International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Smart Air Fertigation (SAF) without using Fertilizers through Air Irrigation for Sustainable Agriculture

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Abstract: *In India approximately 80% of the total water is consumed for agriculture. India does not spend any money in conserving water consumed in agriculture. In the current scenario humans are concerned about potable water, more and more insufficient in relation to the increase of the population and as effect of pollution.*

Crops are watered using various irrigational methods with the ground water. Water consumption in irrigation also depends upon the crop which is cultivated. Sugarcane and rice cultivation consumes nearly 60% of the irrigation water. Further to ensure a bumper produce, farmers are encouraged to use chemical fertilizers. Many of these fertilizers give a promising crop produce but the after effects of consumption of such chemically treated produce leads to harmful effect on human health. Nevertheless, quite a many farmers are now focusing on Organic method of farming wherein chemical fertilizers are totally avoided. However, the produce under this method does not give a bumper crop produce. To tackle the problem of water waste during irrigation process, techniques like drip irrigation, dry farming, irrigation scheduling, and Smart irrigation using Information Technology are applied to ensure least wastage of irrigated water at the same time providing desirable conditions for bumper crop produce. To provide an alternate solution for reducing water wastage in irrigation and providing natural fertilizers to the crops, this research paper suggests the use of Smart Air Fertigation (SAF) without using fertilizers with the aid of Air Irrigation method. Further, by using various IT tools and sensors it is possible to provide Smart Air Fertigation system which will also help reduce labor and will be less time consuming.

Keywords: *SAF; Air Irrigation; Rain Gun; Smart Air Fertigation*

Manuscript received on March 15, 2020.
Revised Manuscript received on March 24, 2020.
Manuscript published on March 30, 2020.

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I. INTRODUCTION

Largest contributor to water wastage in India is irrigation. Agriculture contributes to 80% of water consumption in India; however, this is unregulated and inefficient. Also, India uses 2-3 times more water than countries like China, Brazil and USA which are major agricultural countries to produce one unit of food crop. According to the Central Water Commission, total of 85.3% of water was consumed for agriculture in the year 2000. By 2025 this consumption is likely to decrease to 83.3%. Even though it is evident that Agriculture irrigation contributes to large consumption of water, yet no funds are allocated for conserving water. It is observed that industry and other utility sectors ensure water conservation whereas they consume less than 5% of water. The 2016 budget allocated Rs. 86,500 crores to fund irrigation projects in districts which are water stressed in India. However, it is a general trend that around a third of the irrigation projects start with lots of elaboration but finally end incomplete.

Irrigation in India is facilitated through Wells, Tube Wells, Canals and Tanks. India has 12 million wells and Uttar Pradesh is the leading state. Tamil Nadu is the leading state with largest number of Tube Wells, around 11 lakh Tube Wells States likes Maharashtra, Andhra Pradesh, Karnataka and Tamilnadu also use tanks for irrigation. In India Canals is the main source of irrigation and are of two types – Inundation canals, which are without any regulatory system and Perennial Canals with a barrier system to regulate the flow of water.

Methods like Drip Irrigation, Sprinklers and Surface Irrigation are been used by many farmers. These methods when associated with Information Technology, IoT and Sensors are also termed as Smart Irrigation methods. Smart Irrigation has many advantages, of which the common one being conservation of water.

Smart irrigation which provides precision based water supply to crops and hence ensures least water wastage. Use of IoT technology aided with sensors helps to deliver Smart Irrigation. Weather-based smart irrigation controllers and Soil moisture sensors are used to monitor the irrigation facility at the farms. Weather-based irrigation controllers or evapotranspiration controllers use the local data relating to the weather for adjusting the schedules of irrigation.

Various types of controllers like Signal-based controllers, Historic evapotranspiration controllers and On-site weather measurement controllers are used for applying Smart irrigation. Suspended cycle irrigation systems and Water on demand irrigation systems are Soil moisture sensor-based and used for Smart irrigation.

Most of the Smart irrigation facilities make use of IoT based applications. These applications require Internet to get access to real time data and stored data to take necessary action to implement precision irrigation thus ensuring efficient water usage. IoT applications make use of sensors at various levels to get real time data. These sensors have to be placed strategically to get correct data which can be used in an efficient manner to server the purpose of Smart irrigation. Further, such sensor-based applications also help in detecting faults in the system which can be easily and immediately rectified as the user is informed about the same through mobile applications by sending notifications.

Indian farmers have been encouraged to use chemical fertilizers since the last few decades. This has eventually helped in increasing the produce of fruits and crops alike. However, the aftermath of using such chemical fertilizers has resulted in health issues which are mainly carcinogenic. To counter this problem, which is yet not taken up by fairly many farmers, Organic Farming was the alternative. However, it is observed that following an Organic method of farming does not give the desirable produce. This discourages the farmers as they are unable to make the required amount of income and suffer loses.

II. AIMS AND OBJECTIVES

The study aims to use the method of Smart Air Fertigation (SAF) to -

1. Reduce water waste during irrigation
2. Provide maximum nutrition to plants
3. Maintain optimum humidity for plant growth and flowering

III. LITERATURE REVIEW

V. R. Balaji has proposed Smart irrigation system that provides complete monitoring action by sensors on the field and use of image processing for reviewing the crop health. [1]
Panchal Sachin D. used Smart Irrigation technique which is IoT based that monitors irrigation using soil sensors. [2]
IoT based system using sensors and previous data helps in improving the Smart irrigation and efficiently saves water as mentioned by M. Monica and others in their research work. [3]
Chandan K. S. and Pramitee B. have suggested a low cost sensor based irrigation system which can be used in remote location and can save electricity and water consumption. [4]
Using solar power to provide smart irrigation and reducing the use of grid power is indicated in the research work of S. Harishankar, R. Sathish Kumar and other authors. [5]
Gundlapally P, Satisah P. and Dr. Samalla K. make use of Web based technology along with Raspberry Pi to keep the farmer informed through mobile messages and g-mail about the irrigation at their farm. [6]
Prajkta Bodkhe and M. T. Kolte use alternate energy, solar energy and automatic water flow control for intelligent irrigation. [7]
Rohit Somvanshi and others have used soil moisture sensors and GSM module for reducing water losses as a means of Smart irrigation. [8]
J. Lindblom & B. Nordell has suggested Condensation Irrigation, wherein solar stills are used to humidify air flowing saline water stills and later cooled to generate freshwater. [9]
Hunsaker, Douglas and others have explained the use of elevated use of CO_2 and its impact on Agricultural irrigation and growth of plants, specifically wheat. [10]

IV. METHODOLOGY

The research is based on the data available through secondary sources and actual usage of smart air Fertigation implemented by Mr. Manohar Khake in his farms located at the following locations in the State of Maharashtra with good response of produce:

Table- I: Samples taken for Air Irrigation System

Sr. No.	Location	Area in acres	Plants / Crops
1	Baramati	12 acres	Fruits trees (Mango, Custard apple, Mango, Chickoo, Jambhul, Lemon
2	Pune	1 acre	Fruits trees
3	Solapur	5 acres	Mango, Amla
4	Uruli Kanchan	2 acres	Sugarcane

The research involved the experimental study of 4 locations within the state of Maharashtra where Air Irrigation has been applied and the impact of proposed use of IT to prevent wastage of water and ensure enhanced crop produce. The proposed Smart Air Irrigation technique reduces the amount of water wastage and also enhances the quality of the plants.

V. DISCUSSION

The plant growth depends on various elements and / factors such as water, humidity and elements absorbed from air etc.

A. Rain Water

Rain water is the main source of water for irrigation. It is also the most nutritious source for plants for development and growth. In recent times due to drastic climatic changes, due to Global Warming, which has resulted in non seasonal rains and flooding, many farmers have suffered losses due to destruction of their crops. It is essential that plants receive the right amount of water at regular intervals. Due deforestation and other man-made hurdles, rain water is not getting stored as ground water. The level of ground water has reduced in many places over the globe leading to droughts. It is thus necessary that the water for irrigation requires to be used meticulously.

Rains are formed due to the condensation of water vapor. The raindrops that fall to the ground, as they pass through the atmosphere, absorb dust particles and water-soluble gas molecules (including CO2 and NO2) along the way. It is a general observation that plants look healthier and greener after rains since the air being rich in nitrogen is absorbed within the raindrops and immediately taken up by the leaves and roots of plants. Drops of rain are also rich in oxygen, which serves as a safety net in case soil is heavily saturated after heavy rain. Raindrops also absorb carbon dioxide. When carbon dioxide in rain combines with other atmospheric minerals, the drops become slightly acidic. As soon as these slightly acidic raindrops reach the soil, they facilitate in the release of micro-nutrients like copper, manganese, iron, and zinc (which are important in plant growth) from the soil.

B. Humidity

Humidity is measured by the amount of water vapour contained within the air which is usually expressed as percentage humidity. Humidity is a very important environmental element and must be controlled for a healthy plant growth. Humidity controls the rate of transpiration and how the nutrients are received by the plant. Ideal humidity levels in a grow room ranges between 50% to 70% in vegetative growth, and 50% to 60% for flowering plants.

Just as a lack of CO2 can cause a plant to go dormant, low humidity can cause a plant to have nutrient problems, resulting from the transpiration rate being much too high in low humidity level environments.

When humidity levels get too high, moisture is building up on the plants, forming whole colonies of molds, fungi, and mildews.

The biochemical functions in plants that are required for growth and survival are `temperature dependent' – that is, there is an optimal temperature range within which a particular plant species will be carrying out photosynthesis at its maximum rate (given that sufficient CO2, water and light are also present).

With the provision of high levels of light, CO2 and optimum temperature, an ideal situation for plant growth is achieved. In such situations, the only limiting factor for plant growth would be the speed at which the biochemical reaction such as photosynthesis is being carried out within the plant tissues.

C. How are Rain and Humidity Connected?

Rainy weather easily affects humidity. During rainy weather, there is 100% humidity and the clouds are unable to hold any more water.

Rains increase the relative humidity due to evaporation and the longer it rains; more will be the humidity, due to the air constantly drawing the water.

Evaporation will cool the air and increase the absolute moisture content of the air locally. Rain removes water vapor through air condensation and deposits it on the surface, thus reducing the average relative humidity.

Various factors like Amount of rainfall, temperature, and Volume of space need to be taken into consideration when gauging the Humidity.

When the air is hotter, it will cause the water to evaporate faster, thus creating a higher level of humidity. If the air is cooler, the water will reduce the humidity level and actually make it seem cooler than the temperature outside.

D. Air Irrigation

Air Irrigation uses the natural concept of rainwater falling on the plant and crops. Rains which fall from a great height and pass through the earth's atmosphere collect along its way down towards the earth, various elements and water-soluble gases. Thus, rainwater is enriched in components like carbon dioxide, oxygen, nitrogen and others found in the atmosphere of the earth.

In Air Irrigation, a Rain Gun is used to sprinkle water from a height and for a desired horizontal range. The Rain Gun like the sprinkler moves in circular rotation to cover maximum area to be irrigated. It is a high-performance micro-irrigation device to facilitate high flows and extended radius of the water throws. Generally a Rain gun sprinkler is available with an operating pressure of 2.0 to 7.5 kg/cm2 and flow of 3 to 30 lps. The nozzle diameters range from 10 to 30 mm and a wetting radius of around 27- 60 meter.

Fig. 1.Use of Rain Gun for watering the plants

Different types of Rain Guns based on their specifications are available namely – Impact type, Penguin Pelican, Flamingo Rain Gun, Skipper, Mariner and Triangular Spacing. These Rain Guns range from Rs. 2,000/- to Rs. 20,000/- based on the specifications and the area of coverage.

Retrieval Number: F9702038620/2020©BEIESP
DOI:10.35940/ijrte.F9702.038620
Journal Website: www.ijrte.org

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Fig. 2.Use of Rain Gun for sprinkling water at a desired horizontal range

E. Air Fertigation and Use of Rain Gun by Indian Farmers

Use of Rain Gun is been done by Mr. Manohar Khake, Pune, Maharashtra. He has successfully applied Air Irrigation at several farms in and around Maharashtra with success in crop produce. According to him, we require to follow the indications and learning's, which are free and very obvious all around us, given by the nature. He says that rainwater falling from a distant height makes the entire vegetation green and fresh. This is due to the composition of the rainwater. A drop of rain when travelling through the earth's atmosphere mixes with atmospheric gases which are soluble and also other particles. Similarly, is we are able to irrigate crops or plants from a particular height through micro sprinklers so that the drop of water falling on the crops and plant mixes with atmospheric elements and gases. This method of irrigating the plants and crops without using chemical fertilizers but yet providing them with necessary nutrient absorbed from the atmosphere is termed as Air Fertigation.

Further, he also stresses that, usually during irrigation of crops or even watering of plants, water is just poured out at the roots of the plants. We forget that the primary work of the roots is to hold the plant firmly fixed to the ground. Though roots also absorb nutrient from the ground, when we waster plants just near their base, the roots avoid going deep in the ground as they can get enough water near the base of the plant. It is also observed that when we water the ground thoroughly, the soil becomes hard in such areas. However, sparsely watered ground has soil which is loose due to enough space between the soil particles as they are well aerated.

Leaves of a plant are the actual producers of food for the plant through the process of photosynthesis. It is the leaves which are actually responsible for absorbing nutrients and converting them into food for the plant. Hence, plants and vegetation becomes green after rains since the leaves get nutrients through the rain water. Similarly, Mr. Manohar Khake suggests that if we should water the plant majorly at the leaves. Thus, the Air irrigation system which he suggests, throws water through micro sprinklers attached to a Rain Gun from a distant height and at the same time maintaining a horizontal angle to reach maximum area. The sprinkler throws out water at a specific speed for not more than 15 minutes each day to water the plants.

F. Advantages of Air Fertigation System

Following are the advantages of this system:

- *Less water consumption and saving of time:* The Air Fertigation method sprinkles only specific amount of water and for a very short duration of time (15 to 20 minutes, based on the area of coverage) on the leaves of the plants and crops, thus avoiding water wastage and saving time.
- *Less efforts:* Since the method sprinkles water on the leaves, the ground does not get drenched in by water. As observed, when we drench the soil while irrigation with water, it hardens the soil. This makes it difficult while tilling the soil for the next crop. However, in SAF the amount of water actually accumulating or falling on the ground is negligible but just enough for healthy growth of the plant. Due to this, the soil does not harden and less time and effort is required to till the ground for crops of to prepare pits to plant trees. Since the soil does not harden, it is able to hold enough moisture and other components within the particles of the loose textured soil, thus increasing its fertility.
- *Economic*: The Rain Gun along with the remaining setup for Air Irrigation does not cost much. A general-purpose rain gun with micro sprinkler will cost not more than Rs. 5,000/-

VI. SMART AIR FERTIGATION (SAF)

To optimize the method suggested by Mr. Manohar Khake, it is suggested that Smart Air Fertigation can be implemented.

Further Smart irrigation method through the use of sensors provides information which allows supply of right amount of water based on the humidity levels so that the leaves of the plants are able to absorb maximum moisture from the already element loaded water droplets that fall on them due to the Air Irrigation.

Following will be the changes to be made to the current model of Air Fertigation to make it Smart Air Fertigation:

A. Humidity Sensors

As mentioned above, humidity along with other components like CO2, NO2, etc. is required for plants to produce food. The optimum level of humidity to create ideal conditions for the plants to produce food is between 60% to 80%. Further, if the humidity is less and the plants are receiving less water, this would impact the plants, resulting in poor growth and produce. Also, if the humidity is more and the plants are watered more, this would also to damaging of the plants. Hence, getting the optimum humidity level and water in the plants based on the level of atmospheric humidity will allow the plants to grow substantially to give the right produce.

Thus, in SAF, sensor can be used to guage the humidity level and accordingly decide the amount and the time period for which the water should be sprinkled through the Rain Gun.

Retrieval Number: F9702038620/2020©BEIESP
DOI:10.35940/ijrte.F9702.038620
Journal Website: www.ijrte.org

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Application of sensors that measure the presence of atmospheric gases like CO2 and NO2 will also help to understand the composition and presence of atmospheric components essential for plant growth.

B. Automatic sprinklers

Based on the level of humidity, a software can be designed which will automatically start the sprinklers.

C. Alternate energy

To sprinkle water from a specific height and over a specific horizontal coverage, the Rain Gun requires to be throw out water at a particular speed or force. This would require electric energy. However, here if alternate energy options like Solar Energy are used by storing the solar energy and using it for running the sprinklers, electricity will be not be required, thus saving electric power.

VII. CONCLUSION

After experimentation of the suggested method of Air Fertigation in Baramati, Pune, Solapur and Uruli Kanchan area of the State of Maharashtra, it was found that the plants growth and the quality of produce was remarkably high.

Use of SAF will definitely improve the irrigation system and optimize the crop and plant produce.

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