AN AJSS
An Asian Journal of Soil Science
Volume **12** | Issue 2 | December, 2017 | 355-360 | e ISSN–0976–7231 ■ Visit us : www.researchjournal.co.in

A Case Study

DOI : 10.15740/HAS/AJSS/12.2/355-360

Sustainable soil fertility management for horticultural crops

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Received : 09.09.2017; **Accepted :** 30.11.2017

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Summary

India is bestowed with varied soil conditions, which is highly favourable for growing a large number of horticultural crops from tropical to temperate; seasonal to perennial ensuring good returns throughout the year. The farming community of the country has efficiently exploited this natural endowment (Siddiqui *et al*., 2014). Excessive application of nutrients has the harmful impacts on soil physical, chemical and biological system which are the pillars of soil fertility resulting in several socio-economic and environmental concerns. Further, the food and nutritional security of ever increasing population in the scenario of changing climate, decreasing arable land for production indicates the attention of holistic soil fertility management approach for sustainable production of horticultural crops. Relevant indices of sustainable horticulture and resource management include soil quality and resilience and factors affecting them and temporal changes in productivity and use efficiency of non-renewable or input of limited resources (Lal, 2008) which there by helps in sustainability productivity of horticultural crops.

Key words : Soil fertility, Management, Horticultural crops

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How to cite this article : Nagaharshitha, D. and Gaikwad, Kunal (2017). Sustainable soil fertility management for horticultural crops. *Asian J. Soil Sci.*, **12** (2) : 355-360 : **DOI : 10.15740/HAS/AJSS/12.2/355-360.**

Introduction

Soil fertility is fundamental in determining the productivity of all farming systems. Sustainable soil fertility management practices help in increasing the productivity of horticultural crops. Soil fertility is most commonly defined in terms of the ability of a soil to supply nutrients to crops. Swift and Palm (2000) however, suggest that it is more helpful to view soil fertility as an ecosystem concept integrating the diverse soil functions, including nutrient supply, which promote plant production. This broader definition is appropriate to organic farming, as organic farming recognises the complex relationships that exist between different system components and that the sustainability of the system is dependent upon the functioning of a whole integrated and inter-related system (Atkinson and Watson, 2000). Conventional agriculture often relies on targeted shortterm solutions e.g. application of a soluble fertiliser or herbicide. Organic systems, in contrast, use a strategically different approach, which relies on longer-term solutions (preventative rather than reactive) at the systems level. An example of this is the importance of rotation design for nutrient cycling and conservation and weed, pest and disease control (Stockdale *et al*., 2001).

Soil quality in a broader context includes attributes of environmental quality, human and animal health and food safety and quality. It follows the best means to improve or maintain soil quality through alternative agricultural practices such as crop rotations, recycling of crop residues and animal manures, reduced input of chemical fertilizers and pesticides and increased use of cover crops and green manure crops, including nitrogen-fixing legumes. These help to maintain a high level of soil organic matter that enhances soil tilth, fertility, and productivity, while protecting the soil from erosion and nutrient runoff.

Agriculture can provide positive and negative impacts on soil use, and the use of fertilizers can reduce the natural nutrients on the soil surface (Fred, 1991). Moreover, chemical fertilizers are more resistant in the environment than the natural fertilizer because it's combined with chemicals which in some cases are harmful to the environment-especially, on soil fertility because most of the micro-organism decrease following the increase of the chemical fertilizers used (Katsunori, 2003).

So inorder to reduce this loss to the environment and the soil itself some soil management practices are to be followed in the cultivation of horticultural crops which improves the soil health and also productivity of crops. These include cover crops, crop rotation, organic farming practices etc.

Cover crops :

Cover crops are usually killed on the surface or incorporated into the soil before they mature. (This is the origin of the term green manure.). Since annual cover crop residues are usually low in lignin content and high in nitrogen, they decompose rapidly in the soil. Cover crops help to maintain high populations of mycorrhizal fungi spores during the fallow period between main crops. The fungus also associates with almost all cover crops, which helps to maintain or improve inoculation of the next crop. Many types of plants can be used as cover crops. Legumes and grasses (including cereals) are the most extensively used, but there is increasing interest in brassicas (such as rape, mustard and forage radish). Oat and rye cereals have high potential to increase market and yield of processing tomato in Canada.

Crop rotation :

Crop rotation is a system where different plants are grown in a recurring, defined sequence. Crop rotations, including a mixture of leguminous 'fertility building' andcash crops, are the main mechanism for nutrient supply within organic systems. Rotations can also be designed to minimise the spread of weeds, pests and diseases (Altieri, 1995). Use crop sequences that promote healthier crops. Some crops seem to do well following a particular crop (for example, cabbage family crops following onions, or potatoes following corn). Other crop sequences may have adverse effects, as when potatoes have more scab following peas or oats.

Crop residues:

Crop residues can be an important source of nutrients to subsequent crops. It is well documented that different quantities of N, P, K and minor nutrients are removed from,and returned to, the soil depending on the crop species concerned (Wild, 1988 and Sylvester-Bradley, 1993). The quantity and quality of crop residues will clearly influence the build up of soil organic matter (Jenkinson and Ladd, 1981) and the subsequent availability and timing of release of nutrients to following crops (Jarvis *et al*., 1996). Cereal straw, for example, contains only around 35 kg N ha^{-1} compared with more than 150 kg N ha^{-1} for some vegetables residues (Rahn *et al*., 1992 and Jarvis *et al*.,1996). In tomato soil physical and chemical properties were studied by Babajide *et al*. (2008) after the application of composted Tithonia-biomass and N-mineral fertilizer during 2005 at Nigeria having mildly acidic soils.

The results from the pre-cropping physical and chemical soil analyses revealed that Tithonia biomass effectively improved soil physical properties. Soil moisture increased, as resulted from increased tithonia-biomass application.

Animal manures :

For increasing organic matter and supplying nutrients

– Manure is an excellent soil amendment, providing both organic matter and nutrients

– Animal manures can have very different properties, depending on the animal species, feed, bedding, handling and manure-storage practices.

– The amounts of nutrients in the manure that become available to crops also depend on what time of year the manure is applied and how quickly it is worked into the soil.

– In addition, the influence of manure on soil organic matter and plant growth is influenced by soil type.

– In other words, it's impossible to give blanket manure application recommendations.

– They need to be tailored for every situation.

– Additionally, lots of carbon would be added to the soil, resulting in no loss of soil organic matter.

– High crop residues grown from this manure application would also contribute organic matter.

Effects of manuring on soils:

Effects on organic matter :

When considering the influence of any residue or organic material on soil organic matter, the key question is how much solids are returned to the soil. Equal amounts of different types of manures will have different effects on soil organic matter levels. Dairy and beef manures contain undigested parts of forages and may have significant quantities of bedding. They, therefore, have a high amount of complex substances, such as lignin, that do not decompose readily in soils. Using this type of manure results in a much greater long-term influence on soil organic matter than does a poultry or swine manure without bedding. More solids are commonly applied to soil with solid-manure-handling systems than with liquid systems, because greater amounts of bedding are usually included. A number of trends in dairy farming mean that manures may have less organic material than in the past. One is the use of sand as bedding material in free-stall barns, much of which is recovered and reused. The other is the separation of solids and liquids with the sale of solids or the use of digested solids as bedding. Under both situations much less organic solids are returned to fields. On the other hand, the bedded pack (or compost barn) does produce a manure that is high in organic solid content.

Using composts:

Decomposition of organic materials takes place naturally in forests and fields all around us. Composting is the art and science of combining available organic wastes so that they decompose to form a uniform and stable finished product. Composts are excellent organic amendments for soils. Composting reduces bulk, stabilizes soluble nutrients and hastens the formation of humus. Most organic materials, such as manures, crop residues, grass clippings, leaves, sawdust and many kitchen wastes, can be composted.

Reducing erosion and runoff:

– Erosion is the major hazard or limitation to the use of about half of all crop land.

– Erosion is occurring fast enough to reduce future productivity.

– Erosion is also an organic-matter issue because it removes the richest soil layer, the topsoil.

– The soil removed from fields also has huge negative effects off the farm, as sediment accumulates in streams, rivers, reservoirs and estuaries, or blowing dust reaches towns and cities.

– In fact, sediment remains the number one contaminant for most waters around the world, and it often also carries other contaminants like nutrients, pesticides and other chemicals.

Reduced tillage:

Transition to tillage systems that increase surface cover and reduce disturbance is probably the single most effective and economical approach to reducing erosion. Restricted and no-till regimes succeed in many cropping systems by providing better economic returns than conventional tillage, while also providing excellent runoff and erosion control. Maintaining residues on the soil surface and eliminating the problem of soil loosening by tillage greatly reduce dispersion of surface aggregates by raindrops and runoff waters. The effects of wind on surface soil are also greatly reduced by leaving crop stubble on untilled soil and anchoring the soil with roots. These measures facilitate infiltration of precipitation where it falls, thereby reducing runoff and increasing plant water availability.

Other practices and structures for soil conservation:

Soil-building management practices are the first approach to runoff and erosion control, but structural measures may still be appropriate. For example, diversion ditches are channels or swales that are constructed across slopes to divert water across the slope to a water way or pond. Their primary purpose is to channel water from upslope areas away and prevent the downslope accumulation of runoff water that would then generate increased scouring and gullies.Grassed water ways are field water channels that reduce scouring in areas where runoff water accumulates; they also help prevent surface water pollution by filtering sediments out of runoff.

Reducing surface crusting :

Crusting is a symptom of the breakdown of soil structure that develops especially with intensively and clean-tilled soils. As a short-term solution, farmers sometimes use tools such as rotary hoes to break up the crust. The best long-term approach is to reduce tillage intensity, use tillage and cover cropping systems that leave residue or mulch on the surface and improve aggregate stability with organic matter additions.

Reducing tillage:

Tillage systems:

Tillage systems are often classified by the amount of surface residue left on the soil surface. Conservation tillage systems leave more than 30 per cent of the soil surface covered with crop residue. This amount of surface residue cover is considered to be at a level where erosion is significantly reduced. Of course, this residue cover partially depends on the amount and quality of residue left after harvest, which may vary greatly among crops and harvest method. Although residue cover greatly influences erosion potential, it also is affected by factors such as surface roughness and soil loosening.

In Aonla, mulching with paddy straw had significant effect on reduction of ESP, EC followed by sugarcane trash and lemon grass as compared to black polythene and un mulching . The increase per cent in organic carbon and available nitrogen content were also more due to mulching of paddy straw and sugarcane trash in comparison to initial values. The decomposition of mulching materials in soil helps to increase the organic content and availability of nitrogen (Prasad *et al*., 2004).

Rashidi *et al.* (2012) concluded that in water melon, among tillage treatments, moldboard plow followed two passes of disk harrow, which was found to be more appropriate and profitable tillage method in improving yield and yield components in the arid lands of Iran.

Varma and Chauhane (2013) conducted studies on effect of integrated nutrient application on apple productivity and soil fertility in temperate zone of Himachal Pradesh and concluded that the higher nutrient status of soil due to organic manaure might be because of slow release of nutrients from organic manures and better uptake of nutrients by plants whichin turn increases the leaf mineral content of apple.

Studies conducted on the effect of organic sources of nutrients on the growth, yield and yield attributing characters of cabbage by Chaurasia *et al.* (2004) and revealed that the analysis of cost: benefit ratio indicated for recommendation of FYM @ 20 t ha^{-1}followed by NPK @ 120:60:60 treatments resulted in higher economic return.

Raja *et al*. (2004) concluded that the higher yield in the treatment in the study conducted on influence of *in situ* water harvesting technique on *Moringa* based cropping system in semi arid region may be due to conservation of rain water *in situ* resulting in higher moisture availability in the soil profile throughout the crop season.

Liu *et al*. (2013) conducted study on the effects of

Fig 1 and 2 : Powered tillage tools used with horticultural crops: rotary tiller (left), and spader (right)

composted pineapple residue return on soil properties and the growth and yield of pineapple and found out that the catalase activity was significantly increased by the composted pineapple residue return treatment.

Organic farming :

Organic farming essentially excludes the use of many inputs associated with modern farming, most notably synthetic pesticides and fertilizers. To the maximum extent possible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes. These components maintain soil productivity and tilth, supply plant nutrients and help to control insects, weeds and other pests.

Organic manures *viz.*, FYM and agrigold either alone or their combinations produced higher fruit yield and the B:C ratio can be excelled with the use of organic manures as against application of chemical fertilizers in papaya (Shiva Kumar *et al.*, 2012). Organic production systems have the objective of including a rational use of natural resources with high quality and shelf-life performance.

Conclusion:

All the above discussed systems including organic farming practices helps in protecting soil nutrients from erosing off and depleting off due to different conventional agricultural practices and also human activities that are damaging natural soil properties. These practices help in sustainability of soil properties there by retaining soil nutrient levels which helps in optimum production of horticultural crops. These practices which help in increasing soil fertility will augment sustainability in horticulture crop production.

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