Adoption of Tissue Culture in Horticulture

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By

Ch. Krishna Rao

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CHAPTER I

INTRODUCTION

Society provides human, physical and cultural resources for the growth and development of science and technology. Developments in Science and Technology influence Society. Technology and Society are obviously in a reciprocal relationship. All social Institutions are affected by Technology (Jerry Gaston, 1980). Changes in social institutions may be brought about by several other factors in addition to science and technology. The study of social change acquired significance after the Second World War, because of the increased emphasis on planned change and development by the developing countries, after they gained political independence.

Understanding influence of technology in bringing about social change has assumed greater significance in sociological research with the development of technologies such as Information Technology and Biotechnology. The present study aims at understanding the influence of the adoption of tissue culture, one of the techniques of biotechnology, on the social organization of production, and social relations in the production process, attitudes, knowledge and practices associated with cultivation of fruit crops, which have been commercially important in the context of increasing demand for fruit.

Social Change: Concept and Existing Theories

Social change implies change in the social system over a period of time. MacIver and Page (1986) viewed social change as distinct from cultural change, and defined social change as "change in social relationships, every change in man's relations to his environment leads to some change in his relation to his fellow beings". Harry M. Johnson (1966) defines social change as a change in social structure. Social structure includes structural elements like statuses, roles, groups, sub-groups, and collectivity. Hence, change in any one of these structural elements may be regarded as social change. Bottomore (1962) defined social change as change in the social structure (including changes in the size of society) or in a particular social institution or in the relationships between institutions.

Social change has certain distinctions on the basis of the dimensions of change. These are (i) time (ii) magnitude. Short-term and long-term changes represent the temporal dimension of change. By and large, large-scale change corresponds to long-term change, and small-scale change to short-term change. The number of units is affected by change: the more units affected by change, the greater the magnitude of change.

Culture Change

Structural and cultural changes are interrelated. Changes in social structure, the system of social relations in terms of class, caste, gender and power relations, may trigger changes in culture, attitudes, values, and systems of meaning. Similarly, change in culture may bring about changes in social structure. Sociologists have been engaged in formulating theories about social change. Sociologists have been focusing on understanding the factors that bring about social change in the economy, polity and culture.

Structural-Functionalist Theory

Structural-functionalist theory assumes that there is order in society and there is consensus on the value framework that underlies the order. Each institution serves certain functions in maintaining the order of the society. When events from outside or inside disrupt the social system, the social order, comprised of interrelated social institutions, makes adjustments to restore stability. This perspective has its roots in the work of the early sociologists, especially Durkheim (1950), Herbert Spencer (1903), and Radcliff-Brown (1952). Among contemporary scholars, it is most closely associated with the work of Parsons (1951) and Merton (1969). According to Parsons (1951), the sources of change can be classified as endogenous (from within the social system) or exogenous (from outside the social system); very often, both sources work together and influence the magnitude of change (Coser, 1971).

Structural-functionalists argue that change generally occurs in a gradual fashion and not in sudden, violent, radical fashion. Change in the social order, which is based on consensus on the value framework that underlies the social order, undergoes change with gradual changes in the values related to different institutions that comprise the social order. Even changes that appear to be drastic have not been able to make a great or lasting impact on the core elements of the social and cultural system. A change, according to Parsons (1951) and Merton (1968), comes from basically three sources:

i) Adjustment of the system to exogenous changes (e.g. War, Conquest);
ii) Growth through structural and functional differentiation (e.g. change in the size of the population through births and deaths);
iii) Innovations by members of groups within society (e.g. inventions and discoveries in a society).

Because structural-functionalists' concern is for 'social order,' they are often criticized for not dealing with the problems of social change adequately.

Conflict Theory

Conflict theory takes the principle of dialectic as central to social life. Conflict theorists do not assume that societies evolve smoothly from lower to higher or more complex levels. According to this theory, every pattern of action, belief, and interaction tends to generate opposing reaction.

Marx, in his theory of class struggle, developed the idea of social change resulting from internal conflicts. For Marx, social change is not a smooth, orderly progression, which gradually unfolds in harmonious evolution. Marx believed that the class struggle was the driving force of social change. Marx's views on history are based on the idea of the dialectic. Dialectical movement represents a struggle of opposites, a conflict of contradictions. Conflict provides the dynamic principle, the source of change. Contradiction between relations of production and forces of production manifests as class conflict.

Haralambos (1980) paraphrases Marx's theory of social change as follows: societies change from one type, characterized by a given mode of production, to another type characterized by another mode of production, through revolutionary politics.

Conflict resolution through revolution results in a new social formation, which allows the growth of productive forces up to a point. When contradiction between relations of production and forces of production becomes sharp, the contradiction relates the conditions for another revolution through class struggle. The growth of forces of production, which is a result of the capacity to produce, is essentially a function of scientific and technical knowledge, technological equipment, and the organization of the labour force (Raymond Aron, 1965).

Science, Technology and Social Change: Intertwining Relationship

Both structural-functional theory and Marxist theory recognize the significance of inventions and discoveries for social change. For structural-functionalists the inventions and discoveries bring about social change gradually. For Marx, science and technology are part of the forces of production which come into the sharp contradiction with relations of production. As contradictions cannot remain unresolved beyond a point, the contradiction manifests itself as class conflict and paves the way for qualitative change in the relations of production.

Science in the most general sense is any systematic study of physical and social phenomena. Ina restricted sense; science is the study of physical and social phenomena involving observation, experimentation, appropriate quantification and the search for universal general laws and explanations. And science could be referred to as any specific branch of knowledge in either of the above senses (e.g. social sciences).

Science is social in nature, because science is pursued by human beings in a social environment to produce new knowledge. Science is concerned with understanding the basic natural process in the universe; technology is concerned with developing innovative processes and products (Jerry Gaston, 1980).Science is the act of 'knowing' and 'technology' is the act of doing. This conception of science and technology has been challenged by Haraway (1998),who argued that science and technology are interpenetrating systems, and she uses the term' techno-science' to describe this (quoted in McKenzie and Wazcman, 1999; pp. 41-49).

In sociology, science is seen as involving a complex process of social production, working upon and transforming previously existing knowledge. As a socially located phenomenon, science must also be recognized as occurring in a social context in which the cultural values and interests of the scientist, and also the wider interests, always potentially influence the production of knowledge. According to David Jary and Julia Jary (1995), sociology of science is concerned with the study of the social processes involved in the production of scientific knowledge, as well as the social implications of this knowledge, including technology. For Durkheim (1915), science is a specialized social activity. Michael Mulkay (1979) called science a "socio-cultural phenomenon". According to J. D. Bernal (1983), science is a major factor in maintaining and improving production. Science and technology have been recognized as important factors that bring about structural and cultural changes in human society.

As mentioned earlier, technology is one of the important sources of social change, and technological change produces transformations in all spheres of social life.

Technology is a vitally important aspect of the human condition. Our lives are intertwined with technology from simple tools to large technical systems. Some societies are more responsive to change than others. The response to change depends upon the level of technological advancement. Today, the distinction between science and technology is difficult to maintain because of the interpenetration of science and technology.

Technology: Definitions

Technology constitutes generally, tools, machines, instruments, weapons, appliances; physical devices and associated skills, methods, procedures, routines activities, and so on. The rise of man from his apelike ancestors has depended on his ability to make and use tools. In the few thousand years that have passed since the discovery of agriculture, man's power over his surroundings has been growing at an ever-increasing rate (Nicol Russell, 1978).

According to the International Encyclopaedia of the Social Sciences, technology is described as "bodies of skill, knowledge, and procedures for making, using and doing useful things" (Julius Gould, William L. Kolb, 1969).

Technology refers to the application of cultural knowledge to tasks of living in the environment. It centres on processes that are primarily biological and physical, rather than psychological and social processes. They represent the cultural traditions developed in human communities for dealing with the physical and biological environment, which includes the human biological organism itself. Technology is defined here as a method of using science in producing goods and services. It is a parameter of the system and determined by scientists and technologists (Nicol Russell, 1978).

The term technology also implies: (a) a body of means and skills characteristic of a particular civilization, community or period; (b) technical methods used in a particular field of industry. In other words technology has three components: i) hardware, i.e. the tools, equipment; ii) software, i.e. knowledge underlying the construction of hardware; and iii) orgware, i.e. social organization required for implementation of the technology.

David Jary and Julia Jary (1995), observe that technology is the practical application of knowledge and use of techniques in productive activities. This definition reflects a sociological concern with technology as a social product, which incorporates both the ‘hardware’ of human artefacts, such as tools and machines, and the software knowledge and ideas involved in different productive activities. More recent developments in energy production and information technology may, however, depend upon innovations derived from organized science, sometimes technology is referred to in the narrow sense as machines, whereas wider definitions include productive systems as a whole and even work organization and the division of labour. The narrow definition tends to treat technology as autonomous and ignore the social processes involved in the design and choice of technology; more inclusive definitions make it difficult to distinguish between the technology and the social arrangements with which it is related.

Relationship between Science and Technology

The relationship between science and technology is one of the most controversial problems confronting historians and philosophers interested in technology and its history. John Staudenmeier (1985) has pointed out that they have argued ceaselessly over competing interpretations of the relationship. The philosopher Mario Bunge (1966) has maintained that successful technological practice depends on the systematic application of scientific knowledge. Science influences history in two major ways: i) by the change in the methods of production, and ii) by the impact of its findings and ideas on the ideology of the period.

All science is simply an intensified form of technology, generated by the material needs of society. Throughout the greater part of history, improvements in techniques have arisen mostly under the stimulus of the immediate advantage they would give to certain individuals or classes (Bernal J. D, 1983).

Technology has changed radically in quantity and quality over the millennia. The rise of technological sciences occurred only with the creation of a community of practitioners separate from either the body of inventors or that of scientists. The new group of specialists, who came to be called engineers, possessed scientific training, a grasp of mathematics and physics, and an intimate knowledge of technology. During the first decades of the 19th century, iron became a common material in the construction of building, bridges and other structures.

Technology is not neutral with respect to history, class, country and factor endowments, and technological changes take place with the development of technological knowledge (Stewart Richards, 1983). Technology is a social activity, all the social sciences-Sociology, Economics, Psychology, Political Science, Anthropology - are also pertinent to studies of its social origins and influences of technology.

Donald Cardwell (1965) argued that the growth of science owes a great deal too technological practice, as technological artefacts have provided tools and the techniques for exploring the new ideas. Edwin Layton (1977) argues that science and technology are not abstract functions of knowing and doing; they are social (p. 209).

According to Otto Mayr (1976) this search for a single, timeless account of the relationship between science and technology may be so fruitless because it is a fundamentally flawed endeavour. The critical terms, “science” and “technology”, Otto Mayr (1976) argues, cannot be treated as invariant across different periods of history and different cultural contexts. These terms should be treated as historical objects whose invention and ever-changing definition and mutual relationship cry out for explanation.

Theories of Technology Development

As mentioned earlier, society provides the context and conditions for growth and development of technology. One of the theories of technology is technological determinism. This theory assumes that technology is both autonomous and has determinate effects on society. Technology is seen as a political and as an independent variable in social change. This assumption is criticized for ignoring the social processes and choices, which guide the use of technology and the variety of possible social arrangements, which coexist with different types of technology. In Langdon Winner’s words (Mackenzie, 1985) technology could be political because it is designed, consciously or unconsciously, to open certain social options and close others. The technological deterministic approach looks at technology as an independent factor that causes changes in the social economic, political and cultural aspects of human society. The socio-technical systems approach focuses on functional groups, i.e. builders, inventors, engineers, managers, and financiers, and on inventing and controlling technological systems, heterogeneous social classes/groups, disciplines, organizations and institutions which become part of the ‘seamless web’ (Hughes, 1986).

The Actor-Network theory emphasizes the relations between actors of technical and non-technical worlds (Callon, 1986; Latour, 1987; Law, 1987).The notion of ‘actors,’ physical and social, that are involved in the development of technological systems, replaces the conventional categories distinguishing animate and inanimate things and forces.

The general perception is that new technologies are developed or existing technologies are upgraded to enhance the efficiency whether in the field of agriculture or industrial production. The latent object of all technological improvement is economic efficiency. However, the consequences of scientific and technological advancement are not just confined to economics, but pervade all areas of life. This means that there are always two sides to the advancement of science and technology. On the one hand, the advance of instrumental rationality or of seeking the most efficient means to achieve a given end entails an increasing mastery over the natural and social worlds. On the other, this process also brings about the increasing impersonality of the external conditions of life. That is why Brubaker (1984) endorses Weber's argument that regards science and technology as central to the process of "disenchantment" or the increasing extension of instrumental rationality throughout the social world.

The pervasive influence of technology on society in the contemporary world is much more widely noticed and seems qualitatively different from that of past societies. This is for the following obvious reasons. One, the present day tools are more powerful than any before. For example, while the domestication of animals and invention of the wheel literally turned food production around and lifted the burden from man's back, nowadays computers have freed human beings from all their hectic and complex labours. Compared to the rifle of yester year, nuclear weapons of the modern day could wipe out mankind from the earth. Second, as the quality and finality of modern technology has improved, it has brought the society to explicit awareness of technology as an important determinant of human beings and institutions (Mesthne, 1972).

Technology has been viewed as an important tool in the advancement of production processes. As a consequence, production processes have become complex skill-based, mechanized, and automated. Marx (1974), while analysing the division of labour in the age of technology-driven industrial revolution, distinguished between organic manufacture and heterogeneous manufacture. In organic manufacture, the basic raw material passes through a sequence of stages in which it is converted into the finished product. In heterogeneous manufacture, different parts are manufactured by a large number of detail workers and these parts are collected for the final assembly worker. For example, the making of a watch used to be an individual product of one craftsman, but in the 19th century, it became the social product of a large number of workers, like dial makers, hairspring makers, screw makers and gliders. Marx (1974) did not consider the worker who assembles all the parts at the end in order to make a watch as a craftsman, despite his skill, since he did not work directly for the customer, but for the capitalist who organized the coordination of various component parts (Goody, 1982).

One of the most significant outcomes of technological advancement in the production process during the eighteenth century was the Industrial Revolution. The most important change brought about by the Industrial Revolution was transformation of craft based production to industrial production. Craft based production lacks specialization and division of labour. However, industrial revolution led to specialization and a high degree of division of labour. For example, making pins was broken into 18 separate operations which could be carried out by as many workers with an astonishing 240 fold increase in productivity, using the same technique and tools (Adam Smith, 1776).

In the late twentieth century, with the application of biotechnologies, work in agricultural production processes is undergoing a transition comparable in scope and magnitude to the Industrial Revolution. The Industrial Revolution, brought about by capital investments in machines, was so revolutionary that it substituted mechanical in place of animal and human energy (Simpson, 1999). However, the bio-revolution seems to be more revolutionary, brought about by capital and intellectual investments in general and Research and Development labs that substitute for field and farmer.

Technology and Social Change

As mentioned above, technology is one of the important sources of social change, and technological changes produce transformation in all the spheres of agriculture, industry and services. Technology improves efficiency, productivity. It affects social relations among workers in the work place, and also in class relations in a society. Sometimes technological choices are governed by the goal of controlling the process of production and the workforce involved in production.

The changes in the levels of and the nature of technology in any sphere of activity, be it production, education or entertainment, will have an effect on various aspects of social institutions and culture, thus leading to social change. The choice of an alternate and new technology in the place of an old technology will alter the roles of relationships between individuals, their attitudes, and their values in the course of time, and this leads to social change.

The knowledge underlying technology, interlinked beliefs and values, the degree of complexity and the degree of contact it has with the cultures of other societies, are important sources of social and cultural change. Rahman (1978) believes that science and technology bring deeper changes in attitudes and value systems, and technology satisfies the basic needs and helps in removing traditional inequalities in society (Sharma and Qureshi, 1978).

Ogburn (1979) coined a term “cultural lag” to describe the disequilibrium between material and non-material aspects of a culture. He pointed out how changes in non-material culture, such as values, belief, norms, family, or religion, lag behind changes in material culture, that is, technology, means of production, and output of the economic system.

Ogburn has pointed out that social change is the result of a combination of new inventions. Since cultural change influences the social relations of people, it also tends to increase the pace of social change at a greater tempo through time. Often material inventions result in undermining the established social patterns and giving rise to new patterns as a result of them.

Technological innovations are accepted readily from the utility point of view, but social norms and values are more traditional and get adjusted much more slowly and gradually compared to the changes in material conditions. According to Ogburn (1979), various parts of modern culture are thus not changing at the same rate, since there is a correlation and interdependences between several parts, or rapid change in one part necessitating change in the correlated parts of culture.

As per the Human Development Report (2001), technological change, like all changes, poses risks as shown by the industrial disaster in Bhopal (India), the nuclear disaster in Chernobyl (Ukraine), the birth defects from thalidomide, and the depletion of the ozone layer by chlorofluorocarbons. This report also remarked that technological breakthroughs without attendant social and infrastructural change could produce distorted results, being witnessed in India today in the simultaneous existence of grain stocks and hunger in several states, albeit drought related (HDR, 2001); agriculture is one of the areas where technological improvements have been contributing to increased productivity over time.

Technology and Agriculture

Technology plays a very key role in agricultural productivity. According to the 1997 World Bank Report, about 12% of the world’s total land surface is used to grow crops, about 30% is forest or woodland, 26% is pasture or meadow. The reminder, one third, is used for other human purposes or is unusable because of the climate or topography. In 1961, the amount of land supporting food production was 0.44 hectares per capita. Today it is 0.26 hectares per capita, and based on population projections, it will be in the vicinity of 0.2% a year and continues to fall.

Under these circumstances, there is a need to increase productivity per hectare to feed the increasing population with the decreasing amount of land available for cultivation. Global agriculture has been steadily gaining in production over the past few decades. However, it has not been successful in overcoming the problem of rising demand, which is a result of the increasing population. The challenge is immense because, by 2050, global demand for food may be three times greater than today. Moreover, during the past two decades the production growth has declined, dropping from 3% annually during the 1960s to 2.4% in the 1970s, and finally to 2.2% in the 1980s.

On a global basis, average yields per hectare of wheat, rice and maize have climbed fairly steadily since 1961. The aggregate figures nonetheless mask some disturbing regional trends. In Asia, for instance, rice yields rose drastically in the 1960s with the introduction of new varieties and management practices. Yields continued to increase in the 1970s, but in the 1980s began to level off or decline.

According to Wenke (1980), agriculture was made possible by advancements in technology. Similarly, agriculture allows for further increases in population. As people come into contact with one another, there is diffusion of crops, which has resulted in increased diversity of foodstuffs to consume. Norman Borlaug (1981) lists twenty-three plants that form the base of world agriculture, as indicated in Table No. 1.1.

Over 80% of harvested food by weight is from plants, and just about half of all food and calories are from the five cereal grains. When domesticated plants are diffused to new regions, varieties are bred and adapted to fit the environmental circumstances. Most of the plants have been crossed with local varieties to fit micro climatic and cultural needs. It is interesting to note that the majority of wheat and rice production of the third world comes from plants which share a common ancestry. This is a cause of concern, as this is a prescription for disaster because this will lead to a loss of genetic diversity among the crops.

According to Krimsky and Wrubel (1996), although cultivation of crops was carried out through the past ten to fifteen thousand years, the technological advancements started only 200 years ago. These include mechanization, plant-breeding hybridization, chemical based pesticides and herbicides, and chemical fertilizers. The Green Revolution, a set of techniques involving use of high yielding varieties, assured irrigation facilities, use of chemical fertilizers and pesticides, institutional credit facilities, etc., has radically transformed the agriculture scenario in third world countries.

Table No. 1.1: The twenty-three main crops that form the base of world agriculture

Category	Varieties
Five cereals	Wheat, rice, maize, sorghum and barely
Three root crops	Potato, sweet potato and Cassava
Two sugar crops	Sugar cane and sugar beet
Six grain legumes (pulses)	Dry beans, dry peas, chick pea, broad bean, ground nut and Soya bean
Three oil seeds	Cotton seed, sunflower and rape seed (the pulses groundnut and Soya bean are also oil seeds)
Four tree crops	Banana, coconut, orange and apple

Source: A Theory of Technology: Continuity and Change in Human Development, Thomas R. DeGregori, Ames: The Iowa State University Press, 1982.

Green Revolution Technology in India

In India, the Green Revolution was heralded in the mid-nineteen sixties with the introduction of high yielding dwarf varieties of Mexican wheat and some exotic varieties of paddy on a selected scale. Parthasararthy (1971) stated that the Green Revolution altered social relationships on the farm, caused shift of power within the rural sector from one class to another, and in addition implied fundamental changes in farm economy and in the inter-relationships between the farm and external world. He summed up that it was an Agrarian revolution/Agricultural transformation.

The Green Revolution is the net outcome of a particular type of agrarian system covering a wide variety of measures to enhance the agrarian output. This revolution is based on high yielding varieties of seeds (HYVS) with closely associated agricultural technology, manures, chemical fertilizers, insecticides, pesticides, weedicides, biological stimulators, along with capital investment under well-guided irrigation facilities, i.e., mechanical, chemical, biological and hydrological inputs are essential for such agrarian transformation.

Introduction of institutional inputs with regard to land reforms, consolidation of land holdings, banking system and credit facilities, associated service infrastructure in the form of rural link roads, rural electrification tube well irrigation, marketing support, storage facilities, etc., have also been instrumental in bringing about the Green Revolution. These institutional inputs have brought structural changes in agrarian economy in the country. Keeping all other facilities aside, the introduction and developments in the field of irrigation - tube wells and canals - have been most rewarding in the genesis of the Green Revolution.

Spatially, the Green Revolution is limited to certain parts of the country where necessary infrastructural development in associate aspects is better than other regions. The most prominent among such areas are North-Western Rajasthan, Punjab, Haryana, Chandigarh, Delhi, Western Uttar Pradesh, Regions of the Northern Plains, Krishna-Godavari Delta, Coastal Tamil Nadu (Thanjavur Area), and parts of Maharashtra.

The Green Revolution is appreciably localized in some particular areas of toiling farming communities like the Jats (Punjab, Haryana, Western Uttar Pradesh),the Reddys (Andhra Pradesh) and the Gounders (Tamil Nadu),who have been entrepreneur cultivators since ages past, and they carry almost a mystical love for their farm holdings (Singh, 1974). In Punjab and Haryana, besides an economically viable and socially acceptable technological package, the public polices and service provided were conducive for giving a lead in the field of agricultural affluence (Chopra, 1982).

As per Surender Singh's perceptions (1992), regional disparities have been widened in India in rural development after the Green Revolution. This has led to many socio-cultural and politico-economic repercussions in the country.

Like land reforms, farm machinery has also been instrumental in augmenting farm production. Farm machinery is the direct form of energy input in the agrarian sector. Farm machinery has resulted in several structural changes in agrarian economy in India. The tractor is the basic piece of farm machinery, which is capable of supporting other mechanical inputs. Punjab has only 1.53 per cent of the total geographical area of the country, but has over 25 per cent of the tractors and 8 per cent of the tube wells of the country (Surender Singh, 1998).

Similarly, the highest ratio of stationary threshers, combine harvesters, tillers, harrows, puddles and chemical-spraying apparatus etc. in Punjab, is also proving the relationship between the Green Revolution and farm mechanization. The process of farm mechanization has been directly instrumental in the realization of the Green Revolution.

Increased productivity, area, and production of certain crops have also influenced the market mechanism in the agrarian sector. Over 60% of the food grain production in Punjab, Haryana, part of north-western Rajasthan, and western Uttar Pradesh is rendered surplus to be marketed. Farm input requirements also increased tremendously with the advent of the Green Revolution, demanding huge investment in a traditional static agrarian landscape. It has resulted in the stimulation of institutional infrastructural development in rural areas, which indicates the consequence, as well as the stimulator, of agrarian development.

Technological transformation of agriculture in India has not resulted in dramatic changes, and moreover, its localized nature has set a chain reaction for surrounding peripheral areas for agrarian reforms and development. Rural roads have also proved to be carriers of agrarian progress and a means of rural development. It has eased the transportation of inputs and marketing outputs.

The self-sufficiency of food grains in India may be ascribed to the Green Revolution. Annual food grain production in the country was 51 million tonnes in 1948, which touched 120 million tonnes in 1976, 150 million tonnes in 1984, and 151 million tonnes in 1986, recording an overall growth of three times in thirty-seven years. Suchan increase in the agrarian sector has never been recorded in India. It has been possible due to the increase in cropping intensity. This development has not only made India self-sufficient in food grains, but has also generated a deep-rooted confidence of feeding its fast increasing population.

The realization of the Green Revolution in India is primarily achieved through expansion in irrigation facilities. In 1949-50, the total irrigated area in the country was little over 19 million hectares, which increased to over 63 million hectares in 1983-84, and 70.4 million hectares in 1986-87, recording an overall growth of 3.7 times in thirty-seven years. It has resulted in all round changes in endogenous and exogenous linkages of agriculture's, agricultural community, villages and society, breaking the isolation of the peasantry. The total estimated potential of irrigation in the country has been estimated at around 113 million hectares. This increase is possible in the northern, western and southern regions of the country, and these areas have already out-run other areas in agricultural yields (Soni, 1987).

The Green Revolution has been the cause of the unusual spread of rice (a wet crop) to relatively dry areas of the country, notably in Haryana, Punjab, and North-Western Rajasthan, due to the assured supply of water for irrigation from canals and tube wells. Similarly, wheat has perpetrated in non-traditional areas of Haryana, Rajasthan, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, west Bengal, and Assam, giving a new dimension to our agrarian landscape. The constant rise in production is the outcome of balanced interaction among various favourable forces, including proper inputs, encouraging policies, and quick adaptability of the farm community (Singh, 1987). The Green Revolution has not only changed the agrarian landscape but also helped other economic activities based on agro-products governing a new set up to farming systems.

Food grain production in Punjab was 32 lakh tonnes in 1960-61, which touched the figure of 172 lakh tonnes in 1985-86, recording an overall increase of 5.4 times in 25 years, resulting in socio-economic changes in rural Punjab. During 1968-69, wheat recorded an increase of 229.5 per cent, rice 1221.2 per cent, sugarcane 20.9 per cent, rapeseed 80.1 per cent, and mustarded 126.9 per cent, which, except the sugarcane, is much higher than the national average. The Realization of the Green Revolution comes through the increased productivity of cereal crops. In 1966-67, the average yield of wheat in the country was 8.8 quintals per hectare, which reached 13.8 quintals per hectare in 1971-72, and 18.2 quintals per hectare in 1982-83, recording an overall increase of about 2.1 times in sixteen years.

In the corresponding period, wheat yield in Punjab was 15.1 quintal per hectare in 1966-67, which rose to 24.1 quintals per hectare in 1971-72, and 30 quintals per heater in 1982-83. In Haryana, it was 14.3 quintals per hectare in 1966-67, 20.4 quintals per hectare in 1971-72, and 25.2 quintals in 1982-83. Growth in yield in Punjab was two times and in Haryana 1.8 times. On average, the yields in Punjab and Haryana are numbers one and two in India. Similarly, increasing yield in other crops has also been recorded. The level of yield indirectly reveals the level of inputs for enhancing production and also indicates the potentialities (Singh, 1987).

The phenomenal rise in area for cereals and their production may be attributed to the carefully planned inputs strategy in the field of judicious use of fertilizers, high yielding seeds, and availability of water for irrigating the thirsty lands, along with crop protection programmes, various incentives, subsides, and procurement of cereals by various Government agencies to provide the economic umbrella to the farming community and avoiding the situation of glut in the market. This has all resulted in the orientation of the agrarian system in the country in favour of cereal crops, which has deeply influenced other crops (Singh, 1987).

Socio-Economic Impact of Green Revolution Technology

Socio-economic impacts of the Green Revolution have been different in various areas according to geographic and socio-political environment. It has averted famine and hunger, despite the brunt of the population explosion in various parts of the globe, including India.

So it may not be improper to designate it as the food grain revolution. No doubt, the Green Revolution has heralded the era of self-sufficiency in food grains, but not without repercussions and problems in the socio-cultural and economic-political fields, because the dynamism of the Green Revolution has been introduced into a tradition-bound, static, rural society in India. The process of change in the traditional rural societies is usually very slow, and accepted values are cherished despite their outmoded nature.

Agriculture is a land-based occupation, which is a non-elastic and immovable resource. After the Green Revolution, the significance of landholdings has tremendously increased along with their social values. It has also increased their demand, and with the increasing productivity, this demand is also rising fast. Land holding is fast emerging as the point of social power and status. As the new techniques are not favourable for small holding farmers, so such people sell their meagre holdings and become landless labourers. It has also been observed that the farmers with medium holdings (6-12hectares) are eager to increase their holdings. An important relationship exists between land and people who strive about the nature of property rights, distribution of ownership and control of land, system of land division, and settlement patterns (Smith, 1959). Such relationships are constantly changing in the areas of the Green Revolution.

Land transaction directly influences the distribution of holdings according to size. The numbers of large and medium sized holdings increase, and small sized ones are abolished due to land transactions. Thus the position of operational land holdings' size seems to be controlled by economic and technological forces. Heralding of the Green Revolution has made the traditionally popular system of tenancy cultivation unpopular, and the holding owners now prefer to cultivate their holdings themselves, owing to enhanced returns. The Green Revolution has also adversely affected the share-crops, tenant farmers, and landless agricultural labourers, because 40 percent of farm households (over 8 hectares) are economically capable of investing in the Green Revolution. It has made the rich farmer richer and has resulted in the concentration of wealth and rural power in the hands of rich farmers, while the poor peasants have not benefitted at all (Dutt and Sen, 1986).

Similarly, benami transfers of the land on a very large scale in these areas have also adversely affected the poor and landless farmers, as the Government could get very little surplus land to be distributed among them. The Green Revolution has caused a decrease in the number of small and medium farmers due to economic and technological constraints. It has resulted in an increase in the number of relatively large holdings either by selling or leasing of the land.

It has also caused a significant income differential between the income of farmers and the farm labour. In Punjab, the farmers' income produced an increase of about 195 per cent during 1979-80, but the increase in the income of farm labourers could rise only up to 114 per cent during the corresponding period (Arora, 1987). It has widened the economic gap in the rural areas, which will have its own impact on the socio-economic stratification of the rural society. The higher risk-bearing capacity of large farmers, their greater political power, and control over the developmental resources and agencies have provided them access to credit and input supply systems, while the farmers with relatively limited economic capacity languish behind.

With the advent of the Green Revolution increasing economic returns, the farmers have been encouraged to enlarge their holdings, either by purchase or encroachment on to the common lands, reclaiming the sub-standard areas, or clearing the fruit plantations adjacent to the towns or cities. This tendency is widely prevalent in agriculturally rich areas. Particularly cutting of fruit plantations around the settlements has made them devoid of their traditional green belts. New plantations of dwarf species giving fruits early are of very restrictive utility for green belt purposes. Track gardening around the urban centres has also now become a most potent factor for clearing of the plantations.

Fast growth of towns and cities has also adversely influenced the fruit plantations on the outer periphery of the old parts of the towns and cities, both for agricultural and colonization purposes.

Notable changes have been recorded in agriculture after the Green Revolution. Agricultural labour is one of such fields that have recorded notable changes. It has also influenced the occupational structure due to the increased productivity, mechanization, and replacement of traditional farm techniques with modern methods. Certain types of agriculture have become labour intensive and produced a unique labour cycle. Local labourers have migrated to the cities and towns in the neighbourhood for more remunerative jobs, small business, or self-employment, keeping the residence in villages. All this had resulted in a wide gap in labour availability and requirements.

Consequently migration of labour from distant areas increased. Factors of the cropping pattern and its nature also affected the supply of labour. Rice cultivation in the Punjab area has increased at a very fast rate, and it has penetrated to totally new and non-traditional areas even in southern Punjab. But the local cultivator is not conversant with its cultivation. So the required labour comes from eastern Uttar Pradesh, Bihar, eastern Madhya Pradesh and parts of Orissa. According to an estimate, such a labour force for crop-husbandry may vary from four to six lakh people (Grewal, 1988).

Local labour joins this work only during the peak season of sowing and harvesting when the wages are at the maximum in the year. Thus the traditional labour-farmer relations have changed from Jajimani relations to financial relations on a contractual basis. In some aspects of agriculture, mechanization has also affected the labour negatively, resulting in the need for labour for various farm jobs, which were previously done manually, causing unemployment. Growing unemployment in rural areas will have its own socio-economic consequences.

The Green Revolution has caused a serious disturbance in the cropping pattern in its sprawl. The traditional crop rotation was soil fertility conserving and enriching.

Fertility recharges are essential to get better yields during the next crop. But in the new crop rotation, one soil-exhausting crop is followed by another soil-exhausting crop, with no intervening period of rest and fertility recharge for the soil.

Introduction of new factors in the agrarian landscape in under-developed areas sometimes produces unique and unprecedented results. The introduction of canal irrigation into previously dry areas has produced such noticeable changes in various parts. It has even become the ultimate cause of out-migration and large scale land transactions, because the farming communities of the areas were not aware of the irrigational know-how, which attracted people from irrigated areas. Land transition rendered local people landless labourers. Later it became the cause of social tensions and rising economic disparities, which disturbed the special fabric in a peaceful society.

Singh (1974) propounded that though the term Green Revolution has a global acceptance in academic parlance and social recognition, in the Indian context, as per Singh (1974),the Green Revolution term conjures in the minds of many people a vision of agricultural prosperity, which is not in consonance with the reality (Singh, 1974). Dantawala (1987) reasoned that the Green Revolution was not spread in all types of agro-climatic regions, and further he exemplified that, in the context of attaining food self-sufficiency, less than 15 per cent of the area under food grains in the country (mostly in the GR belt) has contributed as much 56 per cent of the increase in food grain production in the post-Green Revolution period.

As per Surendra Singh (1992), the Green Revolution in India has changed the traditional subsistence farming system to a market-oriented production system. It resulted in multi-facet socio-economic changes in rural areas. The concept of increasing returns per unit of area and per unit of time is the basic consideration. The traditional native farming technology was replaced in the Green Revolution areas in the country, which has been instrumental in some structural changes in the agrarian set-up.

The technological inputs, in the form of tractors and associated implements, tube wells and pumping sets, electricity, threshing and winnowing machines, along with combine harvesters etc. have resulted in positive gains everywhere. Associated biological, chemical, and water technology led to a continuously increasing volume of harvest. Structural change in the agrarian sector encompasses a cross-section of inputs and outputs closely related to various types of farming. Consequently the resultant influence will be different in various areas. These changes have also brought a pattern of crop specialization in India because the infrastructural development proved favourable for particular types of crops, while restrictive for others, e.g. regular growth irrigational facilities have restricted the growth of dry farming crops.

Green Revolution Technology, according to Himmat Singh (2001), paved the way for a new development in Punjab; it eliminated the 'Jajimani' system, and the 'Sefi' and 'Begar' systems, which involved servitude. The demand for new skills and labour led to the breakdown of caste-based occupations and encouraged inter- and intra-generational mobility. There was a real increase in wages and work opportunities for the labour class. It brought a new system of wage labour, like contract work, that grew in importance due to new agricultural technologies leading to better terms, more work for women and less child labour. According to Himmant Singh (2001), new technology has benefited small and marginal farmers.

According to Bhalla and Chadha (1983) the impact of Green Revolution technology in Punjab not only led to accentuation of inequalities, but also resulted in perpetuation of poverty and destitution. According to them, any capital-intensive technological change, by its very nature, was bound to benefit only the upper strata of peasantry and may lead to an accentuation of tensions in the countryside.

Some of the technological change may have direct consequences; other changes may not be directly caused by technological factors, and they may have indirect consequences. The acceptance of a few innovations may not always bring in considerable social change, but the social change could be a cumulative effect of many innovations (Nicol Russell, 1978).

Development of production and productivity has resulted in demand for the creation of certain amenities in rural areas, like drinking water, surfaced roads, transport services, health and sanitation facilities, regulated markets, regular supply of electricity and further electrification, creation of more storage facilities close to the villages, improved housing facilities, educational facilities and local availability of consumer goods to avoid unnecessary commutation.

Transfer of the cultivated land also testifies to the fact that, during the period of the Green Revolution, the large farmers are increasing their real assets while the marginal farmers are selling their small pieces of land and moving to the urban areas in search of employment. Uprooting people who were born and brought-up in a farmer's family leads to psychological depression and social tensions (Hussain, 1987).

Such changes in the socio-economic scenario in rural areas are also leading to changes in other sectors, causing polarization of landless labourers, marginal farmers, share-croppers, and labourers unemployed due to the mechanization of agriculture. This polarization is becoming a great danger to the peace and tranquillity in the rural society.

The potential to improve plant and animal productivity and their proper use in agriculture relies largely on newly developed DNA biotechnology and molecular markers. These techniques enable the selection of successful genotypes, better isolation and cloning of favourable traits, and the creation of transgenic organisms of importance to agriculture. Together, these genetic techniques are both an extension and an integral part of classical breeding, contributing successfully to shortening.

Limitations of Green Revolution Technology

David Tillman (1998) reasoned that, although the Green Revolution in agriculture met the food needs of most of the world's population, it paved the way for contamination of groundwater, release of greenhouse gases, loss of crop genetic diversity and eutrophication of rivers, streams, lakes and coastal marine ecosystems (contamination by organic and inorganic nutrients that cause oxygen depletion, spread of toxic species and changes in the structure of aquatic food webs).

It also unclear whether high-intensity agriculture could be sustained because of the loss of soil fertility, the erosion of soil, the increased incidence of crop and livestock diseases, and the high energy and chemical inputs associated with it. But, as per David Tillman, the hallmark of high-intensity agriculture is its dependence on pesticides and chemical fertilizers, especially those containing nitrogen. Since 1960 the worldwide rate of application of nitrogen fertilizers has increased by several times, and now exceeds 7 tonnes of nitrogen per year. In a nutshell, with the Green Revolution, productivity reached a plateau; environmental hazards increased and raised social inequalities. It is in this context that biotechnology becomes an important technology for the improvement of crops.

Biotechnology: Setting New Technological and Social Agendas

Biotechnology is often hailed as the new 'revolutionary' science. Undoubtedly, it has meant some very big changes in certain fields of strategic and applied science, as well as ushering in new high-tech biological products. Like any other technology, however, its impact and direction reflect the interests of those making use of it and not some asocial unfolding of an inevitable scientific path. Revolutions depend on the interaction of human agency, and social structures and technological revolutions are no exception. There is nothing necessarily revolutionary about any technology; it depends on the way it is adapted by people in specific social circumstances (Webster, 1991).

Moreover the apparent 'novelty' of biotechnology in the late 1970s can also be overplayed, as, like any other field, it has depended on prior developments in biology and biochemistry. At the same time, however, simply because this is the case, we would be wrong to assume, for example, that all biologists in the late 1960s would have considered genetic engineering, the most significant biotechnology, a serious proposition, and a do-able task. Some, such as Stent (1968), even believed the heyday of molecular biology to have come and gone.

Biotechnology: Definitions

Biotechnology is broadly defined by the Congressional Office of Technology Assessment (OTA, 1984) as "any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plant or animals, or to develop microorganism for specific uses". The fermentation of beer, the making of cheese, and the baking of bread can all be considered "biotechnological" processes, given the use they make of yeasts.

Biotechnology is the application of biological methods or processes to produce useful products. The ancient Egyptians were credited with the invention of fermenting beer by using yeast. Several conventional biotechnology processes and approaches, such as fermentation, are in use in India. Indians have been making curds by using biological methods for centuries. Biotechnology was in practice for ages to make fermented foods and drinks.

Biotechnology is defined as the application of biological organisms, systems, or processes, to manufacturing and service industries (John E. Smith, 1988). Biotechnology is the use of living organisms and their components in agriculture, food and other industrial processes (John E. Smith, 1988). While agriculture is a source of livelihood for millions of farmers, biotechnology inputs into it can enhance productivity, improve quality of the produce, minimize adverse environmental impact, and increase sustainability and income of the farmers. Today biotechnology includes (a) fermentation techniques, (b) tissue culture, (c) embryo transfer, (d) cloning, and (e) genetic engineering.

Modern Biotechnology became prominent after the invention of the recombinant DNA in the Biochemistry Department of Stanford University in 1972 by Paul Berg and Dale Kaiser (C. R. Bhatia, 2002). It was shown that genetic material can be cut at specific sites by using the restriction enzymes and these pieces can be cloned, spliced, transferred and expressed in a heterogonous organism. This made it possible to transfer and express genes into cells of other organisms. Genes can now be synthesized and expressed in the desired organism. This is also called genetic engineering.

Plant Biotechnology: An Overview

Plants and their products have been necessary components of the material base on which the complex structures of human societies have been raised, historically, whatever the period and the mode of production.

Crop improvement is as old as agriculture itself, and the earliest agriculturalists were engaged in a simple form of biotechnology. There is a substantial amount of genetic diversity within species. And germ plasma—the complement of genes that shapes the characteristics of an organism—differs from individual to individual. Out of each year's harvest, farmers selected seed from those plants with the most desirable traits. Over thousands of years the slow but steady accumulation of advantageous genes produced more productive cultivars. Following the rediscovery in 1960 of Mendel's work illuminating the hereditary transmission of traits, this global process of simple mass selection was augmented by the systematic "Crossing" of plants by scientists with the express purpose of producing new varieties with specific characteristics.