HEALTH PER ACRE

Organic Solutions to Malnutrition In India

Dr Archana Ainapure
Director
Symbiosis Skills and Professional University
Pune, India

ABSTRACT

Food, nutrition, health, prosperity, future, and growth, as well as hunger, disease, poverty, despair, and national collapse, are hotly debated topics. There is not only a correlation but also a cause-and-effect relationship. Farming, one of the oldest and most tried-and-tested occupations in the world, is no longer an economically viable business for most people, as evidenced by the thousands of farmers around the world. India has witnessed a rise in suicides in the past two decades. However, the question that needs to be answered is whether our farmers committed suicide or our country failed them. The main purpose of a country's agriculture is to promote health and feed people, providing a diet that offers all the necessary nutrients. However, profit maximisation has been promoted as the primary goal of agriculture. The sad reality is that the more profitable agriculture becomes, the higher the farmers' debt and suicide rates, and the worse the food and nutrition crisis becomes. The irony is that, despite all claims, profit maximisation for farmers is still far from being achieved[1], while the country has paid a hefty price. Most proponents of conventional agriculture argue that pesticides, one of the most widely used chemicals in agriculture, have a negligible impact on human health. However, millions of tons of pesticides injected into the environment each year in the name of high-yield agriculture somehow find their way into the human body, as well as water bodies, fish, birds, and other animals. This is evident from the fact that quantifiable levels of certain pesticides have been detected in breast milk, posing a probable risk to breastfed infants[2]. The risk is not insignificant but rather uncertain. The alarming levels of chemicals in honey sold in the Indian market have recently sparked much discussion. Science and technology were born for the benefit of people. In contrast, science and technology in agriculture often serve human greed. Due to the intensive irrigation needs of conventional agriculture, some perennial rivers in the world do not reach the sea but remain half-dry. Conventional agriculture also contributes significantly to global warming and has negative health impacts. In this chapter, we will limit our discussion to the impact of conventional agriculture on population and individual health. This report compares the nutritional and health aspects of foods from organic farming and conventional farming. The scope of the chapter ranges from nutrition produced per acre of farmland by two farming systems to disease trends in populations and how these trends may be related to the food we consume. Conventional farming measures "yield" per acre while excluding the chemical input costs, as well as the environmental and health costs of chemicals. "Yield" measures the results of monoculture, while what we need to measure are the various outcomes of an agricultural system. Yield also fails to provide information about a food's nutritional value. With a focus on health and nutrition, we should measure health per acre rather than yield per acre.

Keywords: Health, Malnutrition, Organic food, Food production

I. WHAT IS "HEALTH"

Malnutrition has reached a crisis in India. An intervention that promises to solve malnutrition crises should consider many forms and levels. The forms include maximising food production, controlling inflation, distribution, education, and implementing healthy health policies, while the levels involve diversifying food production, controlling food inflation, distributing food, educating women, and implementing policies. Maximising nutritional production is a more appropriate approach than maximising the production of specific foods. So far, India has primarily focused on yield per acre. However, a few mass-produced foods cannot provide an ideal mix of nutrients for every person. To ensure proper nutrition, we need to diversify our diet, and to achieve diet diversification, we need to diversify our agricultural land. When comparing the nutrition produced per acre of farmland in the two farming systems, surprisingly different results emerged, favouring mixed cropping based on organic biodiversity. It is essential to emphasise whether the malnutrition crisis can be solved by abundant food production or by abundant production of all the different nutrients. Mixed cropping based on organic biodiversity is a sustainable, time-tested, sensible, intelligent, cost-effective, and eco-friendly solution to the problem of malnutrition in India.

Over the centuries, human health has garnered significant attention. The well-being of individuals, families, and populations has shaped society, culture, nations, and history. Health holds immense importance at all levels of social organization, and disregarding it can not only be futile but also politically and socially irresponsible. Ancient civilisations recognised the significance of health on both individual and communal levels. Myths from various parts of the world mention gods bestowing blessings upon their followers. Apollo in Greek and Roman mythology and Dhanvanti in Hindu mythology are associated with health and healing. This reality highlights the longstanding nature of the concept of health. Health is not a recent achievement for humanity, nor is it a recent remarkable feat.

While the concept of health remains a topic of controversy, there are several accepted definitions. According to Ayurveda, a traditional medicine system originating from the Indian subcontinent, health is defined as "Samadoshah Samagnischa Samadhatumala kriyaha, Prasanna Atmendria Manaha Swastha Ityabhidheeyate." Coined by Vagbhat, this definition implies that a person is in good health when they consistently consume healthy food, lead a balanced lifestyle, practice generosity and forgiveness, cherish truth, and serve others. Only when an individual achieves harmony in their physical, mental, psychological, and emotional aspects can they be considered healthy. Patanjali, the founder of yoga philosophy and practice, states that illness and poor health can hinder the eightfold path leading to Samadhi, a state of well-being also known as union with the Almighty.

Biblical principles, particularly those found in the Old Testament, address nutrition and health. Ezekiel, for instance, was tasked with making nutritious multigrain bread. The health laws given to Moses by God emphasised disease prevention rather than treatment.

Moses recognised the effectiveness of prevention and advocated for pure food, pure water, clean air, a clean body, and a healthy living environment. These biblical principles remain timeless and hold relevance in contemporary times. According to the Bible, God addresses the root cause of disease, not just the symptoms. The biblical concept of health is holistic, encompassing physical, mental, spiritual, and social aspects of a person's well-being. It extends beyond the absence of disease, emphasising a sense of wholeness, completeness, peace, and prosperity. It focuses on being in the right relationship with God and, consequently, being appropriately connected to everything and everyone else. It equips individuals to fulfil God's calling and purpose.

In the Islamic faith, good health is viewed as a gift from Allah, ensuring salvation in the Hereafter and enabling enjoyment of life in this world. The Quran explicitly mentions, "Eat and drink, but waste not by excess" (7:31). This guidance directs followers of the Quran to consume the right foods in appropriate quantities and prohibits overeating as it is detrimental to health. The Buddha considered good health to be the greatest gift, without which life is not truly lived but rather a state of suffering and resembling death. According to the Buddha, maintaining a healthy body is a duty because it supports the strength and clarity of the mind. The Buddhist understanding of good health emphasises the balanced interaction between the mind and body, as well as between life and its environment. Disease tends to arise when this delicate balance is disrupted.

The importance of health does not solely rely on ancient scriptures; it is a reality we have all witnessed through sickness and death around us. The pain and suffering associated with poor health have become increasingly evident. The World Health Organization (WHO) defines health as follows: "Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." This definition can be traced back to the Preamble to the Constitution of the World Health Organization, adopted by the International Health Assembly in New York from June 19 to July 22, 1946. It was signed by representatives of 61 states and came into effect on April 7, 1948. In recent years, this definition has been expanded to encompass the ability to lead a "residentially productive life" that is socially and economically fulfilling.

Throughout the years, we have embraced a new philosophy of health, which can be summarised as follows:
- Health is a fundamental human right.
- Health is the essence of a productive life, not merely the outcome of increased spending on medical care.
- Health is an interdisciplinary field, involving various disciplines and sectors.
- Health is an integral part of development, intertwined with social and economic progress.
- Health lies at the core of the concept of quality of life.
- Health requires personal, state, and international responsibility.
- Investing in health and its maintenance is a significant social investment.
- Health is a global social objective.

These principles highlight the broad and comprehensive nature of health, emphasising its multidimensional aspects and the collective responsibility in achieving and maintaining it.

From a legal standpoint, the Constitution of India, Section 4, explicitly states that "The State shall regard the enhancement of the nutritional and living standards of the people and the improvement of public health as one of its principal functions." This provision establishes the responsibility of the State to prioritise the well-being of its citizens by promoting good nutrition, living standards, and public health.

Building upon the aforementioned quotes, it is evident that overall health is achieved through a combination of physical, mental, and social well-being, collectively referred to as the triangle of health. Some may also include a spiritual component, forming a quadrilateral of health. This perspective emphasises that social welfare is equally vital in attaining good health, alongside maintaining a disease-free body and mind.

In the modern era, people have become increasingly concerned about the quality and impact of the food they consume. There is a growing focus on nutrition and health in relation to food, including the development of scientifically modified foods aimed at improving the health of individuals and communities. However, it is important to question whether the nutritional and health benefits provided by such foods align with the ideals and aspirations of spiritual figures like Patanjali, Jesus, Muhammad, and Buddha. Are we effectively spreading awareness and knowledge about health?

As highlighted in a TIME magazine cover story from June 24, 1996, Western medicine excels in crisis situations, addressing acute infections, healing war wounds, and performing organ transplants. However, the rise of chronic diseases in prosperous societies, such as high blood pressure, back pain, cancer, and AIDS, indicates that stress and lifestyle factors play significant roles. While stress has always been a part of human life, it is debatable whether current stress levels are at an all-time high. The impact of changing eating habits on stress levels is a relevant concern. Additionally, lifestyle-related diseases can be referred to as "diet style-related diseases."

Subsequent paragraphs will delve into the nutritional value of the most commonly consumed foods by modern humans and compare them with the ideal nutritional value of foods. This discussion aims to shed light on the food dilemma faced today, with the rise of success stories driven by large agribusiness organisations that prioritise greed and overconsumption rather than compassion and addressing the global food crisis.

II. WHAT IS NUTRITION?

Nutrition can be defined as the science that explores the relationship between food and its impact on health [3]. Its primary focus lies in understanding the role of nutrients in the body's growth, development, and maintenance. Good nutrition entails maintaining a state of well-being that promotes healthy growth and overall health. Nutrients encompass both organic and inorganic compounds present in food, each serving a specific function within the body. These nutrients can be categorised as follows:

- Macronutrients: These are the primary components of food and include proteins, carbohydrates, and lipids.
- Micronutrients: These are required in smaller quantities and include vitamins and minerals.

In contemporary perspectives, food is seen as more than just a source of essential nutrients. It contains a variety of bioactive compounds, particularly in plant-based foods, which have been associated with health benefits. Numerous studies have demonstrated that individuals who increase their intake of fruits and vegetables experience lower rates of chronic non-communicable diseases such as cancer, heart disease, diabetes, and age-related cognitive decline [4]. The health benefits of consuming fruits and vegetables are widely acknowledged by scientists. Leading organisations such as the American Heart Association and the American Cancer Society recommend incorporating ample amounts of fruits and vegetables into daily diets. Previously, it was believed that the antioxidant effects of the micronutrients found in fruits and vegetables accounted for their health benefits.

Table II. 1: Essential Micronutrients

Essential Micronutrients				
Vitamin A	Pantothenic Acid (?)	Iodine	Manganese	Thiamin
Vitamin D	Vitamin B12	Zinc	Iron	Riboflavin
Vitamin K	Ascorbic Acid	Copper	Chromium	Nicotinic Acid
Vitamin E	Essential Fatty Acids (n6 & n3)	Selenium	Cobalt	Pyridoxine
Folic Acid	Biotin (?)	-	-	-

Table II. 2: Micro Nutrient Rich Foods

Micro Nutrient Rich 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 Chilies (Fresh/Dry), Turmeric, Ginger, Fenugreek, Peppe Garlic, Mango Powder
Nuts & Oilseeds	Coconut (Deoiled/Dry/Milk), Groundnut, Cashew-nut, Pistachio nut, Gingerly Seeds, Garden Cress Seeds, Safflower Seeds, Mustard Seeds, Niger Seeds
Fruits	Indian Gooseberry, Watermelon, Custard Apple Wood Apple, Tomato, Orange, Papaya, Guava, Mango, Pineapple Grapes, Banana, Bael, Pomegranate, Gooseberry, Apricot

Indeed, further research is needed to isolate and identify the specific protective compounds present in plant foods for therapeutic purposes. Scientists have conducted studies on the incidence of chronic diseases in individuals consuming vitamin, mineral, and antioxidant supplements. Surprisingly, these individuals did not demonstrate better health outcomes compared to the general population in terms of cancer rates, heart disease, and other chronic diseases. This led researchers to explore alternative factors in food that could contribute to health benefits.

Bioactive compounds such as phytochemical, phenols, and flavonoids found in plants have been recognised as health-promoting chemicals [4, 5, 6, 7, 8]. Numerous studies have linked these bioactive compounds to the prevention of chronic non-communicable diseases [7, 8]. They significantly contribute to the total antioxidant activity of fruits and vegetables. These compounds have the ability to donate electrons to reactive oxygen species (ROS) produced in the body due to stress, smoking, illness, and other factors. ROS, being highly reactive, can cause damage to cellular macromolecules such as proteins, membranes, DNA, RNA, etc. It is believed that ROS plays a role in the development of cancer, cardiovascular disease, diabetes, and other chronic diseases.

Table II. 3: Major Phytonutrients & Food Sources of Phytonutrients

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

Reports from the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) have also highlighted the link between food, nutrition, and the prevention of non-communicable diseases. Additionally, phytochemical have been associated with the prevention of heart disease and cancer. Many of these phytochemical are present in the traditional Indian diet, which is predominantly vegetarian and incorporates Indian spices. This may help explain the comparatively lower incidence of cancer in the Indian population compared to other developed countries. However, there is still much we do not know about nutrition, and it is advisable to obtain food from a variety of sources to ensure a balanced diet [8, 10].

The Planning Commission of the Government of India has emphasised three basic approaches to addressing micronutrient deficiencies: drug supplementation, food fortification, and dietary diversification through the increased intake of micronutrient-rich foods. While the first two approaches can support one or two specific nutrients, dietary diversification is considered the most sensible and sustainable option for long-term sustainability and ensuring adequate intake of less recognised but deficient nutrients and phytochemical. Moreover, its implementation can be community-based and linked to income generation, particularly for rural women [11].

Table II. 4: Summary of Recommended Daily Allowance for Indians [3]:

Group	Particulars	Body Wt Kg	Net energy Kcal/d	Protein g/d	Fat g/d	Calcium mg/d	Iron mg/d	Vit A µg/d Retinol	Vit A µg/d β-carotene	Thiamin mg/d	Riboflavin mg/d	Nicotinic acid mg/d	Pyridoxin mg/d	Ascorbic acid mg/d	Folic acid µg/d	Vit. B-12 µg/d
Man	Sedentary Work Moderate Work Heavy Work	60	2425 2875 3800	60	20	400	28	600	2400	1.2 1.4 1.6	1.4 1.6 1.9	16 18 21	2.0	40	100	1
Woman	Sedentary Work Moderate Work Heavy Work Pregnant Woman Lactation 0-6 months 6-12 months	50 50 50	1875 2225 2925 +300 +550 +400	50 +15 +25 +18	20 30 45	400 1000 1000	30 38 30	600 600 950	2400 2400 3800	0.9 1.1 1.2 +0.2 +0.3 +0.2	1.1 1.3 1.5 +0.2 +3 +0.2	12 14 16 +2 +4 +3	2.0 2.5 2.5	40 40 80	100 400 150	1 1 1.5
Infants	0-6 months 6-12 months	5.4 8.6	108/kg 98/kg	2.05/kg 1.65/kg		500		350	1200	55 µg/kg 50 µg/kg	65 µg/kg 60 µg/kg	710 µg/kg 650 µg/kg	0.1 0.4	25	25	0.2
Children	1-3 years 4-6 years 7-9 years	12.2 19.0 26.9	1240 1690 1950	22 30 41	25	400	12 18 26	400 400 600	1600 2400	0.6 0.9 1.0	0.7 1.0 1.2	8 11 13	0.9 1.6	40	30 40 60	0.2-1.0
Boys Girls	10-12 years 10-12 years	35.4 31.5	2190 1970	54 57	22	600	34 19	600	2400	1.1 1.0	1.3 1.2	15 13	1.6	40	70	0.2-1.0
Boys Girls	13-15 years 13-15 years	47.8 46.7	2450 2060	70 65	22	600	41 28	600	2400	1.2 1.0	1.5 1.2	16 14	2.0	40	100	0.2-1.0
Boys Girls	13-15 years 13-15 years	57.1 49.9	2640 2060	78 63	22	500	50 30	600	2400	1.3 1.0	1.6 1.2	17 14	2.0	40	100	0.2-1.0

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

A. Proteins:

Protein is an essential component of the human diet and plays a crucial role in various bodily functions. Proteins are complex organic compounds that are composed of smaller units called amino acids. There are approximately 24 amino acids required by the human body, with 9 of them being essential amino acids that cannot be adequately synthesised by the body. Therefore, these essential amino acids must be obtained from dietary sources.

Proteins serve multiple functions in the body, including bodybuilding, maintenance of vital functions, repair, maintenance of osmotic pressure, and synthesis of antibodies, plasma proteins, haemoglobin, enzymes, hormones, and coagulation factors. For a protein to be considered biologically complete, it must contain all the essential amino acids.

In the Indian context, cereals and pulses are the primary sources of dietary protein. The daily human requirement for protein is generally recommended to be 1 gram of protein per kilogram of lean body weight. It is important to note that 1 gram of protein yields approximately 4 kilocalories of energy.

Insufficient intake or malnutrition can lead to protein-energy malnutrition, which can manifest in two clinical forms: kwashiorkor and marasmus. The prevalence of protein-energy malnutrition among preschool children in India is estimated to be around 12%. Adequate nutrition, particularly during the first five years of life, is crucial as malnutrition in children can negatively affect their mental and physical development, potentially leading to permanent disabilities. Undernutrition often results in a deficiency syndrome where multiple nutrients are deficient in the same individual.

Table II. 5: 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
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

B. Fats:

Fat is solid at 20 degrees Celsius. If it is liquid at this temperature, it is called an oil. Fats and oils are concentrated sources of energy.

- Simple lipids - triglycerides
- Complex lipids - phospholipids
- Derived lipids - cholesterol.

Indeed, the human body is capable of endogenously synthesising triglycerides and cholesterol. Triglycerides constitute about 99% of the body fat stored in adipose tissue. When hydrolysed, fats provide fatty acids and glycerol. Fatty acids can be classified into two main types: saturated fatty acids and unsaturated fatty acids. Unsaturated fatty acids are further divided into monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). Polyunsaturated fats, such as those found in vegetable oils, and saturated fats are primarily present in non-fish animal fats.

Among the fatty acids, there are certain essential fatty acids that the body cannot synthesise and must be obtained from the diet. These essential fatty acids include linoleic acid, linolenic acid, and arachidonic acid.

Fats are an energy-dense nutrient, providing approximately 9 kilocalories of energy per gram. They serve as an important energy source, and their utilisation can help conserve proteins for other functions. Additionally, fats act as carriers for fat-soluble vitamins (vitamins A, D, E, and K), aiding in their absorption and utilisation by the body. Fats also play a role in supporting the intestines and providing insulation to protect the body from the cold.

Table II. 6: 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

C. Carbohydrate:

Carbohydrates are the main source of energy, providing 4 kcal of energy per gram. There are three primary sources of carbohydrates: starches, sugars, and cellulose. Cellulose, which contributes to dietary fibre, is indigestible. Starches and complex carbohydrates are digested slowly, aiding in the regulation of body fat. On the other hand, simple carbohydrates or sugars stimulate insulin secretion and are rapidly absorbed into adipose tissue.

D. Vitamin A:

Vitamin A is involved in maintaining normal vision, the integrity and normal functioning of glandular and epithelial tissues, skeletal growth, maintaining immunity, and protecting against certain types of cancer, such as bronchial carcinoma. Deficiency of vitamin A leads to xerophthalmia, which includes ocular conditions like night blindness, xeroconjunctiva, Vito's spots, xerokeratosis, and keratomalacia. Vitamin A deficiency also causes follicular keratosis, anorexia, growth retardation, respiratory and intestinal infections, and infant mortality. Malnutrition and vitamin A deficiency are the primary causes of blindness in children.

Table II. 7: 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
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

E. Vitamin E:

Also called tocopherol. Acts as an antioxidant in lipid (fat) media.

F. Vitamin K:

Vitamin K exists in two forms, K1 and K2. The role of vitamin K is to stimulate the production and release of specific blood clotting factors.

G. Thiamine (B1):

Important for carbohydrate utilisation (direct glucose oxidation pathway). Thiamine is easily lost from rice during the rice milling process. Deficiency of thiamine causes beriberi and Wernick encephalopathy. These diseases are also manifested by excessive alcohol consumption.

H. Riboflavin (B2):

Plays a fundamental role in cellular oxidation, plays an important role in maintaining the integrity of mucosal structures, and is a cofactor for many enzymes involved in energy metabolism.

I. Niacin (B3):

Important in protein, fat and carbohydrate metabolism. It is also essential for the normal functioning of the skin, intestines and nervous system. Niacin deficiency causes pellagra, a disease characterised by diarrhoea, dermatitis, and dementia.

J. B6 (Pyridoxine):

Important for metabolism of amino acids, fats and carbohydrates. B6 deficiency is associated with peripheral neuritis. The anti-tuberculous drug INH causes impaired utilisation of B6

K. Folic acid:

Folic acid is involved in the synthesis of nucleic acids (chromosomes). Folic acid deficiency causes megaloblastic anemia, glossitis, cheilitis, gastrointestinal disorders, infertility and infertility. It is also required for normal development of blood cells in the bone marrow.

L. Vitamin C:

Powerful antioxidant in aqueous (water) media. It has an important function in tissue oxidation and is required for the formation of collagen. It plays an important role in healing and scarring. A lack of vitamin C results in scurvy. Once a major deficiency, scurvy is no longer a disease of global importance.

M. Vitamin B12:

Vitamin B12 is a complex organometallic compound containing a cobalt atom. Along with folic acid, it promotes the synthesis of DNA. Milk is a good source of this vitamin. Vitamin B12 deficiency is associated with megaloblastic anemia, demyelinating neuropathies of the spinal cord, and infertility.

N. Calcium:

Ionised calcium in plasma has many important functions, including bone and tooth formation, blood clotting, muscle contraction, membrane maintenance, enzyme and hormone metabolism, and heart activity. Milk and dairy products are good sources of calcium.

O. Iron:

Iron is necessary for many important functions in the body, including the formation of hemoglobin, brain development and function, thermoregulation, muscle activity, and catecholamine metabolism.

Table III. 8: 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
Chhatisgarh	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
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 anaemic.
2. Percentage of ever married woman of age 15-49 years who are anaemic.
3. Percentage of pregnant woman of age 15-49 years who are anaemic.
4. Percentage of ever married men of age 15-49 years who are anaemic.

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

P. Iodine:

Iodine is an essential micronutrient. It is necessary for the synthesis of thyroid hormones. Iodine deficiency leads to goitre.

Q. Zinc:

Zinc is a component of more than 300 enzymes in the human body. It is active in protein metabolism and is necessary for insulin synthesis and maintenance of immunity. Zinc deficiency leads to stunted growth and impaired sexual function in adolescents. It also causes loss of taste and slows down the healing process. Zinc deficiency in pregnant women leads to spontaneous abortion and birth defects. Zinc also acts as an antioxidant. Milk is a reliable source of zinc.

R. Cobalt:

It is part of vitamin B12. Recently, cobalt deficiency and cobalt-iodine ratio in soil have been shown to cause goitre in humans. It is thought that cobalt may be necessary for the first step in hormone production, i.e. iodine uptake by the cobalt glands may interact with iodine and affect its use.

S. Chromium:

Chromium is thought to play a role in the function of carbohydrates and insulin.

T. Molybdenum

Molybdenum deficiency has been linked to cancers of the mouth and oesophagus.

- **Food, health and nutrition:**

Usually, an individual's medical condition and eating habits are related. We have enough empirical evidence to reveal a causal link between the two. Diseases are generally classified into two groups: infectious and non-infectious. Both of these diseases are directly or indirectly related to nutrition.

The human body is a delicate and beautiful creation of nature. Modern medicine has been criticised for treating the human body like a machine, where a misaligned function results in a particular part being immobilised, and the machine starts working again with a fixed input, providing a constant output at a specific efficiency quotient. However, this is not true for the human body. Science is still trying to decipher all the inputs (macro as well as micro) that the human body needs. The human body is complex, and there is a general agreement that any disturbance in the balance can lead to abnormal physiological functions and can cause disease. Much of this delicate balance depends on the air we breathe, the water we drink, and the food we eat. A large portion of consumers has lost confidence in the foods they eat, in the bodies that certify them as safe, and in the policies that maintain the supply chain. Changing consumer perceptions are a concern.

One topic that is hotly debated around the globe is: "WHAT FOOD IS BETTER FOR US TO EAT, ORGANIC OR CONVENTIONAL?" The exact answer to this question still requires a lot of research. However, we have compelling evidence in favor of organically grown foods. Many myths and assumptions need to be addressed, and that is one of the goals of this chapter. We will discuss these assumptions one by one and provide evidence to challenge them. During the reporting process, the reader should have a clear perspective of organic versus conventional farming, taking into account factors such as yield, nutrition, effects on health, and the opinion of the scientific community.

III. NUTRITION PER ACRE:

Proponents of conventional chemical farming pride themselves on the high yields obtained from this farming method. According to them, conventional agriculture is the solution to the global food crisis. Surprisingly, comparable yields have also been achieved through organic farming practices [1]. "Organic versus conventional" is a distinction derived from the philosophies of the two agricultural practices, with different intentions. On one hand, organic farming methods promote independence, while on the other hand, traditional methods prescribe absolute dependence. The main goals of organic farming practices are sustainability, ecological consideration, low input, high returns, and large profits for the farmer. The main objectives of conventional farming are unsustainability, negative environmental impact, large inputs, relatively moderate returns, and large corporate profits. The debate depends on how we view agriculture. Are we more interested in making profits than in food security? Are we growing food to feed people, or are we growing crops to maximise profits from trading goods? Advocates of conventional agriculture argue that it is the only way to ensure food security. This commitment to food security comes at a time when approximately 40% of the world's food grains destined for livestock are slaughtered on the scheduled date, and when a large portion of the world's population is in short supply of nutrition. Perhaps we don't have enough grain to make hamburgers. We may have entered an age where we need to think more like citizens of the world than like Indians, Americans, or Europeans.

In this section, we compare the nutrients produced on an acre of farmland through organic and conventional farming. First, we use yield data [1], obtained through two agricultural practices, collected by Navdanya in the four Indian states of Sikkim, Rajasthan, Kerala, and Uttaranchal. We also used yield data from three case studies conducted on farms in Navdanya. We then used the nutritional data [12] of each food by referring to "Nutritional Value of Indian Food" published by the National Institute of Nutrition, Indian Medical Research Council, Hyderabad. Throughout this report, the following abbreviations are used for minerals

Table III. 1: Minerals & its Abbreviations

MINERAL	ABBREVIATION
CALCIUM	Ca

IRON	Fe
PHOSPHOROUS	P
MAGNESIUM	Mg
SODIUM	Na
POTASSIUM	K
CHLORINE	Cl
COPPER	Cu
MANGANESE	Mn
MOLYBDENUM	Mo
ZINC	Zn
CHROMIUM	Cr
SULPHUR	S

A. SIKKIM:

CASE STUDY 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 (2Qt)	1.4	6.8	0.2	34000
Mustard leaves (saag)(1qt)	4.0	0.6	2.4	34,000
Peas (2Qt)	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:
- Navdanya
- 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	Thiamine	Riboflavin	Niacin	B6	Folic acid	Vit. C	Choline (mg)
	(mg)	(mg)	(mg)	(mg)	(mg)	(mg)	(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 (9Qt.)	**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	0
Total (5 Qt.)	**450**	**2,100**	**500**	**9,000**	**-**	**100**	**0**	**0**

Source:
- Navdanya
- 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 (9Qt.)	**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:
- Navdanya
- 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 (9Qt.)	**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:
- Navdanya,
- 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 sulphur, per acre of farmland, in Sikkim as conventional mono cropping does.

B. 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

Mixed cropping	Protein (kg)	Carbohydrate (kg)	Fat (kg)	Total energy (kcal)
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:
- Navdanya
- 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	20700	-	409.5	0	0
Moth (3.5 qtl.)	31.5	1575	315	5250	-	-	7000	-
Sesame (0.4 qtl.)	24	404	136	1760	-	53.6	0	-
Total = 12.9 qtl.	**1243.5**	**4949**	**2701**	**27710**	**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:
- Navdanya
- 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	2763	351
Moth (3.5 qtl.)	707	33.25	805	787.5	103.25	3836	31.5
Sesame (0.4 qtl.)	580	3.72	228	-	-	-	-
Total = 12.9 qtl.	**1665**	**108.97**	**3697**	**2020.5**	**201.35**	**6599**	**382.5**
Mono cropping							
Pearl Millet (12 qtl.)	504	96	3,552	1644	130.8	3684	468
Total = 12 qtl.	**504**	**96**	**3,552**	**1644**	**130.8**	**3684**	**468**

Source:
- Navdanya
- 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:
• Navdanya
• 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.

Mixed Cropping	**Protein (kg)**	**Carbohydrate (kg)**	**Fat (kg)**	**Total energy (kcal)**
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:
• Navdanya
• 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.

Mixed Cropping	Carotene (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	B6 mg	Folic acid (mg)	Vit. C (mg)	Choline (mg)
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:
• Navdanya

• 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.

Mixed Cropping	**Ca (g)**	**Fe (g)**	**P (g)**	**Mg (g)**	**Na (g)**	**K (g)**	**Cl (g)**
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:
• Navdanya
• 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.

Mixed Cropping	**Cu (mg)**	**Mn (mg)**	**Mo (mg)**	**Zn (mg)**	**Cr (mg)**	**S (mg)**
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:
• Navdanya
• 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 Rajasthan, 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
Tota l= 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:
- Navdanya
- 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)	B6 (mg)	Folic (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	50,500
Total = 13.5 qt.	**1020.0**	**5895.0**	**1,600.0**	**23,050**	**0**	**552.5**	**0**	**50,500**
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:
- Navdanya

- 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**	**4863.0**	**2054.0**	**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:
- Navdanya
- 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	5280.0	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**	**5143.0**	**42,300.0**	**116.5**	**16,66,500.0**
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:
- Navdanya
- 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.

C. 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:
- Navdanya
- 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)	B6 (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:
- Navdanya
- 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 B6, 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 13 qt. of paddy was grown per acre.

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 = 3 qt.	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:
- Navdanya
- 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 = 3 qt.	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:
- Navdanya
- 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 produced 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:
- Navdanya
- 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)**	**Riboflavin (mg)**	**Niacin (mg)**	**B6 (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	7200	0
Amaranth = 2 qt.	-	200	400	1800	120	164	6000	-
Total=14 qt.	**744**	**4730**	**2050**	**18900**	**120**	**455.3**	**7800**	**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:
- Navdanya
- 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 B6, 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	23.4	1698	822	66	2448	264
Foxtail millet = 3 qt.	93	8.4	870	243	13.8	750	111
French beans = 3 qt.	150	1.83	84	114	12.9	360	30
Amaranth = 2 qt.	318	15.2	1114	6.8	-	1016	-
Total=14 qt.	**2625**	**48.8**	**3766**	**1185.8**	**92.7**	**4574**	**405**
Mono cropping							
Paddy = 12 qt.	120	38.4	2280	1884	0	0	0
Total = 12 qt.	**120**	**38.4**	**2280**	**1884**	**0**	**0**	**0**

Source:
- Navdanya
- 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:
- Navdanya
- 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:
- Navdanya
- 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)	Riboflavin (mg)	Niacin (mg)	B6 (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:
- Navdanya
- 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 B6 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:
- Navdanya
- 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:
- Navdanya
- 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:
- Navdanya
- Nutritive value of Indian Foods, ICMR.

Organic mixed cropping produced 413% more protein than that produced by conventional mixed cropping, per acre farmland.

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

	Carotene (mg)	**Thiamine (mg)**	**Riboflavin (mg)**	**Niacin (mg)**	**B6 (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:
- Navdanya
- 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:
- Navdanya
- 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:
- Navdanya
- 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:
- Navdanya
- 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)**	**B6 (mg)**	**Folic acid (mg)**	**Vit. C (mg)**	**Choline (mg)**
Mixed cropping								
Wheat = 4 qt.	256	1800	680	22,00	228	14	0	-
Mustard =2 qt.	324	1300	520	8000	-	-	0	42200
Barley = 2 qt.	20	940	400	10800	-	-	0	-
Peas = 2 qt.	166	500	20	1600	-	-	1800	40000
Lentil = 1 qt.	270	450	200	2600	-	36	0	29900
Total = 11 qt.	**1036**	**4990**	**1820**	**45000**	**228**	**18**	**1800**	**76100**
Mono cropping								

Wheat =10 qt.	640	4500	1700	55000	570	36	0	0
Total =10 qt.	**640**	**4500**	**1700**	**55000**	**570**	**36**	**0**	**0**

Source:
- Navdanya
- 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:
- Navdanya
- Nutritive value of Indian Foods, ICMR.

Both methods of farming produced 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	**6,800**	**22,900**	**510**	**27,000**	**120**	**12,80,000**

Source:
- Navdanya
- 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).

D. 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.

Table D.1: Organic Mixed Cropping (Baranaja) & Average Production Area)

	Organic Mixed Cropping-Baranaja	**Average (production/ hectare)**	**Average (production/acre)**
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:

- Navdanya
- 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)	B6 (mg)	Folic acid (mg)	Vit. C (mg)	Choline (mg)
Organic Mixed Cropping Baranaja								
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	-	-
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:
- Navdanya
- 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: Comparison 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 Baranaja							
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:
- Navdanya
- 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 Baranaja						
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:
- Navdanya
- 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.

Table D - 2: Organic Mixed Cropping - Navdanya & its Average Product Area

		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
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: Comparison 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:
- Navdanya
- 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: Comparison of vitamins produced per acre farmland- organic mixed cropping (Navdanya) versus conventional mono cropping.

	Carotene (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	B6 (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:
- Navdanya
- 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	
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:
- Navdanya
- 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:
- Navdanya
- 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.

Table D - 3: Organic Mixed Cropping - Septrashi & its Production Average Area

		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:
- Navdanya
- 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)	B6 (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	**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:
- Navdanya
- 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**
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:
- Navdanya
- 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.

IV. WHAT DO THESE TABLES INDICATE?

Researchers and doctors, globally, have reached a collective consensus that one should derive their 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 diversification of the portfolio to reduce risk. This financial concept seems to be equally valuable for agriculture, health, and nutrition. Rui Hai Liu from the 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 meeting their nutrient requirements for optimum health.” How can we expect to consume such a 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].

Table IV. 1 - Times trends in dietary intake & nutritional status of adults

Food	1975	1980	1990	1995	1996-97	RDA
Cereals & 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 & 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 IV. 2 - Intake of Nutrients (Cu/day)

Nutrients	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 B2 (mg)	0.98	0.91	0.94	0.8	0.9	1.4
Vitamin C (mg)	41	52	37	35	40	40

Source: Krishnaswamy et al NNMD 1999

If we closely examine the table, we will realise that our per capita nutrition per day has significantly decreased from 1975 to 1999. The period from 1975 to 1999 is also important from the point of view of the green revolution in 1975. The green revolution and conventional farming were insignificant, while in 1999, conventional farming practices had a significant influence on our society. One possible reason for such a change in average nutrient consumption could be attributed to population explosion. However, attributing everything to population growth would be far-fetched and superficial. Further research is needed to establish a strong correlation.

Another interesting fact that emerges is that an acre of land cultivated under conventional agriculture produces low amounts of most nutrients. However, these farmlands have overproduced some exotic nutrients. This probably reflects on our national health; on one hand, we struggle to treat and eliminate deficiency diseases such as protein-energy malnutrition, night blindness, anemia, etc., and on the other hand, this country is afflicted by the debilitating effects of overeating, such as obesity, fortified vitamins, cardiovascular disease, diabetes, etc. However, to establish a strong correlation, further in-depth studies are needed.

Diversification is not just important from the standpoint of "the amount of nutrients produced per acre." Research has suggested that traditional foods and various fruits and vegetables contain a number of bioactive compounds that are effective in preventing cancer, diabetes, cardiovascular disease, and degenerative diseases [7,8]. To date, not all of these compounds have been identified, the role of these bioactive compounds in the prevention of degenerative diseases has not been determined, and a mixture of nutrients ideal for humans has not yet been recognised [13]. We are almost there, but not quite. Therefore, physicians prescribe a diet derived from a variety of sources, and such recommendations have also proven to be helpful [10].

To provide a more comprehensive picture, we calculated the average (arithmetic mean) of nutrients produced per acre of farmland from all the case studies above. The sample mean of this chapter should be a reasonably good estimator of the population mean. The population in this 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 of farmland on a national scale. Moreover, data has been collected from different states ranging from an arid state, Rajasthan, to an organic state, Uttarakhand. Therefore, the margin of error will be quite small.

The purpose of all these statistics is to provide the reader with an overview of the true impact of the two-agriculture scenario at the national level. The questions are how to maximise nutrient yields, how to minimise environmental risks, and how to ensure a sustainable alternative to address the national and global food crisis.

Table IV. 3 - Average production of macronutrients per acre of 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 According to this table, if we convert an acre of farmland from conventional monoculture to organic mixed farming, we would be able to produce 124 kg more protein than before. The quality of mixed-culture protein is better than that of single-cultured protein. Organic mixed protein is complete as it provides all the essential amino acids and is comparable to animal protein. Plant proteins (with the exception of soy) can be an inadequate source of all the individual essential amino acids. However, when plant proteins are mixed, they become a complete source of all the essential amino acids. For example, the protein in roti or dal, individually, is incomplete because it lacks all the essential amino acids, but when roti and dal are eaten together, they become a complete source of all the essential amino acids [3]. Therefore, the protein produced per acre from an organic mixed crop will be more adequate than the amount produced per acre from a conventional monoculture.

On average, organic polyculture produced 124 kg more protein than conventional monoculture per acre of cultivated land. 124 kg of protein is enough to meet the protein needs of 2,000 adults per day. According to the Central Water Commission, Government of India, the total arable land area (2003-04) in India is 183 million hectares, equivalent to 452,202,848 acres. If all of this land were used for organic polyculture instead of conventional monoculture, the country would produce 56,073,153 tons more protein than it did in the past. This is enough to meet the protein needs of 2.5 billion adults all year round. The remarkable fact is that we only took a difference of 124 kg of protein per acre between organic polyculture and conventional monoculture. The extra protein that we will produce by switching from conventional to organic farming is enough to meet the protein needs of 2.5 billion adults for an entire year. If we consider the total amount of protein produced domestically through organic mixed farming and project the average of our sample over the total arable land, we will produce enough protein to meet the protein needs of about 5 billion adults for the whole year. That's enough protein to feed our entire population and eradicate protein-energy malnutrition from the planet.

If an acre of farmland is converted from conventional monoculture to organic mixed farming, we will produce additional feed containing 12,027,950 kcal of additional energy to consume. This is enough to provide 2,500 kcal of energy for 481 adults per day. If we project this to 183 million hectares, out of the total arable land in India, we would produce enough extra calories in food to meet the energy needs of 600 million adults for the whole year. We would like to reiterate that we only looked at the extra calories created by switching from conventional to organic food. If we consider the average calories produced per acre through organic mixed farming, then nationally, we will produce enough calories to provide 2,500 kcal/day for 2.4 billion people mature in 1 year. If we switch from conventional to organic production, we can ensure that no one goes hungry in our country. In fact, if only India switched from conventional farming to organic farming, we could solve the world hunger problem, as only one billion of the poorest people in the world go hungry.

Table IV. 4 - 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 one acre of farmland were used for organic mixed farming instead of conventional monoculture, we would produce 2,174 mg more carotene than would have been produced otherwise. That's enough carotene to meet the vitamin A needs of about 900 adults per day. Nationwide, we would organically produce 982,670 tons more carotene than conventional production. In other words, we would produce 164,106 tons of retinol equivalent (1 unit of beta-carotene = 0.167 units of RE [3]) more than conventional production. 164,106 tons of RE (retinol equivalent) is enough to meet the daily vitamin A needs of 750 million adults for 1 year. It is also enough to address and fully reverse 1.3 billion early cases of xerophthalmia. Here, we assume that all these equivalent amounts of retinol in food could be isolated and given to patients with blood cancers. The term xerophthalmia (dry eye) includes all ocular manifestations of vitamin A deficiency, from night blindness to corneal ulcers, a serious condition that can leave residual corneal scarring, affecting vision. Corneal keratosis or liquefaction is the main cause of blindness in India.

The cornea becomes tender and may rupture. This is probably the kind of impact that additional carotene generated by organic conversion across the country could have on the health of our population. If we use a sample of the average amount of carotene produced per acre of organic mixed farming to calculate the total amount of carotene produced nationally, we can produce enough carotene to meet the daily vitamin A needs of 1.5 billion adults for a year.

Likewise, the amount of additional thiamine created per acre, switching from conventional to organic, is enough to provide thiamine for approximately 2,100 adults per day. Nationally, the amount of supplemental thiamine produced by switching from conventional to organic would be enough to meet the daily thiamine needs of 2.6 billion adults for one year. If we consider all the thiamine that can be produced biologically in the country, the amount of thiamine produced would be enough for about 5 billion adults for a year. Mild thiamine deficiency is common in some parts of the country [3]. With nationwide organic farming, we can root out and eliminate all forms of thiamine deficiency in the population.

Growing organic mixes in an acre of farmland produces additional amounts of riboflavin that, compared with conventional monocultures per acre, can meet the recommended riboflavin intake for 1,000 adults per day. Nationwide, we can provide enough riboflavin for an additional 1.2 billion adults in one year. Riboflavin deficiency is widespread in India, especially among populations where rice is the staple food [3]. The reality is that we are currently not producing enough riboflavin. Organic farming seems to be a promising solution to the riboflavin crisis.

Folic acid deficiency can occur rapidly in pregnant and lactating women and growing children because the body's folate stores are not large, about 510 mg. One acre of farmland through organic mixed farming can produce extra folic acid that can feed about 1,375 pregnant women for a day. Nationally, the additional folate produced by organic mixed farming is, compared with conventional practices, enough to provide folic acid for 1.7 billion pregnant women, who need four times as much folic acid compared to the average adult, for one year.

Our sample shows that vitamin C produced by conventional monoculture is better than that produced by organic polyculture

Table IV. 5 - 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 34 g of iron, of which 60-70% is in the blood. Iron is needed for many bodily functions, such as haemoglobin formation, brain development and function, body temperature regulation, muscle function, and catecholamine metabolism. The central functions of iron are oxygen transport and cellular respiration. The bioavailability of non-heme (mostly vegetarian) iron is low due to the presence of phytates, oxalates, carbonates, phosphates, and dietary fibre. The Indian diet, which is mainly vegetarian, contains large amounts of phytate inhibitors in bran, phosphates in egg yolks, tannins in tea, and oxalates in vegetables. Iron deficiency in the diet leading to iron deficiency anemia or nutritional anemia is a major public health problem in India. A group of experts from WHO has proposed that anemia is considered to exist when the haemoglobin is below the following levels.

Table IV. 6 - 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

Table IV. 7 - 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)	1.8
Male	1.8
Female	2.4
Adult male	0.9
Adult female	2.8

Menstruation	0.8
Pregnancy -First half	3.5
Pregnancy - Second half	2.4
Lactation Post menopause	0.7

When an acre of farmland is used for organic mixed farming instead of a conventional monoculture, an additional 39 g of iron is produced. This amount is enough to provide iron for 16,250 nursing mothers for a day. Nationally, the amount of bioavailable iron supplemented with will be enough to meet the needs of 20 billion nursing mothers. To reach this conclusion, we assume that all iron consumed will be absorbed.

Table IV. 8 - 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

V. IS GENETIC ENGINEERING THE SOLUTION TO HUNGER & MALNUTRITION:

Part of the scientific community proposes genetic engineering as an important solution to this problem. William Ockham (1285-1349) was an English philosopher who argued 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 doing more than can be done with less is futile. Organic polyculture can increase the production of micronutrients intended for consumption by 72%. Furthermore, it is a durable, tested, sensible, smart, cost-effective, and eco-friendly solution to the problem. GM crops may require increased concentrations of one or two micronutrients. Gene editing is in no way able to provide an ideal mixture of all trace elements. In contrast, organic polyculture resulted in an overall increase in the production of these micronutrients for consumption. Crop genetic engineering is an experimental technology. Companies promoting GM crops want to use our farmland as a testing ground. Profits belong to the company, while society bears the risks associated with GM crops without any reward. All that society gets are fantasies and serious environmental risks. Scientists agree that GM crops do not always work as expected, and the results can be surprising [15].

The variable nature of what genetic engineers do cannot be quantified. The full effects of gene transfer between species and kingdoms are unknown to even the most skilled genetic engineers. Before a technology is put into common use, the positive effect of the technology is weighed against its undesirable effects. Only when the benefits outweigh the risks can a technological product be put to use. A new drug is only introduced in pharmacies when its effects outweigh its side effects. However, genetic modification of crops does not allow for this useful comparison because the full range of effects is still unknown. The situation is metaphorically similar to one in which an individual is introduced into 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. A 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 the pollution of air and pollution of water, genetic modification of crops is pollution of the gene pool, and like the pollution of water and pollution of air, this pollution of the gene pool shall hit back.

The following are some of the known uncertainties 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 profitsan overview of issues in genetically modified foods and crops” by Sophia Kolehmainen (2001)

The GM food that supposedly cannot promote growth in rats is thought to solve the malnutrition crisis among humans, and all this propaganda 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 human health, the environment, and society at large.

The following article [16] was published by The Journal of Agrobiotechnology Management and Economics (Volume 2, Number 3 & 4, Article 3). The title of the paper was "Ten Reasons Biotechnology Won't Ensure Food Security, Environmental Protection, and Poverty Alleviation in Developing Countries." The paper's authors are Miguel A. Altieri and Peter Rosset from the University of California, Berkeley, and Food First/Food and Development Policy Institute.

Biotech companies often claim that genetically modified organisms (GMOs) – specifically genetically modified seeds – are the essential scientific breakthrough needed to feed the world, protect the environment, and alleviate poverty in developing countries. The Consultative Group on International Agricultural Research (CGIAR) and the group of international centres around the world responsible for research to improve food security in developing countries echo this view based on two main assumptions. First, hunger is caused by a gap between food production and population density or growth. The second assumption is that genetic engineering is the only or best way to increase agricultural production and, therefore, meet future food needs.

Our goal is to challenge the notion that biotechnology is the silver bullet for all evils in agriculture, clarifying misconceptions about these basic assumptions.

1. There is no relationship between the hunger rate in a given country and its population. For every populous and hungry country like Bangladesh or Haiti, there is a sparse and hungry country like Brazil and Indonesia. The world today produces more food per capita than ever before. There is enough food to provide each person with 4.3 pounds per day: 2.5 pounds of whole grains, beans, and nuts, about a pound of meat, dairy, and eggs, and a pound of other 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 readily available (but often poorly distributed) food or lack the land and resources to grow their own (Lappe, Collins & Rosset, 1998).
2. Most innovations in agricultural biotechnology are driven by profit rather than demand. The real goal of the genetic engineering industry is not to make Third World agriculture more productive but to make it profitable (Busch et al., 1990). This is illustrated by looking at the key technologies on the market today: (1) herbicide-resistant crops, such as Monsanto's "Roundup Ready" soybeans and Monsanto's Roundup herbicide-tolerant seeds, and (2) "Bt" crops (Bacillus thuringiensis) designed to produce their own insecticides. Initially, the goal was to capture a larger market share of herbicides for a particular product and second, to stimulate seed sales at the expense of reducing the usefulness of a key pest control product (microbiological pesticides made from Bacillus thuringiensis) that many farmers, including most organic farmers, consider an effective alternative to pesticides. These technologies address the need of biotech companies to increase farmers' dependence on seeds protected by so-called "intellectual property rights," which are in direct conflict with the rights of farmers to reproduce, share, or store seeds (Hobbelink, 1991). Whenever possible, companies will require farmers to purchase company-branded inputs and will prohibit farmers from saving or selling seeds. By controlling the sprouts for sale and forcing farmers to pay high prices for packages of seed chemicals, companies are determined to get the most out of their investment (Krimsky & Wrubel, 1996).
3. The combination of the seed and chemical industries seems to accelerate the increase in seed and chemical spending per acre, resulting in significantly lower returns for growers. Companies that develop herbicide-tolerant crops try to shift the cost per acre of herbicide to seed as much as possible through seed costs and technology fees. Increasingly, the reduction in herbicide prices will be more and more limited to growers who purchase a technology package. In Illinois, the adoption of herbicide-resistant crops makes most.
4. Recent experimental tests show that GM seeds do not increase crop yield. A recent study by the United States Department of Agriculture (USDA) Economic Research Service found that in 1998, yields were not significantly different between modified and non-transformed crops in 12 of the 18 crop complex/region. In the six crop/region combinations where Bt crops or herbicide-resistant (HTC) crops performed better, they showed a 530% increase in yield. Glyphosate-tolerant cotton showed no significant yield increase in the two regions it was studied. This was confirmed in another study examining more than 8,000 field trials, in which Roundup Ready soybeans were found to produce fewer bushels of soybeans than similar conventionally bred varieties (USDA, 1999).
5. Many scientists assert that it is safe to eat genetically modified foods. However, recent evidence suggests that there are potential risks associated with the consumption of such foods, as the newly created proteins in these foods can:
   - (1) act on their own as allergens or toxins;
   - (2) alter the metabolism of food-producing plants or animals, causing them to produce new allergens or toxins; or
   - (3) reduce their quality or nutritional value.

In case (3), herbicide-resistant soybeans may contain as little as Isoflavones, an important phytoestrogen found in soybeans, which are thought to protect women against certain cancers. Currently, developing countries import soybeans and corn from the United States, Argentina, and Brazil. Genetically modified foods are beginning to flood the markets of importing countries, but no one can predict the harmful effects they will have on the health of consumers who do not know they are consuming these foods. Because genetically modified foods are not labeled, consumers cannot distinguish between genetically modified (GM) and non-GMO foods, and if serious health problems arise, it would be extremely difficult to determine their origin. Non-labeling also helps protect companies from potential liability (Lappe & Bailey, 1998).

6. Transgenic plants that produce their own pesticides follow the pesticide model, which itself quickly fails due to the pest's resistance to pesticides. Instead of the unsuccessful "one gene, one stone" model, genetic engineering emphasizes the "one gene, one stone" approach, which has been proven time and time again in laboratory tests to be unsuccessful because the pests quickly adapt and develop resistance to the insecticides present in the plant (Alstad & Andow, 1995). Not only do new varieties fail in the short to medium term, despite so-called voluntary resistance management systems (Mallet and Porter, 1992), but in the process, it can expose pesticides to Bt is naturally rendered useless by some organic farmers and others who wish to reduce their dependence on chemicals. Bt crops violate the basic and widely accepted principle of Integrated Pest Management (IPM), which is reliance on a single pest management technology that tends to trigger changes in pest species or the evolution of resistance through one or more mechanisms (NRC, 1996). In general, the greater the selection pressure over time and space, the faster and deeper the

evolutionary response of the pest. One obvious reason to apply this principle is that it reduces the pest's exposure to pesticides, thereby delaying the development of resistance. But when the product is incorporated into the plant itself, the potential for pest exposure increases from minimal and infrequent exposure to extensive and continuous exposure, which rapidly increases tolerance (Gould, 1994). Bacillus thuringiensis will quickly become useless, both as a feature of new seeds and as a stockpile of old to be sprayed as needed by farmers wanting off the pesticide conveyor belt (Pimentel et al., 1989).

7. The competition for global market share leads companies to deploy GM crops worldwide on a massive scale (over 30 million hectares in 1998) without proper prior testing for short- or long-term effects on human health and ecosystems. In the United States, pressure from the private sector led the White House to order "no significant difference" between modified seeds and regular seeds, thus avoiding the usual inspections by the Food and Drug Administration (FDA) and Environmental Protection Agency (EPA). Confidential documents made public as part of an ongoing class-action lawsuit have revealed that FDA scientists disagreed with this decision. One reason is that many scientists are concerned that the large-scale use of transgenic crops poses a range of environmental risks that threaten the sustainability of agriculture (Goldberg, 1992; Paoletti & Pimentel, 1996; Snow and Moran, 1997; Rissler and Mellon, 1996; Kendall et al., 1997; Royal Society, 1998).

These areas of risk include the following:

- Trends in creating large international markets for unique products, simplifying crop systems, and creating genetic homogeneity in rural landscapes. History has shown that planting a large area with a cultivar that is highly susceptible to new strains of pathogens or pests can be detrimental. Furthermore, the widespread use of homogeneous transgenic varieties will inevitably lead to "genetic erosion" as the traditional crop varieties used by thousands of farmers in developing countries are replaced by new varieties (Robinson, 1996).
- The use of herbicide-resistant crops compromises the ability of crops to diversify, reducing agro-biodiversity over time and space (Altieri, 1994).
- Potential transfer through gene flow from herbicide-resistant crops to wild or semi-domestic relatives could lead to the generation of superweeds (Lutman, 1999).
- Herbicide-resistant varieties can become important weeds in other crops.
- The massive use of Bt crops affects non-target organisms and ecological processes. Recent evidence suggests that Bt toxins can affect beneficial insect predators that feed on harmful insects on Bt crops (Hilbeck et al., 1998). In addition, wind-blown pollen from Bt crops can harm off-target insects such as monarch butterflies. After harvest, crop foliage can adversely affect soil invertebrate populations that degrade organic matter and perform other ecological roles (Donnegan et al., 1995; Palm et al., 1996).
- Transgenic crops capable of vector recombinant can generate new virulent virus strains, especially in transgenic plants designed to be resistant to viruses with virus genes. There is a possibility that the coat protein genes in plants could be used by unrelated viruses, altering the structure of the virus envelope and potentially creating new pathogens with more serious disease problems (Steinbrecher, 1996).
- The expansion of this technology in developing countries may not be wise or desirable. The agricultural diversity of many of these countries is a strength that should not be constrained or diminished by widespread monoculture, especially when the consequences lead to social and severe environmental problems (Altieri, 1996).

Although the issue of ecological risk has been discussed in governmental, international, and scientific circles, discussions often pursue a narrow perspective that underestimates the severity of the risks (Kendall et al., 1997; Royal Society, 1998). Risk assessment methods for transgenic crops have not been well-developed, and there is legitimate concern that biosafety field trials provide little insight into the potential environmental risks associated with commercial-scale GM crop production. One major concern is that international pressures for markets and profits are driving companies to release transgenic crops too quickly without giving due consideration to the long-term impacts on people and ecosystems.

8. There are many unanswered ecological questions regarding the impact of transgenic crops. Many environmental groups have advocated the creation of appropriate regulations to oversee the testing and release of GM crops in order to mitigate environmental risks. They demand a much better assessment and understanding of the ecological issues related to genetic engineering. It is important to consider not only the direct effects on insects or weeds but also the indirect effects on plants, including plant growth, nutrient content, metabolic changes, and impacts on soil and non-target organisms. Unfortunately, funding for environmental risk assessment research is severely limited. For example, the USDA allocates only 1% of its biotech research funds, approximately $12 million per year, for risk assessment. With the current level of GM tree deployment, such resources are insufficient to explore the full extent of potential risks. It is tragic that millions of hectares are being planted without adequate biosecurity standards. The global areas of GM crops significantly increased in 1998, with GM cotton covering 6.3 million acres, GM corn 20.8 million acres, and GM soybean 36.3 million acres. This expansion has been facilitated by marketing and distribution agreements between companies and distributors, as well as the lack of regulation in many developing countries. Unlike an oil spill, genetic contamination cannot be controlled by containment efforts.
9. As the private sector has increasingly dominated the advancement of new biotechnology, the public sector has had to allocate more of its limited resources to improve biotechnology capacity in public institutions, including CGIAR. These funds would be better utilised to expand support for agro-ecological research, as all the biological problems addressed by biotechnology can be solved using agronomic approaches. The significant effects of crop rotation and intercropping on crop health and yield, as well as the use of biological control agents for pest management, have been consistently confirmed by scientific studies. The issue is that research in public institutions increasingly reflects the interests of private donors at the expense of research in the public interest, such as biological control, organic production systems, and general agricultural engineering. Civil society must urge universities and other public institutions to conduct more research on alternatives to biotechnology (Krimsky & Wrubel, 1996). There is also an urgent need to challenge the patent and intellectual property rights system inherent in the World Trade Organization (WTO), which not only grants multinational corporations the right to hold and patent genetic resources but also accelerates the promotion of monoculture through genetically identical transgenic varieties. Based on ecological history and theory, it is not difficult to predict the negative effects of such environmental simplification on the health of modern agriculture (Altieri, 1996).
10. Much of the required food can be produced by smallholder farmers worldwide using appropriate agricultural technology (Uphoff & Altieri, 1999). In fact, new rural development approaches and low-input technologies implemented by farmers and non-

governmental organisations (NGOs) have made significant contributions to food security at the household, national, and regional levels in Africa, Asia, and Latin America (Pretty, 1995). Increased production is achieved through technological approaches based on agronomic principles that emphasise diversity, synergy, recycling, and integration, as well as social processes that emphasise community participation and empowerment (Rosset, 1999). When these practices are optimised, improvements in productivity, production stability, and a wide range of ecological services, such as biodiversity conservation, soil and water conservation, and restoration, are achieved. They also enhance natural pest regulation mechanisms, and so on (Altieri et al., 1998). These results represent a breakthrough in achieving food security and environmental sustainability in developing countries. However, their potential and future dissemination depend on investment, policy support, institutional backing, and fundamental changes by policymakers and the scientific community, particularly CGIAR, which should focus its efforts on the 320 million poor farmers living in marginal environments. The failure to promote human-centred agricultural research and development, due to a shift in funding and expertise towards biotechnology, has curtailed the historic opportunity to increase agricultural productivity in an economically efficient, environmentally friendly, and socially uplifting manner.

11. Organic farming is the only solution to combat hunger in this country. It is sustainable and, unlike the Green Revolution hoax, it can solve the problem of food security without creating new and larger problems. Diversification, rather than genetic modification, can provide an abundance of micronutrients in the Indian diet. Additionally, there are numerous unknown compounds of nutritional importance that can be obtained through organic mixed farming, which preserves resources and biodiversity. All of this is made possible by microeconomic progress at the local and village levels, ensuring sustainability, security, and equitable distribution.

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 two groups of rats were fed potatoes.33 One group was fed potatoes that had been genetically modified with a lectin gene to enhance the potatoes' resistance to insects, while 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, while the rats that ate the non-genetically modified potatoes with the same lectin had none of those symptoms.

Table V. 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.

VI. FOOD QUALITY ORGANIC PRODUCTS: AN OVERVIEW

In our comparison above, we made the assumption that the quality of organically and conventionally produced foods is the same, with no difference in the nutritional composition of foods grown by the two farming systems. However, in the qualitative overview below, we will challenge this assumption and demonstrate that organically grown foods have higher nutritional value and pose fewer health risks.

Nutritional superiority and the health risks associated with food are two distinct aspects of food quality. Nutritional superiority refers to the presence of more nutrients and bioactive compounds, as well as higher quantities of these nutrients per unit weight. On the other hand, the health risks posed by a food depend on the presence of various chemicals and organisms that adversely affect human metabolism, leading to acute, chronic, or acute over chronic disorders.

During the process of writing this qualitative review, we examined hundreds of research papers and identified two schools of thought. One school supports the idea that organic food is superior to conventional food, while the other school maintains that there is no difference between organic and conventional foods. However, very few articles suggest that organic food is inferior to conventional food. Some articles have indicated a risk of Escherichia coli infection from consuming organic food, but this is not true because if manure has been properly composted, there is absolutely no risk. Therefore, based on a review of the research literature, one can reasonably conclude that organic food is either the same as or superior to conventional food, except in the case of poor-quality organic food.

Scientific research consistently supports the superiority of organic foods over conventional foods in several aspects. The protein quality in organic food is better than in conventional food. Organic foods contain higher amounts of minerals and vitamins compared to conventional foods. Donald R. Davis and colleagues conducted a study to evaluate potential changes in USDA nutrient content data for 43 vegetables between 1950 and 1999 and found that all 43 varieties showed a decrease in the six nutrients (ranging from 6% for protein to 38% for riboflavin). They concluded that "Mayer and our findings on global nutrient depletion may be the significant result of decades of crossbreeding high-yielding food crops, with unintended trade-offs leading to reduced nutrient concentrations." Paolo Bergamo and colleagues discovered significantly higher levels of healthy fatty acids and fat-soluble vitamins in organic milk and dairy products. Virginia Worthington conducted a similar study comparing the nutrient content of organic and conventional foods and observed a decline in crop nutrition in the United States and United Kingdom over the past sixty-five years, starting around sixty years ago when food was no longer naturally grown.

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

Table VI. 1. Nutrient content of organic versus conventional crops: mean percent difference, level of significance, number of comparison, and number of studies for statistically significant nutrients.

				Number of comparison+			
Nutrients	Mean % difference*	Level of significance p	Range	Organic higher	Organic lower	No difference	No. Of studies
Vitamin C	27%	<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%).

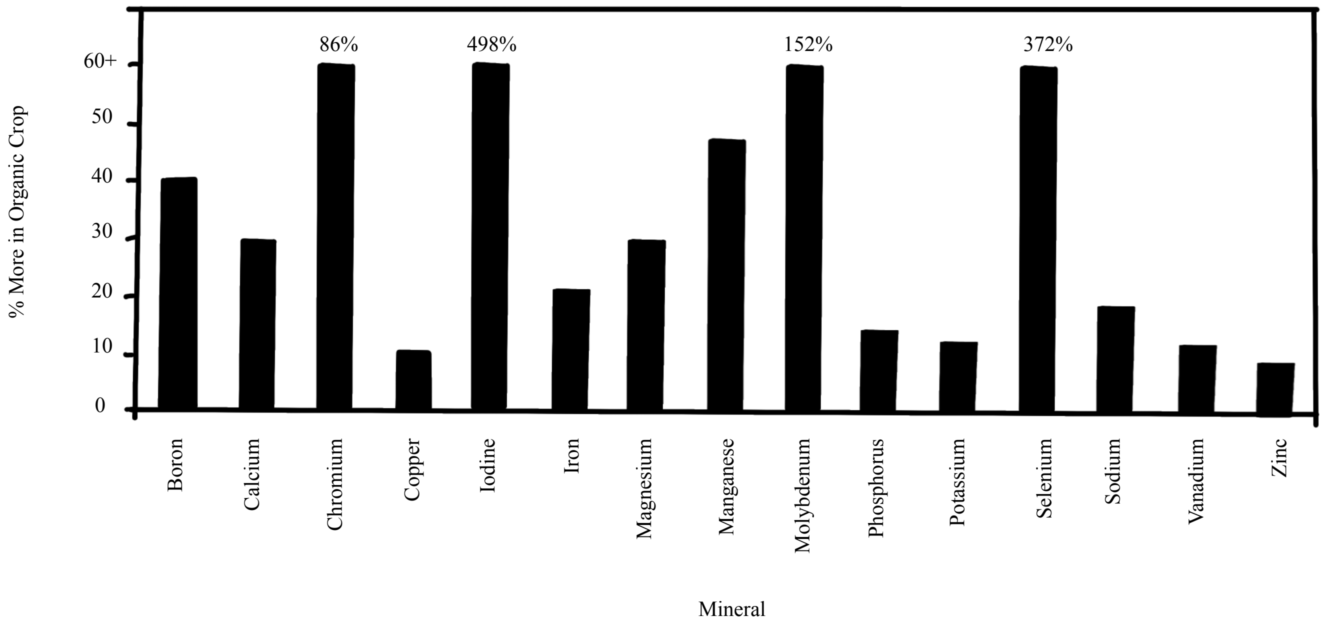
+ A comparison consists of a single nutrient in a single organic crops grown in one season compared to the same conventionally grown crop from the same season, for example, 0.30 mg of zine in organic cabbage compared to 0.25 mg of zinc in conventional cabbage, both grown in 1986.

Table VI. 2. Difference in nutritional content between organic and conventional vegetables: mean percent difference for four nutrients in five frequently studied vegetables.

	Nutrient*			
Vegetable	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%).

Figure VI. 1. Mean percent additional mineral content in organic compared to conventional crops.



Conventional agriculture is pulling a lot of land at an unsustainable rate, leading to land depletion. In turn, plants grown on depleted soil will suffer from a lack of nutrients. The consumption of these plants is a major source of malnutrition in the world. The idea was rightly given 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.

A report conducted by the Centre for Organic and professors from the Department of Horticulture at the University of Florida and Washington State University provides evidence that the average organic food contains 11 nutrients, 25 percent more than common foods. The report is based on estimated differences in nutrient levels across 236 comparisons between organic and conventionally grown foods.

Source: "New evidence confirms the nutritional superiority of plant-based organic foods."

One study found that organic soups sold commercially in the UK contained almost six times more salicylic acid than non-organic soups. John Paterson, a biochemist at the Royal Dumfries and Galloway Hospital, and scientists from the University of Strathclyde in Scotland analysed 11 brands of organic soups and compared their concentrations of salicylic acid to those of non-organic soups. Salicylic acid, responsible for aspirin's anti-inflammatory activity, has been shown to help prevent hardening of the arteries and bowel cancer.
The level of salicylic acid in 11 brands of organic vegetable soup was 117 nano-grams/gram, compared with 20 nano-grams/gram in 24 non-organic soups. The highest levels (1,040 nano-grams/gram) were found in organic carrot and coriander soups. Four of the regular soups had no detectable salicylic acid content.

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

Research by chemistry professor Theo Clark and undergraduate students at Truman State University in Missouri has found that organically grown oranges contain 30% more vitamin C than conventionally grown oranges. Presenting the results at the June 2 Great Lakes Regional Meeting of the American Chemical Society, Clark said he expected conventional oranges, which are much larger than organic oranges, to contain twice as much vitamin C. Instead, chemical isolation combined with nuclear magnetic resonance spectroscopy showed the highest levels in organic oranges.

Source: Science Daily, June 2, 2002.

A study commissioned by the Organic Growers and Retailers Association of Australia (ORGAA) found that commonly grown fruit and vegetables purchased from supermarkets and other commercial stores have ten times less mineral content compared to organically grown fruits and vegetables. For the study, tomatoes, beans, peppers, and turnips grown on a certified organic farm using soil regeneration techniques were analysed for mineral elements. The Australian Government Analytical Laboratory also analysed a similar range of commonly grown vegetables purchased from supermarkets. However, a major flaw in the study was that it compared farm-fresh produce with supermarket produce. As a result, there may be differences in freshness, which may affect the measured nutrients.

Source: Australian Organic Growers and Retailers Association, 2000, as cited in Pesticides and You, Vol. 20, issue 1, spring 2000, News from Beyond Pesticides / National Coalition Against Pesticides Abuse.

A comparative study conducted by researchers at the Research Institute of Organic Agriculture (FiBL) in Switzerland found that organically grown apples are superior to conventionally grown apples in terms of health-related parameters, taste (taste score, sweet and sour index, dietary fibre phenol content, and "vigor index" according to quality assessment methods for total quality assessment).

Source: "Are organic apples tastier and healthier?" F.P. Weibel, R. Bickel, S. Leuthold and T. Alföldi), Acta Hort. 517: 417427 (year 2000).

Research by Alyson Mitchell of the University of California Davis has shown that flavonoid content increases over time in crops grown in organically grown fields. The results of the study showed that organic tomatoes contained more quercetin and kaempferol aglycones (beneficial flavonoids) that were 79 and 97 percent higher on average, respectively, than conventionally grown tomatoes. In the study, Mitchell and colleagues compared the levels of major flavonoids in tomatoes harvested over a ten-year period from two suitable fields, one organically grown and one grown with conventional methods, including commercial fertilisers. The researchers analysed organic and conventional tomatoes that were dried and stored under identical conditions between 1994 and 2004. "Flavonoid levels increased over time in samples from this method. Organic treatments, while flavonoid levels were not significantly changed under conventional treatments," the report said.

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

A research team from the University of California, Davis has found that organic kiwifruit has a much higher total polyphenol content than conventional kiwifruit, which has higher antioxidant activity than conventional fruits. Research results also show that organic kiwifruit has a higher vitamin C content. The kiwis studied came from neighbouring vineyards on the same farm in Marysville, California.

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

At the 2005 International Congress on Organic Agriculture, Food Quality, and Human Health, Professor Carlo Leifert of the University of Newcastle reported the results that organically produced foods have high levels of antioxidants, higher chemical specificity, and lower mycotoxin levels compared with conventional samples, and organic cattle diets reduced the risk of E. coli infection while conventional grain-based diets increased risk.

A Dane's findings show that organic vegetables have higher levels of natural antioxidants called flavonoids. The randomised double-blind study had two intervention periods, with trial participants receiving either organic or conventional foods for three weeks. Results are based on tested blood and urine samples. The study was carried out by the Institute for Food Safety and Nutrition of the Danish Food and Veterinary Department, the Department of Human Nutrition, and the Centre for Advanced Food Research of the Royal College of Veterinary Medicine and Agriculture and the Department of Agriculture and Rural Development. National experiment from Risø.

Source: Journal of Agricultural and Food Chemistry, Vol. 51, No. 19, 2003, p. 56715676.

According to study results published by researchers at the University of California, Davis, organic fruits and vegetables have significantly higher levels of antioxidants than conventionally grown fruits. For the study, researchers led by food scientist Alyson Mitchell compared antioxidant levels in sustainably grown, organic corn, strawberries, and blueberries (using fertilizers but no herbicides or pesticides) and conventional organic. Antioxidant levels in sustainably grown maize have been 58.5% more than conventionally grown corn, while organically and sustainably grown puppets contain about 50% more antioxidants than conventionally grown berries. Organic and sustainable strawberries contain 19% more antioxidants than regular strawberries. The results were published in the February 26, 2003 print edition of the peer-reviewed Journal of Agricultural and Food Chemistry of the American Chemical Society. Research also shows that organic and sustainably grown produce contains more ascorbic acid, which the body converts into vitamin C.

"Marionberry, frozen, air-dried strawberries, and corn are grown using conventional, organic, and sustainable agricultural methods," said D.K. Asami, Y.J. Hong, D.M. Barrett, and A.E. Mitchell, Journal of Agricultural and Food Chemistry, 51 (5): 12371, 1241 (2003).

If we combine these additional numbers, the gap between the average nutrition produced per acre organically and the nutrient produced per acre conventionally increases dramatically. There are a number of cases where researchers have found the nutritional advantage of organic foods.

A report conducted by the Centre for Organic and professors from the Department of Horticulture at the University of Florida and Washington State University provides evidence that the average organic food contains 11 nutrients, 25 percent more than common foods. The report is based on estimated differences in nutrient levels across 236 comparisons between organic and conventionally grown foods. Source: "New evidence supports superior nutrition of plant-based organic foods."

One study found that organic soups sold commercially in the UK contained nearly six times more salicylic acid than non-organic soups. John Paterson, a biochemist at the Royal Dumfries and Galloway Hospital, and scientists from the University of Strathclyde in Scotland analysed 11 brands of organic soups and compared their concentrations of salicylic acid to those of non-organic soups. Salicylic acid, responsible for aspirin's anti-inflammatory activity, has been shown to help prevent hardening of the arteries and bowel cancer.

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Table VI. 3 - Figures of recent findings:

Study	Experimental Material	Parameters Analyzed	Findings	Reference
Asami et. Al., 2003	Marion-berry, strawberry, corn.	Total phenolics (TP), ascorbic acid (AA)	Increased TP and AA in organic and sustainable practices	26
Carbona ro & Mattera, 2001	Peach, pear	Polypgenoloxidas 2 activity (PPO), TP	Increased TP &PPO activity in organic fruit	23
Carbona ro & Mattera, 2002	Peach, pear	PPO activity, TP, AA, citric acid (CA), aplha-tocopherol (TH)	Increased TP & PPO activity in organic fruit; AA & AC 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 has higher Q, trends of higher K and lower I: higher urinary excretion of Q and K in organic diet	28
Häkkinen and Törröne n, 2000	Vaccinium berries, strawberry	Q, K, elegiac acid, p-coumarin 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, quin-gen-cai, no difference in green pepper; antimutagenic activity higher in organic samples; generally higher flavonoids in organic samples	25

As a result, there is a great deal of scientific evidence to support the nutritional superiority of organic products. Organic products contain more vitamins, minerals, and bioactive compounds than conventional products. We need these unique blends of nutrients to lead an active, disease-free life and improve the health of our entire population.

Anemia is very common in the Indian population, as shown by the National Family Health Survey II (1998-99), which indicated that 74.3% of children under three years of age were anaemic. Every pregnant woman in India is advised to consume iron and folic acid tablets, as most cases of anemia in our country are caused by iron deficiency in the diet. Do we not need to increase the iron concentration in plants to obtain more iron in our diet?

Similar correlations have been found between reduced dietary vitamin B-complex levels and psychiatric disorders such as stress and depression [24]. Do we not need more B-complex vitamins in our crops to increase the amount of this vitamin in our diets?

Do we not need higher levels of trace minerals in our crops to increase consumption and improve the overall health of our population? Do we not need higher levels of antioxidants, phytochemical, and bioactive compounds in our crops so that our population is better equipped to fight chronic diseases like cancer and diabetes?

We also need high levels of vitamin C in every Indian meal to reduce the amount of iron in our diet to a form that our bodies can absorb. The oxidised form of iron, which is not absorbed by humans, can be counteracted by drizzling antioxidant-rich lemon juice over the food. As a homemade experiment, cut an apple in half and drizzle lemon juice over one half while leaving the other half without lemon. The part without the lemon will turn reddish brown due to oxidation from the iron form to the iron form. This form of iron is not absorbed by the body and does not need to be consumed. The Indian diet is rich in phytates that make iron unabsorbable, partly explaining the prevalence of iron-deficiency anemia in India. We can counteract the effects of phytates by increasing the level of vitamin C in our diet, as vitamin C prevents the formation of soluble non-heme iron by phytates. The easiest way to increase the amount of vitamin C and antioxidants in the Indian diet is to grow plants with higher concentrations of vitamin C, antioxidants, phytochemicals, and bioactive compounds.

Let's consider another qualitative aspect of the food hazard presented by food. Organic foods contain fewer nitrates than conventional foods. Nitrate is the main form of nitrogen supplied to plants from the soil, and its content in food has always been a matter of uncertainty. Two possible effects of high levels of nitrates in the stomach are methemoglobinemia in infants and neonates (Craun et al., 1981; Avery, 2001b) and the formation of carcinogenic N-nitros compounds (BruningFann et al., Kaneene, 1993; Vermeer and van Maanen, 2001). While such nitrates have not been shown to produce carcinogenic effects in animals, they can be converted to nitrite by bacteria in human saliva and the gut, potentially reacting with amines and amides normally present in the body to form nitrosamines (BruningFann and Kaneene, 1993; Vermeer and van Maanen, 2001). Approximately 300 nitrosamines have been tested for carcinogenicity in high-dose animal cancer trials, and about 90% of them have been shown to be carcinogenic (Havender and Coulombe, 1996). Nitrosamine has the ability to initiate and promote the cancer process.

Figure VI. 2.

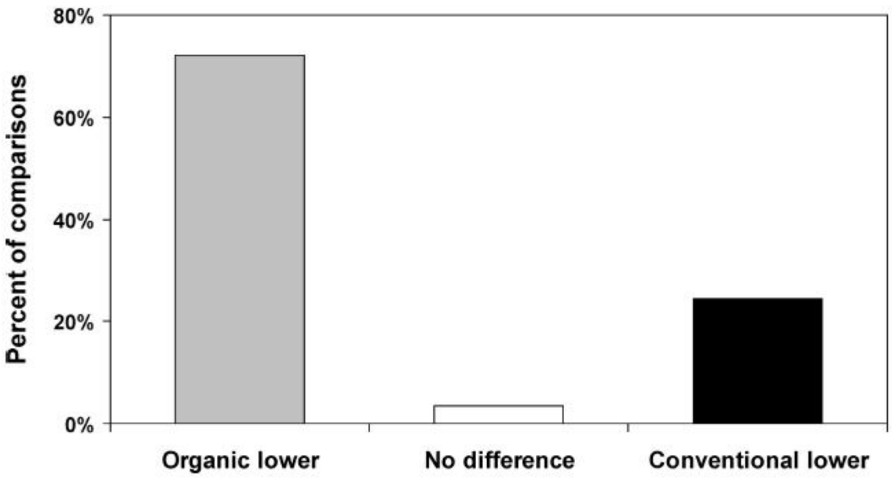

Figure VI. 2. Nitrate content of organic and conventional crops. The results from 18 published studies including a total of 176 comparisons on the nitrate content of organic and conventional crops, including beetroot, cabbage, carrot, celeriac, chard, corn salad, endive, kale, leek, lettuce, potato, 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).

In conventional agriculture, there are certain chemicals that are used wisely or unwisely. Most of these chemicals pose threats to the environment, wildlife, biodiversity and people. The world is experiencing species extinction, the development of resistant strains of pests and weeds, the development of dead zones in the oceans, desertification and salinization of farmland. Only 0.1% of the pesticides used reach their target, i.e. the pests. The remaining 99.9% has an impact on the environment. The debate of

The total impact of pesticides on health is very large. About 1600 different pesticides are used worldwide. Some of these chemicals are found at alarming levels in some animals by bioaccumulation. These chemicals are also found in breast milk. These fat-soluble pesticides bioaccumulate in humans and end up in breast milk [2]. Unfortunately, this breastfed infant was exposed to these toxic chemicals. DDT and its metabolites, dieldrin, aldrin, endrin, lindane, hexachlorobenzene, the insecticide cyclodiene, polychlorinated biphenyls, dioxins and dibenzofurans were among the many agricultural pesticides detected in human milk. The risk that these chemicals pose to a breastfed infant needs to be quantified. However, the risk is not insignificant but uncertain. Curl et al also found that children with a predominantly organic diet had significantly lower exposure to organophosphate pesticides than children with a predominantly conventional diet [25]. Dose estimates generated from pesticide metabolite data suggest that organic diets can reduce children's exposure from above to below the chronic EPA United States reference dose. period, thereby shifting exposure from a series of uncertain risks to a series of insignificant risks. Consuming organic produce is a relatively simple way for parents to reduce their children's pesticide exposure. Organic produce contains less pesticide residues and is less likely to contain residues of certain pesticides than conventional produce.

Figure VI. 3.

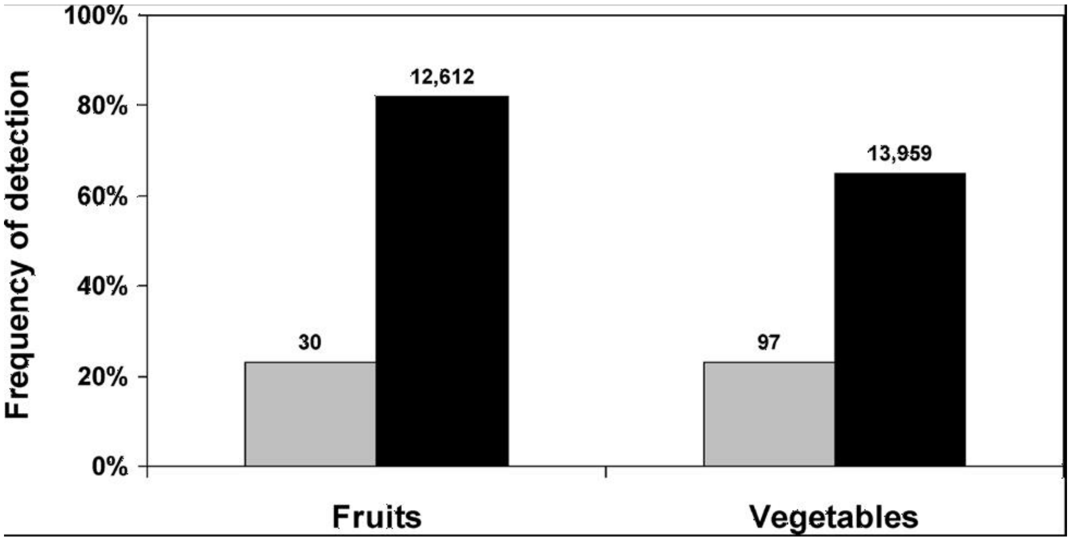

Figure VI. 3. Frequency of detecting at least one type of pesticide residue in organic and conventional fruits and vegetables. Data on pesticide residues in organically grown foods (gray bars) and foods with no market claim (assumed to be conventionally grown; black bars) were collected from the Pesticide 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 VI. 4.

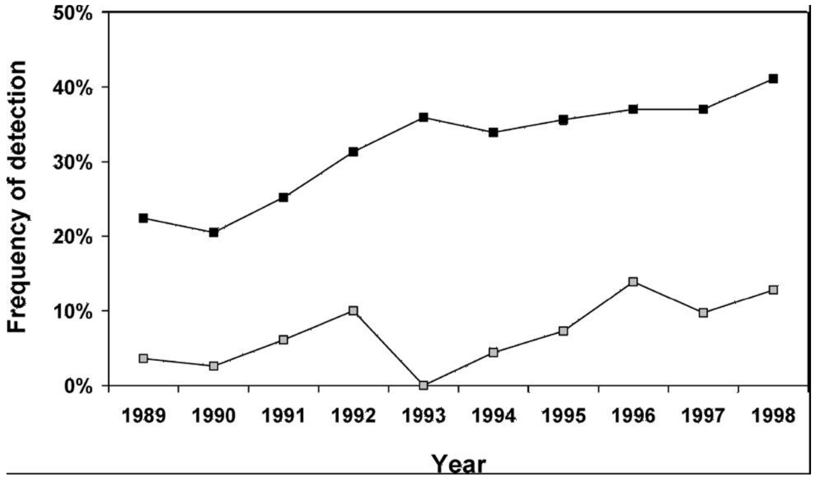

Figure VI. 4. Ten-year trends of contamination rates with pesticides of organic and conventional fruits and vegetables. Data on pesticide residues in organically grown foods (grey squares) and foods with no market claim (assumed to be conventionally grown; black squares) were collected from the Marketplace 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)

Table: VI. 3 - Comparison of organic & 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)		Mycotoxins

(a) vegetables and fruits
(b) Nitrophilic vegetables
(c) Foods of animal origin
(d) Heavy metal (e.g. cadmium, lead), dioxins, polychlorinated biphenyls, radioactive nuclides.

The Navdanya Pesticide Hazards Resource Handbook provides a more detailed list of pesticides and their health hazards. There is not a single organ or tissue in the body that is not affected by pesticides. Below is a table that provides an overview of the actual situation.

Table: VI. 4 - 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-tissue sarcoma, prostate leukaemia, non-Hodgkin's lymphoma, soft-tissue sarcoma, pancreas, lung, breast.
Organochlorine insecticides Arsenical insecticides Triazine herbicides	Non-Hodgkin's lymphoma, leukaemia Lung, skin Ovary

Data from Blair & Zahm (87)

Pesticides have both short-term and long-term effects on human health. The United Nations estimates that around 2 million poisonings and 10,000 deaths occur each year due to pesticides, about three-quarters of which occur in developing countries. Pesticides widely used in industrial agriculture have been linked to high cancer risks for workers and consumers and are coming under closer scrutiny for their link to endocrine and endocrine disorders. reproductive dysfunction.

VII. CONCLUSION

Health Per Acer is a correct solution to 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 stabilise 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 a 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 cognisance 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- maximising 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. Maximising nutritional production is rather a more appropriate approach than maximising 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 maximise 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 maximising 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 favour 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.

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