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Innovative approaches enhancing input use efficiency of horticultural crops

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The term 'Input use efficiency of horticultural crops' may be defined as the concepts of technical, spatial, chemical and environmental efficiency for sustainable production of horticulture crops. An efficient farmer maintain his land, water and other resources in an optimal manner, so as to maximize his income, at lowest cost, on sustainable basis. However, there are many studies indicating that farmers often use their resources sub-optimally, whereas, some farmers may attain maximum outputs at a high cost, some others achieve maximum profit per unit of inputs used. Logically all enterprising farmers would try to maximize their farm returns by allocating inputs in an efficient manner by incorporating innovative approaches. But as inputs and managerial efficiency of different farmers vary widely, the net returns per unit of inputs used also vary significantly from orchard to orchard. Also a farmer's access to technology, credit, market and other infrastructure and policy support, coupled with risk perception and risk management capacity under erratic weather and price situations would determine his orchard efficiency. Moreover, a farmer knowingly or unknowingly may over-exploit his land, water and other resources for maximizing orchard income in the short run, thereby, resulting in soil and water degradation and rapid depletion of ground water and also posing a problem of sustainability of horticulture in the long run. Furthermore, a farmer may not be often either fully aware or properly guided and aided for alternative, albeit best possible uses of his scarce resources like drip irrigation and fertigation, high density planting, (HDP) mulching, bio fertilizers and plant bio regulators (PBRs). Thus, there are economic as well as environmental aspects of input use efficiency in horticulture. Besides, appropriate risk management policy would be crucial for stabilizing orchard income, which would encourage the farming communities to take proper interest in farming and maintain input use efficiency.

Innovative approaches for enhancing input use efficiency of horticultural crops:

Drip irrigation and fertigation: Drip irrigation considered as one of the latest innovation which optimizes the use of irrigation water by providing it uniformly and directly to the roots of the plants, through a close network of plastic pipes and emitters. However, fertigation means application of soluble fertilizers through irrigation system. It is the most important management factor which affect plant growth and development, resulting higher production with better quality. The drip irrigation and fertigation are the best substitute over traditional irrigation system in developing countries like India. The advantages of drip irrigation and fertigation includes; it ensures regular flow of both water and nutrients, resulting in increased growth rates and higher yields. Offers greater versatility in the timing of the nutrient application to meet specific demands at predetermined times according to the crop, Improves availability of nutrients and their uptake by the plants. It is a safer application method as it eliminates the danger of burning the plant root system, since the fertilizer is applied in very low concentration. Combining liquid fertilizers with insecticides and herbicides saves labour and machinery for their application separately. Substantial savings in quantity of fertilizers (30 to 50%). It also facilitate irrigation in undulating terrains and results in minimum pollution to soil coupled with less incidence of pests and diseases. Hence, it is intellectually satisfying and economically rewarding technique for enhancing input use efficiency. These techniques has to be used as per the recommendations. It has been seen that most of the farmers still use traditional method of water and nutrient application due to fear of quality and yield loss because of less application of water and fertilizers. However, motivating the farmer's communities about the technologies may fetch economic yield and quality of horticultural produce from same piece of land.

High density orcharding and rootstocks: For efficient

use of horizontal and vertical space, HDP technologies have been developed in many horticultural crops. Planting of these crops rather at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity per unit area without sacrificing quality is often referred as 'High density planting' or HDP. This technique is well established in many advanced and developing countries including India. The trees of HDP should have maximum number of fruiting branches and structural branches. The trees are generally trained with a central leader surrounded by nearly horizontal fruiting branches. These branches should be pruned in such a way that each branch casts a minimum amount of shade on other branches. However, success of HDP depends upon the control of tree size. This can be achieved by use of dwarfing and intermediate root stocks like MM 106, MM 109 and MM 111 in apple; Quince A, Adam and Quince C in pears. Use of spur type scions, training and pruning methods can also induce dwarfness. Growth regulators such as diaminozide, ethephon, chlormaquat and paclobutrazal are extensively used to reduce shoot growth by 30-0%. This

results in increased flowering in the subsequent years. Tying down the branches to make them grow to an angle of 45° from the main stem are some of the standard practices to control tree size. High density orcharding appears to be the most appropriate answer to overcome low productivity and long gestation period for early returns and export of horticultural crops. To meet the challenge of high productivity, optimization of growth parameters and minimization of the unproductive components of trees without sacrificing the overall health of the tree and quality of the product are required. The control of excessive vegetative growth in the tree for increased productivity is the major principle of high density orcharding. Therefore, controlling tree size by dwarfing rootstocks in high density orchards is one of the methods of increasing production. In high density system, yields are improved in early years of orchard life. Once the trees have filled their allotted spaces, crowding may occur and canopies of an adjacent tree begin to overlap. This may lead to excessive shading and reduction in photosynthesis by layered leaves within the tree canopy resulting in poor yields. In fact, at some point of time most horticultural trees require controlled vegetative growth particularly in high density orcharding. The horticultural methods most commonly known to control tree growth are training and pruning. The training begins when the tree is first planted and continues throughout its productive life. Once the tree is mature, excessive growth can be regularly removed by pruning to provide a short term or immediate benefit.

Mulching: The word mulch is derived from German word 'Molsch' means 'soft or beginning to decay'. The application of a covering layer of any material to the soil surface, which

does not harm the crop and it can be either of organic or inorganic in nature. The process of application of such layer is referred to as "mulching". Plasticulture is crucial to horticulture in view of the changing technological scenario for boosting quality and yield of horticultural produce. Introduction of linear low density polyethylene (LLDPE) as a mulch film has brought a revolution in horticultural water management. It is actually a boon to dry land horticulture. This is one of the fastest growing plasticultural applications in the world. The cost of LLDPE film is also lesser than one third of LDPE mulch film. Moreover, for mulch activity lower thickness (15 to 20 microns) are highly suitable. The major advantage of mulching includes; it helps in quick germination of seed. Conserve soil moisture besides, regulating of soil temperature. It prevents weeds, insect-pests and disease population drastically. Boosting soil fertility. It also provide more unified and tidy appearance to field. Ultimately, mulching results in increasing yield of horticultural crops. However, due to increasing cost of raw materials the films are costlier now. Hence, Government should take all possible measures to produce the film in a mass scale and make it available to the farmers at a reasonable price.

Subsidy may also be given through banks to encourage the farmer to adoption soil mulching. Hence, with the incorporation of mulching in the field the production and quality produce can be harvest with increases economic value.

Bio-fertilizers: Bio fertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilize plant nutrients in soil from

unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. Previously it is mainly used for field crops but now a days it is used for horticultural crops also. Bio fertilizers are able to fix 20-200 kg N/ha/year, solubilize phosphorus in the range of 30-50 kg P_2O_5/ha/year and mobilizes P, Zn, Fe and Mo to varying extent. Bio fertilizers are use in live formulation of beneficial microorganism which on application to seed, root or soil, mobilize the availability of nutrients particularly by their biological activity and help to build up the lost microflora and in turn improve the soil health. Generally horticultural crops have now received more attention than field crops. *Glomus fasciculatum, Glomus mosseae, Azospirillum, Azotobactor* and phosphate solubilizing bacteria (PSB) are found useful for different horticultural crops. Nitrogenous bio fertilizers can provide 25-30% of chemical fertilizer equivalent nitrogen, whereas, PSB bio fertilizer can provide 12-20 kg P_2O_5/ha/season. Mycorrhiza effectively provide adequate phosphorous and other micro nutrients. These bio fertilizers helps in increased water absorption, keeping soils biologically active and help in soil health maintenance. Thus, the use of bio fertilizer is increasing day by day due to increase in the price of chemical fertilizers, its beneficial effect on soil health and increase in production of horticultural crop while saving the cost of cultivation thereby, increasing input use efficiency of the orchard.

Plant bio regulators: Plant Bio regulators (PBR_s) are organic compound other than nutrient which in small amount promote/inhibit or otherwise modified any physiological response in plant. The exogenous application of bio-regulators (auxin, gibberellin, cytokinin, abscisic acid, ethylene, brassinosteroide, jasmonates and salicylic acid) might, therefore, act as a powerful tool not only for enhancing the growth, productivity, quality of horticultural crops but also in combating the ill effects generated by various biotic and abiotic stresses in plants in the near future. Some other important application of these plant bio regulators varies with crop to crop. Accelerating germination of seed, asexual propagation (budding, grafting, layering and cutting), tissue culture, flowering, fruiting, ripening, crop regulation, quality and storage. Therefore, researchers require a better understanding of the mechanism responsible for developmental processes in plants at the cellular and molecular levels and a more comprehensive description of the specificity of bio regulators in mediating key biochemical steps. The use of these plant bio regulators thus results in enhancing quality, improving yield and shelf life of horticulture produce which are otherwise highly perishable in nature and indirectly accelerating input use efficiency.

Conclusion: From the fore going discussion it is clearly indicated that these innovative approaches results in sustainable production of horticultural crops at lowest cost thereby, enhancing input use efficiency. It will not, however, be the magic bullet to solve the overuse of input in horticulture system and still, wide range of approaches need to come together if we are to succeed in improving input use efficiency by above means. The approaches should aim at becoming more efficient and low-input horticulture needs to increase in productivity while retaining high efficiency of input use. Although, intensive and high-input horticulture has a key present and future role to play; however, it must attempt to do more with less and as argued by several researchers, it should aim at being more sustainable. To meet the increasing quality and quantity food requirements from limited land resources, keeping the problems of climate change, increasing population in mind there is an urgent need to focus on theses smarter technologies like drip irrigation and fertigation, high density planting, mulching, bio fertilizers and plant bio regulators both on farm and under protected cultivation for round the year quality horticulture produce on commercial scale.

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