 qt. | 88.0 | 228.8 | 2.0 | 12,84,000 |
| Amaranth = 2 qt. | 28.0 | 130.0 | 14 | 7,42,000 |
| Potato = 2 qt. | 3.2 | 45.2 | 0.2 | 1,94,000 |
| Total = 16 qt. | 275.6 | 891.8 | 16.4 | 49,16,000 |
| **Mono cropping** | | | | |
| Potato = 13 qt. | 20.8 | 293.8 | 1.3 | 12,61,000 |
| Total = 13 qt. | 20.8 | 293.8 | 1.3 | 12,61,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 1225% more protein than that produced by conventional mono cropping, per acre farmland.

**Table U-C-2: Comparative study of vitamins produced per acre farmland- mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Ribofla-vin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | | |
| Barnyard millet = 2 qt. | 0 | 660 | 200 | 8400 | - | - | - | - |
| Black gram = 6 qt. | 228 | 2520 | 1200 | 12000 | 0 | 792 | 0 | 1236000 |
| Horse gram = 4 qt. | 284 | 1680 | 800 | 6000 | 0 | 0 | 400 | 0 |
| Amaranth = 2 qt. | - | 200 | 400 | 1800 | 1200 | 164 | 6000 | - |
| Potato = 2 qt. | 48 | 200 | 20 | 2400 | - | 14 | 34000 | 200000 |
| Total = 16 qt. | 560 | 5260 | 2620 | 30600 | 1200 | 970 | 40400 | 1436000 |
| **Mono cropping** | | | | | | | | |
| Potato = 13 qt. | 312 | 1300 | 130 | 15600 | - | 91 | 221000 | 1300000 |
| Total = 13 qt. | 312 | 1300 | 130 | 15600 | - | 91 | 221000 | 1300000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 80% more carotene, 305% more thiamine, 1915% more riboflavin, 96% more niacin, and 966% more folic acid than those produced by conventional mono cropping, per acre farm land. Organic mixed cropping produced Vitamin $B_6$ that conventional mono cropping did not produce. Conventional mono cropping produced more of Vitamin C and choline because potato is a richer source of these vitamins and is grown in an amount equal to 13 qt.

**Table U-C-3: Comparative study of major minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | |
| Barnyard millet = 2 qt. | 40.0 | 10.0 | 560.0 | 164.0 | - | - | - |
| Black gram = 6 qt. | 924.0 | 22.8 | 2310.0 | 780.0 | 238.8 | 4800.0 | 54.0 |
| Horse gram = 4 qt. | 1,148.0 | 27.1 | 1,244.0 | 624.0 | 46.0 | 3,048.0 | 32.0 |
| Amaranth = 2 qt. | 318.0 | 15.2 | 1114.0 | 6.8 | - | 1016.0 | - |
| Potato = 2 qt. | 20.0 | 1.0 | 80.0 | 60.0 | 22.0 | 494.0 | 32.0 |
| Total = 16 qt. | 2450.0 | 76.1 | 5308.0 | 1634.0 | 306.8 | 9358.0 | 118.0 |
| **Mono cropping** | | | | | | | |
| Potato = 13 qt. | 130.0 | 6.2 | 520.0 | 390.0 | 143.0 | 3211.0 | 208.0 |
| Total = 13 qt. | 130.0 | 6.2 | 520.0 | 390.0 | 143.0 | 3211.0 | 208.0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals produced per acre farmland (organic mixed cropping) = 19,251 g.
Total amount of major minerals produced per acre farmland (conventional mono cropping) = 4,608 g.

Organic mixed cropping produced 318% more major minerals and 1127% more iron than those produced by conventionl mono cropping, per acre farmland.

**Table U-C-4: Comaprative study of trace minerals produced per acre farmland: mixed cropping versus mono cropping**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | |
| Barnyard millet = 2 qt. | 1200.0 | 1,920.0 | - | 6,000.0 | 180.0 | - |
| Black gram = 6 qt. | 5580.0 | 5,760.0 | 2550.0 | 18,000.0 | 174.0 | 10,44,000.0 |
| Horse gram = 4 qt. | 7,240.0 | 6,280.0 | 2,996.0 | 11,200.0 | 96.0 | 7,24,000.0 |
| Amaranth = 2 qt. | 1600.0 | 6800.0 | - | 5,800.0 | - | - |
| Potato = 2 qt. | 320.0 | 260.0 | 140.0 | 1,060.0 | 14.0 | 74,000.0 |
| Total = 16 qt. | 15,940.0 | 21,020 | 7506.0 | 42,060.0 | 464.0 | 18,42,000.0 |
| **Mono cropping** | | | | | | |
| Potato = 13 qt. | 2080.0 | 1,690.0 | 910.0 | 6890.0 | 91.0 | 4,81,000.0 |
| Total = 13 qt. | 2080.0 | 1,690.0 | 910.0 | 6890.0 | 91.0 | 4,81,000.0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland (organic mixed cropping) = 20,15,980mg.
Total amount of trace minerals produced per acre farmland (conventional mono cropping) = 4,92,661 mg.

Organic mixed cropping produced 309% more trace minerals than those produced by conventional mono cropping, per acre farmland.

## Case Study 4:

**Table U-D-1: Comparative study of major macronutrients produced per acre farmland: Mixed cropping versus Mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed cropping** | | | | |
| Kidney beans = 2 qt. | 45.8 | 121.2 | 2.6 | 6,92,000 |
| Amaranth = 4 qt. | 56.0 | 260.0 | 28.0 | 14,84,000 |
| Potato = 3 qt. | 4.8 | 67.8 | 0.3 | 2,91,000 |
| Total = 9 qt. | 106.6 | 449.0 | 30.9 | 24,67,000 |
| **Mono cropping** | | | | |
| Potato = 13 qt. | 20.8 | 293.8 | 1.3 | 12,61,000 |
| Total = 13 qt. | 20.8 | 293.8 | 1.3 | 12,61,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 413% more protein than that produced by conventional mixed cropping to conventional mono cropping.

**Table U-D-2: Comparative study of vitamins produced per acre farmland-mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Ribofla-vin (mg) | Niacin (mg) | $B_6$ (mg) | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | | |
| Kidney beans = 2 qt. | - | 1752 | 412 | 3918 | 618 | 852 | 0 | 132990 |
| Amaranth = 4 qt. | 0 | 400 | 800 | 3600 | 2900 | 328 | 12000 | - |
| Potato = 3 qt. | 72 | 300 | 30 | 3600 | - | 21 | 51000 | 300000 |
| Total = 9 qt. | 72 | 2452 | 1242 | 11118 | 3518 | 1201 | 63000 | 432990 |
| **Mono cropping** | | | | | | | | |
| Potato = 13 qt. | 312 | 1300 | 130 | 15600 | - | 91 | 221000 | 1300000 |
| Total = 13 qt. | 312 | 1300 | 130 | 15600 | - | 91 | 221000 | 1300000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced amounts of different vitamins comparable to the amounts produced by conventional mono cropping.

**Table U-D-3: Comparative study of major minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | |
| Kidney beans = 2 qt. | 520.0 | 10.2 | 820.0 | 368.0 | - | - | - |
| Amaranth = 4 qt. | 636.0 | 30.4 | 2228.0 | 13.6 | - | 2032.0 | - |
| Potato = 3 qt. | 30.0 | 1.4 | 120.0 | 90.0 | 33.0 | 741.0 | 48.0 |
| Total = 9 qt. | 1186.0 | 42.0 | 3168.0 | 471.6 | 33.0 | 2773.0 | 48.0 |
| **Mono cropping** | | | | | | | |
| Potato = 13 qt. | 130.0 | 6.2 | 520.0 | 390.0 | 143.0 | 3211.0 | 208.0 |
| Total = 13 qt. | 130.0 | 6.2 | 520.0 | 390.0 | 143.0 | 3211.0 | 208.0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 812% more calcium, 577% more iron, 509% more phosphorous, and 20% more magnesium than those produced by conventional mono cropping. The amounts of sodium, potassium, and chlorine are not as relevant as the above mentioned minerals from the Indian dietary perspective.

**Table U-D-4: Comparative study of trace minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | |
| Kidney beans = 2 qt. | 2900.0 | 3,200.0 | - | 9,000.0 | 58.0 | - |
| Amaranth = 4 qt. | 3200.0 | 13,600.0 | - | 11,600.0 | - | - |
| Potato = 3 qt. | 480.0 | 390.0 | 210.0 | 1,590.0 | 21.0 | 1,11,000 |
| Total = 9 qt. | 6580.0 | 17,190.0 | 210.0 | 22,190.0 | 79.0 | 1,11,000 |
| **Mono cropping** | | | | | | |
| Potato = 13 qt. | 2080.0 | 1,690.0 | 910 | 6,890.0 | 91.0 | 4,81,000 |
| Total = 13 qt. | 2080.0 | 1,690.0 | 910 | 6,890.0 | 91.0 | 4,81,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

If we exclude sulphur, deficiency of which is highly unlikely, from our analysis, then organic mixed cropping produces 297% more trace minerals (excluding sulphur) than those produced by conventional mono cropping, per acre farmland.

## Case Study 5:

**Table U-E-1: Comparative study of macronutrients produced per acre farmland- mixed cropping versus mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Mixed cropping** | | | | |
| Wheat = 4 qt. | 47.2 | 284.8 | 6.0 | 13,84,000 |
| Mustard = 2 qt. | 40.0 | 47.6 | 79.4 | 10,82,000 |
| Barley = 2 qt. | 23 | 139.2 | 2.6 | 6,72,000 |
| Peas = 2 qt. | 14.4 | 31.8 | 0.2 | 1,86,000 |
| Lentil = 1 qt. | 25.1 | 59 | 0.7 | 3,43,000 |
| Total = 11 qt. | 149.7 | 562.4 | 88.9 | 36,67,000 |
| **Mono cropping** | | | | |
| Wheat = 10 qt. | 118.0 | 1139.2 | 15.0 | 34,60,000 |
| Total = 10 qt. | 118.0 | 1139.2 | 15.0 | 34,60,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 27% more protein than that produced by conventional mono cropping, per acre farmland.

**Table U-E-2: Comparative study of vitamins produced per acre farmland- mixed cropping versus mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | | |
| Wheat = 4 qt. | 256 | 1800 | 680 | 22,000 | 2280 | 144 | 0 | - |
| Mustard = 2 qt. | 324 | 1300 | 520 | 8000 | - | - | 0 | 422000 |
| Barley = 2 qt. | 20 | 940 | 400 | 10800 | - | - | 0 | - |
| Peas = 2 qt. | 166 | 500 | 20 | 1600 | - | - | 18000 | 40000 |
| Lentil = 1 qt. | 270 | 450 | 200 | 2600 | - | 36 | 0 | 299000 |
| Total = 11 qt. | 1036 | 4990 | 1820 | 45000 | 2280 | 180 | 18000 | 761000 |
| **Mono cropping** | | | | | | | | |
| Wheat = 10 qt. | 640 | 4500 | 1700 | 55000 | 5700 | 360 | 0 | 0 |
| Total = 10 qt. | 640 | 4500 | 1700 | 55000 | 5700 | 360 | 0 | 0 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of vitamins produced per acre farmland (organic mixed cropping) = 8,34,306 mg.
Total amount of vitamins produced per acre farmland (conventional mono cropping) = 67,900 mg.

Organic mixed cropping produced 1129% more vitamins than those produced by conventional mono cropping, per acre farmland.

**Table U-E-3: Comparative study of major minerals produced per acre farmland- mixed cropping versus mono cropping**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | | |
| Wheat = 4 qt. | 164 | 21.2 | 1224 | 552 | 68.4 | 1136 | 188 |
| Mustard = 2 qt. | 980 | 15.8 | 1400 | - | - | - | - |
| Barley = 2 qt. | 52 | 3.34 | 430 | 42 | - | - | 182 |
| Peas = 2 qt. | 40 | 3.0 | 278 | 68 | 15.6 | 158 | 40 |
| Lentil = 1 qt. | 69 | 7.6 | 293 | 80 | 40.1 | 629 | 199 |
| Total = 11 qt. | 1,305 | 50.9 | 3625 | 742 | 124.1 | 1923 | 609 |
| **Mono cropping** | | | | | | | |
| Wheat = 10 qt. | 410 | 53 | 3060 | 1380 | 171 | 2840 | 470 |
| Total = 10 qt. | 410 | 53 | 3060 | 1380 | 171 | 2840 | 470 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

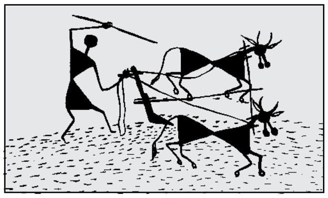
Both methods of farming prod uced almost equal amount of major minerals.

**Table U-E-4: Comparative study of trace minerals produced per acre farmland- mixed cropping versus mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Mixed cropping** | | | | | | |
| Wheat = 4 qt. | 2720 | 9160 | 204 | 10800 | 48 | 5,12,000 |
| Mustard = 2 qt. | 1660 | 5120 | 178 | 9600 | 126 | - |
| Barley = 2 qt. | 2380 | 2060 | 0 | 2400 | 32 | 2,60,000 |
| Peas = 2 qt. | 460 | - | - | - | - | 1,90,000 |
| Lentil = 1 qt. | 1870 | 1040 | 171 | 2800 | 24 | 1,04,000 |
| Total = 11 qt. | 9,090 | 17,380 | 553 | 25,600 | 230 | 10,66,000 |
| **Mono cropping** | | | | | | |
| Wheat = 10 qt. | 6800 | 22900 | 510 | 27000 | 120 | 12,80,000 |
| Total = 10 qt. | 6,800 | 22,900 | 510 | 27,000 | 120 | 12,80,000 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Both methods of farming produced comparable amounts of trace minerals, if we exclude sulphur from our analysis (deficiency of sulphur is highly unlikely).



# Navdanya Farms

Navdanya conducted field experiments in its organic farm in which farmers grew 12 crops (Baranaja), 9 crops (Navdanya), and 7 crops (Septrashi). It compared the yield produced by mixed cropping with that produced by mono cropping in a land of the same size.

## Case Study 1- Baranaja

The original data uses the unit hectare. We converted the yield per hectare to yield per acre for our current report.

| | | Average production/hectare | Average production/acre |
|---|---|---|---|
| | **Organic Mixed Cropping- Baranaja** | | |
| 1) | Bajra | 440.0 kg | 178.14 kg = 1.78 qt |
| 2) | Maize | 1280.0 kg | 518.22 kg = 5.18 qt |
| 3) | Sefed Chemi | 600.0 kg | 242.91 kg = 2.43 qt |
| 4) | Ogal | 360.0 kg | 145.75 kg = 1.46 qt |
| 5) | Mandua | 600.0 kg | 242.91 kg = 2.43 qt |
| 6) | Jhangora | 440.0 kg | 178.14 kg = 1.78 qt |
| 7) | Urd | 600.0 kg | 242.91 kg = 2.43 qt |
| 8) | Navrangi | 680.0 kg | 275.30 kg = 2.75 qt |
| 9) | Koni No. 1 | 280.0 kg | 113.36 kg = 1.13 qt |
| 10) | Lobia | 600.0 kg | 242.91 kg = 2.43 qt |
| 11) | Till | 400.0 kg | 161.94 kg = 1.62 qt |
| 12) | Koni No. 2 | 340.0 kg | 137.65 kg = 1.38 qt |
| | Total | 6620.0 kg | 2680.14 kg = 26.8 qt |
| | **Mono Cropping** | | |
| 1) | Maize | 5400.0 kg | 2186.23 kg = 21.86 qt |
| | Total | 5400.0 kg | 2186.23 kg = 21.86 qt |

**Table N-A-1: Comparision of macronutrients produced per acre farmland-Organic mixed cropping (Baranaja) versus conventional mono cropping**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Organic Mixed Cropping- Baranaja** | | | | |
| Bajra = 1.78 qt | 20.7 | 120.2 | 8.9 | 642580 |
| Maize = 5.18 qt | 57.5 | 342.9 | 18.7 | 1771560 |
| Sefed Chemi = 2.43 qt | 55.7 | 147.3 | 3.2 | 840780 |
| Ogal = 1.46 qt | 15.0 | 95.1 | 3.5 | 471580 |
| Mandua = 2.43 qt | 17.7 | 175.0 | 3.2 | 797040 |
| Jhangora = 1.78 qt | 11.0 | 116.6 | 3.9 | 546460 |
| Urd = 2.43 qt | 58.3 | 144.8 | 3.4 | 843210 |
| Navrangi = 2.75 qt | 66.0 | 155.9 | 3.6 | 918500 |
| Koni No. 1 = 1.13 qt | 13.9 | 68.8 | 4.9 | 374030 |
| Lobia = 2.43 qt | 58.6 | 132.4 | 2.4 | 784890 |
| Till = 1.62 qt | 29.7 | 40.5 | 70.2 | 912060 |
| Koni No. 2 = 1.38 qt | 17.0 | 84.0 | 5.9 | 456780 |
| Total = 26.8 qt | 421.1 | 1622.9 | 131.8 | 9359470 |
| **Mono Cropping** | | | | |
| Maize = 21.86 qt | 242.7 | 1447.1 | 78.7 | 7476120 |
| Total = 21.86 qt | 242.7 | 1447.1 | 78.7 | 7476120 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic Baranaja produced 73.5% more protein than conventional mono cropping did, in an acre of farmland.

**Table N-A-2: Comparision of vitamins produced per acre farmland- mixed organic cropping (baranaja) versus mono cropping**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Organic Mixed Cropping** | | | | | | | | |
| Bajra = 1.78 qt | 235.0 | 587.4 | 445.0 | 4090.0 | - | 81.0 | - | - |
| Maize = 5.18 qt | 466.2 | 2175.6 | 5180.0 | 9324.0 | - | 103.6 | - | - |
| Sefed Chemi = 2.43 qt | - | 2129.2 | 500.6 | 4759.9 | 751.4 | 1078.4 | - | 161582 |
| Ogal = 1.46 qt | - | 1314.0 | 496.4 | 6424.0 | - | - | - | - |
| Mandua = 2.43 qt | 102.1 | 1021.0 | 461.7 | 2673.0 | - | 44.5 | - | - |
| Jhangora = 1.78 qt | - | 587.4 | 178.0 | 7476.0 | - | - | - | - |
| Urd = 2.43 qt | 92.3 | 1020.6 | 486.0 | 4860.0 | - | 320.8 | - | 500580 |
| Navrangi = 2.75 qt | 258.5 | 1292.5 | 742.5 | 5775.0 | - | - | - | 459250 |
| Koni No. 1 = 1.13 qt | 36.2 | 666.7 | 124.3 | 3616.0 | - | 17.0 | - | - |

| | Carotene (mg) | Thiamine (mg) | Ribofla-vin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| Lobia = 2.43 qt | 29.2 | 1239.3 | 486.0 | 3159.0 | - | 323.2 | - | 490860 |
| Till = 1.62 qt | 97.2 | 1636.2 | 550.8 | 7128.0 | - | 217.1 | - | - |
| Koni No. 2 = 1.38 qt | 44.2 | 814.2 | 151.8 | 4416.0 | - | 20.7 | - | - |
| Total = 26.8 qt | 1360.9 | 14484.1 | 9803.1 | 63700.9 | 751.4 | 2206.3 | - | 1612272 |
| **Mono Cropping** | | | | | | | | |
| Maize = 21.86 qt | 1967.4 | 9181.2 | 2186.0 | 39348.0 | - | 437.2 | - | - |
| Total = 21.86 qt | 1967.4 | 9181.2 | 2186.0 | 39348.0 | - | 437.2 | - | - |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of vitamins produced per acre by organic baranaja = 1704579 mg.
Total amount of vitamins produced per acre by conventional mono cropping = 53120 mg.

Organic baranaja produced 32 times as much vitamin as conventional mono cropping did, in an acre of farmland.

**Table N-A-3: Comparision of major minerals produced per acre farmland-organic mixed cropping (baranaja) versus mono cropping**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Organic Mixed Cropping** | | | | | | | |
| Bajra = 1.78 qt | 74.8 | 14.2 | 526.9 | 243.9 | 19.4 | 546.5 | 69.4 |
| Maize = 5.18 qt | 51.8 | 11.9 | 1802.6 | 720.0 | 82.4 | 1481.5 | 170.9 |
| Sefed Chemi = 2.43 qt | 631.8 | 12.4 | 996.3 | 447.1 | - | - | - |
| Ogal = 1.46 qt | 93.4 | 22.6 | 518.3 | 331.4 | 23.7 | 528.5 | 8.8 |
| Mandua = 2.43 qt | 835.9 | 9.5 | 687.7 | 332.9 | 26.7 | 991.4 | 106.9 |
| Jhangora = 1.78 qt | 35.6 | 8.9 | 498.4 | 150.0 | - | - | - |
| Urd = 2.43 qt | 374.2 | 9.2 | 935.6 | 315.9 | 96.7 | 1944.0 | 21.9 |
| Navrangi = 2.75 qt | 341.0 | 12.1 | 896.5 | 349.3 | 77.0 | 2318.3 | 33.0 |
| Koni No. 1 = 1.13 qt | 35.0 | 3.2 | 327.7 | 91.5 | 5.2 | 282.5 | 41.8 |
| Lobia = 2.43 qt | 187.1 | 20.9 | 1006.0 | 510.3 | 56.4 | 2748.3 | 24.3 |
| Till = 1.62 qt | 2349 | 15.1 | 912.0 | - | - | - | - |
| Koni No. 2 = 1.38 qt | 42.8 | 3.9 | 400.2 | 111.8 | 6.4 | 345.0 | 51.1 |
| Total = 26.8 qt | 5052.4 | 143.9 | 9508.2 | 3604.1 | 393.9 | 11186.0 | 528.1 |
| **Mono Cropping** | | | | | | | |
| Maize = 21.86 qt | 218.6 | 50.3 | 7607.3 | 3038.5 | 347.6 | 6252.0 | 721.4 |
| Total = 21.86 qt | 218.6 | 50.3 | 7607.3 | 3038.5 | 347.6 | 6252.0 | 721.4 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals produced per acre by organic baranaja = 30417 g.
Total amount of major minerals produced per acre by conventional mono cropping = 18236 g

Organic baranaja produced 67% more minerals than conventional mono cropping did, per acre farmland. Moreover, organic baranaja produced 186% more iron than conventional mono cropping did, per acre farmland.

**Table N-A-4: Comparision of trace minerals produced per acre farmland- organic mixed cropping (baranaja) versus mono cropping**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Organic Mixed Cropping** | | | | | | |
| Bajra = 1.78 qt | 1886.8 | 2047.0 | 122.8 | 5518.0 | 40.9 | 261660 |
| Maize = 5.18 qt | 2123.8 | 2486.4 | 196.8 | 14504.0 | 20.7 | 590520 |
| Sefed Chemi = 2.43 qt | 3523.5 | 3888.0 | - | 10935.0 | 70.5 | - |
| Ogal = 1.46 qt | 248.2 | - | - | - | - | 216080 |
| Mandua = 2.43 qt | 1142.1 | 13340.7 | 247.9 | 5589.0 | 68.0 | 388800 |
| Jhangora = 1.78 qt | 1068.0 | 1708.8 | - | 5340.0 | 160.2 | - |
| Urd = 2.43 qt | 2259.9 | 2332.8 | 1032.8 | 7290.0 | 70.5 | 422820 |
| Navrangi = 2.75 qt | 1072.5 | 6792.5 | 836.0 | 8250.0 | 38.5 | 517000 |
| Koni No. 1 = 1.13 qt | 1582.0 | 678.0 | 79.1 | 2712.0 | 33.9 | 193230 |
| Lobia = 2.43 qt | 2114.1 | 3256.2 | 4592.7 | 11178.0 | 70.5 | 400950 |
| Till = 1.62 qt | 3709.8 | 2138.4 | 330.5 | 19764.0 | 140.9 | - |
| Koni No. 2 = 1.38 qt | 1932.0 | 828.0 | 96.6 | 3312.0 | 41.4 | 235980 |
| Total = 26.8 qt | 22662.7 | 39496.8 | 7535.2 | 94392.0 | 756.0 | 3227040 |
| **Mono Cropping** | | | | | | |
| Maize = 21.86 qt | 8962.6 | 10492.8 | 830.7 | 61208.0 | 87.4 | 2492040 |
| Total = 21.86 qt | 8962.6 | 10492.8 | 830.7 | 61208.0 | 87.4 | 2492040 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland by organic baranaja = 3391883 mg.
Total amount of trace minerals produced per acre farmland by conventional mono cropping = 2573622 mg.

Organic baranaja produced 32% more trace minerals than conventional mono cropping did, per acre farmland.

## Case Study 2: Navdanya

Navdanya refers to growing 9 different crops on a single farmland. The table below converts the production per hectare to production per acre in organic mixed cropping (Navdanya) and in conventional mono cropping for this report under consideration.

| | | Average prouction/hectare | Average production/acre |
|---|---|---|---|
| | **Organic mixed cropping- Navdanya** | | |
| 1. | Till | 400 kg | 161.9 kg = 1.62 qt |
| 2. | Sefed chemi | 720 kg | 291.5 kg = 2.92 qt |
| 3. | Mandua | 1120 kg | 453.4 kg = 4.53 qt |
| 4. | Dholiya dal | 640 kg | 259.1 kg = 2.59 qt |
| 5. | Sefed bhatt | 760 kg | 307.7 kg = 3.08 qt |

| | | Average prouction/hectare | Average production/acre |
|---|---|---|---|
| 6. | Lobia | 800 kg | 323.9 kg = 3.24 qt |
| 7. | Jhongora | 520 kg | 210.5 kg = 2.11 qt |
| 8. | Maize | 560 kg | 226.7 kg = 2.27 qt |
| 9. | Gahat | 480 kg | 194.3 kg = 1.94 qt |
| | Total | 6000 kg | 2429.2 kg = 24.29 qt |
| | **Conventional mono cropping** | | |
| 1. | Mandua | 3600 kg | 1457.5 kg = 14.58 qt |
| | Total | 3600 kg | 14.58 qt |

**Table N-B-1: Comparision of macronutrients produced per acre farmland- organic mixed cropping (Navdanya) versus conventional mono cropping**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Organic mixed cropping- Navdanya** | | | | |
| Till = 1.62 qt | 29.7 | 40.5 | 70.2 | 912060 |
| Sefed chemi = 2.92 qt | 67.0 | 177.2 | 3.8 | 1011696 |
| Mandua = 4.53 qt | 33.1 | 326.2 | 5.9 | 1485840 |
| Dholiya dal = 2.59 qt | 62.2 | 146.9 | 3.4 | 865060 |
| Sefed bhatt = 3.08 qt | 133.1 | 64.4 | 60.1 | 1330560 |
| Lobia = 3.24 qt | 78.1 | 176.6 | 3.2 | 1046520 |
| Jhongora = 2.11 qt | 13.1 | 138.2 | 4.6 | 647770 |
| Maize = 2.27 qt | 25.2 | 150.3 | 8.2 | 776340 |
| Gahat = 1.94 qt | 42.7 | 111.0 | 1.0 | 622740 |
| Total = 24.29 qt | 484.2 | 1331.3 | 160.4 | 8698586 |
| **Conventional mono cropping** | | | | |
| Mandua = 14.58 qt | 106.4 | 1049.8 | 19.0 | 4782240 |
| Total = 14.58 qt | 106.4 | 1049.8 | 19.0 | 4782240 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic Navdanya produced 355% more protein than conventional mono cropping did, per acre of farmland.

**Table N-B-2: Comparision of vitamins produced per acre farmland- organic mixed cropping (Navdanya) versus conventional mono cropping.**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ (mg) | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Organic mixed cropping- Navdanya** | | | | | | | | |
| Till = 1.62 qt | 97.2 | 1636.2 | 550.8 | 7128.0 | - | 217.1 | - | - |
| Sefed chemi = 2.92 qt | - | 2562.0 | 602.3 | 5727.5 | 904.1 | 1297.7 | - | 194429 |
| Mandua = 4.53 qt | 190.3 | 1903.0 | 860.7 | 4983.0 | - | 82.9 | - | - |
| Dholiya dal = 2.59 qt | 243.5 | 1217.3 | 699.3 | 5439.0 | - | - | - | 432530 |
| Sefed bhatt = 3.08 qt | 1312.1 | 2248.4 | 1201.2 | 9856.0 | - | 308.0 | - | - |
| Lobia = 3.24 qt | 38.9 | 1652.4 | 648.0 | 4212.0 | - | 430.9 | - | 654480 |
| Jhongora = 2.11 qt | - | 696.3 | 211.0 | 8862.0 | - | - | - | - |
| Maize = 2.27 qt | 204.3 | 953.4 | 227.0 | 4086.0 | - | 45.4 | - | - |
| Gahat = 1.94 qt | 137.7 | 814.8 | 388.0 | 2910.0 | - | - | 1940.0 | - |
| Total = 24.29 qt | 2224.0 | 13683.8 | 5388.3 | 53203.5 | 904.1 | 2382.0 | 1940.0 | 1281439 |
| **Conventional mono cropping** | | | | | | | | |
| Mandua = 14.58 qt | 612.4 | 6124.0 | 2770.2 | 16038.0 | - | 266.8 | - | - |
| Total = 14.58 qt | 612.4 | 6124.0 | 2770.2 | 16038.0 | - | 266.8 | - | - |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of vitamins produced per acre farmland by organic navdanya = 1361165 mg.
Total amount of vitamins produced per acre farmland by conventional mono cropping = 25812 mg.

Organic navdanya produced 5174% more vitamins than conventional mono cropping did, per acre farmland.

**Table N-B-3: Comparision of major minerals produced per acre farmland- organic mixed cropping (Navdanya) versus conventional mono cropping**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Organic mixed cropping- Navdanya** | | | | | | | |
| Till = 1.62 qt | 234.0 | 15.1 | 912.0 | - | - | - | - |
| Sefed chemi = 2.92 qt | 760.2 | 15.0 | 1198.8 | 538.0 | - | - | - |
| Mandua = 4.53 qt | 1558.3 | 17.7 | 1282.0 | 620.6 | 49.8 | 1848.2 | 199.3 |
| Dholiya dal = 2.59 qt | 321.2 | 11.4 | 844.3 | 328.9 | 72.5 | 2183.4 | 31.1 |
| Sefed bhatt = 3.08 qt | 739.2 | 32.0 | 2125.2 | 539.0 | - | - | - |
| Lobia = 3.24 qt | 249.5 | 27.9 | 1341.4 | 680.4 | 75.2 | 3664.4 | 32.4 |
| Jhongora = 2.11 qt | 42.2 | 10.6 | 590.8 | 173.0 | - | - | - |
| Maize = 2.27 qt | 22.7 | 5.2 | 790.0 | 315.5 | 36.1 | 649.2 | 74.9 |
| Gahat = 1.94 qt | 556.8 | 13.1 | 603.3 | 302.6 | 22.3 | 1478.3 | 15.5 |

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| Total = 24.29 qt | 4484.1 | 148.0 | 9687.8 | 3498.0 | 255.9 | 9823.5 | 353.2 |
| **Conventional mono cropping** | | | | | | | |
| Mandua = 14.58 qt | 5015.5 | 56.9 | 4126.1 | 1997.5 | 160.4 | 5948.6 | 641.5 |
| Total = 14.58 qt | 5015.5 | 56.9 | 4126.1 | 1997.5 | 160.4 | 5948.6 | 641.5 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals produced per acre farmland by organic navdanya = 28,251 g.
Total amount of major minerals produced per acre farmland by conventional mono cropping = 17,947 g.

Organic navdanya produced 57% more major minerals than conventional mono cropping did, per acre farmland. Organic Navdanya produced 160% more iron than conventional mono cropping did, per acre farmland.

**Table N-B-4: Comparision of trace minerals produced per acre farmland- organic mixed cropping (Navdanya) versus conventional mono cropping**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Organic mixed cropping- Navdanya** | | | | | | |
| Till = 1.62 qt | 3709.8 | 2138.4 | 330.5 | 19764.0 | 140.9 | - |
| Sefed chemi = 2.92 qt | 4239.8 | 4678.4 | - | 12931.0 | 84.8 | - |
| Mandua = 4.53 qt | 2129.1 | 24869.7 | 462.1 | 10419.0 | 126.8 | 724800 |
| Dholiya dal = 2.59 qt | 1010.1 | 6397.3 | 787.4 | 7770.0 | 36.3 | 486920 |
| Sefed bhatt = 3.08 qt | 3449.6 | 6498.8 | - | 10472.0 | 86.2 | - |
| Lobia = 3.24 qt | 2818.8 | 4341.6 | 6123.6 | 14904.0 | 93.7 | 534600 |
| Jhongora = 2.11 qt | 1266.0 | 2025.6 | - | 6330.0 | 189.9 | - |
| Maize = 2.27 qt | 930.7 | 1089.6 | 86.3 | 6356.0 | 9.1 | 258780 |
| Gahat = 1.94 qt | 3511.4 | 3045.8 | 1453.1 | 5432.0 | 46.6 | 351140 |
| Total = 24.29 qt | 23065.3 | 55085.2 | 9243.0 | 94378.0 | 814.3 | 2356240 |
| **Conventional mono cropping** | | | | | | |
| Mandua = 14.58 qt | 6852.6 | 80044.2 | 1487.2 | 33534.0 | 408.2 | 2332800 |
| Total = 14.58 qt | 6852.6 | 80044.2 | 1487.2 | 33534.0 | 408.2 | 2332800 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland by organic navdanya = 25,38,826 mg.
Total amount of trace minerals produced per acre farmland by conventional mono cropping = 24,55,126 mg.

## Case Study 3- Septrashi

Septrashi is the practice of growing a mixture of 7 crops in one farmland. The table below converts the production per hectare to production per acre in organic mixed cropping (Septrashi) and in conventional mono cropping.

| | | Average production/hectare | Average production/acre |
|---|---|---|---|
| | **Organic mixed cropping (Septrashi)** | | |
| 1. | Urd | 600 kg | 242.9 kg = 2.43 qt |
| 2. | Moong | 520 kg | 210.5 kg = 2.11 qt |
| 3. | Mandua | 560 kg | 226.7 kg = 2.27 qt |
| 4. | Sefed Bhatt | 680 kg | 275.3 kg =2.75qt |
| 5. | Dohyalya dal | 560 kg | 226.7 kg =2.27qt |
| 6. | Maize | 680 kg | 275.3 kg = 2.75qt |
| 7. | Lobia dal | 600 kg | 242.9 kg = 2.43qt |
| | Total | 4200 kg | 1700.4 kg = 17.0 qt |
| | **Conventional Mixed Cropping** | | |
| 1. | Urd | 2400 kg | 971.7 kg = 9.72qt |
| | Total | 2400 kg | 971.7 kg = 9.72qt |

**Table N-C-1: Comparision of macronutrients produced per acre farmland- organic mixed cropping (Septrashi) versus conventional mono cropping.**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| **Organic mixed cropping (Septrashi)** | | | | |
| Urd = 2.43 qt | 58.3 | 144.8 | 3.4 | 843210 |
| Moong = 2.11 qt | 50.6 | 119.6 | 2.7 | 704740 |
| Mandua = 2.27 qt | 16.6 | 163.4 | 3.0 | 744560 |
| Sefed Bhatt = 2.75 qt | 118.8 | 57.5 | 53.6 | 1188000 |
| Dohyalya dal = 2.27 qt | 54.5 | 128.7 | 3.0 | 758180 |
| Maize = 2.75 qt | 30.5 | 182.1 | 9.9 | 940500 |
| Lobia dal = 2.43 qt | 58.6 | 132.4 | 2.4 | 784890 |
| Total = 17.0 | 388.0 | 928.5 | 78.1 | 5964080 |
| **Conventional Mixed Cropping** | | | | |
| Urd = 9.72 qt | 233.3 | 579.3 | 13.6 | 3372840 |
| Total = 9.72 qt | 233.3 | 579.3 | 13.6 | 3372840 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.

Organic Septrashi produced 66% more protein than conventional mono cropping did, per acre farmland.

**Table N-C-2: Comparision of vitamins produced per acre farmland- organic mixed cropping (Septrashi) versus conventional mono cropping**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | $B_6$ mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| **Organic mixed cropping (Septrashi)** | | | | | | | | |
| Urd = 2.43 qt | 92.3 | 1020.6 | 486.0 | 4860 | - | 320.8 | - | 500580 |
| Moong = 2.11 qt | 198.3 | 991.7 | 569.7 | 4431 | - | - | - | 352370 |
| Mandua = 2.27 qt | 95.3 | 953.0 | 431.3 | 2497 | - | 41.5 | - | - |
| Sefed Bhatt = 2.75 qt | 1171.5 | 2007.5 | 1072.5 | 8800 | - | 275.0 | - | - |
| Dohyalya dal = 2.27 qt | 213.4 | 1066.9 | 612.9 | 4767 | - | - | - | 379090 |
| Maize = 2.75 qt | 247.5 | 1155.0 | 275.0 | 4950 | - | 55.0 | - | - |
| Lobia dal = 2.43 qt | 29.2 | 1239.3 | 486.0 | 3159 | - | 323.2 | - | 490860 |
| Total = 17.0 qt | 2047.5 | 8434.0 | 3933.4 | 33464 | - | 1015.5 | - | 1722900 |
| **Conventional Mixed Cropping** | | | | | | | | |
| Urd = 9.72 qt | 369.4 | 4082.4 | 1944.0 | 19440 | - | 1283.0 | - | 2002320 |
| Total = 9.72 qt | 369.4 | 4082.4 | 1944.0 | 19440 | - | 1283.0 | - | 2002320 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of vitamins produced per acre farmland by organic septrashi = 1771795 mg.
Total amount of vitamins produced per acre farmland by conventional mono cropping = 2029438 mg.

However, if we exclude choline, which is abundantly present in Urd, then organic septrashi produced 454% more carotene, 107% more thiamine, 102% more riboflavin, and 72% more niacin than conventional mono cropping did, per acre farmland.

**Table N-C-3: Comparision of major minerals prouced per acre farmland- organic mixed cropping (Septrashi) versus conventional mono cropping**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Organic mixed cropping (Septrashi)** | | | | | | | |
| Urd = 2.43 qt | 374.2 | 9.2 | 935.6 | 315.9 | 96.7 | 1944.0 | 21.9 |
| Moong = 2.11 qt | 261.6 | 9.3 | 687.9 | 268.0 | 59.1 | 1778.7 | 25.3 |
| Mandua = 2.27 qt | 780.9 | 8.9 | 642.4 | 311.0 | 25.0 | 926.2 | 99.9 |
| Sefed Bhatt = 2.75 qt | 660.0 | 28.6 | 1897.5 | 481.3 | - | - | - |
| Dohyalya dal = 2.27 qt | 281.5 | 10.0 | 740.0 | 288.3 | 63.6 | 1913.6 | 27.2 |
| Maize = 2.75 qt | 27.5 | 6.3 | 957.0 | 382.3 | 43.7 | 786.5 | 90.8 |
| Lobia dal = 2.43 qt | 187.1 | 20.9 | 1006.0 | 510.3 | 56.4 | 2748.3 | 24.3 |
| Total = 17.0 | 2572.8 | 93.2 | 6866.4 | 2557.1 | 344.5 | 10097.3 | 289.4 |

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| **Conventional Mixed Cropping** | | | | | | | |
| Urd = 9.72 qt | 1496.9 | 36.9 | 3742.2 | 1263.6 | 386.9 | 7776.0 | 87.5 |
| Total = 9.72 qt | 1496.9 | 36.9 | 3742.2 | 1263.6 | 386.9 | 7776.0 | 87.5 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of major minerals produced per acre farmland by organic septrashi = 22821 g.
Total amount of major minerals produced per acre farmland by conventional mono cropping = 14790 g.

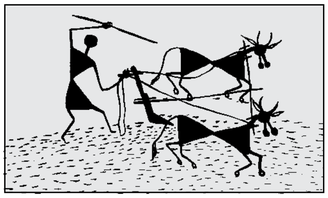
Organic septrashi produced 54% more major minerals than conventional mono cropping did, per acre farmland. Organic septrashi produced 153% more iron than conventional mono cropping did, per acre farmland.

**Table N-C-4: Comparision of trace minerals produced per acre farmland- organic mixed cropping (Septrashi) versus conventional mono cropping.**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| **Organic mixed cropping (Septrashi)** | | | | | | |
| Urd = 2.43 qt | 2259.9 | 2332.8 | 1032.8 | 7290.0 | 70.5 | 422820 |
| Moong = 2.11 qt | 822.9 | 5211.7 | 641.4 | 6330.0 | 29.5 | 396680 |
| Mandua = 2.27 qt | 1066.9 | 12462.3 | 231.5 | 5221.0 | 63.6 | 363200 |
| Sefed Bhatt = 2.75 qt | 3080.0 | 5802.5 | - | 9350.0 | 77.0 | - |
| Dohyalya dal = 2.27 qt | 885.3 | 5606.9 | 690.1 | 6810.0 | 31.8 | 426760 |
| Maize = 2.75 qt | 1127.5 | 1320.0 | 104.5 | 7700.0 | 11.0 | 313500 |
| Lobia dal = 2.43 qt | 2114.1 | 3256.2 | 4592.7 | 11178.0 | 70.5 | 400950 |
| Total = 17.0 | 11356.6 | 35992.4 | 7293.0 | 53879.0 | 353.9 | 2323910 |
| **Conventional Mixed Cropping** | | | | | | |
| Urd = 9.72 qt | 9039.6 | 9331.2 | 4131.0 | 29160.0 | 281.9 | 1691280 |
| Total = 9.72 qt | 9039.6 | 9331.2 | 4131.0 | 29160.0 | 281.9 | 1691280 |

Source: 1) Navdanya; 2) Nutritive value of Indian Foods, ICMR.
Total amount of trace minerals produced per acre farmland by organic septrashi = 2432785 mg.
Total amount of trace minerals produced per acre farmland by conventional mono cropping = 1743223 mg.

Organic septrashi produced 40% more trace minerals than conventional mono cropping did, per acre farmland.



# What do these Tables Indicate?

Researchers and doctors, globally, have reached a collective consensus that one should derive his or her nutrition from diverse sources[8,10]. How will our meal plate or thali be diverse if our farms aren't . There is a concept in finance that emphasizes upon diversification of portfolio to reduce risk. This concept of finance seems to be equally valuable for agriculture, health, and nutrition. Rui Hai Liu from Department of Food Science, Cornell University, Ithaca, NY recommends, "We believe that a recommendation that consumers eat 5 to 10 servings of a wide variety of fruits and vegetables daily is an appropriate strategy for significantly reducing the risk of chronic diseases and to meet their nutrient requirements for optimum health." How can we expect to consume such wide variety of foods if we do not grow such a wide variety? The following table was published by the Planning Commission of India in 1999[11].

If we look at the table carefully we will realize that our per capita nutrition or average nutrition per person per day has declined significantly from 1975 to 1999. The period between 1975 and 1999 is also significant from the green revolution point of view- in 1975 effects of green revolution and conventional farming were negligible, whereas in 1999 the conventional farming practices had gripped our soceity substantially. One probable reason for such change in average nutritional consumption could be population explosion. However, to blame everything on rise in population would be too shortsighted and superficial. Further extensive research is required to prove a definite correlation.

**Time trends in dietary intake and nutritional status of adults.**

**Table-5.11 Consumption of different foods (Cu/day) Vs RDA**

| Food | 1975 | 1980 | 1990 | 1995 | 1996-97 | RDA |
|---|---|---|---|---|---|---|
| Cereals and millets (g) | 523 | 533 | 490 | 464 | 450 | 460 |
| Pulses | 32 | 33 | 32 | 33 | 27 | 40 |
| GLV | 11 | 14 | 11 | 13 | 15 | 40 |
| Other Vegetables | 51 | 75 | 49 | 40 | 47 | 60 |
| Fruits | 10 | 25 | 23 | 22 | - | - |
| Fats and oils | 9 | 10 | 13 | 13 | 12 | 20 |
| Sugar/Jaggery | 19 | 18 | 29 | 23 | 21 | 30 |
| Milk & milk products | 80 | 88 | 96 | 95 | 86 | 150 |

**Table-5.12 Intake of Nutrients (Cu/day)**

| Nutrient | 1975 | 1980 | 1990 | 1995 | 1996-97 | RDA |
|---|---|---|---|---|---|---|
| Protein g | 64 | 52 | 62 | 56 | 54 | 60 |
| Energy (K cal) | 2296 | 2404 | 2283 | 2172 | 2108 | 2425 |
| Iron (mg) | 32 | 30 | 28 | 26 | 25(14*) | 30 |
| Vitamin A (eq. μg) | 263 | 313 | 294 | 298 | 282 | 600 |
| Vitamin $B_2$ (mg) | 0.98 | 0.91 | 0.94 | 0.8 | 0.9 | 14 |
| Vitamin C (mg) | 41 | 52 | 37 | 35 | 40 | 40 |

Source: Krishnaswamy et at NNMB 1999

Another interesting fact that came out was that an acre of farmland under conventional agriculture produced low amounts of most nutrients. However, such farmland produced a few odd nutrients excessively. This is probably reflected on our national health; on one hand we are struggling to treat and eradicate deficiency diseases like protein energy malnutrition, night blindness, anemia, etc. and on the other hand the nation is distressed by debilitating effects of excessive nutrition like obesity, hypervitaminosis, cardiovascular diseases, diabetes, etc. However, in order to prove a definite correlation, further extensive research is the call of the hour.

Diversification is not just important from the “amount of nutrient produced per acre” point of view. Research has suggested that traditional foods and different varieties of fruits and vegetables contain several bioactive compounds that prevent cancer, diabetes, cardiovascular diseases, and other degenerative diseases[7,8]. All such compounds have not been identified till date, role of such bioactive compounds in preventing these degerative diseases has not, yet, been pin pointed, and an ideal blend of nutrients for human consumption has not been recognized[13]. We are almost there, but not quite there. As a result, medical practitioners prescribe a diet that is derived from varied sources and such recommendation proved useful too[10].

In order to provide a more comprehensible picture, we took the average (arithmetic mean) of nutrients produced per acre farmland from all the case studies above. The sample mean of our report should be a fairly good estimator of the population mean. The population in our case is the total arable land in India. Hence, the average production of nutrients per acre of farmland is a reasonably fair point estimator of the average production per acre farmland on a national scale. Moreover, we have collected data from different states ranging from an arid state, Rajasthan, to an organic state, Uttaranchal. As a result the margin of error should be fairly low. The purpose of all the statistic is to allow the reader have a glimpse of the actual scenario- effect of two forms of agriculture on a national level. The questions are how to maximize nutrient production, how to minimize environmental risk, and how to ensure a sustainable alternative to solve the national and global food crisis.

**Average production of macronutrients per acre farmland- organic mixed cropping versus conventional mono cropping**

| | Protein (kg) | Carbohydrate (kg) | Fat (kg) | Total energy (kcal) |
|---|---|---|---|---|
| Average production of nutrients from organic mixed farming | 240 | 833 | 66 | 4,914,270 |
| Average production of nutrients from conventional mono cropping | 116 | 785 | 23 | 3,711,475 |

According to the table, if we switch an acre of farmland from conventional mono cropping to organic mixed cropping, we shall be able to produce 124 kg of protein more than earlier. The quality of mixed cropping protein is better than that of mono cropping protein. The organic mixed cropping protein is complete because it provides all the essential amino acids- it is comparable to animal protein. Vegetarian protein (except soy) may be an inadequete source of all essential amino acids individually. However, when vegetarian proteins are mixed, they become an adequete source of all essential amino acids. For example, the protein in roti or dal, individually, is incomplete because it does not contain all the essential amino acids, but when roti and dal are consumed together, they become a complete source of all essential amino acids[3]. Hence, the protein produced in an acre of farmland from organic mixed cropping is more complete than protein produced in an acre from conventional mono cropping.

On an average, organic mixed cropping produces 124 kg of protein more than conventional mono cropping, per acre farmland. 124 kg of protein is enough to fulfil the protein requirement of 2000 adults for a day. According to Central Water Commission, Govt. of India, total cultivable land (2003-04) in India is 183 M. Ha., which is approximately equal to 452202848 acres. If all of this land is used for organic mixed cropping instead of conventional mono cropping, the country shall produce 56073153 metric tons of protein more than that producd earlier. This is enough to fulfil the protein requirement of 2.5 billion adults for the entire year. A fact worthy of notice is that we have only taken the difference of 124 kg protein per acre between organic mixed cropping and conventional mono cropping. The additional amount of protein that we would produce by switching from conventional agriculture to organic agriculture is sufficient to fulfil the protein requirement of 2.5 billion adults for the entire year. If we consider the entire amount of protein produced in the country through organic mixed cropping, by projecting our sample average to the total cultivable land, we would produce enough protein to fulfil the protein requirement of approximately 5 billion adults for the whole year. This is enough protein to feed our entire population and to eradicate protein energy malnutrition from the planet.

If an acre of farmland is diverted from conventional mono cropping to organic mixed cropping, we shall produce additional food containing 12,02,795 kcal of extra energy to be consumed. This is enough to supply 2500 kcal of energy to 481 adults for a day. If we project this figure to 183 M. Ha. of total cultivable land in India, we shall produce additional calories in food that is sufficient to fulfil the energy requirement of 600 million adults for the whole year. We would again like to mention that we only considered the extra calories produced by switching from conventional to organic. If we consider the sample average amount of calories produced per acre through organic mixed cropping, then, on a national scale, we shall produce enough calories to supply 2500 kcal/day to 2.4 billion adults for 1 year. If we switch from conventional to organic, we can ensure that no individual is hungry in our country. Infact, if only India switches from conventional agriculture to organic agriculture, we can resolve the global hunger problem because it is just the bottom billion of the world population that is hungry.

**Average production of vitamins per acre farmland- organic mixed cropping versus conventional mono cropping**

| | Carotene (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | B6 mg | Folic acid (mg) | Vit. C (mg) | Choline (mg) |
|---|---|---|---|---|---|---|---|---|
| Average production of nutrients from organic mixed farming | 2,919 | 6,550 | 3179 | 31,443 | 821 | 878 | 24145 | 680675 |
| Average production of nutrients from conventional mono cropping | 745 | 3,911 | 1685 | 28,381 | 475 | 328 | 36833 | 537527 |

If an acre of farmland is used for organic mixed cropping rather than conventional mono croping, we shall produce 2174 mg of carotene more than that produced otherwise. This is enough carotene to fulfil vitamin A requirement of approximately 900 adults for a day. On a national scale, we would produce 982670 metric tons of carotene organically more than that produced conventionally. In other words, we would produce 164106 metric tons of retinol equivalent (1 unit of B-carotene= 0.167 unit of RE[3]) more than that produced conventionally. 164106 metric tons of RE (retinol equivalent) is sufficient to satisfy the daily vitamin A requirement of 750 million adults for 1 year. 164106 metric tons of RE is sufficient to completely treat and reverse 1.3 billion early cases of Xerophthalmia. We assumed here that all this retinol equivalent in food can be isolated and administered to Xerophthalmia patients. The term Xerophthalmia (dry eye) comprises all the occular manifestations of vitamin A deficiency ranging from nightblindness to keratomalacia. Vitamin A deficiency first causes nightblindness and then progresses to corneal ulcers- a serious condition that may leave residual corneal scar, affecting vision. Keratomalacia or liquifaction of cornea is a major cause of blindness in India- the cornea becomes soft and may burst open. This may be the kind of impact that extra carotene produced, by switching to organic on a national scale, can have on the health of our population. If we use the sample average amount of carotene produced per acre farmland by organic mixed cropping to calculate the total amount of carotene produced nationally, we can produce enough carotene to fulfil the daily Vitamin A requirement of 1.5 billion adults for one year.

Similarly, the extra amount of thiamine produced per acre, by switching from conventional to organic, is enough to supply thiamine to approximately 2100 adults for a day. On a national scale, the extra amount of thiamine produced by switching from conventional to organic would be sufficient to fulfil daily thiamine requirement of 2.6 billion adults for one year. If we consider all the thiamine that can be produced organically in the country, then the thiamine produced would be sufficient for approximately 5 billion adults for a year. Minor degrees of thiamine deficiency is endemic in certain sections of the country[3]. With organic farming on a national scale, we can uproot and eradicate all forms of thiamine deficiency from our population.

Organic mixed cropping in an acre of farmland produces extra riboflavin, compared to conventional mono cropping in one acre, that can fulfil the recommended riboflavin allowance of 1000 adults for a day. On a national scale, we could supply adequete amounts of riboflavin to 1.2 billion extra adults for a year. Riboflavin deficiency is widespread in India, particularly in population where rice is the staple[3]- the fact reveals that we are currently not producing enough riboflavin. Organic mixed cropping seems to be a promising solution to resolve the riboflavin crisis.

Folic acid deficiency can occur rapidly in pregnant and lactating mothers and growing children because body stores of folate are not large- about 5-10 mg. An acre of farmland through organic mixed cropping can produce extra folic acid that can nourish approximately 1375 pregnant mothers for a day. On a national scale, the extra amount of folate produced through organic mixed cropping, compared to its conventional counterpart, is sufficient to supply folic acid to 1.7 billion pregnant woman, who require four times as much folic acid as a normal adult, for one year.

Our sample shows that vitamin C produced by conventional mono cropping was more than that produced by organic mixed cropping. Nevertheless, there are a few points that need to be highlighted. Although the mean production of vitamin C of our sample favours conventional mono cropping, the median value is zero in conventional mono cropping compared to organic mixed cropping that has a median value of 4470 mg. The fact hints that a farmer in Rajasthan or Sikkim, practicing conventional mono cropping, would suffer from Vit. C deficiency, whereas the farmer in Uttaranchal who produced excess vitamin C would excrete the excess vitamin C in his urine- we assumed that the farmers consumed only the food that they grew.

According to a research publication by Virginia Worthington- Nutritional quality of organic versus conventional fruits, vegetables, and grains, The Journal of Alternative and Complementary Medicine, volume 7, number 2, 2001, organically grown food has 27% more Vitamin C, on an average, than conventionally grown food[14]. If we include the difference of 27% in our sample mean, the difference decreases drastically.

**Average production of major minerals per acre farmland- organic mixed cropping versus conventional mono cropping**

| | Ca (g) | Fe (g) | P (g) | Mg (g) | Na (g) | K (g) | Cl (g) |
|---|---|---|---|---|---|---|---|
| Average production of nutrients from organic mixed farming | 2,166 | 82 | 5,158 | 1,866 | 197 | 6,076 | 323 |
| Average production of nutrients from conventional mono cropping | 731 | 43 | 3117 | 1,496 | 158 | 3,465 | 320 |

Iron is of great importance to human health. The adult human body contains about 3-4 g of iron of which 60-70% is present in blood. Iron is required for many functions in the body such as haemoglobin formation, brain development and function, regulation of body temperature, muscle activity, and catecholamine metabolism. The central function of iron is oxygen transport and cell respiration. The bioavailability of non-haem iron (mostly vegetarian) is poor owing to the presence of phytates, oxalates, carbonates, phosphates, and dietary fibre. The Indian diet which is predominantly vegetarian contains large amounts of such inhibitors- phytates in bran, phosphates in egg yolk, tannin in tea, and oxalates in vegetables. Deficiency of iron in diet leading to iron deficiency anemia or nutritional anemia is a major public health problem in India. A WHO expert group proposed that anemia should be considered to exist when haemoglobin is below the following levels.

**Cut off points for diagnosis of anemia[3]**

| | Haemoglobin (g/dl) in venous blood |
|---|---|
| Adult Males | 13 |
| Adult female- non pregnant | 12 |
| Adult female- pregnant | 11 |
| Children- 6 months to 6 years | 11 |
| Children- 6 to 14 years | 12 |

**Requirement of iron for different age groups[3]**

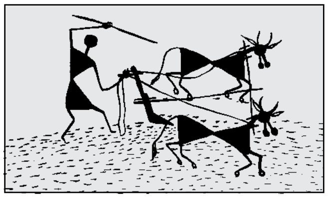
| Age group | Iron in mg that should be absorbed daily |
|---|---|
| Infants (5-12 months) | 0.7 |
| Children (1-12 years) | 1.0 |
| Adolescents (13-16 years) | |
| Male | 1.8 |
| Female | 2.4 |
| Adult male | 0.9 |
| Adult female | |
| Menstruation | 2.8 |
| Pregnancy | |
| -First half | 0.8 |
| -Second half | 3.5 |
| Lactation | 2.4 |
| Post menopause | 0.7 |

When an acre of farmland is used for organic mixed cropping in place of conventional mono cropping, 39 g of extra iron is produced. This amount is sufficient to nourish 16,250 lactating mothers with iron for a day. On a national scale, the extra amount of iron produced organically would be sufficient to meet the requirement of 20 billion hypothetical lactating mothers. To reach this conclusion, we assumed that all of the iron consumed would be absorbed.

**Average production of trace minerals per acre farmland- organic mixed cropping versus conventional mono cropping**

| | Cu (mg) | Mn (mg) | Mo (mg) | Zn (mg) | Cr (mg) | S (mg) |
|---|---|---|---|---|---|---|
| Average production of nutrients from organic mixed farming | 12,591 | 25,124 | 3,694 | 43,977 | 345 | 1,640,791 |
| Average production of nutrients from conventional mono cropping | 6,101 | 15,629 | 1077 | 26,769 | 157 | 1,303,224 |

Organic mixed cropping, on an average, produces 106% more copper, 61% manganese, 243% more molybednum, 64% more zinc, and 120% more chromium than those produced by conventional mono cropping. Collectively, organic mixed cropping produces 72% of these trace minerals more than conventional mono cropping does. Micronutrient deficiency is increasingly being observed in soil and in humans.



# Is Genetic Engineering a Solution to Hunger and Malnutrition?

A part of the scientific community proposes genetic engineering as a vital solution to the problem. William Ockham (1285-1349) was an English philosopher who maintained that a complicated explanation should not be accepted without good reason. William Ockham wrote, " Frustra fit per plura, quod fieri potest per pauciora", which means that it is vain to do with more what can be done with less. Organic mixed cropping can increase the production of micronutrients, for consumption, by 72%. Moreover, it is sustainable, time tested,reasonable, intelligent, cost effective and ecological solution to the problem. Genetically modified crops can claim to increase the concentration of one or two micronutrients. By no means can genetic modification provide an ideal blend of all trace minerals. On the contrary, organic mixed cropping causes a holistic increase in the production of such micronutrients for consumption. Genetic engineering of crops is an experimental technology. Companies that promote GM crops want to use our farmlands as an experimental platform. The profit goes to the company, whereas the soceity shall bear the risk associated with GM crops with absolutely no reward. All what the soceity is getting is fantasy and grave environmental risks. Scientists agree that GM crops may not always function as predicted and results could be surprising[15].

The transformative nature of what genetic engineers are doing can not be quantified. The full effects of transfering genes between species and kingdoms are unknown to even the most highly trained genetic engineers. Before a technology is introduced for common use, the positive effect of technology is compared with its unwanted effects. It is only when the benefit outweighs risk that a new technological product is introduced. A new drug is introduced in the pharmacy only when effect is more substantial than its side effect. However, genetic modification of crops does not allow this useful comparision because the complete array of effects is unknown. The situation is metaphorically similar to one in which an individual is introduced in a tiger cage claiming that it is good for the individual to learn a few traits from the tiger- what the tiger shall do to the individual is unknown and unpredictable. Tiger is a very revered animal, but GM crops carry the potential to turn the planet into a cage and the natural habitat into an invincible monster looking at us- humans. Similar to pollution of air and pollution of water, genetic modification of crops is pollution of gene pool, and like pollution of water and pollution of air, this pollution of gene pool shall hit back. The following are some of the known uncertainities with GM crops[15]:

- Risks to human health
- Results can be predicted but they cannot be guaranteed
- Antibiotic resistance
- Allergens and food allergy

- Genetic pollution
- Threat to wildlife, insects, and soil organisms
- Issues in food security such as patents, monopolies, monocultures

The following was published by the National Agricultural Law Centre, University of Arkansas, School of Law, Division of Agriculture, "Precaution before profits- an overview of issues in genetically modified foods and crops" by Sophia Kolehmainen (2001):

"This unpredictability has led to surprising results in several experiments with genetically engineered plants. For example, in 1999, Science magazine reported on a study in which tow groups of rats were fed potatoes. One group was fed potatoes that had been genetically modified with a lectin gene to enhance the potatoes' resistance to insects, which the other group was fed non-genetically modified potatoes supplemented with the same lectin. The rats that ate the genetically modified potatoes showed stunted growth and suppressed immune systems, which the rats that ate the non-genetically modified potatoes with the same lectin had none of those symptoms."

The GM food that, supposedly, cannot promote growth in rats is thought to solve the malnutrition crisis among humans, and all this propoganda is coming at a time when we have clearly indicated that organic mixed cropping can enhance micronutrient production for consumption by 72% without any risk to the human health, to the environment, and to the soceity at large.

The following article[16] was published by The Journal of Agrobiotechnology Management and Economics (volume 2//number 3 & 4//article 3). The name of the article is " Ten reasons why biotechnology will not ensure food security, protect the environment, and reduce poverty in developing world." The authors of the article are Miguel A. Altieri and Peter Rosset, University of California, Berkeley & Food First/Institute for Food and Development Policy.

Biotechnology companies often claim that genetically modified organisms (GMOs)—specifically, genetically altered seeds—are essential scientific breakthroughs needed to feed the world, protect the environment, and reduce poverty in developing countries. The Consultative Group on International Agricultural Research (CGIAR) and its constellation of international centers around the world charged with research to enhance food security in the developing world echo this view, which rests on two critical assumptions. The first is that hunger is due to a gap between food production and human population density or growth rate. The second is that genetic engineering is the only or best way to increase agricultural production and, thus, meet future food needs.

Our objective is to challenge the notion of biotechnology as a magic bullet solution to all of agriculture's ills, by clarifying misconceptions concerning these underlying assumptions.

1. There is no relationship between the prevalence of hunger in a given country and its population. For every densely populated and hungry nation like Bangladesh or Haiti, there is a sparsely populated and hungry nation like Brazil and Indonesia. The world today produces more food per inhabitant than ever before. Enough food is available to provide 4.3 pounds for every person everyday: 2.5 pounds of grain, beans and nuts, about a pound of meat, milk and eggs and another of fruits and vegetables. The real causes of hunger are poverty, inequality and lack of access to food and land. Too many people are too poor to buy the food that is available (but often poorly distributed) or lack the land and resources to grow it themselves (Lappe, Collins & Rosset, 1998).
2. Most innovations in agricultural biotechnology have been profit-driven rather than need-driven. The real thrust of the genetic engineering industry is not to make third world agriculture more productive, but rather to generate profits (Busch et al., l990). This is illustrated by reviewing the principle technologies on the market today: (1) herbicide resistant crops, such as Monsanto's "Roundup Ready" soybeans,

seeds that are tolerant to Monsanto's herbicide Roundup, and (2) "Bt" (Bacillus thuringiensis) crops which are engineered to produce their own insecticide. In the first instance, the goal is to win a greater herbicide market-share for a proprietary product and, in the second, to boost seed sales at the cost of damaging the usefulness of a key pest management product (the Bacillus thuringiensis based microbial insecticide) relied upon by many farmers, including most organic farmers, as a powerful alternative to insecticides. These technologies respond to the need of biotechnology companies to intensify farmers' dependence upon seeds protected by so-called "intellectual property rights" which conflict directly with the age-old rights of farmers to reproduce, share or store seeds (Hobbelink, 1991). Whenever possible corporations will require farmers to buy a company's brand of inputs and will forbid farmers from keeping or selling seed. By controlling germplasm from seed to sale, and by forcing farmers to pay inflated prices for seed-chemical packages, companies are determined to extract the most profit from their investment (Krimsky & Wrubel, 1996).

3. The integration of the seed and chemical industries appears destined to accelerate increases in per acre expenditures for seeds plus chemicals, delivering significantly lower returns to growers. Companies developing herbicide tolerant crops are trying to shift as much per acre cost as possible from the herbicide onto the seed via seed costs and technology charges. Increasingly price reductions for herbicides will be limited to growers purchasing technology packages. In Illinois, the adoption of herbicide resistant crops makes for the most expensive soybean seed-plus-weed management system in modern history—between $40.00 and $60.00 per acre depending on fee rates, weed pressure, and so on. Three years ago, the average seed-plus-weed control costs on Illinois farms was $26 per acre, and represented 23% of variable costs; today they represent 35-40% (Benbrook, 1999). Many farmers are willing to pay for the simplicity and robustness of the new weed management system, but such advantages may be short-lived as ecological problems arise.

4. Recent experimental trials have shown that genetically engineered seeds do not increase the yield of crops. A recent study by the United States Department of Agriculture (USDA) Economic Research Service shows that in 1998 yields were not significantly different in engineered versus non-engineered crops in 12 of 18 crop/region combinations. In the six crop/region combinations where Bt crops or herbicide tolerant crops (HTCs) fared better, they exhibited increased yields between 5-30%. Glyphosphate tolerant cotton showed no significant yield increase in either region where it was surveyed. This was confirmed in another study examining more than 8,000 field trials, where it was found that Roundup Ready soybean seeds produced fewer bushels of soybeans than similar conventionally bred varieties (USDA, 1999).

5. Many scientists claim that the ingestion of genetically engineered food is harmless. Recent evidence, however, shows that there are potential risks of eating such foods as the new proteins produced in such foods could: (1) act themselves as allergens or toxins; (2) alter the metabolism of the food producing plant or animal, causing it to produce new allergens or toxins; or (3) reduce its nutritional quality or value. In the case of (3), herbicide resistant soybeans can contain less isoflavones, an important phytoestrogen present in soybeans, believed to protect women from a number of cancers. At present, developing countries are importing soybean and corn from the United States, Argentina, and Brazil. Genetically engineered foods are beginning to flood the markets in the importing countries, yet no one can predict all their health effects on consumers, who are unaware that they are eating such food. Because genetically engineered food remains unlabeled, consumers cannot discriminate between genetically engineered (GE) and non-GE food, and should serious health problems arise, it will be extremely difficult to trace them to their source. Lack of labeling also helps to shield the corporations that could be potentially responsible from liability (Lappe & Bailey, 1998).

6. Transgenic plants which produce their own insecticides, closely follow the pesticide paradigm, which is itself rapidly failing due to pest resistance to insecticides. Instead of the failed "one pest-one chemical" model, genetic engineering emphasizes a "one pest-one gene" approach, shown over and over again in laboratory trials to fail, as pest species rapidly adapt and develop resistance to the insecticide present in the plant (Alstad & Andow, 1995). Not only will the new varieties fail over the short-to-medium term, despite so-called voluntary resistance management schemes (Mallet & Porter, 1992), but in the process may render useless the natural Bt-pesticide which is relied upon by organic farmers and others desiring to reduce chemical dependence. Bt crops violate the basic and widely accepted principle of integrated pest management (IPM), which is that reliance on any single pest management technology tends to trigger shifts in pest species or the evolution of resistance through one or more mechanisms (NRC, 1996). In general, the greater the selection pressure across time and space, the quicker and more profound the pests evolutionary response. An obvious reason for adopting this principle is that it reduces pest exposure to pesticides, retarding the evolution of resistance. But when the product is engineered into the plant itself, pest exposure leaps from minimal and occasional to massive and continuous exposure, dramatically accelerating resistance (Gould, 1994). Bacillus thuringiensis will rapidly become useless, both as a feature of the new seeds and as an old standby sprayed when needed by farmers that want out of the pesticide treadmill (Pimentel et al., 1989).
7. The global fight for market share is leading companies to massively deploy transgenic crops around the world (more than 30 million hectares in 1998) without proper advance testing of short- or long-term impacts on human health and ecosystems. In the United States, private sector pressure led the White House to decree "no substantial difference" between altered and normal seeds, thus evading normal Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) testing. Confidential documents made public in an on-going class action lawsuit have revealed that the FDA's own scientists do not agree with this determination. One reason is that many scientists are concerned that the large scale use of transgenic crops poses a series of environmental risks that threaten the sustainability of agriculture (Goldberg, 1992; Paoletti & Pimentel, 1996; Snow & Moran, 1997; Rissler & Mellon, 1996; Kendall et al., 1997; Royal Society, 1998). These risk areas are as follows:
    - The trend to create broad international markets for single products, is simplifying cropping systems and creating genetic uniformity in rural landscapes. History has shown that a huge area planted to a single crop variety is very vulnerable to new matching strains of pathogens or insect pests. Furthermore, the widespread use of homogeneous transgenic varieties will unavoidably lead to "genetic erosion," as the local varieties used by thousands of farmers in the developing world are replaced by the new seeds (Robinson, 1996).
    - The use of herbicide resistant crops undermines the possibilities of crop diversification, thus, reducing agrobiodiversity in time and space (Altieri, 1994).
    - The potential transfer through gene flow of genes from herbicide resistant crops to wild or semidomesticated relatives can lead to the creation of superweeds (Lutman, 1999).
    - There is potential for herbicide resistant varieties to become serious weeds in other crops (Duke 1996; Holt & Le Baron, 1990).
    - Massive use of Bt crops affects non-target organisms and ecological processes. Recent evidence shows that the Bt toxin can affect beneficial insect predators that feed on insect pests present on Bt crops (Hilbeck et al., 1998). In addition, windblown pollen from Bt crops, found on natural vegetation surrounding transgenic fields, can kill non-target insects such as the monarch butterfly (Losey et al., 1999). Moreover, Bt toxin present in crop foliage plowed under after harvest can

adhere to soil colloids for up to 3 months, negatively affecting the soil invertebrate populations that break down organic matter and play other ecological roles (Donnegan et al., 1995; Palm et al. 1996).

- There is potential for vector recombination to generate new virulent strains of viruses, especially in transgenic plants engineered for viral resistance with viral genes. In plants containing coat protein genes, there is a possibility that such genes will be taken up by unrelated viruses infecting the plant. In such situations, the foreign gene changes the coat structure of the viruses and may confer properties, such as changed method of transmission between plants. The second potential risk is that recombination between RNA virus and a viral RNA inside the transgenic crop could produce a new pathogen leading to more severe disease problems. Some researchers have shown that recombination occurs in transgenic plants and that under certain conditions it produces a new viral strain with altered host range (Steinbrecher, 1996).

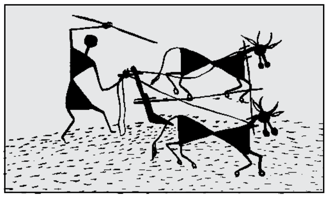
Ecological theory predicts that the large-scale landscape homogenization with transgenic crops will exacerbate the ecological problems already associated with monoculture agriculture. Unquestioned expansion of this technology into developing countries may not be wise or desirable. There is strength in the agricultural diversity of many of these countries, and it should not be inhibited or reduced by extensive monoculture, especially when consequences of doing so results in serious social and environmental problems (Altieri, 1996).

Although the ecological risks issue has received some discussion in government, international, and scientific circles, discussions have often been pursued from a narrow perspective that has downplayed the seriousness of the risks (Kendall et al., 1997; Royal Society, 1998). In fact, methods for risk assessment of transgenic crops are not well developed (Kjellsson & Simmsen, 1994) and there is justifiable concern that current field biosafety tests tell little about potential environmental risks associated with commercial-scale production of transgenic crops. A main concern is that international pressures to gain markets and profits is resulting in companies releasing transgenic crops too fast, without proper consideration for the long-term impacts on people or the ecosystem.

8. There are many unanswered ecological questions regarding the impact of transgenic crops. Many environmental groups have argued for the creation of suitable regulation to mediate the testing and release of transgenic crops to offset environmental risks and demand a much better assessment and understanding of ecological issues associated with genetic engineering. This is crucial, as many results emerging from the environmental performance of released transgenic crops suggest that in the development of resistant crops not only is there a need to test direct effects on the target insect or weed, but the indirect effects on the plant. Plant growth, nutrient content, metabolic changes, and effects on the soil and non-target organisms should all be examined. Unfortunately, funds for research on environmental risk assessment are very limited. For example, the USDA spends only 1% of the funds allocated to biotechnology research on risk assessment, about $1-2 million per year. Given the current level of deployment of genetically engineered plants, such resources are not enough to even discover the "tip of the iceberg". It is a tragedy-in-the-making that so many millions of hectares have been planted without proper biosafety standards. Worldwide such acreage expanded considerably in 1998 with transgenic cotton reaching 6.3 million acres, transgenic corn reaching 20.8 million acres, and transgenic soybean 36.3 million acres. This expansion has been helped along by marketing and distribution agreements entered into by corporations and marketers (i.e., Ciba Seeds with Growmark and Mycogen Plant Sciences with Cargill), and in the absence of regulations in many developing countries. Genetic pollution, unlike oil spills, cannot be controlled by throwing a boom around it.

9. As the private sector has exerted more and more dominance in advancing new biotechnologies, the public sector has had to invest a growing share of its scarce resources in enhancing biotechnological capacities in public institutions, including the CGIAR, and in evaluating and responding to the challenges posed by incorporating private sector technologies into existing farming systems. Such funds would be much better used to expand support for ecologically based agricultural research, as all the biological problems that biotechnology aims at can be solved using agroecological approaches. The dramatic effects of rotations and intercropping on crop health and productivity, as well as of the use of biological control agents on pest regulation have been confirmed repeatedly by scientific research. The problem is that research at public institutions increasingly reflects the interests of private funders at the expense of public good research, such as biological control, organic production systems and general agroecological techniques. Civil society must request for more research on alternatives to biotechnology by universities and other public organizations (Krimsky & Wrubel, l996). There is also an urgent need to challenge the patent system and intellectual property rights intrinsic to the World Trade Organization (WTO) which not only provide multinational corporations with the right to seize and patent genetic resources, but will also accelerate the rate at which market forces already encourage monocultural cropping with genetically uniform transgenic varieties. Based on history and ecological theory, it is not difficult to predict the negative impacts of such environmental simplification on the health of modern agriculture (Altieri, l996).
10. Much of the needed food can be produced by small farmers located throughout the world using agroecological technologies (Uphoff & Altieri, l999). In fact, new rural development approaches and low-input technologies spearheaded by farmers and non-governmental organizations (NGOs) around the world are already making a significant contribution to food security at the household, national, and regional levels in Africa, Asia and Latin America (Pretty, l995). Yield increases are being achieved by using technological approaches, based on agroecological principles that emphasize diversity, synergy, recycling and integration; and social processes that emphasize community participation and empowerment (Rosset, l999). When such features are optimized, yield enhancement and stability of production are achieved, as well as a series of ecological services such conservation of biodiversity, soil and water restoration and conservation, improved natural pest regulation mechanisms, and so on (Altieri et al., 1998). These results are a breakthrough for achieving food security and environmental preservation in the developing world, but their potential and further spread depends on investments, policies, institutional support, and attitude changes on the part of policy makers and the scientific community; especially the CGIAR who should devote much of its efforts to the 320 million poor farmers living in marginal environments. Failure to promote such people-centered agricultural research and development due to the diversion of funds and expertise towards biotechnology will forego an historical opportunity to raise agricultural productivity in economically viable, environmentally benign, and socially uplifting ways.

Organic mixed cropping is the only solution to combat hunger in the country. It is sustainable and, unlike the hoax of Green Revolution, it will solve the problem of food security without creating a new and bigger problem. Abundance of micronutrients in Indian diet can be accomplished by diversification, and not by genetic modification. Apart from these known micronutrients, there are several unknown compounds of nutritional importance, supply of which in Indian diets can be achieved through organic mixed cropping and biodiversification, and all this is won alongwith microeconomic progress at local and village level, sustainability, safety, and equitable distribution.



# Quality of Food Produced– Organic Versus Conventional An Overview

In our comparison above, we assumed that the quality of food produced organically and that produced conventionally is same, that there is no difference in the nutritional composition of food grown by two farming systems, and that it makes no difference to human health whether the food consumed is grown organically or conventionally. In the qualitative overview below, we shall weaken this assumption and shall indicate that food grown organically is nutritionally superior and less hazardous.

Nutritional superiority of food and health hazard of food are two different aspects of the quality of food. Nutritional superiority points to the presence of more variety of nutrients and bioactive substances and to the presence of such nutrients in greater quantity per unit weight. On the contrary, health hazard that a food presents depends on the presence of various chemicals and organisms that alter the human metabolism negatively, leading to acute, chronic, or acute on chronic disorders. During the process of writing this qualitative overview, we went through hundreds of research articles and identified two schools of thought. One school of thought supported the idea that organic food is superior to conventional food, whereas the other school of thought favoured the convention that there is no difference between organic food and conventional food. However, there were very few articles that mentioned that organic food is inferior to conventional food ( some articles presented the risk of Escherichia coli infection from consumption of organic food, but this is not true because, if manure has undergone composting properly, there is absolutely no risk of E. coli infection.) Hence, from the review of research articles, one can safely and casually conclude that organic food is either same as or superior to conventional food. There is no possibility of organic food being inferior.

Incidentally, scientific research favours superiority of organic food over conventional food in many aspects. The quality of protein in organic food is better than that in conventional food. Organic food has greater amounts of minerals and vitamins than conventional food. Donald R. Davis et al., conducted a research to evaluate possible changes in USDA nutrient content data for 43 garden crops between 1950 and 1999 and found that the 43 foods showed declines (ranging from 6% for protein to 38% for riboflavin) for 6 nutrients- protein, calcium, phosphorous, iron, riboflavin, ascorbic acid[17]. They concluded," We hypothesize that Mayer's and our findings of overall nutrient declines may result importantly from decades of selecting food crops for high yield, with resulting inadvertent trade-offs of reduced nutrient concentrations." Paolo Bergamo et al., found significantly higher healthy fatty acid and fat soluble vitamins in organic milk and dairy products. Virginia Worthington performed a similar research, comparing nutrient content of organic and conventional foods; she found decline in nutrition of crops in US and UK in the previous sixty five years as presented below- sixty years before food was grown more naturally.

**Table 1 Percentage Decline in Mineral Content of U.S and British Crops in the Last Sixty Years**

| Mineral | U.S. 1963-1992 (13 fruits & vegetables) | Britain 1936-1987 (20 fruits & 20 vegetables) |
|---|---|---|
| Calcium | -29 | -19 |
| Magnesium | -21 | -35 |
| Sodium | N/A | -43 |
| Potassium | -6 | -14 |
| Phosphorus | -11 | -6 |
| Iron | -32 | -22 |
| Copper | N/A | -81 |

N/A, not analyzed. * U.S. (Berginer, 1997) and British (Mayer, 1997) data.

Virginia worthington also reviewed literature and found significant differences in the food grown organically and that grown conventionally as presented below.

**Table 4 Nutrient Content of Organic Versus Conventional Crops Mean Percent Difference Level of Significance Number of Comparison and Number or Studies for Statistically Significant Nutrients**

| Nutrient | Mean % difference* | Level of significance p | Range | Number of comparison* | | | No. of studies |
|---|---|---|---|---|---|---|---|
| | | | | Organic higher | Organic lower | No difference | |
| Vitamin C | +27.0% | <0.0001 | -100%-+507% | 83 | 38 | 11 | 20 |
| Iron | +21.1% | <0.001 | -73%-+240% | 51 | 30 | 2 | 16 |
| Magnesium | +29.3% | <0.001 | -35%-+1206% | 59 | 31 | 12 | 17 |
| Phosphorus | +13.6% | <0.01 | -44%-+240% | 55 | 37 | 10 | 18 |
| Nitrates | -15.1% | <0.0001 | -97%-+819% | 43 | 127 | 6 | 18 |

*Plus and minus signs refer to conventional crops as the baseline for comparison. For example, vitamin C is 27.0% more abundant in the organic crop (conventional 100%, organic 127%)

+A comparison consists of a single nutrient in a single organic crops grown in one season compared to the same conventionally grown crop from the same season, for example 0.30 mg of zinc n organic cabbage compared to 0.25 mg of zinc in conventional cabbage, both grown in 1986.

**Table 5 Differences in Nutritional Content Between Organic and Conventional Vegetables Mean Percent Difference for four Nutrients in Five Frequents Studied Vegetable**

| Vegetable | Nutrient* | | | |
|---|---|---|---|---|
| | Vitamin C | Iron | Magnesium | Phosphorus |
| Lettuce | +17 | +17 | +29 | +14 |
| Spinach | +52 | +25 | -13 | +14 |
| Carrot | -6 | +12 | +69 | +13 |
| Potato | +22 | +21 | +5 | 0 |
| Cabbage | +43 | +41 | +40 | +22 |

*Plus and minus signs refer to conventional crops as the baseline for comparison. For example, vitamin C is 17.0% more abundant in organic lettuce (conventional 100%, organic 117%)

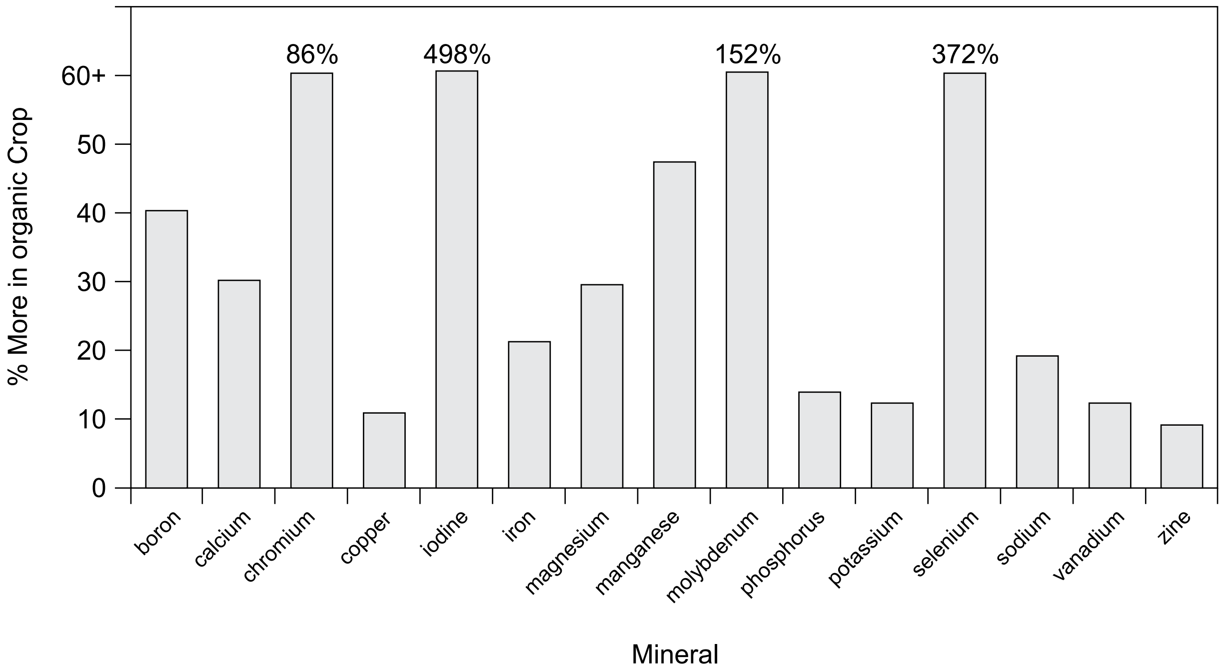



Fig. 2 Mean percent additional mineral content in organic compared to conventional crops.

Conventional agriculture derives a lot from soil at an unsustainable rate, leading to soil depletion. Plants grown on a depleted soil would, in turn, be deficient of nutrients. Consumption of such plants is a major source of malnutrition worldwide. The idea is put rightly by Empty Harvest.

"…all animals get their food directly or indirectly from plants, and all plants get their food from the soil. Therefore, mineral-deficient soil may be one of the greatest original sources of disease in the world today. According to D.W. Cavanaugh, M.D., of Cornell University, 'There is only one major disease and that is malnutrition. All ailments and afflictions to which we may fall heir are directly traceable to this major disease.' Simply stated, food crops grown on depleted soil produce malnourished bodies, and disease preys on malnourished bodies."

**– Empty Harvest, 1990.**

If we incorporate these additional figures, the gap between average nutrition produced per acre organically and that produced per acre conventionally would widen drastically. There are several such instances when researchers have found nutritional superiority of organic food.

- A report jointly produced by The Organic Center and professors from the University of Florida Department of Horticulture and Washington State University provides evidence that organic foods contain, on average, 25 percent higher concentration of 11 nutrients than their conventional counterparts. The report was based on estimated differences in nutrient levels across 236 comparisons of organically and conventionally grown foods.

  Source: "New Evidence Confirms the Nutritional Superiority of Plant-Based Organic Foods,"

- A study has shown that organic soups sold commercially in the United Kingdom contain almost six times as much salicylic acid as non-organic soups. John Paterson, a biochemist at Dumfries and

Galloway Royal Infirmary, and scientists at the University of Strathclyde in Scotland analyzed 11 brands of organic soup and compared their levels of salicylic acid with those in non-organic varieties. Salicylic acid, which is responsible for the anti-inflammatory action of aspirin, has been shown to help prevent hardening of the arteries and bowel cancer. The average level of salicylic acid in 11 brands of organic vegetable soup was 117 nanograms per gram, compared with 20 nanograms per gram in 24 types of non-organic soup. The highest level (1,040 nanograms per gram) was found in an organic carrot and coriander soup. Four of the conventional soups had no detectable levels of salicylic acid.

Source: New Scientist magazine, March 16, 2002, page 10; European Journal of Nutrition, Vol. 40, page 289.

- Research by visiting chemistry professor Theo Clark and undergraduate students at Truman State University in Missouri found organically grown oranges contained up to 30 percent more vitamin C than those grown conventionally. Reporting the findings at the June 2 Great Lakes Regional meeting of the American Chemical Society, Clark said he had expected the conventional oranges, which were much larger than the organic oranges, to have twice as much vitamin C as the organic versions. Instead, chemical isolation combined with nuclear magnetic resonance spectroscopy revealed the higher level in the organic oranges.

Source: Science Daily Magazine, June 2, 2002.

- A study commissioned by the Organic Retailers and Growers Association of Australia (ORGAA) found that conventionally grown fruit and vegetables purchased in supermarkets and other commercial retail outlets had ten times less mineral content than fruit and vegetables grown organically. For the study, tomatoes, beans, capsicums and silver beets grown on a certified organic farm using soil regenerative techniques were analyzed for mineral elements. The Australian Government Analytical Laboratory also analyzed a similar range of vegetables grown conventionally and purchased from a supermarket. A major flaw of the study, however, is that it compared fresh produce at the farm to produce in a supermarket. Thus, there could have been a difference in freshness, which could have affected the nutrients measured.

Source: Organic Retailers and Growers Association of Australia, 2000, as cited in Pesticides and You, Vol. 20, No. 1, Spring 2000, News from Beyond Pesticides/National Coalition Against the Misuse of Pesticides.

- A comparative study conducted by researchers at the Research Institute of Organic Agriculture (FiBL) in Switzerland found that organically grown apples were of higher quality than conventionally grown apples with respect to parameters that relate to health and taste (taste score, sugar-acidity-firmness index, nutritional fiber content, phenolic compounds content, and "vitality index" according to picture-grading methods for holistic quality assessment).

Source: "Are organically grown apples tastier and healthier? A comparative field study using conventional and alternative methods to measure fruit quality," F.P. Weibel, R.Bickel, S. Leuthold, and T. Alföldi), Acta Hort. 517: 417-427 (2000).

- Research led by Alyson Mitchell at the University of California-Davis has shown that levels of flavonoids increase over time in crops grown in organically farmed fields. Study results found that organic tomatoes contain on average 79 and 97 percent more quercetin and kaempferol aglycones (beneficial flavonoids) that their conventionally grown counterparts. In the study, Mitchell and colleagues compared levels of key flavonoids in tomatoes harvested over a ten-year period from two matched fields—one farmed organically and the other with conventional methods including commercial fertilizers. Researchers analyzed organic and conventional tomatoes that had been dried and archived under identical conditions from 1994 to 2004. "The levels of flavonoids increased over time in samples from organic treatments, whereas the levels of flavonoids did not vary significantly in conventional treatments," the report stated.

Source: Journal of Agricultural and Food Chemistry, posted online June 23, 2007.

- A research team at the University of California at Davis has found organic kiwi fruit had much higher levels of total polyphenol content than conventional kiwi fruit, resulting in higher antioxidant activity than their conventional counterparts. Study results also showed that organic kiwi fruit had higher levels of vitamin C. The kiwis studied were from nearby vineyards on the same farm in Marysville, CA.

Source: March 27, 2007, online edition of the Journal of the Science of Food and Agriculture.

- At the 2005 international congress Organic Farming, Food Quality and Human Health, Professor Carlo Leifert of Newcastle University reported findings that organically produced food had higher level of specific antioxidants and lower mycotoxin levels than conventional samples, and that grass-based organic cattle diets reduce the risk of E. coli contamination while grain-based conventional diets increase the risk.
- Findings from a Danish showed organic vegetables have a higher concentration of natural antioxidants called flavonoids. The double-blind randomized, crossover study had two intervention periods, with test participants given organic food or conventional food for three weeks. Results were based on blood and urine samples tested. The study was conducted by The Institute of Food Safety and Nutrition under The Danish Veterinary and Food Administration, The Department of Human Nutrition and Centre for Advanced Food Studies under The Royal Veterinary and Agricultural University, and Risø National Laboratory.

Source: Journal of Agricultural and Food Chemistry, Vol. 51, No. 19, 2003, pp. 5671-5676.

- Organic fruits and vegetables show significantly higher levels of antioxidants than their conventionally grown counterparts, according to findings published by researchers at the University of California at Davis. In the study, researchers led by food scientist Alyson Mitchell compared the antioxidant levels in corn, strawberries and marionberries grown organically, sustainably (using fertilizer but no herbicides or pesticides) and conventionally. Antioxidant levels in sustainably grown corn were 58.5 percent higher than conventionally grown corn, while organically and sustainably grown marionberries had approximately 50 percent more antioxidants than conventionally grown berries. Sustainably and organically grown strawberries had about 19 percent more antioxidants than their conventional counterparts. The findings were published in the Feb. 26, 2003, print edition of the American Chemical Society peer-reviewed Journal of Agricultural and Food Chemistry. The study also showed sustainably grown and organic produce had more ascorbic acid, which the body converts to vitamin C.

Source: "Comparison of the Total Phenolic and Ascorbic Content of Freeze-Dried and Air-Dried Marionberry, Strawberry, and Corn Grown Using Conventional, Organic, and Sustainable Agricultural Practices," D.K. Asami, Y.-J. Hong, D.M. Barrett, and A.E. Mitchell, Journal of Agricultural and Food Chemistry, 51(5):1,237-1,241 (2003)

- An Italian study has found organic pears, peaches and oranges had higher antioxidant levels than their conventional counterparts. The study was conducted by the Istituto nazionale di ricerca per gli alimenti e la nutrizione (National Institute of Food and Nutrition Research). In particular, researchers found that organic William's pears contain less fiber but more natural sugar, vitamin C and antioxidants compared to their conventional counterparts, and were more resistant to mildew and fungi. Organic Regina Bianca peaches, meanwhile, contain more antioxidants.

Source: Journal of Agricultural and Food Chemistry. August 2002.

- A European research team led by Swiss scientist Lukas Rist has found that mothers consuming mostly organic milk and meat products have about 50 percent higher levels of rumenic acid, a conjugated linoleic acid, in their breast milk.

Source: June 2007 British Journal of Nutrition.

Organic food has several bioactive compounds, plant phenols, phytochemicals, and flavinoids in abundance that conventional food is deficient in. These bioactive compounds are produced as a result of natural defense mechanism of plants- produced in response to stress. Pests, herbs, fungi, other organisms, environment, etc., put the plant under stress. Since plants grown organically are not treated with such chemicals as pesticides, herbicides, fungicides, fertilizers, etc., these plants produce bioactive compounds and phytochemicals, abundantly and naturally, as a result of stress. Consumption of these bioactive compounds and phytochemicals is known to decrease the risk of chronic diseases such as cancer, cardiovascular diseases, and diabetes. Several studies have proved that organic food has greater amount of these bioactive compounds and phytochemicals (phenols, flavinoids, etc.). Marie E. Olsson et al conducted a research on effects of extracts from organically and conventionally grown strawberries on proliferation of colon cancer cells and breast cancer cells in vitro. The article concluded, "The extracts from organically grown strawberries had a higher antiproliferative activity for both cell types at the highest concentration than the conventionally grown, and this might indicate a higher content of secondary metabolites with anticarcinogenic properties in the organically grown strawberries." Moreover, the concentration of these phytochemicals and bioactive compounds seem to increase over years when the farmland is treated only organically as shown by the famous research conducted by A.E. Mitchell that showed that the flavonoid content of organic tomato increased over a ten year period in farmland treated organically. Other researches that point to increase in the density of phytochemicals and bioactive compounds in organic food are listed below.

**Table 1 Review of Recent Finding**

| Study | Experiment Material | Parameters Analyzed | Findings | Reference |
|---|---|---|---|---|
| Asami et at., 2003 | Marionberry, strawberry corn | Total phenolics (TP) ascorbic acid (AA) | Increased TP and AA in organic and sustainable Practices | 26 |
| Carbonro and Mattera 2001 | Peach pear | Polyphenoloxidase activity (PPO) TP | Increased TP and PPO activity in organic fruit | 23 |
| Carbonro et al., 2002 | Peach. pear | PPO activity, TP AA citric acid (CA), $\alpha$-tocopherol (TH) | Increased TP and PPO activity in organic fruit, AA and CA higher in organic peaches $\alpha$-TH higher in organic pear and lower in peach | 24 |
| Grinder Petersen et al., 2003 | Human excretion metabolites following organic vs conventional diets | Quercetin (Q) kaempferol (K) hesperetin (H), naringenin, isorhamnetin (I) | Organic foods had higher Q, trends of higher K and lower I, Higher urinary excretion of Q and K in organic diet | 28 |
| Hakkinen and Torronen 2002 | Vaccinium berries strawberry | Q. K. ellagic acid p-coumaric acid | No consistent difference between organic and conventional techniques. | 27 |
| Ren et al., 2001 | Qing-gen-cai Chinese cabbage, spinach, welsh onion, green pepper | Antioxidant and antimutagenic activity, flavonoids (Q.K.H. caffeic acid, myricetin, quercitrin, hesperitin, apigenin, baicalein) | Higher antioxidant activity in organic spinach, onion, cabbage, qing-gen-cai, no difference in green pepper, antimutagenic activity higher in organic samples; Generally higher flavonoids in organic samples | 25 |

Hence, there exists numerous scientific evidences that prove nutritional superiority of organic produce. Organic produce has more vitamins, more minerals and more bioactive compounds than conventional. We need these unique blends of nutrients to lead an active disease free life and to improve the health of the population as a whole. Anemia is so prevalent in the Indian population that the National Family Health Survey-II (1998-99) revealed that 74.3 percent children under the age of three years were anemic. Every pregnant mother in India is advised to consume iron and folic acid tablets because most cases of anemia in our country occur due to deficiency of iron in diet. Do we not need increased concentration of iron in our crops so that we have more iron in our diets? A similar correlation has been found between decreased levels of B-complex vitamins in diet and mental disorders such as stress and depression[24]. Do we not need greater amount of B-complex vitamins in our crops so that we have increased amounts of such vitamins in our diet? Do we not need greater amounts of trace minerals in our crops to increase consumption and to improve the overall health of our population, and do we not need higher levels of antioxidant, phytochemicals, and other bioactive compounds in our crops so that our population is better equipped to fight such chronic diseases as cancer and diabetes? We also need high levels of vitamin C in every Indian meal to reduce the iron in our diet to Ferrous form that is absorbed by our bodies- incidentally, the oxidized form of iron, Ferric, is not absorbed by humans. As a home experiment, cut apple into two portions and sprinkle some lemon juice, rich in antioxidants, on one portion and keep the other portion as it is with no lemon. The portion without lemon on it will turn reddish brown due to oxidation of ferrous to ferric form. This ferric form is not absorbed by the body and is useless to consume. Indian diets are rich in phytates which render iron non-absorbable, a fact that partly explains the high prevalence of iron deficiency anemia in India. We can counter the effect of phytates by increasing the level of vitamin C in our diets- vitamin C prevents chelation of soluble non-haem iron by phytates. The easiest way to increase the amount of vitamin C and antioxidants in Indian diet is to grow crops that have higher concentrations of vitamin C, antioxidants, phytochemicals, and bioactive compounds.

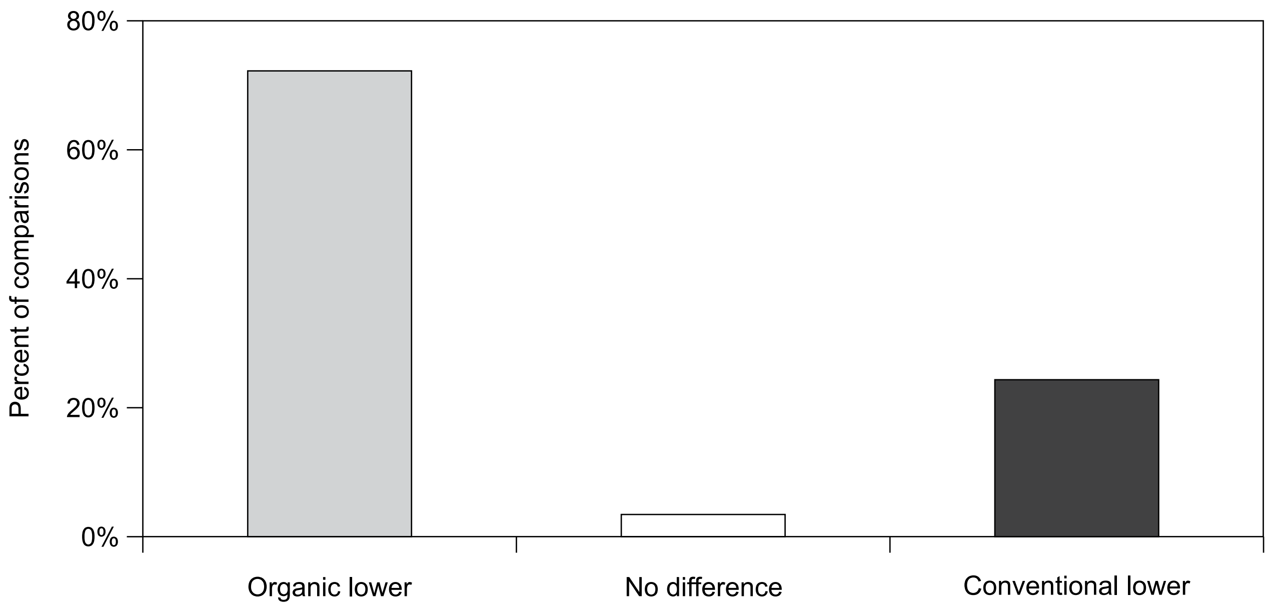



Figure 6 Nitrate content of organic and conventional crops. The results from 18 published studies including a total of 176 comparisons on the nitrate content of organic and conventional crops, including beetroot, cabbage, carrot, celeriac, chard, corn salad, endive, kale, leek, lettuce, potato, radish, spinach, and turnip, are presented. The percent of total comparisons indicating lower (gray bars), equal (white bars), or higher (black bars) nitrate content in organic compared with conventional produce is shown. Derived from Worthington (2001).

Let us consider the other aspect of quality of food- hazard that the food presents. Organic food contains less nitrate than conventional food. Nitrate is the main form of nitrogen supplied to crops from soil, and its content in food has historically been an ambiguous issue. Two potentially deleterious effects of high gastric concentrations of nitrate are methemoglobinemia among young children and infants (Craun et al., 1981; Avery, 2001b), and formation of carcinogenic N-nitroso compounds (Bruning-Fann and Kaneene, 1993; Vermeer and van Maanen, 2001). Nitrate per se has not been shown to produce a carcinogenic effect in animals, but can be converted into nitrite by bacteria in human saliva and in the intestine, which in turn may react with certain amines and amides, normally present in the body, to produce nitrosamines (Bruning-Fann and Kaneene, 1993; Vermeer and van Maanen, 2001). About 300 nitrosamines have been tested for carcinogenicity in high-dose animal cancer tests, and roughly 90% of them have been found to be carcinogenic (Havender and Coulombe, 1996). Nitrosamines are capable of both initiating and promoting the cancer process.

In the conventional form of agriculture, there are several chemicals that are used judiciously or non-judiciously. Most of these chemicals pose a threat to the environment, to the wildlife, to ecological diversity, and to humans. World is experiencing extinction of species, development of resistant strains of pests and weeds, development of dead zones in oceans, and decertification and salinisation of arable land. Only 0.1% of the pesticide used reaches its target, that is, the pests. Rest 99.9% impacts the environment. The discussion of entire health impact of pesticides is enormous. Approximately, 1600 different varieties of pesticides are used worldwide. Some of these chemicals are found in alarming levels in certain animals due to bioaccumulation. These chemicals are also found in human breast milk. These fat soluble pesticides bioaccumulate in humans and find their way in human milk[2]. Unfortunately, the infants feeding on such milk are exposed to these harmful chemicals. DDT and its metabolites, dieldrin, aldrin, endrin, lindane, hexachlorobenzene, cyclodiene pesticide, polychlorinated biphenyls, dioxins and dibenzofurans are some of the many agricultural pesticides detected in human milk. The risk that these chemicals pose on infants feeding on breast milk needs to be quantified. However, the risk is not negligible but rather uncertain. Curl et al also found that children

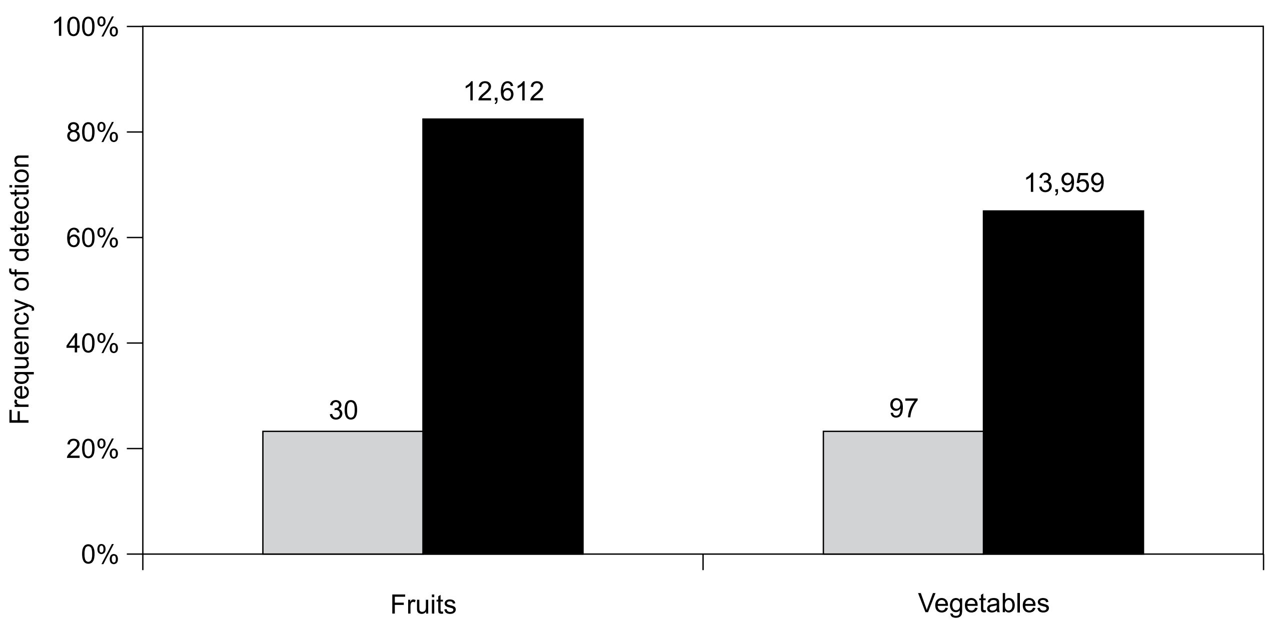



Figure 1 Frequency of detecting at least one type of pesticide residue in organic and conventional fruits and vegetables. Data on pesticide residues in organically grown foods (gray bars) and foods with no market claim (assumed to be conventionally grown; black bars) were collected from the Pesticide Data Program of the US Department of Agriculture. The total number of samples tested is shown on top of the respective bars. Derived from Baker et al. (2002).

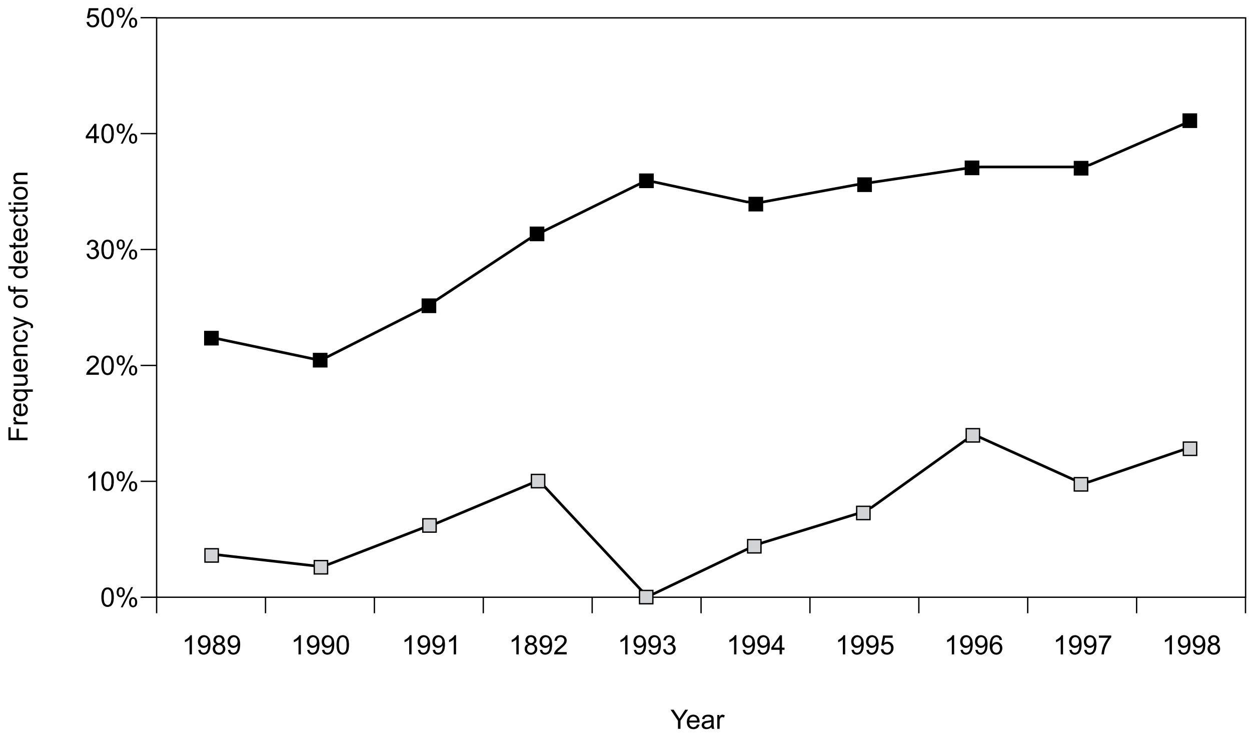



Figure 2 Ten-year trends of contamination rates with pesticides of organic and conventional fruits and vegetables. Data on pesticide residues in organically grown foods (gray squares) and foods with no market claim (assumed to be conventionally grown; black squares) were collected from the Marketplace Surveillance Program of the California Department of Pesticide Regulation. A total of 67,154 samples (1,097 organic and 66,057 conventional) were examined. Derived from Baker et al (2002)

with primarily organic diets had significantly lower organophosphorus pesticide exposure than did children with primarily conventional diets[25]. Dose estimates generated from pesticide metabolite data suggest that organic diets can reduce children's exposure levels from above to below the U.S. EPA's chronic reference doses, thereby shifting exposures from a range of uncertain risk to a range of negligible risk. Consumption of organic produce represents a relatively simple means for parents to reduce their children's exposure to pesticides. Organic produce has lower level pesticide residue and are less likely to have residue of multiple pesticide than conventional produce.

**Table 6 Comparison of organic and conventional products with respect to food hazards**

| Organic < Conventional | Organic = Conventional | Unknown |
|---|---|---|
| Synthetic agrochemicals[a] | Environmental pollutants[d] | Natural plant toxins |
| Nitrate[b] | | Biological pesticides |
| Contaminants in feedstuffs[c] | | Pathogenic microbes |
| Veterinary drugs[c] | | |

[a]vegetable and fruits
[b]nitrophillic vegetables
[c]foods of animal origin
[d]heavy metals (e.g. cadmium, lead), dioxins. polychlorinated biphenyls radioactive nuclides

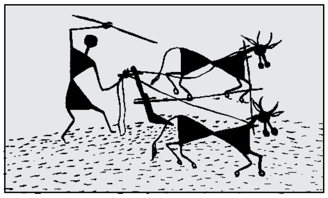
"Resource manual on hazards of pesticides" by Navdanya presents a more detailed list of pesticides and their health hazard. There is not a single organ or tissue of the body that is not affected by pesticides. Underneath is a table that gives a glimpse of the real scenario.

**Table 1 Associations between various classes of pesticide and various forms of cancer**

| Class of pesticide | Cancer |
|---|---|
| Phenoxyacetic acid herbicides Organochlorine insecticides | Non-Hodgkin's lymphoma, soft-issue sarcoma, prostate<br>Leukemia, non-Hodgkin's lymphoma, soft-tissue sarcoma, pancreas, lung breast |
| Organophosphate insecticides | Non-Hodgkin's lymphoma, leukemia |
| Arsenical insecticides | Lung, skin |
| Triazine herbicides | Ovary |

Data from Blair and Zahm (87)

Pesticides produce both short- and long-term effects on human health. The United Nations has estimated that about 2 million poisonings and 10,000 deaths occur each year from pesticides, with about three-fourths of these occurring in developing countries. The pesticides used heavily in industrial agriculture are associated with elevated cancer risks for workers and consumers and are coming under greater scrutiny for their links to endocrine disruption and reproductive dysfunction.



# Conclusion:
## Health Per Acre as a Real Solution to Hunger and Malnutrition

Malnutrition is a major public health problem in India. The causes of malnutrition are many ranging from inefficient farming practices, crop failures, and lack of adequate production of food to inequitable distribution, inflation, and poor governmental policies and intervention. India is an immensely densely populated country, has a population greater than 1 billion, and is expected to stabilize at a population of size 1.65 billion by the middle of this century. Malnutrition has already gripped the Indian population, and with such a massive population growth rate, India has the potential to harbor the maximum number of wasted and cognitively degenerated individuals who, in the past as children, were malnourished and who, in the future as adults, see little hope of their struggle coming to an end. This is especially not expected from a country- India- that is proposed to deserve a place in the United Nations Security Council, that is experiencing a booming economic growth, and that is looked at as an emerging superpower; India has to act as a responsible country because stability of India is essential to the global stability. The right to food to its entire population is one among many targets that India has to achieve in order to comply with what is expected from it.

In India, malnutrition is not just a clinical diagnosis, but rather a reflection of corruption in society, governmental inadequacy, poor policies, and debilitating farming practices. The following is extracted from HNP (Health, Nutrition, and Population) paper, World Bank-India's undernourished children: A call for reform and action by Michele Gragnolati et al.,

The consequences of child undernutrition for morbidity and mortality are enormous – and there is, in addition, an appreciable impact of undernutrition on productivity so that a failure to invest in combating nutrition reduces potential economic growth. In India, with one of the highest percentages of undernourished children in the world, the situation is dire. Moreover, inequalities in undernutrition between demographic, socioeconomic and geographic groups increased during the 1990s. More, and better, investments are needed if India is to reach the nutrition MDGs. Economic growth will not be enough.

The prevalence of underweight among children in India is amongst the highest in the world, and nearly double that of Sub-Saharan Africa. In 1998/99, 47 percent of children under three were underweight or severely underweight, and a further 26 percent were mildly underweight such that, in total, underweight afflicted almost three-quarters of Indian children. Levels of malnutrition have declined modestly, with the prevalence of underweight among children under three falling by 11 percent between 1992/93 and 1998/99. However, this lags far behind that achieved by countries with similar economic growth rates.

Undernutrition, both protein-energy malnutrition and micronutrient deficiencies, directly affects many aspects of children's development. In particular, it retards their physical and cognitive growth and increases susceptibility to infection, further increasing the probability of malnutrition. Child malnutrition is responsible for 22 percent of India's burden of disease. Undernutrition also undermines educational attainment, and productivity, with adverse implications for income and economic growth.

Disaggregation of underweight statistics by socioeconomic and demographic characteristics reveals which groups are most at risk of malnutrition. Most growth retardation occurs by the age of two, and is largely irreversible. Underweight prevalence is higher in rural areas (50 percent) than in urban areas (38 percent); higher among girls (48.9 percent) than among boys (45.5 percent); higher among scheduled castes (53.2 percent) and scheduled tribes (56.2 percent) than among other castes (44.1 percent); and, although underweight is pervasive throughout the wealth distribution, the prevalence of underweight reaches as high as 60 percent in the lowest wealth quintile. Moreover, during the 1990s, urban-rural, inter-caste, male-female and inter-quintile inequalities in nutritional status widened.

There is also large inter-state variation in the patterns and trends in underweight. In six states, at least one in two children are underweight, namely Maharashtra, Orissa, Bihar, Madhya Pradesh, Uttar Pradesh, and Rajasthan. The four latter states account for more than 43 percent of all underweight children in India. Moreover, the prevalence in underweight is falling more slowly in the high prevalence states. Finally, the demographic and socioeconomic patterns at the state level do not necessarily mirror those at the national level and nutrition policy should take cognizance of these variations.

Undernutrition is concentrated in a relatively small number of districts and villages with a mere 10 percent of villages and districts accounting for 27-28 percent of all underweight children, and a quarter of districts and villages accounting for more than half of all underweight children.

Micronutrient deficiencies are also widespread in India. More than 75 percent of preschool children suffer from iron deficiency anemia (IDA) and 57 percent of preschool children have sub-clinical Vitamin A deficiency (VAD). Iodine deficiency is endemic in 85 percent of districts. Progress in reducing the prevalence of micronutrient deficiencies in India has been slow. As with underweight, the prevalence of different micronutrient deficiencies varies widely across states.

The intervention that promises to solve the malnutrition crises should have many facets and should also have many levels. By facets, we mean that we will have to choose areas where change is needed- maximizing food production, controlling inflation, distributing justly and equitably, educating, and implementing sound health policies. By levels, we mean that each area of intervention should identify the target and the limiting factors and put in effort accordingly- diversifying food production, controlling food inflation, distributing in rural areas and among schedule tribes and schedule caste, educating woman, and implementing policies that keenly caters to the need of under five children and women. Maximizing nutritional production is rather a more appropriate approach than maximizing production of specific food items. Although malnutrition refers to both over nutrition and under nutrition, under nutrition has reached a crisis stage in India. Moreover, macronutrient and micronutrient deficiencies have to be dealt with simultaneously. Health per acre is a concept that covers nutrition produced per acre of farmland, that deals with diversification of farmlands because dietary diversification is current recommendation, that describes quality of food produced, and that also takes into account the environmental and ecological cost of food produced.

Organic biodiversity based mixed cropping is the foundation of the concept of health per acre. It is a system of farming that increases nutrition produced per acre of farmland. A great amount of food, as well as a variety of food, produced and consumed at local level helps in equitable distribution. The system promotes growing traditional local foods, and hence, also promotes the consumption of such foods at local level. The wide variety of local food items covers the entire profile of nutrients required essentially by human body. Organic mixed cropping methods maximize the nutrition produced per acre and, hence, help control inflation of food items. Another reason why such cropping method would control food price is that food produced and consumed locally avoids the huge cost of transportation and storage usually included in the price consumer pays for food item. Population, at large, usually knows quite a lot about local food items and its health benefit. As a result, educating people, especially woman, with the various aspects of health and nutrition becomes easier. Implementation of such knowledge also becomes easier as adaption, availability, and cost are not mutually exclusive, but rather facilitating one another. The approach focuses more on the root cause of the problem of under nutrition rather than on the treatment of current cases of malnutrition. Treatment is just one aspect of solving the crises. However, irrespective of how sophisticated treatment we offer, under nutrition cannot be eradicated until we make adequate quantity of a variety of food available to the target population, sustainably.

Nutrition produced per acre gives an insight and a glimpse of the impact that organic mixed cropping method can have on the health of the population. Till now, we have focused primarily on the yield per acre. Looking at agriculture and health in terms of yield per acre makes an important assumption that maximizing yield of specific food items would solve the under nutrition crisis. However, a few food items produced abundantly cannot ensure an ideal blend of nutrients supplied to every person in the society because any single food item is not the adequate source of all nutrients needed by human body. To ensure proper nutrition we need dietary diversification, and to ensure dietary diversification, we need to diversify our farmlands. There is a huge discussion that tries to find the answer to the question that which farming practice can ensure food security- organic mixed cropping or conventional mono copping. The yield per acre of specific food items, used as a measure of effectiveness, appeared to favor conventional mono cropping. However, when nutrition produced per acre of farmland in the two farming systems were compared, strikingly different results came out. What needs to be pointed out is whether abundant production of rice, wheat, corn, or soybean would solve the crisis of under nutrition or abundant production of all the different nutrients would. Organic biodiversity based mixed cropping is sustainable, time tested, reasonable, intelligent, cost effective and ecological solution to the problem of malnutrition in India.

# References


1. Biodiversity based organic farming- A new paradigm for food security and food safety by Navdanya.
2. Chemical contaminants in human milk: an overview by Babasaheb R. Sonawane, U.S. Environmental Protection Agency, Washington, DC.
3. Textbook of Preventive and Social Medicine by K. Park.
4. Heber D. Vegetables, fruits and phytoestrogens in the prevention of diseases. J Postgrad Med [serial online] 2004 [cited 2010 Nov 14];50:145-9.
5. Health-promoting properties of common herbs, American Journal of Clinical Nutrition, Vol. 70, No. 3, 491S-499S, September 1999.
6. Flavonoid rich fraction from Sageretia theezans leaves scavenges reactive oxygen radical species and increases the resistance of low density lipoproteins to oxidation, J Med food 12 (6), 2009, 1310-1315.
7. Bioactive Compounds in Foods: Their Role in the Prevention of Cardiovascular Disease and Cancer by Penny M. Kris-Etherton, PhD, RD, Kari D. Hecker, MS, RD, Andrea Bonanome, MD, Stacie M. Coval, MS, Amy E. Binkoski, BS, RD, Kirsten F. Hilpert, BS, Amy E. Griel, MEd, Terry D. Etherton, PhD.
8. Potential Synergy of Phytochemicals in Cancer Prevention: Mechanism of Action, International Research Conference on Food, Nutrition, and Cancer, Rui Hai Liu.
9. Biochemical and Molecular Actions of Nutrients, Flavonoids from Almond Skins Are Bioavailable and Act Synergistically with Vitamins C and E to Enhance Hamster and Human LDL Resistance to Oxidation, by Chung Yen Chen et al, J. Nutr. 135:1366-1373, June 2005.
10. Diet and Lifestyle Recommendations Revision 2006 - A Scientific Statement from the American Heart Association Nutrition Committee
11. Report of the steering committee of nutrition, Planning Commission, Govt. of India, New Delhi.
12. "Nutritive value of Indian Foods" published by National Institute of Nutrition, Indian Council of Medical Research, Hyderabad.

13. Proposed Criteria for Assessing the Efficacy of Cancer Reduction by Plant Foods Enriched in Carotenoids, Glucosinolates, Polyphenols and Selenocompounds by John W. Finley, Oxford Journals, Life Sciences, Annals of Botany, Volume 95, Issue 7.

14. Virginia Worthington- Nutritional quality of organic versus conventional fruits, vegetables, and grains, The Journal of Alternative and Complementary Medicine, volume 7, number 2, 2001.

15. Precaution before Profits: An Overview of Issues in Genetically Engineered Food and Crops by Sophia Kolehmainen Originally published in VIRGINIA ENVIRONMENTAL LAW JOURNAL, 20 VA. ENVTL. L. J. 267 (200)

16. The Journal of Agrobiotechnology Management and Economics (volume 2//number 3 & 4//article 3)- Ten reasons why biotechnology will not ensure food security, protect the environment, and reduce poverty in developing world, by Miguel A. Altieri and Peter Rosset, University of California, Berkeley & Food First/Institute for Food and Development Policy.

17. Changes in USDA Food Composition Data for 43 Garden Crops, 1950 to 1999 by Donald R. Davis, PhD, FACN, Melvin D. Epp, PhD and Hugh D. Riordan, MD, Bio-Communications Research Institute, Wichita, Kansas (D.R.D., M.D.E., H.D.R.), Biochemical Institute, The University of Texas, Austin, Texas (D.R.D.)

18. New Evidence Confirms the Nutritional Superiority of Plant-Based Organic Foods, by The Organic Center and the University of Florida, Department of Horticulture and Washington State University.

19. New Scientist magazine, March 16, 2002, page 10; European Journal of Nutrition, Vol. 40, page 289.

20. Organic Retailers and Growers Association of Australia, 2000, as cited in Pesticides and You, Vol. 20, No. 1, Spring 2000, News from Beyond Pesticides/National Coalition Against the Misuse of Pesticides.

21. Are organically grown apples tastier and healthier?- A comparative field study using conventional and alternative methods to measure fruit quality," F.P. Weibel, R.Bickel, S. Leuthold, and T. Alföldi), Acta Hort. 517: 417-427 (2000).

22. Comparison of the Total Phenolic and Ascorbic Acid Content of Freeze-Dried and Air-Dried Marionberry, Strawberry, and Corn Grown Using Conventional, Organic, and Sustainable Agricultural Practices by DANNY K. ASAMI, YUN-JEONG HONG, DIANE M. BARRETT, AND ALYSON E. MITCHELL, J. Agric. Food Chem. 2003, 51, 1237-1241 1237

23. Ten-Year Comparison of the Influence of Organic and Conventional Crop Management Practices on the Content of Flavonoids in Tomatoes by MITCHELL A.E. et al, Journal of Agricultural and Food Chemistry 23 June 2007

24. Folate and cobalamin in psychiatric illness by Burton R. Hutto, Department of Psychiatry, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA, Comprehensive psychiatry volume 38, issue 6, November-December 1997, Pages 305-314

25. Organophosphorus Pesticide Exposure of Urban and Suburban Preschool Children with Organic and Conventional Diets by Cynthia L. Curl, Richard A. Fenske, Kai Elgethun, Department of Environmental Health, School of Public Health and Community Medicine, University of Washington, Seattle, Washington, USA.