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INTERCROPPING FOR EFFICIENT RESOURCE UTILIZATION IN INDIAN AGRICULTURE: A REVIEW

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ABSTRACT : In India, agriculture is driven by small and marginal farmers mostly and hence effective land utilization is an only way to get more harvest and simultaneously targeting important upcoming environmental problems, including reduced soil fertility and reduced biodiversity. Intercropping of two or more crops is an age old practice in India especially under rainfed conditions. The most common advantage of intercropping is to produce a greater yield on a given piece of land by achieving more efficient use of the available growth resources that would otherwise not be utilized by each single crop grown alone. Cereals, oilseeds, legumes, cash crops like sugarcane and horticultural crops; all can be efficiently used in intercropping for taking advantage of ecological balance, more utilization of resources, increasing the quantity and quality of harvest and reducing damage by pests, diseases and weeds simultaneously.

Keywords : *Intereropping, resource utilization, ecology.*

All over the world, farmers work hard but do not make money, especially small farmers because there is very little left after they pay for all inputs. Human race depends more on farm products for their existence than anything else since food and clothing – the prime necessaries are products of farming. Even for industrial prosperity, farming forms the basic raw material. To sustain and satisfy as many as their needs, the farmers include crop production, livestock, poultry, fisheries, beekeeping etc. at their farms. Presently, the farming objective is the sustainable economic yields for the present generations without dislocating the natural resource base for the future generations. In India, due to prevailing socio-economic situations (such as; dependency of large population on agriculture, small land-holding size, very high population pressure on land resource etc.), improving household food security has been an issue of supreme importance specially considering many million farmers of India, constituted by 56.15 million marginal (<1.0 hectare), 17.92 million small (1.0-2.0 hectare) and 13.25 million semi-medium (2.0-4.0 hectare) farm holdings, making together 90 per cent of 97.15 million operational holdings. An important consequence of this has been that crop production in India remained to be considered, by and large, a subsistence rather than commercial activity (Das, 4).

In terms of ecology and environment, monocropping has been caused a series of serious problems. Human by excessive use of resources such as water, soil, forests, pastures and natural resources not only put them at risk of extinction, but also with the creation of pollution caused by industrial activities, chemical fertilizers and pesticides, threatens the earth. If farming activities be conducted based on ecological principles, in addition to preventing the destruction of natural ecosystems, the result is stable condition. Also agricultural systems must provide needs of people today and future generations; therefore it seems that is essential achieving to sustainable agriculture. One of the key strategies in sustainable agriculture is restoration diversity to agricultural ecosystems, and its effective management.

The major challenge, which lies ahead, is to develop technologies that enhance quality and productivity of crops under reducing land, declining natural resources, increasing biotic and abiotic stresses and ever increasing population. As stated above agriculture in India is driven by small and marginal farmers mostly and hence effective land utilization through intensive cropping pays high dividend and simultaneously targeting important environmental problems, including reduced soil fertility and reduced biodiversity. Intercropping can be a more-efficient means of exploiting the resources required for plant growth (Gangwar, 6).

Traditional agriculture, as practiced through the centuries all around the country has always included different forms of intercropping. In fact, many crops have been grown in association with one another for

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hundred years. Intercropping of two or more crops is an old practice in India also, especially under rainfed conditions. The total percentage of cropped land actually devoted to intercropping in India is about 17 percent. Farmers use intercropping to the mutual advantage of both main and secondary crops in a multiple-crop-production system (Coolman and Hoyt, 3). Integration of trees with crops adds a significant element of biological diversity and favourable micro climate to crop growing systems and also promotes sustanable, protective and production land/resource use (Singh *et. al.,* 13). This system helps to improve utilization of natural resources, i.e. sunlight, land and water, and to combine cultural practices, often resulting increased productivity per unit area and time. Improved and vibrant new agro-technologies adoption is the only way to minimizing the outbreak of diseases and insect pests as well as improving productivity of agri-horticultural crops (Singh *et al.,* 15).

The term intercropping is used when two or more crops are grown simultaneously on the same plot of land. Such crops may be mixed planted, that is, the plants of different crops are intermingled; or they may be sole (pure stand) planted in alternating rows, that is, the plants of each crop are grown inseparate rows or strips (wide rows). When one crop is interplanted with a second crop as the first crop approaches maturity, the practice is termed "relay cropping." All of these cropping practices come under the general heading of multiple cropping. Intercropping is a ways to increase diversity in an agricultural ecosystem. Intercropping as an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality and reduce yield damage to pests, diseases and weeds.

Plant interactions are both competitive and cooperative. Farmers use intercropping to the mutual advantage of both main and secondary crops in a multiple-crop-production system. Multiple farming exists in many forms depending on external and internal factors. External factors are weather patterns, market prices, political stability, technological developments, etc. Internal factors relate to local soil characteristics, composition of the family and farmers' ingenuity. Farmers can decide to opt for mixed enterprises when they want to save resources by interchanging them on the farm - because these permit wider crop rotations and thus reduce dependence on chemicals, because they consider mixed systems closer to nature, or because they allow diversification for better risk management.

The most common advantage of intercropping is to produce a greater yield on a given piece of land by achieving more efficient use of the available growth resources that would otherwise not be utilized by each single crop grown alone. One important reason for intercropping is the improvement and maintenance of fertility. An example of this is when a cereal crop or tuber crop is intercropped with legumes (beans, peas, ground nuts. After the intercrop is harvested, decaying roots and fallen leaves provide nitrogen and other nutrients for the next crop, legumes also fix nitrogen. The crop residues of the legumes can also be used as fodder, by cutting and carrying them to the animals, or by letting the animals graze the residues in the field. The nutrients in the crop residues can then be recycled when manure is used to fertilize crops. Legumes in an intercrop system also provide humus in the soil, due to decaying crop remains resulting in improved soil structure, reducing the need for soil tillage. Water losses, soil erosion and leaching of nutrients are also reduced in intercropping systems due to the improved structure and better soil cover. In intercropping, nitrogen fixation by the legume is not sufficient to maintain soil fertility. If chemical fertilizers are applied, it is not necessary to use nitrogen fertilizer on the cereal crop. Fertilizers are more efficiently used in an intercropping system, due to the increased amount of humus and the different rooting systems of the crops as well as differences in the amount of nutrients taken up. Intercropping practices are also helpful in conservation of the soil resource, improvement of soil health and protection of the environment by minimizing nitrate leaching, besides improving nutrient and water-use efficiencies (Gangwar and Prasad, 7).

Intercropping requires only 60-80 percent of the land to equal the production of monocropping systems. Traditional farmers in many parts of the world-have practiced intercropping in various forms for many centuries. This form of multiple cropping, which generally involves the growing of rain-fed crops in mixtures, uses available resources and permits farmers to maintain low but often adequate and relatively steady production. Intercropping can take any of three forms–strip planting, row planting, or mixed planting. The form chosen should be based on crops grown and such factors as ease of planting, weeding, and harvesting. Yield also may be affected. Intercropping is particularly suited to those situations where laboris abundant and land is not. If it is to be successful economically, the sum of the competition of the interplanted species should be less than when the species are grown alone. Crops of different maturities

have varying peak requirements for water, fertilizer, light, and space. Thus, there may be less competition between different crops than there is in a sole planting of identical plants (Gangwar, 6; Mousavi and Eskandari, 9).

Disease and insect infestation of intercropped plants tends to be less. For example, virus diseases may spread more easily through adjacent plants than to those separated by unlike, and frequently non-susceptible, neighbouring plants. Insects that spread disease are also thwarted or at least slowed. Insects tend to be less attracted to plants that are intermingled with other species than to those in solid stands of the same species. Good agronomic practices (GAP) are in general non-monetary effective tools minimizing diseases and pests infestations in any crop (Singh and Umrao, 12).

The development of herbicide-resistant biotypes, environmental sustainability and public health risk are cause of concern of herbicide-dominated systems. Use of herbicides in any crop mixture is a risky endeavour and certainly not eco-friendly approach. Therefore, of late, scientists as well as farmers are seeking a broader perspective to weed management than relying primarily on herbicides. Cultural tactics, sometimes referred to as the 'many little hammers' approach, are alternative weed management options that can effectively substitute for herbicides and reduce herbicide inputs and cost. Biological and cultural weed controls are important components of integrated weed management. Diversification of cropping systems, for instance by increasing the number of crop species grown, has been proposed as a solution to some problems of modern agriculture (Sharma and Banik, 11).

Some common combinations are maize-bean, maize-soybean, maize-rice, maize-sorghum, sorghum-millet, sweet potato (*Ipomoea batatas* Lam.) in sugarcane and cotton with peanuts. The net result of such combinations can vary widely from productive to unproductive compared to sole planting of the same crops. Factors such as fertilization schedule, seeding rate and spacing, selection of variety and type of plant, e.g., dwarf versus normal (maize), bush versus pole (bean), as well as many other cultural factors can markedly influence results.

In nutshell, the overall advantages of intercropping include the following:

1. provides increased protection against erosion;
2. insures against crop failure;
3. spreads labour and harvesting more evenly during the growing season and helps minimize storage problems;
4. helps allocate space for crops required in small quantities, and facilitates production of many commodities in a limited area;
5. results in efficient use of resources by plants of different heights, rooting systems, and nutrient requirements;
6. where legumes are grown with grasses (or other non-legumes), grasses may benefit from the nitrogen fixed by the legume companion crop; and
7. inhibits the spread of diseases and pests since not all crops involved are susceptible to the same extent to the same problems.

Drawbacks, on the other hand, are:

1. mechanized planting and harvesting are difficult;
2. it is more difficult to apply needed fertilizers and other chemicals as in sole cropping; and
3. experimentation with intercropping is more complex and difficult to manage than with sole cropping.
4. Allelopathic effects if any (Allelopathy is defined as "any direct or indirect harmful effect that one plant has on another through the production of chemical compounds that escape into the environment."The harmful compound may take varied forms such as volatile chemicals produced by roots, or leached from leaves. Dead or decaying plant tissues may also be a source of allelopathic substances. The nitrogen released from legumes is not considered as a form of allelopathy. By due emplasis, allelopathy could play a major role in enhancing the production and productivity in ago forestry systems by having their better understanding about interopping following tree-crop combination (Singh *et al.,* 14).

To take advantage of the slow initial growth and lack of lateral spread across the vacant space between rows of sugarcane, and of good amount of moisture available in ridges between sugarcane planted furrows, a number of crops have been tested by planting simultaneously with sugarcane in different parts of India. Aiyer (1) recommended vegetable crops for intercropping with sugarcane, while Arakeri *et al.* (2) found lucerne (*Medicago sativa*), a good crop for this purpose. Gill (8), in his exhaustive countrywide review of intercropping in sugarcane, concluded that although on numerous occasions, the number of tillers and of millable canes and the yield of sugarcane were

reduced, juice quality was unaffected by companion crops.

Pulses leguminous vegetables and oilseeds are popular for their suitability in different cropping systems. Since pulses due to economic considerations on their own cannot replace other profitable cereals, oilseeds or commercial crops, the area under the crop could be increased only by including pulses under various cropping systems along with the regular crops by exploiting their intrinsic potential of growing along with other crops without competitive interferences. In this, pulses like French bean hold promise. Being wider spaced, maize crop provides an opportunity for introducing a short duration pulse crop like French bean as an intercrop in additive series. Recent advances in the development of large number of varieties of pulse and oilseed crops, varying largely for maturity duration, have made it possible to include them in irrigated crop sequences. The popular cropping systems are pigeon pea-wheat in Madhya Pradesh and groundnutwheat in Gujarat, Maharashtra and Madhya Pradesh and groundnut-sorghum in Andhra Pradesh and Karnataka. Legumes are most suited inter-crop in cassava. Intercropping of blackgram in Tamil Nadu, greengram or blackgram in Andhra Pradesh and French bean in Assam are suitable and profitable. (Ganajaxi *et al.,* 5; Sharma and Banik, 11)

Regarding short-term and early bearing fruit crops as intercrops, due consideration is essential in the selection of a particular fruit. This is essential because the roots of such trees may start competing with the roots of main fruit trees for nutrients and moisture. The filler trees, unless removed at appropriate time when primary fruit trees start giving economic crop, may create problems of low orchard efficiency. Keeping this point in mind, it is apparent that wherever pineapple and strawberry can be grown, these may serve as an ideal intercrop. Wherever frost hazard is less, an intercrop of papaya can be taken profitably in a mango orchard. Phalsa and guava could also be included in the early stages of growth of the trees, provided these are maintained properly by adequate pruning and removal at proper time. (Ouma and Jeruto, 10) The partial shade loving crops like pineapple, ginger, turmeric, etc. can be grown in fully grown orchards. In addition to field crops, some short duration, less exhaustive and dwarf type inter-fillers like papaya, moringa, curry leaf, etc. can also be grown till these do not interfere with the main mango crop. Inter-cropping can be taken up till the mango trees attain suitable height and develop canopy (at 5-6 years of age).

Most of the vegetables, being short duration crops, fit very well in the intensive cropping system and are capable of giving very high yields and very high economic returns to the growers besides providing better health standards to the people. They either vacate the field early or start yielding in a short time. Small and marginal farmers can even grow vegetables all the year round. In north India, it is possible to grow each of radish, turnip, carrot, cauliflower and potato being short duration in *rabi* season. Vegetables like tomato, brinjal, okra, beans and cucurbits, though being yielding early, carry on for a longer period. Inter-cropping of vegetables in field crops like sugarcane, maize, cabbage and mustard has proved useful. Intercropping of spinach, onion and radish with tomato, cauliflower and cabbage has been found more profitable.

All crops harvested remove nutrients from the soil. Make sure these nutrients are replenished. All legumes have the ability to fix nitrogen from the atmosphere, but some are better than others. Yam production has great potential as an intercrop besides as a monocrop under annual or perennial systems. It can be cultivated as an intercrop in home gardens, an annual monocrop in shifting cultivation or an annual intercrop in sedentary system with semi-perennials, perennials or as an intercrop in large plantations.

After considering various aspects of intercropping and its potential applications in different crop groups, finally it can be concluded that intercropping is a ways to increase diversity in an agricultural ecosystem. Ecological balance, more utilization of resources, increases the quantity and quality of products and reduction damage by pests, diseases and weeds will increases with use of intercropping systems. Mixed farming has both its advantages and disadvantages. For example, farmers in mixed systems have to divide their attention and resources over several activities, thus leading to reduced economies of scale. Advantages include the possibility of reducing risk, spreading labour and re-utilizing resources. The importance of these advantages and disadvantages also differs according to the socio-cultural preferences of the farmers and to the biophysical conditions as determined by rainfall, radiation, soil type and disease pressure. The research results during the last two decades have clearly established that these adverse impacts of green revolution technologies may be mitigated through an appropriate choice of alternative crops and cropping systems, which are efficient user of resource base (land, water, light and energy), economically more remunerative and environment-

friendly. (Das, 4; Gangwar, 6). An adoption of well-designed situation-specific alternative cropping systems along with appropriate method of cultivation could minimize the occurrence or intensity of diseases and insect pests, including weeds, considerably. These are also helpful in conservation of the soil resource, improvement of soil health and protection of the environment by minimizing nitrate leaching, besides improving nutrient and water-use efficiencies.

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