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The Changing Scenario of Agriculture

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Research in science or for that matter in any field of activity is *curiosity-driven*. Einstein was curious to know how the laws of motion of planetary bodies given by Newton would behave if time is measured relative to some external frame instead of being treated as absolute. It led to the famous special theory of *relativity* published in a reputed journal in 1905. Mendel, an Austrian monk, was curious to know, through hybridization experiments on garden pea plants, whether factors for characters like color of flower, seed coat color etc. blend in F_1 generation or preserve their identities and reappear in subsequent generations in definite proportions. He published his results, as two laws of inheritance, in an obscure journal, in 1865 with the result that they remained unnoticed for as long as 35 years when in 1900 they were rediscovered independently by De Vries in Holland, Correns in Germany and Tschermak in Austria. In very recent times researchers observed defense mechanism adopted by bacteria to repeated viral infections in a cup of yoghurt and got curious to know whether this trick of bacterium could be used to cut not only viral DNA but *any* DNA sequence in *any* organism at a selected gene position. This led to the genome editing (GE) technology *CRISPR/Cas9,* released as a biotechnological tool in 2012. This illustrates the boosting of curiosity by technology. There are several instances of curiosity-cum-technology driven researches in plant genetics and breeding as discussed in an article entitled 'Some Aspects of Plant Genetics and Breeding in the context of Scientific and Technological Advancement' in this issue elsewhere. However it is only when such attempts to find something new and original gets published expeditiously and circulated widely for sharing with other researchers and even made public that the benefits accruing therefrom can be used by one and all. Scientific journal publishing therefore serves the community in many useful ways.

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Open access journal publishing is currently gaining momentum since its start by PLOS Biology in 2003 and has shown how it can result in reducing the cost of publication for the overall academic community, apart from making research open to all, particularly the public. This is made possible by the technology of *internet* in that the discovered knowledge is distributed more widely and more efficiently and at a lower cost than was previously possible. It is linked to *open research* which is research conducted in a spirit of free and open-source software via the internet and thus permitting a massively distributed collaboration and one in which anyone may participate at any level. When the research is scientific in nature, it is referred to as *open science*. It is estimated that in open science model universities pay to publishers around $4 billion per year to process the papers so that anyone can read them for free as against paying them around $10 billion in closed science model to enable their scientists to read the papers, there being a saving of about $6 billion every year to them by adopting the open science model [3].

The launch of Journal of Agronomy Research (JAR) based on this model is the latest venture of *openaccesspub* (oap-journals). Through original research articles, reviews, literature reviews, conference proceedings, case reports, short communication, thesis, letter to editor and Editorials, it aims to focus on agro-climatology, soil science, crop contamination, crop conservation, crop physiology, in fact plant science as a whole. It will cater to the needs of concerned scientists and others in their respective disciplines. It will particularly stress furthering such issues that matter the agricultural community in the context of modern challenges of climate change, increased human population and interplay of plant-soil as a system for sustainable food production.

Ever since the origin of agriculture around 10,000 years ago in the Fertile Crescent of the Middle East, cultivators have faced the problem of depletion in soil fertility due to poor agronomic practices. To grow and produce food, crop plants use carbon dioxide and oxygen from the air as well as water and mineral nutrients from the soil. If soil health is not taken care of, intensive cultivation may give higher yields in the short run but deteriorate the yields in the long run. This has happened time and again in agricultural production all over the world, in developed, developing as well as under-developed countries. The prime consideration everywhere is therefore to discover ways and means to ensure sustainability in food production. It has led to several models of agricultural production, some tried, some being attempted and some given up. We discuss them briefly in what follows.

At the one end of the spectrum is the high-technology, high-input agriculture, the so called industrial agriculture. Use of plant genetic engineering methods coupled with irrigation and use of market-purchased inputs of fertilizers, pesticides and herbicides to maximize production are the hallmark of such agriculture mostly practiced in developed countries like USA. This has no doubt led to enormous gain in productivity but at the cost of depleting the soil health in terms of increased salinity and alkalinity which has often been ignored due to economic considerations. At the other end of the spectrum is the indigenous agriculture or traditional agriculture based on use of organic fertilizers, rain-fed water and traditional crop varieties mostly adopted in developing and under-developed countries like Africa. Such agriculture is obviously accompanied by poor food production and increase in poverty. In between the two extremes, there has evolved several other forms of agriculture like alternative agriculture, sustainable agriculture, farming in nature's image, green revolution, and dialectical agriculture.

Alternative agriculture is a system comprising of 'organic farming', 'low-input agriculture', and/or 'sustainable farming'. There is emphasis on management practices and on biological relationship between organisms in each of the components. A crop field is regarded as an ecosystem with interaction amongst the organisms which must remain in balance. It does not use inorganic fertilizers but stresses integrated pest management (IPM), tillage, animal and green manure, and crop rotation. It does not use genetically altered varieties but crops improved by classical plant breeding methods.

Sustainable agriculture emphasizes conservation of its own resources with modern technologies of certified seeds, low-tillage practices, IPM with focus on biological control, and weed control by using crop rotation and intercropping. It attempts to use wind or solar energy as against purchased energy and use organic animal manure and nitrogen-fixing legumes as green manure to maintain soil fertility so as to minimize the need of purchased inputs from the market. Plant genetically engineered varieties as well as those evolved by traditional plant breeding methods are equally used in this type of agriculture. The basic rule is to avoid agronomic practices that lead to environmental degradation as well as to minimize inputs.

Farming in nature's image [5] is another type of sustainable agriculture in which a farm is to be regarded as an ecosystem that should reflect the natural ecosystem that existed before the land was put to plow and native vegetation eliminated. Such a system was proposed by JS Smith about 40 years ago as both ecologically sustainable and cost effective. In essence it consisted of an over-story of legume trees (honey locust) and an understory of Chinese bush clover that can be cut as hay or grazed directly. The clover provided a permanent cover, so there was no erosion, just as in nature. The use of two legumes eliminated the need for nitrogen fertilizers, and grazing ensured that the nutrients were recycled, again as in nature. Purchased inputs, including labor, were low, and the resulting productivity (5 tons per hectare of hay and 3 tons per hectare of honey locust nuts) was high. This system can lead to a *perennial agricultural ecosystem* if devised like US prairie with similar temperate climates, moderate rainfall and a composition of grasses, herbs, and shrubs rather than trees as the dominant vegetation type.

Green Revolution is a top-down approach to improving crop productivity. It refers to large increases in food production in developing countries like India, Iran etc. due to the use of improved strains of wheat, rice, maize and other cereals in the 1960s developed by noble laureate Dr. Norman Borlaug and others under the sponsorship of the Rockefeller Foundation and other organizations. The agronomic practices involved the use of chemical fertilizers (NPK), pesticides and irrigation. In India it made a tremendous change in the food situation in that the country, suffering from food deficit for ages, became a surplus state capable of exporting food. The success story of green revolution in India became a model to emulate. The states of Punjab, Haryana and Western Uttar Pradesh, where wheat and rice are predominantly grown under irrigated conditions, were prime contributors to this revolution. However the gains in productivity were not sustainable over time. In this context, it is important to note that the green revolution strategy involved, given the dwarf varieties of wheat and rice, searching for levels of inputs that would give high yields ignoring the irreversible losses in the form of soil erosion and loss of pest resistance. The dwarf varieties put more of their energy into grains instead of the vegetative parts of the plant that no doubt increases the yield but also makes it easier for weeds to outgrow them making the herbicide treatment necessary. Their reduced root growth makes the plant more sensitive to shortage of water. So while the age old problem of 'lodging of plants' with tall Indian varieties was solved with the advent of dwarf varieties, it created simultaneously problems for soil health and ecosystem due to the mandatory application of high-nitrogen fertilizer, irrigation and pest management. The strategy became environment non-friendly and led to an ecologically unstable system. Moreover in view of the above in-built capital-intensive nature of the green revolution strategy, which is though scale-neutral but not resources-neutral, it led to agricultural growth with non-equity, there being increased disparity between rich and poor farmers.

Dialectical agriculture [4] is altogether on a different footing than the above described forms of agriculture in that it is conceptual rather than a set of fixed management practices. It is based on *dialectic* [1,2], a *thought* process visualized by Friedrich Hegel, a German philosopher, that moves in a three-beat rhythm. It begins with an idea- a thesis- then proceeds to develop into its opposite, the antithesis; after that the mind sees the relatedness of thesis and antithesis and weaves them together into a synthesis. This synthesis, in turn, becomes another thesis, and the dialectic continues. For instance, cultivating a crop on a given piece of land in a given season can be regarded as a thesis. In the next season on the same piece of land it is *not* cultivated (kept fallow) – opposite to cultivating, the antithesis. Cultivating and keeping fallow are two opposing forces operating on the same piece of land. In the third season the synthesis is brought about by cultivating the crop again. Looked upon from the 'soil' point of view, in the first season the organic matter of soil is used in growing the crop; in the second season as the land is kept fallow the organic matter of the soil is not used, in other words the piece of land builds up the organic matter of the soil and in the third season when crop is cultivated again the built up soil matter is used in its cultivation. The consumption of organic matter for cultivating the crop in the first season is replenished in the second season with its renewed use in the third season thereby preventing the loss in soil fertility. One needs therefore to 'invent' a management practice as the situation demands and keep on doing it as a regular process in crop husbandry.

In quantitative terms, in most of the forms of agriculture, the approach normally followed is unidirectional - from input factors to the output. The strategy for sustainable crop production, however, depends on understanding how the plant production system influences and is influenced by the environmental system. In intensive cropping systems, plant growth extracts nutrients from the soil that adversely affects its health. If the health status of the soil is to be preserved at some desired level for future use, the production process gets constrained in that the production would become *less* than what it would be if we ignore the effect of increased production on the characteristics of soil. We have therefore to determine by how much the production gets *lowered* in maintaining the soil status. At the same time when soils deteriorate, as a feedback, the plant productivity goes down. We have then to determine by how much the soil erosion is to be prevented to maintain the productivity at the same level. In other words, according to dialectical agriculture, an appropriate sustainable production strategy should take into account both, the environmental effect of crop production process as well as the feedback from the quality of environmental resources to crop productivity.

It is apparent from the above discussion that the scenario of agriculture has been changing according to needs and resources of the regions where it has been practiced with no firm strategy for adoption. The bottom line however is the need for maintaining sustainability in food production to be able to feed the ever growing population of the world.

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