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Landless Urban Rooftop Farming Context of Soilless Culture for Microbe Free Cultivation, Roof Security and Environmental Sustainability

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Landless rooftop farming is an artificial cultivation on the roof which uses organic solid or liquid media called solution culture "media culture" or water culture "hydroponics". Media culture and hydroponics has been used sporadically throughout the world in rooftop and tissue culture also has been used the world as commercial means of growing both food and ornamental plants. It supplies fresh vegetables in countries with limited arable land as well as in small countries with large populations. Plants grown by hydroponics have concisely superior quality, high yield, rapid harvest, and high content, at present it is used widely in research facilities as a technique for studying plant nutrition. Gravel or sand is sometimes used in soilless systems to provide plant support, and retain some nutrients and water. The retention and water can be for their improvement through the used materials, but others such as rice hulls, bagasse, sedge peat, and sawdust are used sometime as constituents in soilless mixture straw bales have been used as the growing medium in England and Canada. Rockwool (porous stone fiber) is used in Europe. Since the major constituent of the media in artificial growing systems may be solid or liquid, it is appropriate to use the term soil culture in

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reference to this general type of growing system and reserve the term hydroponics for those in which water is the principal constituent. Soilless organic media preparation and use has a tremendous effect in land less culture. It is basically used in Rooftop vegetable cultivation.

Keywords: *Rooftop farming; soilless culture; substrate, liquid medium; roof security; environmental security.*

1. INTRODUCTION

Soil is generally the most important constituent of growing for all kinds of plants but the common problem of field soil is not uniformly distributed land over the world. Different soil has different nutrients. They cannot grow plants with the same variety of nutrition in soil. The shrinkage of agricultural land due to continued Industrialization and urbanization causes soilless culture adopted by rooftop farmers. Presently many countries are focusing special attention towards soilless cultivation. Pathogenic Organisms are a common problem in field soil. Heavy weight of soil unable to cultivate on the rooftop farming but soilless culture media essay to use in rooftop and container garden. It is to increase the productivity in land less urban agriculture in our country to meet the future demand. The soilless cultivation uses media like hydroponics, aeroponics and other solid substrate medium like coco peat, compost. Soilless cultivation is another way of growing agricultural and horticultural crops in rooftop, terrace, balcony garden. In soilless culture media use bags, pots, loans, containers. There are different types of containers available i.e. long wooden trough in which one or two rows of plant are grown. Polyethylene bags or rigid plastic pots containing one to their plant in the bag or pot system. These are all used in soilless culture. The recent scientific invention proved that soilless culture crops plants without soil. Soilless culture safe to roof due to light weight and check water shippage. The soilless culture environment from soil contamination. Soilless culture is very much demanded in urban agriculture.

1.1 Study Area

Bhubaneswar [20.270N 85.840 E] is an ancient city in India's eastern state of Odisha. It is a smart city declared on 28 January 2016 and also called as temple city and capital of state Odisha. Due to the India declared smart city, the smart framings growing on the rooftops is one of the interesting cultivation systems in Bhubaneswar city of India. Bhubaneswar is a densely populated city of India with a large area of roof. The people of Bhubaneswar are very much

interested in soilless cultivation on rooftops, terraces and balconies.

2. MATERIALS AND METHODS

The preparation of soilless media using organic and inorganic substrate systems. The mixture of following substrate [Table-1 and 2] in appropriate proportion in a container and put in a well ventilated dome for decomposition for 7-12 days. After time of decomposition the soilless solid media is ready for use.

3. RESULTS AND DISCUSSION

3.1 Organic Substrate

3.1.1 Peat moss

Peat moss is formed by the accumulation of plant materials in poorly drained areas. The type of the plant's material and degrees of decomposition largely determine its value of use in a growing medium. Although the compositions of different peat deposited vary widely four distinct categories may be identified:

- hypnaceae moss.
- rede and sedge
- humus or muck
- sphagnum moss

Sphagnum moss is perhaps the most described form of organic matter for the preparation of growing medium and the sphagnum moss is light in weight and has the ability to absorb 10 to 20 times its weight in water. This is attributed to the large groups of water holding cells, characteristic of the genus. Peat substrate may be used in various ways for raising crops the most popular are bags modules and through but also basins, rings, batteries and boosters [Fig. 1].

3.1.2 Wood residues

Wood residue constitutes a significant source of soilless growing media. These materials are generally bi-products of the timber industry and are readily available in large quantities. Nitrogen duplication by soil microorganism during the

decomposition process is one of the primary problems associated with this material, however supplementary application of the growing media can make most wood residue available amendments.

3.1.3 Sawdust

Several sawdust such as walnut and non-composted, are known to have direct phototoxic effects. However the C: N ratio of sawdust is such that it is not readily decomposed. The high cellulose and lignin content with insufficient nitrogen supply creates duplication problems which can severely restrict plant growth however supplementary application of nitrogen can reduce this problem. best bio-compost prepared from sawdust [Fig. 2].

3.1.4 Barks

Bark is a primary bi-products of the pulp paper and plywood industries . particle size is by hammer milling and the screening .This products a material which is suitable for use in container media. Physical properties obinted for tree barks are similar to those of sphagnum moss.

3.1.5 Coco peat

Coconut peel or coco peat it used for a wide range of soilless crop production through the world including Tomatoes, Cucumbers, Elephants, Capsicums, Zucchinis, Strawberries, Melons, Carnation, Rose, Grebe, Gyphosphalas, Lisianthus, Chrysanthemums. The number of harmful environmental impacts is done. This high water holding capacity of this substrate provides a buffer in a high temperature in the high cope lode demand without comprising air supply, the presence of organic compounds in coconut peat can stimulate root growth and offer the same resistance to plant disease [Fig. 3].

3.2 Arka Fermented Coco Peat Substrate

The technology for raw waste into farmed coco peat has been standardized at ICAR-Indian institute horticultural research Bangalore and released as a called arka fermented coco peat (AFC).Ref.[2]. Arka fermented coco peat is very popular and used as a growing media in the nursery and rooftop farming for raising seedling of various vegetable crops and rootstock and different fruit crops .However it has not been cultivated so far as growing media for cultivation for vegetables under soilless condition. Therefore an experiment on soilless cultivation of different vegetables was conducted at ICAR-IIHR to suit

the suitability of arka fermented coco peat as substrate along with commercial coco peat and soil [Fig- 4].

3.3 Inorganic Substrate

3.3.1 Perlite

Perlite is a unique volcanic mineral, which expands from four twenties to its original volume when it is quickly heated to a temperature of approximately 1600-1700°F. This expression is due to the presences of two to six percent combined water in the curd perlit rock which causes the perlite to pop in a manner smaller to that of popcorn, when expended each granular shoe-white particle of perlite is sterile with natural PH and contain many time close cells are bubbles .the surface of each particle is covered with time cavities which providing and extremely large surface area. These surfaces hold moisture and make them available to roots, in addition become the physical safe of each particle where passages are formed which provide optimum aeration and drainage. Because pertite is sterittle it is free of disease seeds and insects.

3.3.2 Sand

Sand is a basic component of soil. and ranges in particle size from 0.05 mm to 2.0mm in diameter .fine sand (0.05mm to 0.25mm) due to improve the physical properties of a growing media and may result in reduced draining and aeration .medium and coarse sand particles are those, which provides optimum adjustment In media texture. Although sand is generally the least expensive of all inorganic amendment and it is also the harvest. This may result in prohibitive transportation costs. Sand is an available amendment for both potting and propagation media. But washed sand should be purchased since it is nearly free of clay and organic matter.[Fig-2]

3.3.3 Vermiculite

Vermiculite is a micaceous mineral produced by heating to approximately 745* c. The expanded plate-like particles which are formed have a very high water holding capacity and do in aeration and derange. Vermiculite has excellent exchange and buffering capacities as well as the ability to supply potassium and magnesium. Although vermiculite is less durable than sand and perlite, its chemical and physical properties are very desirable for container media [Fig.-5].

Table 1. The Organic substrate use in soilless culture system is used in Bhubaneswar

SI/NO	Organic substrates	Quantity In dry weight/100 gm.
1	Peat mosses	17.8 %
2	Wood Residues	13.3 %
3	Sawdust	11.5 %
4	Bark	14.4 %
5	Coco peat	32.6 %
6	Arka	10.4 %



Fig. 1. Use Peat Moss in Rooftop Garden in Bhubaneswar



Fig. 2. Mixture of bio-compost to produce growing solid media use in rooftop farming

Table 2. The Inorganic substrate use in soilless culture system is used in Bhubaneswar

SI/NO	Inorganic substrates	Quantity In dry weight/100 gm.
1	Perlite	27.4 %
2	Sand	9.3 %
3	Vermiculite	18.2 %
4	Calcined clays	22.6 %
5	Plemice	9.1 %
6	Rockwool	13.4 %



Fig. 3. Coco peat use in rooftop garden in Bhubaneswar



Fig. 4. ARKA fermented coco peat use in rooftop garden.



Fig. 5. Vermiculite use in rooftop garden in bhubaneswar

3.3.4 Calcined clays

Heating montmorillonite clay minerals to approximately 690°C forms calcined clays. The pottery-like particle from an area six times as heavy as perlite. Calcined clays have a relatively high cation exchange as water holding capacity. This material is a very durable and useful amendment.

3.3.5 Pumice

Pumice is a direct product of acidic volcanism. pumice is a high vesicular volcanic glass silica in composition and occurs as a massive block or unconsolidated fragmented material. The vesicles are glass-walled bubble casts which give pumice low density compared to natural glass pumice, the commercial term for fine grained, fragmented pumice. Ref. [13]. Pumice diameter may be deposited some distance from the source. Pumices are formed from silica larva rich in dissolved volatiles particularly where vapor on eruption sudden release of pressure led to expansion of volatiles which in turn generate a frontally mass of explained larva. This mass may solidify on contact with the atmosphere as a vent felling or flow or may be shattered by a violent eruption

pumice has many advantages such as high strength-to-weight ratio. Violent insulation and light surface area which result from the vesicles nature of this rock. Ref. [8].

3.3.6 Rockwool

Rockwool is manufactured from three natural raw materials: 60% diabase (form of basalt), 20% limestone and 20% rock wool is coke. Debase is rock from which the name rock wall as three materials are methods to gather temperature. of 1600°C The molten mass is then spun at its high speed into the fiber of 0.005 mm diameter erected with certain activities (a resin) behind the fiber together then pressed into slabs to various sizes. The most common size are 90x20x7.5 cm and recently 90x10x7.5 cm part a part from growing slabs Rockwool clubs of 3.0, 4.0 or 5.0 cm size with a central hole are used for the propagation of seeding. these are single or grouped wrapped in polythene or paper. Rockwool is also produced as loose flock which is used as a growing medium in port in a smaller way to peat as a additive to their media an average 95% of the volume of dray Rockwool sable in area space in only 5% in fiber [Fig-6].

Table 3. Organic and Inorganic substrate available in Bhubaneswar.

SI/NO	Organic substrate	Quantity	Inorganic substrate	Quantity
1	Peat moss	26.32 %	Perlite	08.12 %
2	Wood residues	16.22 %	Sand	24.13 %
3	Sawdust	14.35 %	Vermiculite	16.35 %
4	Bark	28.46 %	Calcined Clays	7.69 %
5	Coco peat	46.56 %	Pumice	6.58 %
6	Arka	13.28 %	Rock wool	4.32 %



Fig. 6. Peat contains rockwool from Bhubaneswar

4. NUTRIENT MANAGEMENT IN SOILLESS CULTURE

plants requires 17 essential elements for their growing and development without these nutrients plant cannot complete their life cycles and their roles in plants gross weight cannot be replaced by any other elements .all essential nutrients are supplied to soilless culture plants in the form of nutrients solution which consequences of fertilizer, salt dissolved of water in field culture of the clay fraction of soils can be expected to supply adequate amount of at least some of the nutrient required by plants supply adequate amount of last some of the nutrients required by plants especially to minor elements . fertilizer program for soilless-culture system must supply all nutrients required by the plants .Carbon be the plants hydrogen by oxygen by providing from water and carbon dioxide on carbon the grower will supply Nitrogen. Phosphorous, Potassium, Calcium, Magnesium, Sulfur, Iron, Boron, Copper, Zinc, Manganese, Molybdenum, and Chlorine most medium materials contain small amount of these elements but they should not be considered in planning the fertilizer program because they are small proportion in the requirements of they may in be forms not readily available of the plants liquid medium substance such as NFT and gravel bead culture use complete nutrient solution prepared from soluble inorganic salts containing various elements. The soilless culture grower must have a good knowledge of the plants nutrients as management of plants nutrients through supply nutrient solution is the key to success in soilless cultivation.Ref. [7]. The soilless culture method enables growth to control the availability of essential elements by adjusting or changing the

nutrient solution. to salt the plant growth stage and provide them in a balanced amount. As the nutrients are present in ionic form in the nutrients solution and also not needing to search completely for available nutrients they do in soil, easily achieved in soilless culture then in soil. While optimum nutrients in assay to achieve in soilless culture, incorrect management of the nutrient solution and damage the plant and lead to complete failure, the success failure of a soilless cultivation there for, depending primarily on the strict nutrient management program .carefully main putting the nutrient solution pH level temperature and replacing the solution whenever necessary.This leads to successful cultivation of any kind of crops in soilless culture under protected conditions. Ref. [3].

Preparatory mixes of all required elements are available which are simply dissolved in water to prepare the nutrient solution. These mixes are available in various concatenations and ratios of elements. Nutrient solution can also be prepared by the grower easily reading available soluble salts. The complete nutrient solution formula has been developed and used successfully. All contain the same elements and are generally prepared from the same compounds. Although in somewhat different perpetration, one formula is necessary the best of all plants but all the capable of providing adequate nutrients .special formula are often recommended for a particular crop plant based upon research under the prevailing climate and the water quality conditions .but one should based construed as the being the best universally under the conditions. They are good points agriculture and dissolving a feeding program for the crop for which they are recommended and may be well

suited for use without alteration.[Ref-9] successfully managers seek as much information as possible from reliable source to develop a sound understanding of plants nutrients and organic chemistry before attempting to alter published formulas for their imagined or perceived needs. Improper alternation of formulas can lead to serious adverse effects due to excess or deficiency.Ref.[1]. Applied up several time requires either a supply tank for the nutrients solution is applied up to several time as day to maintain the medium is a most (but no saturated) conditions .this system requires either a supply tank for the nutrients solution or a ratio feeder fertilization that proportioned that preparers solution upon demand from stock nutrient concentration. for small greenhouses the frequents chore of relationship the solution supply in a tank may be more attractive than investment in a fertilizer proportioned .when using the supply-tank method for a recalculated growing system .the tank should be large enough to hold a volume of solution about twice that required to fill the system .this provides a safe margin of nutrients supply Proper nutrition factors such as EC the type of nutrition the composition of nutrients irrigated and so and the key factors to improve the quality of the yield EC is considered to be one of the most important properties of the nutrients used in soilless culture .if the EC of a nutrient solution is low the supply of some nutrients to the crop may be inadequate similarly when the EC is too high the plants are exposed to stagnantly however yield among the different space to the EC the nutrients solution may vary widely among different species,

therefore for each cultivated plant species the term too low and too high need to be quantitatively defined based on experimental result.Ref. [5].

5. WATER MANAGEMENT IN SOILLESS CULTURE

Nutrient solution is delivered to the containers by supplying lines of black polyethylene tubing to spaghetti tubing spray or ring dippers in the containers, application devices have different wetting's patterns and are available at different flow rates. The choice of application system is important in order to provide proper wetting of the medium at each irrigation. Texture and porosity of the growing medium and the surface area to be wetted are important considerations in making the choice.Ref.[10] Tubing provides a point-source wetting that might be appropriate for a fine-textured type of medium and allows water to be conducted alterably with ease. In lay flat bags ,single spaghetti tubes at individual plant holes will provide good wetting of peat-lit media .In a vertical bag containing porous medium, a spray stick with a 90-degree spray pattern will do a good job of irrigation if it is located where we get the majority of the surface. Ring dippers are also a good choice for vertical bags although somewhat more expensive .when choosing an application system for bag container uniformly so that the objective of irrigation is to distribute internet solution uniformly so that the anterior medium is wet. Since root systems cannot function in a dry medium [Fig-7].



Fig. 7. Preparing nutrient solution media using cow urine for rooftop garden

A considerable amount of research work was published in recent years stating those advantages of soilless culture. The advantages to mention in this paper are those not necessarily applied to all soilless systems and all substrates employed taking into account the difference between the system and the degree of sophistication applied to each one of them. There are mainly advantages of growing plants under soilless culture over soil-based culture. Soilless culture offer opportunity to provide optimal conditions for plants growth and therefore, higher yields can be obtained compared to open field agriculture gardening is clean and extremely easy requiring very little effort .soilless culture offers mains control over soil-borne disease and pests which is especially desirable in the tropic where the life cycle of these organism continues uninterrupted and so does the thread of infestation is also effective of the region of the world having scarcities of durable or fertile land for agriculture.Ref.[8].It reduce the cost and time taken of various which as

In soilless cultivation it offers a clean working environment and thus hearing labour is an easy list of other advantages of soilless culture is given below. Control of plant nutrients. Ability to control pH and EC.Water economy and control. Reducing labour requirements. Sterilization practices. Control of the root environment. Multiple crops per year. Unsuitable soil can be used.

6. LIMITATIONS OF SOILLESS CULTURE

Despite many advantages, soilless culture has some limitations. Application on a commercial scale requires technical knowledge and higher initial capital expenditure. this will be future high if the soilless culture is combined with controlled environmental agriculture .high degree of management skill less is necessary for solution preparation maintenance of pH and EC nutrients deficiency judgment and correction.ensuring aeration: maintenance of favorable condition inside protected ensuring aeration maintenance to favorable condition inside protected structure etc. Greater care is required with respect to plants' health control.Ref.[6]. Finally energy inputs are necessary to run the system .Considering the significantly high cost the soil-less culture is limited to high value crops of the area of cultivation.

Rise with large population plants grown by hydroponics and concisely superior quality, high

yield, rapid harvest, and high content. At present it is used widely in research facilities as a technique for studying plant nutrition. Gravel or sand is sometimes used in soilless systems to provide plant support, and retain some nutrients and water. The retentions and water can be for their improve through the used materials, but other such as rice hulls, bagasses sadge pet, and sawdust are used sometime as constituents in soilless mixture straw bales have been used the growing medium in England and Canada .Rockwool (porous stone fiber) is used in Europe.Ref.[9]. Since the major constituent of the media in artificial growing systems may be solid or liquid, it is appropriate to use the term soil culture in reference to this general type of growing system and reserve the term hydroponics for those in which water is the principal constituent.[Ref-12]

7. SOILLESS CONTAINER GARDENING

Soilless culture bags, pots, or through with a light weight medium is the simplest, most economical and easiest to manage of all soilless systems. There are different types of containers available i.e. long wooden trough in which one or two rows of plant are grown. Polyethylene bags or rigid plastic pots containing one to three plants in the bag or pot system. The solution is not circulated. The most common type of media used in containerized systems of soilless culture is peat-lite, of a mixture of break and wood chips .Ref.[4]. Bag or pot systems using bark chips or pet-lite are in common use. Nutrient solution is supplied for a fertilizer proportioned or medium. Any excess is drained out from the system through drain holes in the base of the containers. Thus, the concentration and balance of nutrients in solution feed to the plants periodically to determine the kind of necessary adjustment, and avoids the possibility of solution excess or deficiencies.[Fig-8 and 9]. The soilless culture accommodates the best result in rooftop garden, balcony garden, terrace garden, substrate culture, media culture, soil less culture is best for container gardens for their opportunity point of view plants, alive pest and microorganism free environment. In the rooftop garden use different containers for solid and liquid media. We may say "**Soilless culture is water less culture**" because less water is needed for this culture by proper maintenance and management. Fresh nutritive uncontaminated agrochemical free food is grown by soilless culture. Soilless culture protects soil pollution by the restriction of hazardous chemical use for pesticide and

insecticide and chemical fertilizer. It is one of the challenges for urban people to perform soilless

culture. In the future soilless culture will grow very rapidly all over the world. Ref. [11].

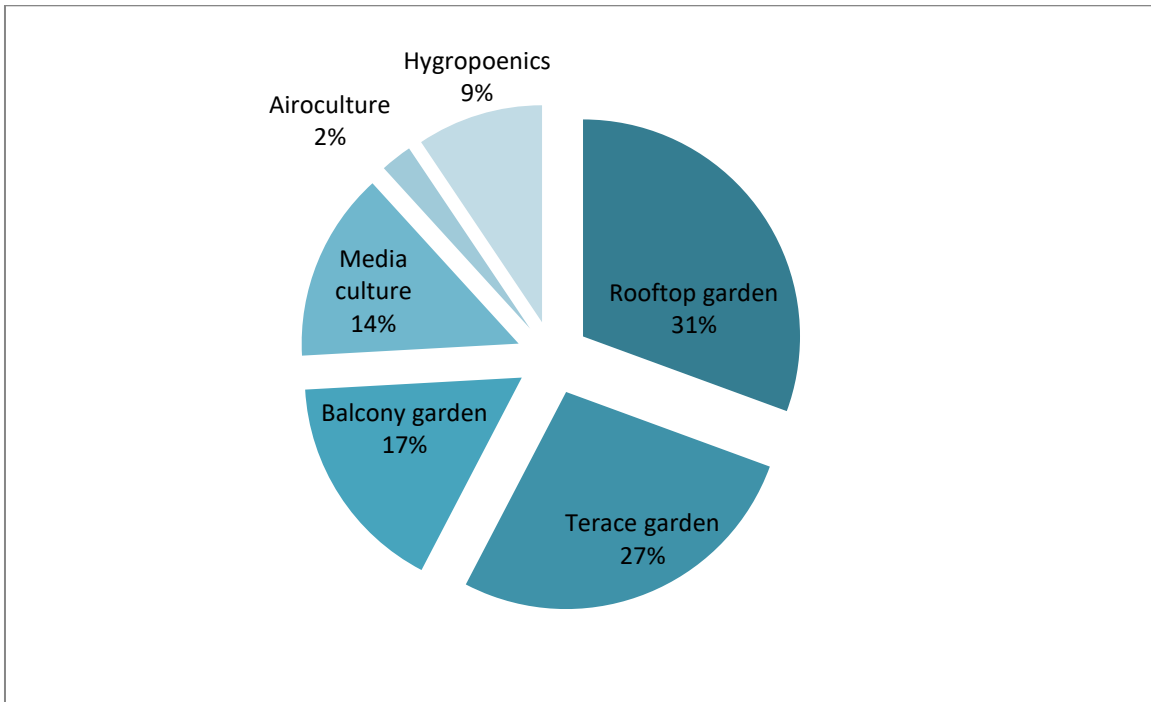


Fig. 8. Survey of soilless cultivation in different urban farming in Bhubaneswar 2020

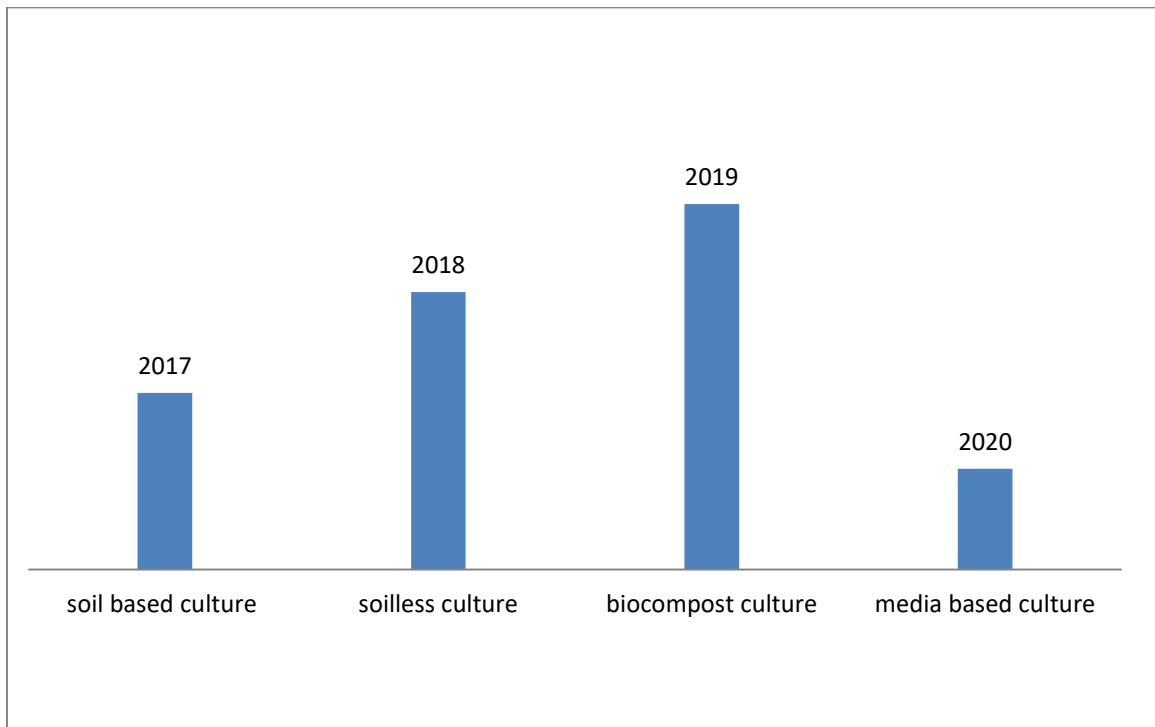


Fig. 9. Survey of different roof farming in Bhubaneswar 2020

8. CONCLUSION

We must keep up with the times and use whatever available technology to achieve high standards of soilless culture practices even if we have to use technology from our neighboring cities as this time they can only survey environmental ecology and be progressive nation. Soilless culture or cultivation is germ free cultivation that grows uncontaminated food for food security and environmental sustainability. This will bring about a new generation looking out for roof farming as a model for success and growth for entire cities of the world. Soilless culture is necessary for respondents of study area Bhubaneswar.

9. RECOMMENDATION

Soilless culture in rooftop farming has a large advantage to heavy load to the building. All should use soilless culture in rooftop gardening. The soilless culture provides organic based farming in which microorganism free vegetables. Soilless media has plenty of organic nutrients which grow plants very well and increase food production. Soilless culture makes it easy to maintain roof farming in containers and save water. All mega metro cities should recommend the soil less culture for their rooftop garden.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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