

Exploiting the benefits of mixed cropping and crop rotation using biotechnology for sustainable agriculture

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In the mid era use of fertilizers, pesticides and other chemicals was increased by farmers inappropriately for increasing the productivity to fulfill the food requirement of large population. This led to decreasing the quality and productivity of soil and affects other natural resources such as water. As per the present scenario of farming, selective production of staple crops results in more productivity but with less nutritional quality. This is affecting the farmers economically because the new generation is more concerned about the quality food. Therefore, there is a need to give more emphasis on to increase the nutritional quality along with higher yield of crops. In past years, some mixed cropping patterns were followed in different regions according to their traditional crops, climatic zone and soil and water conditions. But now days because of the preference of some particular food by consumers, farmers are not following their traditional cultivation system which includes the cultivation of different crops at same time in same field followed by crop rotation. These mixed cropping systems including crop rotation have great importance not only from productivity point of view but also from quality point of view and also do not require additional fertilizers for crop development. Further, addition of fertilizers is not needed because the remaining of previously harvested crop being processed by soil micro-biota is used as organic fertilizers. As these cultivation patterns do not require the addition of chemical fertilizers, they have great significance for healthy environment. By studying the benefits of such cropping system and exploiting this knowledge with the integration of molecular biology and biotechnology one can improve the quantity of crop yield along with nutritional quality so that value added products can be facilitated to the consumers as per their requirements.

Understanding mixed cropping and crop rotation: Mixed cropping also known as inter cropping or co-cultivation, is a type of agriculture that involves planting two or more of plants simultaneously in the same field one being the main crop and the others the subsidiaries. It

is also known as inter-cropping or co-cultivation. It is a form of poly-culture in which planting multiple crops at once will allow the crops to work together. It can take the form of double-cropping, in which a second crop is planted after the first has been harvested, or relay cropping, in which the second crop is started amidst the first crop before it has been harvested. Multiple cropping is found in many agricultural traditions Traditional crops are being grown in combination with other crops in the different region of India as well as world for ages and still in some areas the same practices are followed. The different crops are



such that which can grow in harmony with each other so that can plant together on the same terraced fields. According to the season combination of cereals, pulses and other creeper legumes, vegetables and root vegetables are grown. In multi-cropping cultivation system, different crops to be grown together are so selected that the products and waste materials from one crop stimulates the growth of the other crop. Care is taken to select crops that do not compete with each other for light, nutrients and water.



The concept of this type of farming was to achieve self-sustainability although, the year without any commercial interest by enlarge. This system of bio-farming helps maintain ecological balance and enables the farmer to get benefit from certain varieties even in case of damage to some crops. Different crops harvested at different time of the year provide security against food shortage, as well as against drought and crop failure in a small piece of

land. The crops under this system make their own social society and nevertheless, they are very much scientifically fit for the sustainability of agriculture in hills as well as in plains. In future, diversification in crop cultivation will even be more important because of providing variety of crops and breeding stock that enable farmers to change the productivity along with balanced environmental and climatic conditions. It also provides more emphasis on conservation of all these diversified local crop plants by the use of their natural genetic resources and their development for food and agriculture and the ecosystem services they provide, which is compulsorily required. The traditional mixed cropping system is a symbol of our well-being and prosperity and a hope for the future. The ultimate goal of mixed crop cultivation is to provide high and quality productivity at low cost, preservation and maintenance of biodiversity and moreover economic upliftment and prosperity for its population depending on farming.

Benefits of mixed cropping and crop rotation: The crops included in mixed cultivation system are inherently in tune with the local ecological and climatic system. The different crops are supportive of each other rather than competitive as the creepers of legumes uses stems of grain plants as a natural support and replenishing nitrogen, while the grain roots grip the soil firmly, preventing soil erosion. The diverse root system hold the soil tightly and much efficiently along with prevention of soil erosion, water loss and maintains the water holding capacity of soil particles with increasing nutrient quality of soil. In these traditional cropping system, Simultaneous cultivation of multiple crops prevents not only the losses by pests but also shows effective for weed control and therefore, there is no need of chemical control measures. The different aspects of mixed cropping and crop rotation are discussed here under:

Enhancing quantity and quality of agricultural commodity: Traditional crops included in mixed cropping system are complimentary and possess all the necessary ingredients for the community's food and nutrition security. It is a key to highly nutritious disease free food and healthy life. Field used for mixed cropping following crop rotation contains a diverse microbiotic environment of soil, which plays significant role to increase not only the fertility and nutrient quality of soil but also the overall quality of plant so that highly nutritious products with higher yield can be produce. Therefore, there is a need to study the interaction of soil microbiota among each other as well as with crop plants through metagenomics approaches. This can further be exploited not only to decipher the knowledge of soil

microbiotic environment and their significant role for these crop's development but also for the development of bio fertilizers. Use of these bio fertilizers would play significant role to increase the productivity of these crops without the use of chemical or additional fertilizers. Because of the use of such bio fertilizers the nutritional quality of these crops also increasing provides the economic advancement with long term environmental stability.

Environmental sustainability by promoting organic farming: Use of chemicals may damage the soil flora and fauna or even microbiotic environment of soil may get affected and as the people are becoming more cautious to their health therefore, moving towards the healthy and chemical free food. Because of this reason there is very high demand of organic food in the market. Mixed cropping cultivation system facilitates the production of chemical free, nutrition rich and organic food. Some small plants and fruit plants grown along with crop plants will provide more diversity to the ecosystem. Higher diversity in the form of trees and the crops would mean more efficient conversion of carbon dioxide to organic form during photosynthesis and through leaf fall, it also acts as a stable and steady production zone for a fair amount of organic matter. This makes the product organic by default as the fallen leaves and the remaining of previously harvested crop can serve as organic fertilizer. The diverse microbiotic environment of soil is responsible for leaf degradation and increases the fertility of soil therefore, no need to add fertilizers further. Cultivation of multiple crops promoting organic farming led to sustain the environment.

Health benefits for consumers including human and animals: Since the traditional mixed cropping system avoids hazardous pesticides, the cultivation of cereals and other crops and their product are safe for all the consumers as well as for environment. From the consumer's perspective, establishment of these crops as a nutraceutical can surpass the usual wait, efforts and cost inputs to bring conventional healthcare to the market and provides "self-care" for their satisfaction. Driving innovations are carried out on mixed cropping and crop rotation not only from food security point of view but also from nutritional security. Functional foods formulations from these crops and grains provide more diverse nutritional aspects and taste as per the requirement therefore, facilitate more attraction to the consumers. Consumption of different combinations of multigrain is an access to safe and nutritious food that meets dietary needs and food preferences for disease free healthy life.

Boosting farmer's economy: As per the requirement of consumers the industries are exploiting the values of these crops for more production of all the nutraceutical products and facilitate more marketing of the products for greater sale and greater benefit. Nano-bio-information technology integrates nanotechnology, biotechnology and information technology holds immense potential to accelerate agricultural and economic growth of farmers and producers by exploring all the important and beneficial factors and information about the mixed cropping cultivation system. Therefore, initially at small scale following with for a global scale, exploitation of their rich nutritional value assumes importance to provide food security, agricultural development, self-dependence and economic enhancement of the farmers along with the country. As if the value addition to these crops and their products takes place there will be an automatic increase in the price of these products which will lead to the upliftment of the farmers economically. Until the livelihood of the farmers will not be better, true efforts will not be given by them for the production.

Role of biotechnology to explore the benefits of mixed cropping: Understanding the structural and functional roles of potential candidate genes in conferring the complex agricultural traits such as nutritional quality and biofortification (high protein quality and calcium nutrition) along with disease resistance, nitrogen use efficiency and responsiveness are the main and directional research efforts following integration of three molecular strategies which comprises Molecular marker technology, Functional genomics and proteomics. Targeting of nutritionally important genes and proteins through the emerging biotechnology tools and techniques can lead to creation of 'smart' biofortified crops. Products from these

value-added crops can help to cope with several health problems such as protein-energy malnutrition. Research should establish impact of these products on the body's absorption, defense, regulation of homeostasis and nervous systems and then delve into hypo-allergenic foods and modern approaches to nutraceutical production. Innovation in mixed cropping system are required not only to give input to the scientific society but needed also for the welfare of local population cultivating these crops, economically as well as nutritionally.

Conclusion: Mixed cropping cultivation system is very much beneficial for farmers as well as for the environment because there is no need to invest in seeds, organic fertilizers and pest control and as there is no application of chemical fertilizers externally therefore, the human health did not get compromised through this system. Such cultivation system includes the crops which show resistance or tolerance to adverse conditions like drought and provide food security even at the time of major distress or natural calamity. Moreover, due to the diversity of crops, it also provides for nutritional security along with organic produce as the remaining of pre-harvested crop is being used as organic fertilizer by the next cultivating crop. Integration of molecular biology with biotechnology and omics technology led to the development of biofortified crops and their value added products with greater yield so that the economy of the farmers can be increased. Food and nutrition requirement of large population can be fulfilled by the production of such value added products. Therefore, innovation in mixed cropping system are required not only to give input to the scientific society but needed also for the welfare of local as well as global population, economically as well as nutritionally.

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