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SUSTAINABLE PRACTICES FOR SHAPING THE FUTURE HORTICULTURE

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ABSTRACT

Malnutrition is one of the biggest challenges among population in SAARC countries, and malnutrition is still alarming in the world. This challenging situation need the diversified diet from fruits and vegetables owing to their richness in vitamins, minerals and essential bioactive compounds designated as protective foods. Horticulture has emerged as the major driver of growth in the agriculture sector of SAARC countries. Among the existing agricultural enterprises, horticulture offers the best alternative for increased food-sufficiency, improved nutrition and ensuring the generation of increased incomes and employment. Moreover food security is not just a supply issue but also a function of income and purchasing power. Hence, its relationship to poverty but it is necessary to cultivate horticultural crops; efforts need to be put in place for more sustainable horticultural practices for greater crop yield and quality without post-harvest loss. Therefore, any attempt to integrate approaches in order to diversify production across countries need to go beyond the land-based production to adopt good practices in horticulture. Not only quantity and quality matters for production point of view because appearance fruits and vegetables are affected, and their market value is reduced. Crop management practices for quality produce by eco-friendly bee pollination management strategy, Fruit bagging, crop covers to protect the produce from severity of climate shocks, use different eco-friendly bio-formulations by using different useful microbes to protect the crop from phytopathogens and pests in order to have lesser reliance on chemical fertilizers and pesticides as continuous application of these chemicals not only showed detrimental effect on ecosystem but also resulted in health risks to human and animals, moreover, use of synthetic fertilizers and pesticides are intensive and costly and its application increases the production cost. Adopting sustainable alternatives for quality produce from horticultural crop production, concurrently, research efforts need to be focused on best production practices for eradicating hunger through meeting the food requirements is an urgent solution to feed future.

Key words: Horticulture, bio-formulations, bee pollination

INTRODUCTION

South Asia population is equivalent to 24.89% of total world population (8 billion). India is projected to surpass China as the world's most populous country in 2023. This will put enormous pressure on resources, including land, water and food and also increases demand for nutritious, safe, and healthy food but to produce quality food while facing climate change, pledge to maintain

biodiversity and other resources, pose major challenges for food production to cater the needs of growing population. To ensure food security and nutritional security economic access of food along with food production and food availability is needed. But in India agriculture is caught in low equilibrium trap with low productivity of staples, supply shortfalls, high prices, low returns to farmers and area diversification because agriculture system in India is highly vulnerable due to frequency and severity of climate shocks such as drought, floods, heat stress made difficult to feed poor people with about 40 per cent of the world's hungry, besides land for agriculture is shrinking day-by day. Hence, to tackle these issues and to overcome different constraints in order to improve food and nutritional security. Moreover food security is not just a supply issue but also a function of income and purchasing power. Hence, its relationship to poverty. Among the existing agricultural enterprises, horticulture offers the best alternative for increased food-sufficiency, improved nutrition and ensuring the generation of increased incomes and employment. Therefore, any attempt to integrate approaches in order to diversify production across countries need to go beyond the land- based production to adopt other subsector such as Horticulture.

Horticultural crops are high value crops generating higher profits than staple food crops per unit land and the income thus generated can be used for different purposes in terms of eradicating hunger through meeting the food requirements and other necessities to access the food. But it is necessary to cultivate horticultural crops efforts need to be put in place for more sustainable horticultural practices for greater crop yield and quality without post-harvest loss. Reduction of post-harvest losses of fruits and vegetables is a complementary means for increasing production. Not only quantity and quality matters for production point of view because appearance fruits and vegetables are affected, and their market value is reduced. Crop management practices such as improved land management practices, selecting quality planting materials, improved method of irrigations, eco-friendly plant protection measures, Nano fertilization, crop enhancement through pollination, thinning, assessment of best harvest indices for crop for harvesting and harvesting practices, organized supply chain and storage, crop features allowing longer storage life processing and value addition in horticultural produce.

1. Eco-Friendly Bee Pollination Management Strategy For Quality Produce

More than 75% of 115 leading crop species world-wide are dependent on or at the benefits from bee pollination, whereas, wind and self-pollination are sufficient for 28 crop species. Thereby, pollination improves the yield of horticultural crop species and contributes to one-third of global crop production, and pollination is underestimated by international policies, which is particularly alarming in times of horticultural intensification and diminishing pollination services. In horticultural crops such as in Kiwi, melons, pumpkins, watermelons, cocoa beans and quince yield reduction reported greater than 90% without pollinators (Marcelo Aizen *et al*., 2019)

Advantages of bee pollination in horticultural crops

1. Bee pollinated fruits are heavier and less malformed and reach high higher commercial grade
2. Increase red colour
3. Increase in sugar to acid ratio
4. Increase in firmness of fruits and vegetables
5. Increase shelf-life
6. Increase fruit size and growth rate
7. Bee pollination results in higher number of fruits, berries or seeds with better quality
8. Value of bee pollination is 30-50 times the value of honey and wax harvests

Table 1. Percentage of horticultural crops relying on bee pollination

S.No.	Name of Horticultural crop	Percentage of crop pollinated by bee
1	Almond, avocado,	100%
2	Blueberries, apples, cherries, sweet cherries, grape fruit, Tangerines	90%
3	peaches	48%
4	Oranges	27%
5	Strawberry	2%
6	Grapes	1%

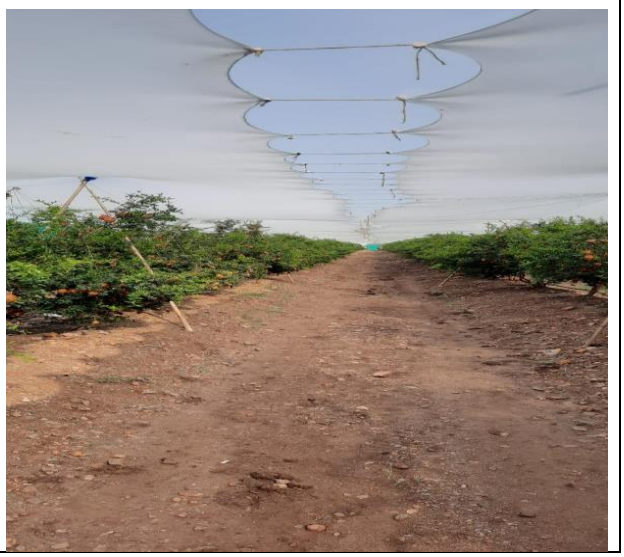
From the research it is evident that seven of the nine crops (Oranges, cabbages, peppers, tomatoes, watermelons, melons, tangerines) that provide at least half the vitamin C to human diet depends on insect pollination and five major fruit crops such as apple, almond, avocado, blueberry and cranberry are completely reliant on insect pollination. By considering the importance of bee role in quality horticultural production extent of research need to be done to identify the realised and potential contributions of bees in horticulture towards achieving the sustainable development goal to achieve synergy between human well-being and the maintenance of environmental resources by 2030.

2. Fruit Bagging and crop covers for quality produce

Bagging During maturity, many fruits should be bagged. By this bagging technique we can reduce the risks of physical damage and improves fruit colour at harvest time (Muchui et al., 2010). It is a major fruit conservation technique that not only protects the fruit from insect-pests and diseases, but also influences the quality of fruit by changing the microenvironment during fruit production (Hamedi et al., 2019). Fruit bagging is one of the most significant methods for producing the quality of fruit and has long been used in production of fruits (Zhai et al., 2006). Mostly all fruit fly species are quarantine threats (Abbasi et al., 2009). Mainly which countries import the fruits bagging must be required (Qin et al., 2012) treatment combination of 50 percent fruit thinning and bagging with white polythene of guava may be considered depending on no. of fruits per plant, diameter of fruit, length of fruit, weight of fruit, thickness of mesocarp and yield per plant as well as guava fruit quality (Rahman et al., 2020). Bagging is an important physical protection method to pomegranate (*Punica granatum*).

Crop covers/grow covers are new initiatives to produce quality crop by giving protection from direct sunlight, prevent black spot on fruit, give uniform size and colour of fruits, it protects from outer atmosphere effect on fruit, reduce pesticide usage, protect from bird and animal and increase shining on fruits

Fig 1. Fruit bagging and crop cover protection for quality produce in pomegranate

Fruit bagging	Crop covers
	

3. Use of bioformulations/ biologicals for Horticultural crops production & protection

The role of microbes in sustainable horticulture has provided new insights to horticultural economy, and one of the direct benefits is the lesser reliance on chemical fertilizers and pesticides as continuous application of these chemicals not only showed detrimental effect on ecosystem but also resulted in health risks to human and animals, moreover, use of synthetic fertilizers and pesticides are intensive and costly and its application increases the production cost and the continuous use of fertilizers is responsible for the decline of soil quality and productivity. Recently in a study, Liang et al. (2013) also showed that excessive application of nitrogen and phosphorus fertilizers induces soil acidification and phosphorus enrichment during vegetable production.

Microbe-based formulations also known as bioformulations are more robust than synthetic chemicals as the formulation product of a single microbe may involve direct interactions with pathogens, and numerous mechanisms take part in disease suppression and plant growth promotion (Rodrigo *et al*., 2011).

Typically a formulation is a mixture of an active ingredient in a formulated product with inert (inactive) substances (http://npic.orst.edu/ factsheets/formulations.html). However regarding bioformulation we see that there is no uniform definition available and various authors define it in their own way. Burges and Jones (1998) stated bioformulation comprises aids to preserve organisms, to deliver them to their targets, and once there to improve their activities, whereas Arora et al. (2010) define the term bioformulation to preparations of microorganism(s) that may be partial or complete substitute for chemical fertilization/pesticides. But any operative definition must include an active ingredient, a carrier material, and an additive. The following bioformulations are indigenously developed in India and available for use in the market.

Commercialized Indigenous bioformulation developed by ICAR in India

S. No.	Name of bioformulation product	Inoculants (Organisms)	Target horticultural crops	Target/uses
1	Bio NPK (liquid formulation)	(N2) fixing (*Azotobacter chroococum*), P-solubilizing (*Paenibacillus tylopili*) and K-solubilizing (*Bacillus decolorationis*) bacteria.	Vegetables, ginger and turmeric, citrus orchards, papaya	Increase yield save chemical fertilizers 25-50%
2	BIOGROW	Consortium of bacterial species, *Bacillus* sp. BC39, *Bacillus* sp. RC25, *Pseudomonas* sp. K30 and *Pseudomonas* sp. K31," endowed with phosphorus solubilization, IAA and siderophore production attributes.	Solanaceous Vegetables like tomato, brinjal, potato and floriculture crops	Increase yield by 25-30%, increase nutritional quality
3	Bio Phos and Bio Phos+	P-solubilizing bacteria containing *Kluyvera cryocrescens* and *Paenibacillus tylopili*	Vegetables	Reduce 50% of P-fertilizer application
4	Bio Zn	Zinc solubilizing bacteria (*Bacillus endophyticus*)	Vegetables	Enhances uptake of Zn
5	Bio Potash	K-solubilizing bacterium (*Bacillus decolorationis*)	Potato	Helps plant to utilize K fixed in soil
6	Bio-Bacter	highly efficient nitrogen fixing *Azotobacter chroococcum*	All horticultural crops	Save 20-25 kg N/ha
7	RhizoNBAIM	highly efficient nitrogen fixing rhizobial strains specific to Pea	Pea	Save 25-30 kg N/ha
8	Eco-Pesticide	*Pseudomonas fluorescens*, a free-living bacterium	Vegetables, Commercial plantation crops	Protection from wilt in tomato and against to soil born and seed born pathogen, impart resistance to

				biotic and abiotic stresses
9	Bio-Pulse	*Trichoderma harzianum* and *Bacillus amyloliquefaciens* and has biocontrol	Vegetables, plantation crops, papaya	Reduce damping off in papaya and protect from soil and seed borne pathogens
10	Cyanobiocon A& C	containing a native cyanobacterial strain - *Anabaena laxa* (A) or *Calothrix elenkinii* (C),	Nursery grown vegetables (Tomato)	Exhibit fungicidal activity against phytopathogenic fungi (*Fusarium oxysporum* / *F. solani*, *Rhizoctonia solani*, *Macrophomina phaseolina*, and Pythium aphanidermatum / P. debaryanum
11	Arka Microbial Consortium	N fixing *Azotobacter tropicalis* strain PANMC 1, P and Zn solubilizing *Bacillus aryabhattai* strain Bel 6, K mobilizing and plant growth promoting *Pseudomonas taiwanensis* strain Mpf2.	All horticultural crops	Increase yield 6-16%, reduce 25% of N&P fertilizers application
12	Arka Actino-Plus	Actinobacterial strains viz., *Streptomyces viridobrunneus* strain Pan Act1, *Streptomyces bullii* strain Pan Act2 and *Streptomyces griseorubens* strain Pan Act3	All horticultural crops	Enhances rhizospheric availability of organic matter, It recovers guava plants bronzing symptoms
13	Isaria Fumosorosea Pfu-5	Isaria fumosorosea ICAR-NBAIR Pfu-5	Coconut, oilpalm	Manage Rugose Spiralling Whitefly (Aleurodicus

				rugioperculatus) in coconut and oilpalm
14	ICAR-FUSICONT	antagonistic fungal isolate CSR-T-3 of *Trichoderma reesei* and a bacterial PGPR isolate CSR-A-11 of *Lysnibacillus fusiforms*	Banana, tomato, potato, capsicum, chilli, cumin, fenugreek	Control wilt disease
15	Arka Krishi Samrakshak	*Pseudomonas fluorescens* IIHR Pf-2	Capsicum, onion, cabbage, cauliflower, crossandra, roses, gerbera, banana, grapes, guava, acid lime, papaya, tomato and egg plant	Controls nemadodes, several soil born pathogens
16	Arka Krishi Veera	*Trichoderma viride* IIHR Tv-5	Capsicum, onion, cabbage, cauliflower, crossandra, roses, gerbera, banana, grapes, guava, acid lime, papaya, tomato and egg plan	excellent antagonistic activity against root-knot nematode, *Meloidogyne incognita* by suppressing the egg hatching and causing juvenile mortality.

Many of these bioformulations are successful in managing diseases and pest. The smartness of these bioformulations can be surmised by the fact that a particular strain in the vicinity of a plant is capable to control disease without producing lasting effects on the rest of the microbial community or other organisms in the ecosystem (Howarth 1991). Although, after so many years of intensive research and despite all the success stories of bioformulation science, it is evident that the number of commercially available biocontrol products is far lower than chemical counterparts. So it is vital for policy makers to facilitate the registration of product and stringent enough to regulate the spurious products in the market.

Conclusion

The use of chemical pesticides, no doubt has led to dramatic improvements in productivity and in turn provided a reliable supply of cheap food therefore, and their use were initially welcomed. of late, consumers are becoming increasingly concerned both about food quality and safety and of the real and perceived effects of modern farming methods on the fast deteriorating environment. While many of these fears have been exaggerated but there is a consensus that modern petro-chemical inputs based farming is ultimately non-sustainable for India. As a result, more ecological approaches for enhancing the food production as well as quality are now being researched. Concurrently, research efforts are being focused on use of traditional practices, botanical pesticides and biologicals, organic amendments, and summer ploughing and other agronomic practices and in the same way to establish self-sustainability.

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