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Full Length Research Article

Adopting Hydroponic Farming in Indian Agriculture: A Comparison of Hydroponics with Traditional Farming

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A B S T R A C T

Agriculture is the most important sector in India for the reason that majority of the population depends on this sector for their livelihood. The method of cultivation is still very traditional and hence the production is very less. The population in India is growing so fast but the production of food grains to feed the growing population is not equalizing with that. To increase the production of food grains the method of cultivation should be changed. From the traditional method it has to transformed to new and innovative methods, Hydroponics is the method that is being adopted by many countries and there has been significant improvement in the production. The unique feature of hydroponics is that it is a method where less water, no soil, no fertilizer and no chemicals are used in this method of farming. Only the required amount of nutrient that is essential for the crop production are followed in hydroponics method of farming. Hydroponics is water less, soil less and have other advantages which will be explained in this paper and it further throws light on the global perspective of hydroponics and gives some information on how some countries are benefitted by this hydroponics methods of farming. Another objective of this paper is to compare traditional type of farming with that of hydroponics and how this kind of farming can be adopted in India. Finally, there are few suggestions given as to how the hydroponics farming can be improved in India.

***Key words*:** Agriculture, Innovative, Traditional farming, Hydroponics, Soil less, Water less, Nutrients, Production

Hydroponics is a technique of growing plants in soil less condition with their roots immersed in nutrient solution [1]. The word "Hydroponics' comes from 'Hydro' which means water and ponics. The word 'Ponics means the labour that is required. The main aim of this method is to grow plants in gravel or liquid without soil. This kind of Hydroponics cultivation is a farming technique which does not require sunlight and rain. According to UN reports on global population, plants grown in hydroponic systems have achieved 20-25 percent higher yield than the traditional agricultural system with its productivity being 2-5 times higher. India is a country where nearly 75 percent of them depend on agriculture. Even though the country is agrarian based, there are numerous problem that are faced in this sector. Indian farmers still follow the old conventional farming technique where the yield is very less. There are other major issues like soil infertility, water scarcity, lack of finance, debt burden and so on. To put an end to all these problems there is a need for farmers to transform from old conventional type of farming to innovative farming techniques. One such latest technique that is currently followed by other nations is Hydroponics.

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MATERIALS AND METHODS

The required data for this study has been collected through secondary sources. The global level study about hydroponics has been collected from various research journals, books websites and various reports. The study reviews about the hydroponic method of farming in global level. A comparison is made between the traditional method of farming and Hydroponics farming. This paper makes an attempt to examine how the hydroponic method of farming can be adopted in India. All materials on the current status about hydroponics is taken into account. Using the available literature, the present study is being done.

Arikita Jain *et al*. [2] in their research article titled "A review on hydroponic system hope and hype' have examined how hydroponic system farming will be very beneficial for the countries where the soil is not fertile and the countries which actually lack in water and space. The authors have stated the importance of soil less agriculture farming which is becoming more relevant in the present scenario. This kind of farming is gaining more importance because of the prevailing condition where the population is increasing in developing countries like India. Hence the traditional method of farming cannot be

sufficient enough meet the food shortages and water scarcity. Also, the authors have stated the future scope of this method of farming and the various advantages of it. Finally, they have given their positive comments about how hydroponics maintains the minerals on the soil and most importantly how this system is easy to handle. Further the authors have concluded that there is definitely a better hope for the farmers in future.

Madhuri Shrikant [3] in her research paper titled "Hydroponic an upcoming and innovative way of future farming" has stated how hydroponic is more relevant in the present context. The main aim of this research paper is to know about the available techniques for soil less culture, to understand the current methods of hydroponics and also to know about the benefits and disadvantages of this method of farming. Author has given various important benefits of hydroponics such as the availability of nutrients, conservation of water. Less occurrence of pests and diseases. Less space requirement and so on. Author also has stated the limitation such as lack of technical knowledge, high cost and high energy inputs. Most importantly a very high initial investment is a major drawback of the hydroponics method. The author clearly listed the crops that can be grown in soil less cultivation and the source and elements found in the nutrient of the plants. The conclusion has clearly been mentioned as how important is government interventions and the focus of research initiatives. Only then the focus of hydroponic method of farming can be improvised.

RESULTS AND DISCUSSION

Hydroponic farming – A global perspective

'Hydroponic Farming' is the latest technique that is followed throughout the world and this is in fact a growing market in Asia. Among Asian countries, China is the fastest growing market for Hydroponic farming. Global Hydroponic market will grow from $226.45 million in 2016 to reach $724.87 million by 2023. This is reported to be growing at a very fast phase of 18 percent Compounded Average Growth Rate [4]. In Global level if we take, hydroponic farming is thriving and reaching greater yield and profits. Research shows that the global hydroponics market is expected to reach $17.9 billion by the year 2026.

Table 1 Hydroponics market globally in Aggregate Revenue (in USD million)

Year	Aggregate revenue
2014	15000
2015	16000
2016	17000
2017	1800
2018	20000

Hydroponic farming in Japan

The Hydroponic System in Japan was forecasted to reach approximately 8.6 billion Japanese yen in 2021, down from a market size of around 9.1 billion yen in 2019. Through hydroponic systems, crops are cultivated in a soil-less environment. The common method of hydroponics are hydroculture and Static solution culture farming. The farmer uses a soilless medium, such as water or liquid fertilizers to grow crops and are planted in a solid-cultures medium instead of soil [5]. Hydroponic farming is highly supported by the government of Japan. Japanese government allocated 147 million yen to initiate an experimental project on hydroponic farming in urban areas also. Production of Tomatoes and Lettuce are cultivated. The government conducted a survey in 2012 regarding the pricing and products that are grown hydroponically. The findings of the survey states that the vegies growth is fresh and also, they are willing to pay 20 percent to 40 percent more for these crops.

Singapore

Singapore has scarce land resources and the country depend more on food imports. To tackle the issues of limited arable land and heavy reliance on imported food, hydroponic farm has been set up. The hydroponic farm can produce about one tones of vegetable each day. This type of farming is of great demand in the country and it is fast developing in the crop cultivation.

Hydroponics in Bangladesh

Hydroponics is becoming a success in Bangladesh also. Abdul Salam has stated that hydroponics requires 90 percent less water than conventional soil-based farming. Also, he explained how lettuce will take 60 days to grow in conventional farming but in hydroponics it takes only 28 to 30 days. Another example given by him was, that in 1500 plants that grow in soil-based farming, requires 200 liters of water but in hydroponics only 20 liters of water is enough.

Hydroponic farming in Africa

In Africa, Hydroponic farming has increased the food security in many ways. For more than 40 years, Africa has been facing severe drought. Due to this, people have seen the worst scenario. The country faced environmental damage, economic and soil instability and also severe hunger and starvation. To solve these issues, an innovative and cost-effective method of hydroponic farming was introduced by the founder of hydroponics in Africa, Peter Chege. This brought in many changes specially to improve the food security.

Hydroponic fights hunger in Africa

The social condition has become very infertile in most places in Africa. But hydroponics has made a change to combat the food insecurity and to improve the income level of the farmers. With the introduction of hydroponics, the production rates increased. By adopting the hydroponic method of farming in drought stridden areas where the soil conditions are very poor. The hydroponic method definitely fights hunger in Africa. Hydroponics in Africa has installed 365 greenhouses units and 700 fodder units and this has helped to save 500 million liters of water and support 6000 tons of crop yields. The company has also trained 20,000 farmers to use the hydroponics farming techniques [6]. Hydroponics farming helps fight hunger in areas poorly suited to traditional agriculture. The traditional farming in most of the place pushed the farmers in severe poverty level. Whereas the hydroponics method improved the income level due to usage of diss soil, space and water.

Hydroponics in India

India is yet to give more importance to hydroponics farming as it is still in the beginning stage. There are only 40 commercially functioning hydroponic farms in India. When compared to the northern states, southern states fair better in this type of farming. States like, Hyderabad, Bangalore and Chennai have many numbers of hydroponic farms. In the state of Maharashtra, it is slowly gaining more importance and cities like Nashik and Kolhapur, there are more number of hydroponic farms. Also, one more important point is that according to research, there are few vegetables that are given more

important. They are tomatoes, Cucumbers, red and yellow peppers and large greens. Even cucumber is gaining more production in hydroponic farming. There is lot more initiative required to improve hydroponic farming method in India. The method of using this kind of farming is still in a nascent stage in our country. But still it can be taken to a better position. Report by Data M Intelligence which states that a Hyderabad based market research predicts that the Indian Hydroponics market is likely to grow at a compound annual growth rate of 13.53 percent between 2020 and 2027 [7].

Comparison of hydroponics farming and traditional farming

Traditional farming method is followed in most of the countries and especially in India majority of the people depends on agriculture. It is in a traditional method only. We cannot deny the fact that the crop production from this method is definitely not sufficient for the growing population. Hence to equalize with the increasing in population, it is necessary that new methods are followed. The methods that are followed should increase the production and reap profit for the farmers. Hydroponic is a new method where less of land and soil required. It is also seen in the previous section, that there is an increase in the crop production. Many vegetables and crops have seen a vast improvement through hydroponics method of farming.

Traditional vs Hydroponics

(a) *More land requirement*

In traditional farming, more land is required to undertake for more cultivation. So, for the more land requirement, the forest areas are destroyed and it will be further used for farming activities. When the lands are utilized more and more there is a tendency for the soil to lose the fertility. When more and more lands are brought in this, it leads to deforestation and deflection of nutrients. Hydroponics do not require more soil and the cultivation can be undertaken even in indoor and very less land in required.

(b) *Water usage*

In traditional farming the requirement of water is more. About 70% of freshwater is used globally for traditional farming. When population is increasing rapidly, more production of food is required and due to the fast growth in population there is increase in the amount of land and water which are very essential. As the water resources are limited in most places, the expansion puts more strain on water bodies which are already depleted. In Hydroponics farming the main idea that is adopted is the recycling of water. In this system, water does not enter the soil nor does it evaporate. But this is collected and stored and it is reused again and again. So, there will not be a situation of water scarcity.

(c) *Pesticide free crops*

In traditional farming the usage of pesticides is more. Since more land is used, there is a more chance of insects that will be attacked. So, to solve this issue of insects and bugs are more and to get rid of these insects and bugs more pesticides are used. This in turn affects the crops. In Hydroponics farming, very less land is used and the usage of pesticides are limited. Since very less land space are used, the growth of bugs or insects is not seen. Hence this type of farming does not depend on pesticides.

(d) *No weeds*

In traditional farming, growth of more weeds is seen. The growth of weeds creates more problem to the farmers as these weeds will take away the nutrition content and also creates a space crunch for the crops. The chance of growing weeds is not found in hydroponics type of farming. As this kind of farming eliminates the chance of weeds the farmers can save their time and use it productively for other purpose.

(e) *Greenhouse gas (GHG) emissions*

When it comes to Greenhouse gas emissions it is the traditional farming which accounts for almost 30 percent of all GHG's. This is more in traditional farming because of land usage, increase in crop production, more pesticides that is used and also due to the usage of animal wastes. All this increases the GHG emissions to a very high level in traditional farming. There is very less level of GHG emissions in Hydroponics farming. The main reason is very less land and soil are used in this type of farming. There are lack of pesticides and chemical fertilizers that are used. This method of cultivation creates more green spaces and it plays an essential role in in oxygen generation and carbon storage. This method paves way for better environment and it shows positive way of creating a better way of cultivation.

(f) *Increased production*

In traditional farming even though more lands are under cultivation the production seems to be less because of water shortage and other constraints. There are various other problems like over usage of pesticides, increase in pests, bugs and diseases which decreases the crop production. In Hydroponics farming method, more than sunlight, this type of farming requires LED's which enhances the growth in a better way. Also, even during the winter season, there seems to be an increase in production. The produce that is acquired from hydroponics farming method is more than in the traditional methods. There is a vast difference between the crop that is yielded using soil and that which is used by hydroponics. The water usage is very less. The following data will indicate the difference in the field using soil and using hydroponics.

Table 2 Crop and the yield using soil and using hydroponics

Type of crop/vegetable	Yield (using soil tons per hectare at harvest time)	Yield (using hydroponics) (tones per hectare at harvest time)
Lettice	52	300-330
Tomato	80-100	350-400
Cucumber	10-30	700-800
Carrot	15-20	55-75
Potato	20-40	120
Peppers	20-30	85-105
Cabbage	20-40	180-190

(g) *No soil erosion*

There will not be soil erosion in hydroponics method of farming. Soil erosion and weeds are the two important issues in traditional farming. Soil losses is fertility when it is tilled more and more times. And also, the problem of weeds is serious issue in traditional farming. This is not the case in hydroponics as less amount of soil or no soil in some cases that is followed. Over the past few years, traditional farming has resulted in soil erosion. Many farmers have completely lost the fertility of their soil and hence production has reduced. This is not the issue in hydroponics, because the soil is not being used. The same is the case for weeds also where in hydroponic system don't provide weeds with an environment that conductive to growth.

(h) *Control of nutrients in hydroponics*

In traditional method of farming the nutrient content is lost to some extent as more pesticides are used. Nutrient level are very important as it keeps the people healthy. This is maintained well in hydroponics. As the pesticides are not used in this, the nutrient level is more. The test and acidity vitamins on the carotenoids in tomatoes are better in hydroponics farming where soil less culture system is followed [8].

(j) *Crops can be grown in any weather condition*

Farmers can grow crops in any kind of weather condition. They can grow any kind of crops vegetables and fruits in a year where the production can be increased multiple times than in the traditional method of cultivation. Before using hydroponics, crops like corn and tomatoes are very difficult to be grown during winter season and farmers will be idle in that season. But by using hydroponics method of farming, there will be high yield throughout the year. Due to this there will be no price fluctuation, because of continues supply.

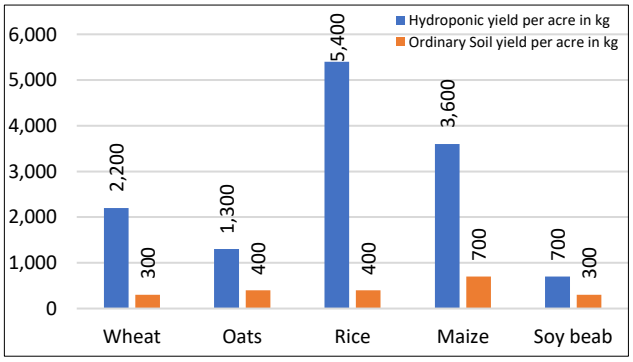
(k) *Higher production in hydroponics*

One of the best advantages in hydroponic method is that there is higher production in this type when compared to soil forming. In soil forming, plants spend high amount of energy on root growth that is a natural. Whereas, in hydroponic farming plants do not spend energy on root growth. Plants need not spend their energy on root expansion. Due to this hydroponic farming have higher food production than average soil plants.

Table 3 Hydroponic averages in crops compared with ordinary soil yield

Name of the crops	Hydroponic yield per acre in Kg	Ordinary soil yield per acre in Kg
Wheat	2,200	300
Oats	1,300	400
Rice	5,400	400
Maize	3,600	700
Soy bean	700	300

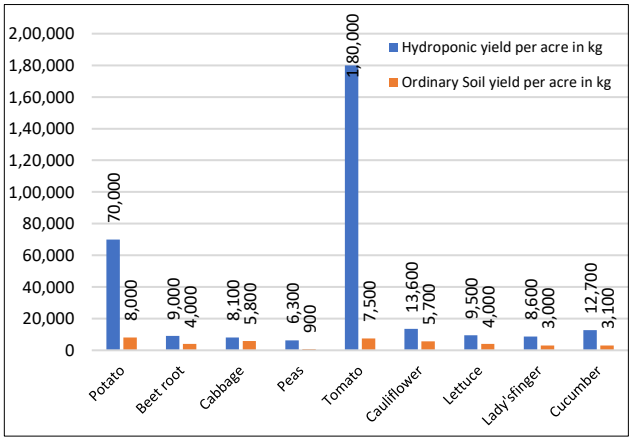
The (Table 3) compares the hydroponic yield per acre with that of soil yield. It is clearly given as how the yield for wheat is in hydroponic farming when compared to that of soil cultivation. The figure given states that there has been a drastic increase in all the crops in hydroponic cultivation than in the soil type farming. It is almost three times higher yield in hydroponic farming. Not only in crops but also in vegetables there is seen an increase when it comes to hydroponic than in soil cultivation.



Source: Mamta *et al*. [9]

Fig 1 Hydroponic averages in crops compared with ordinary soil yield

The (Fig 1) explains the amount of yield in certain crops and it shows a comparison between the hydroponic and soil cultivation. From this figure it is understood that the yield per acre is high in hydroponics farming than in soil cultivation. In case of wheat, it can be seen that the ordinary soil yield is only 300kg whereas in hydroponics farming it is 2200 kg there seems to be highest yield in hydroponic farming than in ordinary soil cultivation. The crop yield for rice shows a drastic increase which touches 5400 kgs in hydroponics farming than 400 kgs in soil cultivation. The same is the case with maize and oats also.



Source: Mamta *et al*. [9]

Fig 2 Hydroponic averages in vegetables compared with ordinary soil yield

The (Fig 2) depicts the comparative yield of hydroponics and ordinary soil cultivation. From the figure it is clear that the yield of tomato is very high with 80,000 kgs in hydroponic farming and very meagre yield growth in case of soil cultivation which shows a data of 7500 kgs only. The same is the case with potato with 70000 kgs increases in the yield when compared to just 8000 kgs in ordinary soil cultivation.

(l) *Water efficiency*

In soil farming, water requirement is more. A traditional method of farming requires more quantity of water in general. This completely is quite contrast in hydroponic farming where evaporation does not happen in this method because, the water surface is not subjected to too much heat as soil. There are almost most of the countries in the world where increasing water scarcity is found. WHO has estimated that half of the world population will be living in water stressed areas by 2025. Hydroponics farming will use just 320 gallons of water and hundred square feet of land to produce the same amount of leafy greens that 8,27,640 square feet of land and 2,50,000 gallons of water would produce using traditional farming methods [10].

Conventional farming requires large land treatment then hydroponics farming. Disease contamination is lower with hydroponics farming than conventional farming [11] former can control the spread of insects and diseases in a hydroponic farm than in the open conventional farm [12]. Hydroponic farming has no particular season. It is a major advantage of the farming system [13]. Unlike conventional farming which is affected by seasons, hydroponic farming can be done yearly.

Adopting hydroponic farming in Indian agriculture

In India the major requirement for cultivation over the years is land and water. As generation pass through, the land is subdivided and fragmented and hence most of the farmers have very small land holdings. The size of the holdings is decreasing and this is a major defect in our country. The number of small and marginal agricultural land holdings in the country (Known

as operational holding) has registered marginal increase in 2015 to 16 compared to 2010 to level according to the 10th agricultural census[14]. Another major issue faced in India is the requirement of water. Most of the states in the country are facing severe water shortage and agricultural sector needs extensive use of water. Farmers face serious consequences due to water scarcity which is a major hindrance for agricultural sector.

Decrease in imports

India is currently importing more than 85 percent of its exotic vegetables, creating a growth rate of 15-20 percent per year. In case if lettuce is grown in India, it could be 30 percent cheaper than what is being imported. Also, there will be a positive impact when the country produces itself. Another imported vegetable is cherry tomatoes. The cost involved is Rs.1000/Kg but if is domestically produced, then the cost involved will be Rs. 200/Kg. All these can be done with the help of hydroponics. This type of farming definitely improves the cultivation of lettuce and cherry tomatoes. The National Restaurant Association of India and Technopark has estimated that India's food services market is $48 billion. It is estimated to increase to $78 billion in 5 years. This can be done by adopting Hydroponic method of farming. There are number of reasons to adopt Hydroponics in India.

Table 4 Vegetable production under hydroponics in India

Vegetables	Production (g/sqm/day)
Carrot	56.5
Cucumber	226
Garlic	57
Ginger	57
Leek	57
Greek bean	113
Lettuce	226
Onion	56.5
Pea	113
Potato	56.5
Salad greens	226
Tomato	113

Source: Frezza *et al.* [15]

The (Table 4) indicates the production of vegetables under hydroponics method of farming in India. From these data it can be understood that the production level has seen a significant improvement in the production of certain vegetables.

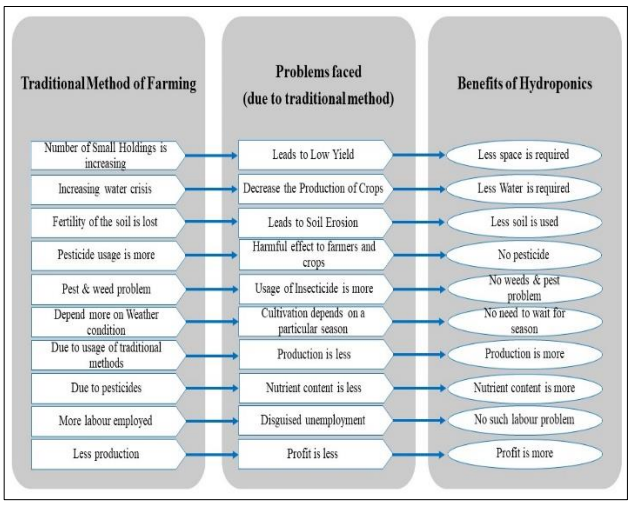


Fig 1 Problems of traditional farming and Benefits of hydroponic farming

From the above chart it is clearly understood that hydroponics method farming can be implemented in a large scale. There are number of problems that are shown in the above chart due to traditional farming. The chart also explains the benefits that can be obtained if hydroponics is followed. For every problem that is faced due to soil cultivation there is solution when hydroponics method is followed. Almost all the problems faced due to the traditional method of farming can be solved due to the implementation of hydroponics method. Only concern is how it will reach the farmers and how readily will they accept such transformation is the question. If proper implementation is done from the government side this method of hydroponics will definitely be a success. The following discussions will give some suggestions to improve hydroponics farming in India.

Suggestions to improve hydroponics farming in India

For the future well-being of the farmers, it is better to think in an innovative manner so that there will be higher production with better farming techniques. In the previous section of this article the various benefits were seen and also it is explained how hydroponics method of farming is better than the conventional/ traditional method of farming. This section suggests some policy measures to improve the hydroponic farming method in India.

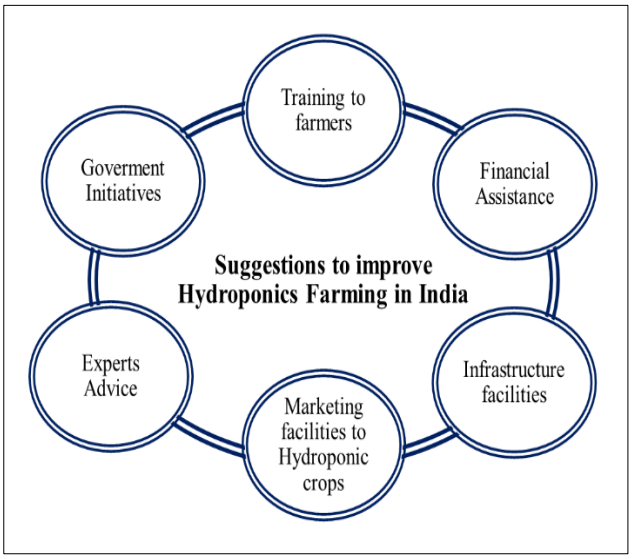


Fig 2 Suggestion to improve hydroponics farming in India

(a) *Awareness about hydroponics method*

Farmers should know about the various benefits of hydroponic method of farming. Also, they should understand how it will be beneficial to them than the traditional method. As most of the farmers are illiterate, the alternate method of farming should be conveyed to them properly.

(b) *Incentives to farmers*

Farmers can be given various kinds of incentives if they follow a different method in agriculture. Government should encourage them by providing more subsidies and incentives if they follow the new method.

(c) *Initiatives by the government*

Both the State and the Central government should take all initiatives to help the farmers to follow the new method of farming. The government should provide credit facilities to the farmers who are interested in following this method, providing them with other infrastructure facilities and also make necessary arrangements for training and marketing facilities.

(d) *Training to farmers*

Adopting a new technology like Hydroponics may be easier, but this also should be done by proper training to the farmers. This method of farming can be fruitful if farmers are trained properly to install and follow this method.

(f) *Financial assistance*

More number of farmers in India are having small and marginal land. They do not have adequate financial facilities. So, there should be more financial assistance that is required for the farmers to adopt new technologies like hydroponics.

(g) *Infrastructure facilities*

The required infrastructure facilities should be provided to the farmers. Only then they can go about in following such alternative methods. Without proper infrastructure, no new method can be adopted.

(h) *Marketing facilities to hydroponic crops*

Farmers should be given assurance about the available marketing facilities. They should be aware about how they can market the product that are cultivated through this method. This will be very helpful for the farmers.

(i) *Expert advice*

Farmers should get the advice of the experts regarding hydroponics. Experts who thoroughly know about this method of farming should assist the farmers and their guidance is very essential.

CONCLUSION

It is time to change the methods of farming in India. As we say that more than seventy percentage of people depend on this sector, the old or the traditional methods of farming should be changed. The developed nations have already entered into a new mode of farming. Most countries follow hydroponics method and have shown significant increase in the production of agriculture sector. As we discussed in the earlier paragraph, about the comparison between the traditional and the hydroponics method where it is seen that hydroponics method have more advantages. The most important problem faced by our Indian agriculture system is the dependance of monsoon and in the case of dry weather conditions there will a huge loss in the production of crops. The only solution to this major problem is adopting hydroponics type of farming as there is no over dependance of climatic condition. Hydroponics farming is well suited for countries like ours due to the fact that whatever be the weather condition this farming method can be adopted. Also, it can be noted that more awareness should be there among the farmers to adopt this kind of method. The role of government is very essential where it can bring more changes in the field of agriculture to enhance the production of food grains. Thus, hydroponic farming method is well suited for our country and it can be followed by our farmers if all facilities are made available for them.

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