The Changing Scenario in Indian Agriculture: A Review

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Abstract. Farming is an important and key factor for the economy of developing countries. Since last several years, farmers once again welcomed many traditional farming systems to get crop yield for completion of food requirement. Although, traditional techniques are not much sufficient in new agriculture world because farming is getting new challenges from biotic and abiotic factors. New techniques and systems are getting popularity in present farming because of their important benefits which can solve all challenges on farming. In this review, new farming systems especially organic farming system and genetically modified crop system have been discussed along with traditional farming system in India. The aim of present review is to highlights the benefits of organic farming system and genetically modified crop system over traditional farming. A comparison has also been made between organic and genetically modified crop systems.

Keywords: Abiotic factor, biotic factor, genetically modified crops, organic farming, traditional farming

1. INTRODUCTION

Agriculture has undergone significant developments since the time of the earliest cultivation. Involvement of revelation of plants and animals in agriculture was developed around 10,000 B.C.E., altering of communities of flora and fauna were already started by earlier people for their benefit by other means such as fire-stick farming (Bar-Yosef and Meadows, 1995). Each farming system has its pros and cons in past as well as in present scenario. Like nature, change is an avoidable rule in agricultural practices as well. From ancient to present time we have seen development of many such patterns to get better quality and quantity using available resources with new dimensions. India being an agriculture based country is been discussed here.

1.1. History of agriculture in India

In India, agriculture started around 9000 BCE as a consequence of early farming of plants, crops along with animal’s domestication. Almost immediately people established life with the implication of practices developed for agriculture (Bowman and Rogan, 1999). Due to the occurrence of double monsoon harvesting were done twice a year (Baber, 1996). Barley, wheat and jujube were cultivated in the Indian subcontinent by 9000 BC (Dev, 2006). Varieties of tropical fruit like muskmelon and mango were indigenous to the Indian subcontinent (Gulati, 2006). The Indians also domesticated hemp and rice which was cultivated in the Indus Valley Civilization (Dev, 2006). It was also stated that rice cultivation was started during second millennium BC in Kashmir and Harrappan regions (Pillay, 1972). The basis of farming in Indus valley economy was mixed farming (Dev, 2006). The development of irrigation was made in the Indus Valley Civilization about 4500 B.C. Due to the development of irrigation prosperity grew in Indus valley civilization and eventually these leads to more sophisticated settlement of make use of drainage and sewers (Rodda and Ubertini, 2004).

In Vedic period the ploughing of top soil was done several times and seeds were spread. Definite succession of cropping was made from time to time. Cow dung was usually utilized in the form of the preferred fertilizer. Irrigation was adept accordingly in this period. The cultivation of jute was also done in India and was used to make rope and cordage in this period (Ray et al., 1985).

During ancient Mauryan-Empire (322–185 BCE) meteorological observations were made and categorization of soils were made for agricultural use
1.1. High Middle Ages (200–1200 CE): Early Common Era

In high middle Ages for sustained agriculture methodical ploughing, weeding, manuring, irrigation and crop safeguard was implemented (Burton, 1998). Water storage systems were also developed during this era. A dam named Kallanai was built during (1st – 2nd century CE) on river Kaveri during this period, and it is considered as one of the oldest water-regulation structures in the world still in use (Dev, 2006).

1.2. Different Agricultural practices in India

1.2.1. Traditional agriculture

The evolution of traditional farming was over the foremost 10,000 years of agriculture. Traditional agriculture is basically sustainable and steady farming system that has been employed for a number of generations and is able to produce the material required by its producers. Through traditional farming a production of incredible variety of household crops and livestock, and systems of farming was made possible. Several conventional farmers in the developing world are still employing these farming methods that are in equilibrium with the nearby ecosystems, steady, sustainable and highly organized. Conventional agriculture symbolizes the novel system of farming that developed through the interaction of societal and ecological systems. This system involves the rigorous use of local information and natural wealth supporting biological diversity by means of alternating practices. Conventional farmers centered on methods that preserve soil fertility, check the loss of topsoil, grip water in the soil and produce steady harvests. Farming system of this type is distinguished above all by a high degree of biodiversity (Burton, 1998; Acquaah, 2002; Alam, 2014).

1.2.1.1. Types of traditional farming (Deshmukh, 1986)

Forest gardening,

Forest gardening is considered as one of the oldest agro-ecosystem, it is a plant- based food production system. Useful trees and plant species were identified, protected and improved and undesirable species were eliminated. Likewise superior species were selected and incorporated in family’s garden (Altieri, 1987).

Agro-Pastoralism,

In India agro-pastoralism incorporated threshing, planting crops in strips either of two or of six and storing up of grains in granaries (Baber, 1996).

Mixed farming,

Mixed farming was the basis of the Indus valley economy (Thulasamma, 2006). In mixed farming arable farming is mixed with rising of livestock hence it is an agrarian system (Myrdal and Morell, 2011). Often the dung from the cattle is used as manure for increasing the production of cereal crops. Horses and cattle raised and used for haulage and bullocks to haul the cart and the plough (Grigg, 1974).

Shifting cultivation,

It is also known as ‘slash and burn’ farming. It is a system in which forests are burnt for the release of nutrients which support for several years in the cultivation of annual as well as perennial crops (Acquaah, 2002). Then the plot is left as it is to grow again as a forest, mean while the farmer moves to another plot. Basically it is an ancient agricultural technique in which forests or woodlands are cleaned by burning of trees and plants so that the land can be used for farming. It is subsistence agriculture which typically uses little technology or other tools. It is a typical part of transhumance livestock herding and shifting cultivation agriculture (Tony, 2007).

1.2.1.1.1. Characteristics of Conventional farming

(a) Traditional farming center on threat diminution.
(b) Perennial vegetative cover of soils is attained through it.
(c) System diversity: Farm systems based on numerous cropping systems, and cropping systems are based on a combination of crops, and crops with varietal and other genetic variability upholds system diversity.
(d) Tropic complexity impending natural systems: Manifold interactions among plants, weeds, pathogens and insects occur in conventional farming because of which complexity occurs and remain maintained in natural systems.
(e) Traditional farming systems also promote genetic diversity: In India the Mangifera indica (mango), has been bred to produce 1,000 varieties, and some 100,000 varieties produced by one species of rice, Oryza sativa. India had more than 40 thousand varieties of rice, as of 1987, only 30 were commonly grown (Green, 1987).

1.2.1.1.2. Disadvantages of traditional farming

(Lynda, 2000). In this period facilitation like construction and maintenance of dams were done along with provision of horse-drawn chariots (Singh and Yadava, 2003).
During the old days, agricultural technology was not well developed compared to now. People did not use any machinery to farm their land, machinery which are much more efficient replaced those animals used in the agricultural.

Previously, farmers had to be depended on land suitability, climate factor and the availability of adequate water supply before planting a crop that suited those criteria.

In the old days, farmers worked on their land to produce crops for their own domestic use because with the methods used in traditional agriculture were not very effective to produce huge amount of crops. The crop yield was really low according to the population in traditional agriculture.

Pest management and disease management were not so effective in traditional agriculture.

Due to environmental factors and undeveloped techniques overall production was low in traditional farming.

**1.2.2. New farming systems**

Due to many challenges in traditional farming system, new techniques are used now days. In new techniques, organic farming, genetically modified crops, vertical farming, polytonal farming, green house farming and multi-crop farming are main farming system. Two most important systems are described:

### 1.2.2.1. Organic farming system

Organic farming is a method of crop production that involves much more than choosing not to utilize pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones. It works in agreement with nature and involves using techniques to get good crop yields without harming the natural environment. Organic farming, evolved on the basic theoretical expositions of Rodale in the United States, Lady Balfour in England and Sir Albert Howard in India in the 1940s, has progressed to cover about 23 million hectares of land all over the world. In modern times, the general population is more aware about environmental benefit that’s why organic farming is gradually getting popularity throughout the world (Behera et al., 2012).

#### 1.2.2.1.1. Overview of organic farming system

This system relies on such techniques like crop rotation, green manure, compost, and biological pest control. This system focused on the appropriate application of soil organic matter to augment soil fertility. Animal dung, crop residue, green manure, food processing wastes and biofertilizers are some resources which are usually used for enhancing soil fertility in this system (Ramesh et al., 2005).

There are many types of organic farming system which are mentioned here:

- **Biodynamic farming** was developed by Rudolf Steiner. This method emphasizes the use of manures and composts and excludes the use of artificial chemicals on soil and plants. It treats soil fertility, plant growth, and livestock care as ecologically interrelated tasks.

- Do nothing or Natural farming is established by Masanobu Fukuoka, Japanese farmer (Fukuoka, 1975). This farming is a closed system, in which system demands no inputs and imitates nature (Mirret, 2001). This farming have refined into five ideologies that are no use tillage, fertilizer, pesticides, weeding and pruning.

- Bio-intensive farming system is based on closed system which main aims maximum crop yield from minimum area of land. This system is focused on simultaneously improving and maintaining the fertility of the soil (http://bionica.org/classes-library/biointensive-method/). Other systems of this organic farming are holistic management, permaculture, SRI and no-till farming (Murray, 2011).

#### 1.2.2.1.2. Major benefits of organic farming system

(a) **Crop yield and plant diversity**

Many reports have shown that higher yield in organic agriculture system observed than comparable traditional agriculture. Although, many studies reported that in organic transition effect period (first 1-4 year of organic agriculture in a land) crop yield decline, followed by a yield increment with well developed biological activity of soil (Liebhardt et al., 1989; Peters, 1994; Neera et al., 1999). A report on trial of organic cotton at Nagpur (Maharastra; India) showed that after 3 year transition period of organic farming, organic farm produced as a large amount of cotton as that cultivate with them (Rajendran et al., 2000). A similar report conducted in Punjab, clearly indicates that after initial 3 years of organic farming, this system gave higher or equal yields of different cropping systems in comparison of chemical farming (Kler et al., 2002).

Now days, this system seems to be beneficial for biodiversity. Organic methods of this farming such as rotating crops to build soil fertility and naturally raising animals helps to promote biodiversity, which returns health to each species. Many reports support this positive effect of organic farming in enhancement of soil fertility and enrichment of biodiversity (Stockdale et al., 2000; Rundolf and Smith, 2010; Rundlof et al., 2010). Rundlof and Smith (2010)
demonstrated in their study that organic farming practice at a local and a landscape level independently can influence plant species richness. Another report supports this fact and reported that extension of organic farming could contribute to restoration of biodiversity in agricultural landscapes (Rundlof et al., 2010).

(b) Organic farming and environmental earnings

Many reports have indicated that significant environmental amelioration through conversion from conventional farming to organic farming is awesome (Kler et al., 2001). A review report showed that in 12 environmental factors out of 18, organic farming performed better than conventional farming (Kler et al., 2002). Organic farming is a system in which chemical and pesticides are avoided for crop production. So, organic farming discourages environmental exposure to these harmful inputs and fight for environment protection (Kler et al., 2002).

This system can be helpful in the fighting against green house effect. It has shown by Rodale Institute Farming Systems (U.S.A) that an organic agriculture system can actually reduce CO₂, play an important role in slowing down the climate change. In fact, the Rodale research shows that: "If only 10,000 medium sized farms in the U.S. converted to organic production, they would store so much carbon in the soil that it would be equivalent to taking 1,174,400 cars off the road, or reducing car miles driven by 14.62 billion miles" (Stolze et al., 2000).

(c) Insect and ailment control in organic farming

In organic farming system, prevention from pest and disease is done by means of naturally resistant crops against disease and pest or by selecting suitable sowing times that avoid pest and disease and subsequent pest epidemics. Other methods which generally applied to control pest and disease attack are; encouraging natural biological agents for control of diseases, insects; rotating crops; by using chemical for trapping pests (Ramesh et al., 2005).

Some reports have indicated that organic crops are more tolerant and opposing to insect attack. Organic rice is reported to have bulky cell wall and lesser level of free amino acid than customary rice (Lotter et al., 1999; Kajimura et al., 1995). Studies have reported that root diseases are less severe in organic crops than conventional crops because of regular and prolong use of diverse crop rotation, crop mixtures in organic farming (Van Bruggen, 1995; Azcon Aguilar and Barea, 1996).

(d) Nutrient management and safety of organic foods

In recent time, organic farming system is getting value and popularity due to its positive results in nutrient management and safety of food produced. Crop rotation and use of varieties of crops are suitable method in this system because of potential to balance the demand of nitrogen for crops (Ramesh et al., 2005).

Organic foods as conventional foods have same quality and safety standards according to CODEX General Principles of Food Hygiene and Food Safety Programmes (Joint FAO/WHO Food Standards Program, 1999). Studies have found out that Nitrate contaminants are lesser in organic food in comparison of conventional food (Woese et al., 1997; Muramoto, 2008).

1.2.2.2. Genetically modified crops system

Genetically modified crops (GM crops) are crops of which, the DNA has been modified using various genetic engineering techniques. The aim of making GM crops is to set up a new characteristic to the plant which does not occur in nature in particular plant species e.g. in food crops various pest resistant, abiotic stress resistant, spoilage resistant, chemical resistant genes have been incorporated along with those genes which have improved the nutrient profile of the crop. In India this system is not very popular because of serious socio-economical reasons but the system is getting attention at the level of research for various factors.

1.2.2.2.1. Making of GM crops

As earlier stated, GM crops are developed in a laboratory conditions by altering their genetic configuration. This is generally done by adding up one or more genes to a genome of selected plants using various gene manipulating methods (Boyle, 2011). However, most of the GM crops by and large are developed using biolistic method (particle gun) or Agrobacterium tumefaciens mediated transformation method. The best known example of making of GM crops is the use of Bt (Bacillus thuringiensis) genes in the crops like corn and cotton. It is a naturally occurring bacterium that produces crystal (cry) proteins which are fatal to insect larvae. Bt crystal protein genes have been transferred into crops, facilitating the crops to produce its own pesticides against insects like corn borer (Whitman, 2000). Tobacco and Arabidopsis thaliana are the most accepted GM plants due to well settled and trusted methods of transformation, effortless propagation and well studied genomes (Koornneef and Meinke, 2010; Banjara et al., 2012). Hence, they serve as model organisms for other plant species also.
1.2.2.2.2. Advantages of GM crops

GM crops grown or under trial development, have been tailored with traits according to benefit of farmers, customers, and industry. In recent times, few researches have been targeted the development of crops which will be important for developing nations such as insect resistant brinjal for India (ISAAA Pocket K No. 35), and insect-resistant cowpea for Africa (CSIRO 2006 press release). Some major advantages are as follows:

(a) Stress resistance

GM crops are engineered to tolerate various kind of stresses like drought, cold and high soil salinity. Cold stress causes sensitive seedlings viability. For making GM crops targeted for cold stress tolerance, an antifreeze gene isolated from cold water fish has been successfully incorporated into plants such as tobacco and potato. As a result, these GM plants are able to survive in very cold temperature that normally destroys seedling viability (Kenward et al., 1999).

To overcome the drastic effect of drought and salt stress on the yield of crops, some GM crops have been engineered that can survive with long periods of drought or high salt concentration in the farm (Zhang and Blumwald, 2001).

(b) Pathogen resistance

Pathogens attack on crops resulting in distressing monetary loss for farmers and shortage of food in developing nations. Generally, farmers use chemical pesticides for preventing their crops from these pathogens. BT Tobacco, corn, rice and many other crops have been generated that express genes encoding for insecticidal proteins from Bacillus thuringiensis and can help eliminate the excess use of chemical pesticides (Moellenback et al., 2001; US Patent 6313378, Nov 2001).

GM squash, papaya and potatoes have been developed to combat certain viral pathogens, such as cucumber mosaic virus (CMV) which is contagious to a wide variety of plants (National Academy of Sciences, 2001). However, the use of these is somewhat restricted in India.

(c) Improved nutrition

Other important aim of making GM plant is to improve nutrition in crops. Some examples of GM crops under development include a genetically tailored cassava with lesser cyanogen glucosides content and better-quality of protein and other nutrients (called BioCassava, funded by the Bill & Melinda Gates Foundation) (Sayre et al., 2011), while "Golden Rice", rice containing an unusually high content of β-carotene (vitamin A) was produced by researchers at the Swiss Federal Institute of Technology Institute for Plant Sciences (Burkhardt, 1996). By making of golden rice malnutrition from developing nations including India can be conquer (Burkhardt, 1996; St. Louis, 1999) Strategies are also underway to develop golden rice that also has increased iron content. An international group of scientists has developed a corn variety (M37W) derived from South African white corn which is enriched with vitamins with 169 fold increase in β carotene, 6 fold the vitamin C and 2 fold folate, but still it is not in production anywhere due to some issue (Naqvi et al., 2009). Camelina sativa has been modified in research labs to produce plants with elevated content of oils parallel to fish oils (Ruiz-Lopez et al., 2013).

(d) Herbicide resistance

"Roundup Ready" is one of the most widespread types of GM crops. Monsanto has created this strain of soybeans genetically modified to be not affected by their herbicide product Roundup (http://www.biotechknowledge.monsanto.com/biotech/knowcenter.nsf). Tobacco plants have been produced to be resistant against herbicide bromoxynil (MacKenzie, 1994). Crops have been commercialized that are resistant to the herbicide glufosinate (Gianessi et al., 2002).

(e) Production of biofuels

Genetically modified Jatropha sp., has been modified for its traits improvement for better fuel product. Recently, Swiss-based Syngenta has get USDA approval to market genetically developed maize seed trademarked ‘Enogen’ which covert its own starch into sugar to speed up process of ethanol conversion into biofuel (Lochhead, 2012).

(f) Role in Bioremediation

GM plants have also been developed and used for bioremediation of tainted soils. GM plants containing genes which produce bacterial enzymes responsible for bioremediation have been utilized to remove heavy metals like mercury, selenium and organic pollutants such as polychlorinated biphenyls (PCBs), RDX and TNT from soil (Meagher, 2000; Martins dos Santos et al., 2008).

1.3. Organic farming system verses GM crops

Organic farming system and GM crops both have their characteristic value on the basis of their benefits for human being. But many environment activists are against the use of GM crops. In India, many objections are coming in the light by which organic...
farming is seems more beneficial than GM crops in following aspects:

Unintended harm to non-targeted organisms is major disadvantage of GM crops: For example in BT crops, produced Bt toxins, kill many species which are not harmful for crops. This study was re scrutinized by the USDA, the U.S. Environmental Protection Agency (EPA) by which concluded that this fact may be imperfect (Niller, 1999; Powell, 2000), while in case of organic farming system, farmers never face such problem.

Genetic contamination -Possibilities of desired gene transfer into non-targeted species are much high in GM crops: For example if GM crop of herbicide tolerance and weed will cross breed, ensuing in the transfer of the genes for herbicide resistance from source crops into weeds. These “superweeds” would be then become herbicide tolerant which would be harmful for crops (Whitman, 2000). On the other hand, this kind of problems is not faced in organic farming system.

Human health issue is very controversial issue in the regarding of GM crops: Allergenicity is one of the most negative aspects of GM crop uses. Many children in US and Europe have affected with allergy to transgenic peanut and other food. That’s why proposal of making transgenic soybean through Brazil nuts gene was dump (Nordlee et al., 1996). Other unknown effect also observed on health like effect of GM potatoes on digestive tract on rats but these studies are not fully confirmed yet (Ewen and Pusztai, 1999; Enserink, 1999). Moreover, a gene of snowdrop flower, lecintin introduced into potatoes is known as toxic for humans so these potatoes were never used for humans (Whitman, 2000). All these kind of issues are not faced in organic based farming based system because there are many kind of natural source used for nutrient management of crops (Ramesh et al., 2005).

According to economics concern, bringing of GM food to market is a very extensive and expensive process. Many researches are remains to solve unidentified risk of GM foods with human health which are time taking and costly. So GM crops are not economically favorable (Whitman, 2000). On the other hand, organic farming is seems to be favorable to economic point of any country because of less financial input (Ramesh et al., 2005).

2. CONCLUSION

Farming is backbone of economy in most of the countries, including India. Humans are using different techniques to enhance crop yield from many years before. But in present time that traditional techniques are not completely fruitful according to ever increasing requirement of food because this type of farming has many drawbacks like diseases and pest management, making them economically less beneficial. So, new techniques are trying to get more yields of crops with reference to environment health. In new techniques, organic farming is getting fame due to its environmental benefits with yield enhancement, nutrient management, health and safety; economical benefits and most important pest and disease management. If government of India will get some major steps in favour of organic farming to get it popular in farmers, this technique will surely play a major role to get better results in agriculture. On the other hand, GM crops have future possibilities to solve major problems in agriculture but it takes time to sort out many harmful aspects like negative effect on human health are coming to the reference of GM crops. In Future, major researches will be required for GM crops to convert it 100% beneficial for humans. So, more researches and financial support from government are required for exploration of organic farming and GM crops in the realm of common agriculture practice.

Classification of organic food is based on whether pesticides and other chemicals are used in production of that particular food or not. While, the nutrient profile of the food being grown based on the quality of soil and air. Hence, organic food is more costly, it's more difficult to grow as one can't do it in huge fields and saturate it all in chemical. It maintains health just fine, probably better because ingestion of fewer chemicals.

GMO foods aren't inherently bad. However, the methods they use to add new genes into the plants genome isn't a "cut and paste" affair as they'd have you believe. We don't understand yet the DNA and genes entirely. Very few genes are actually ‘one-gene-one-effect’. Genes act together in many ways and researchers are just at the initial stages of perception. If we add one gene in that is completely foreign to an organism, it's very hard to tell exactly what effect it has. It may demonstrate the trait we want it to, but it may be doing something else that is unseen to the eye.

Once the GMO plants are out there, it is almost impossible to take it back any negative effect because seeds scatter uncontrolled, causing gene flow. We owe it to ourselves and the world to properly investigate - like several years long studies - not a few weeks on a few animals, which is what is out there, and, these studies frequently have shown negative effects on the digestive tract. A lot of these studies are swept away and not made public.

It is also interesting to note that the manner a lot of GMOs are declared as "safe" is by research done by the company that is hoping to sell the product. Does that appear correct? Of course they would like it to be declared safe! A lot of these studies have been
reviewed by outsiders to the company and the methods used to gather the "safe" results are doubtful. Hence, GMO is not essentially a bad craze within a limit because we need to make sure about each facet of GM crops especially in India. In present scenario Government of India banned the genetically modified crops and taking several steps for the promotion of organic crop system.

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