Transition to Smart Farming with the help of Technology: Using Soil Moisture Measuring Device

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***Abstract*— Water is a very important resource in irrigation. Efficient irrigation watering helps in saving water, getting better plant yields, reduce dependency on fertilizers and improve crop quality. Various methods, both laboratory and field including sensing are available to measure soil moisture content, but the quickest and better one is with the use of soil moisture sensor electronic devices. For successful irrigation, it is necessary to monitor soil moisture content continuously in the irrigation fields. The selection of soil moisture probes is an important criterion in measuring soil moisture as different soil moisture sensors have their own advantages and disadvantages. The soil moisture sensors are used intensively at present because it gives real time readings. An attempt is made in this article to review some of the sensors available, their specifications, properties, applicability, advantages and disadvantages so that an informed decision on selection of appropriate sensor can be made for a particular application**.

Keywords—Component; Formatting; Style; Styling;

I. INTRODUCTION

All know water is an important resource for farming. At present we are at a global crisis of water shortage which has led to depletion in the development agriculture and hence the food production. And therefore, it is necessary to use water resource carefully and methodically; optimum use of water has become a necessity in agriculture as most part of our country faces a scarcity and shortage of water. Over the years there have many techniques and devices that has been developed to increase the productivity of farming using less or accurate resources. Use of machinery for harvesting and use of fertilizers for increasing nutrients in the soil and irrigation these are some of the techniques used by a farmer for agriculture.

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A. Problem caused due to old methods in farming

Dr John Augustus Voelcker, the Consulting Chemist to the Royal Agricultural Society of England, was sent by the British government to study Indian agriculture in 1889. Voelcker toured the country extensively for over one year. His report was published in 1893, and since then has often been cited as an authoritative work on Indian agriculture of this period. For instance, the Report of the Royal Commission on Agriculture (1928) said of the Voelcker

Report, "Although thirty-five years have elapsed since this work was written, the ability which Dr Voelcker displayed in his comprehensive survey of the agricultural conditions of India, in his analysis of problems they present and in the recommendations for their solution, still renders it a book of the utmost value to all students of agriculture in India."

How did Dr Voelcker view Indian agriculture as it existed nearly a hundred years back? Did he consider it in backward way and incapable of giving a good yield? The essence of what Dr Voelcker said can be summarized in the following extract from his report : "I explain that I do not share the opinions which have been expressed as to Indian Agriculture being, as a whole, primitive and backward, but I believe that in many parts there is little or nothing than can be improved, whilst where agriculture is manifestly inferior, it is more generally the result of the absence of facilities which exist in the better districts than form inherent bad systems of cultivation . . . I make bold to say that it is a much easier task to propose improvements in English agriculture than to make really valuable suggestions for that of India . . . the conviction has forced itself upon me that, taking everything together and more especially considering the conditions under which Indian crops are grown, they are wonderfully good. At his best the Indian raiyat or cultivator is quite as good as, and in some respects, the superior of, the average British farmer, while at his worst it can only be said that this state is brought about largely by an absence of facilities for improvement which is probably unequalled in any other country . . . I have remarked earlier about the general excellence of the cultivation; the crops grown here are numerous and varied, much more indeed than in England. That the cultivation should often be magnificent is not to be wondered at when it is remembered that many of the crops have been known to the raiyats for several centuries, rice is a prominent instance in point."[1]

B. What is soil moisture and how does it help?

Water contained in soil is called soil moisture. The water is held within the soil pores. Soil water is the major component of the soil in relation to plant growth. Soil moisture is primary information in achieving optimum water requirements for the crops. If the moisture content of a soil is optimum for plant growth, plants can readily absorb soil water. Not all the water, held in soil, is available to plants. A percentage of water still remains in the soil as a thin film. Soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants.

C. Why Soil moisture is important?

Soil moisture is very important from an agriculture point of view as its availability is required to support plant growth is a primary factor in farm productivity. Too little moisture can result in yield loss and plant death. Too much causes root disease and wasted water.

Water is a delivery mechanism is important for any nutrients that are not tightly bound to the soil. Whether these nutrients are delivered to the field through the irrigation system or through other means, movement of water within the soil governs how they are delivered to the plant roots. A good water management is important within itself, but good water management system also means good nutrient management

D. How can Technology help in increasing the efficiency of farming?

Using Information and Technology for precision agriculture has become a popular research with the greenhouse effect. Farmers are utilizing the merits of embedded system into monitoring and control system for agriculture parameter. Monitoring parameters of temperature and humidity is an important means for obtaining high-quality environment. Method of remote monitoring is a very effective monitoring system which is used in order to avoid interference from environment and improve efficiency.

E. What are the benefits of monitoring soil moisture?

Local climate, as reflected by daily weather conditions, is one of the major factors driving the daily and seasonal transpiration demand of crops. The transpiration rate of the crop, the rainfall pattern, and the soil type combined determine the timing and amount of irrigation that needs to be applied to avoid crop stress and produce high crop yields. Since weather conditions are unpredictable, especially under a changing and varying climate, it is difficult to develop consistent guidelines about how to irrigate crops. Therefore, measuring soil moisture is proper way to determine irrigation timing and amount. Measuring soil moisture can help farmers save water, reduce energy costs, increase yields, and protect the environment. Excess irrigation will increase cost of production and can have negative environmental effects such as runoff, water logging, and leaching of soil nutrients and other chemicals that can eventually contaminate water sources and reduce yield. Insufficient irrigation, on the other hand, can result in crop stress and reduced yields.

Although it is common for farmers to estimate soil moisture by the hand-feel method, soil moisture can be measured or monitored more effectively and accurately using a variety of commercially available soil moisture monitoring systems, some provide continuous data collection.

II. RESEARCH STUDY

The research study includes issues of farming without technology (Soil Moisture Measuring Device). The study included the various ways technology (Soil Moisture Measuring Device) can help overcome the problems which are caused due to old methods and how feasible and reliable this technology is.

F. Objective

The primary research has been taken up with the following objectives:

- To identify various problems of the farmers regarding Soil Moisture Measuring Device.
- To try and answer as many question regarding the technology.

G. Methodology

Secondary data was collected from the internet and reports. Various research papers on the same lines were also consulted. Findings from them have been listed in the following paragraph.

As a source of livelihood, agriculture remains the largest sector of Indian Economy. While its output share fell from 28.3% in 1993-94 to 14.4% in 2011-12, employment share declined from 64.8% to 48.9% over the same period. Therefore, almost half of the workforce in India still remains dependent on agriculture. Given the low share of this workforce in the GDP, on average, it earns much lower income poorer than its counterpart in industry and services.

“The common interaction model between farmer and technology developing company is that of consumer-producer. This needs some collaboration as the consumer has to ensure that the output of the producer satisfies the needs to a large extent. Interestingly, even this rather obvious kind of interaction does not occur in a structured manner, as both the sides maintain a distant relationship. Though there are many reasons for this the main reason is lack of suitable forums and platforms to facilitate this.”

Companies use several methods to create visibility on technology to reach farmers, providing demonstration and advertising their product and show them how effective it is and can be good for their productivity.

Primary questions have been collected from farmers about the technology. Structured questionnaire was sent across to different farmers across India. Two different questionnaires were designed for industry and farmers.

III. ANALYSIS AND DISCUSSION

A. Question 1: Can I afford it?

In answering this question, assess both the initial and the annual costs of a product.

Initial cost is usually the most important factor considered by irrigators when a product is purchased. Cheaper products tend to be manually read and so can be more labor-intensive. If labor can be provided easily and cost-effectively, then this will not be an issue.

Labor can be an issue if its true cost over many seasons is considered. The cost of labor, mainly in data collection, can be quite high, as readings may need to be taken every two to three days at each site throughout the season.

It is important to look at methods such as the automatic collection of data as a means of reducing the labor cost of data collection. The trade-off is usually the increased initial purchase cost of the product, but in some cases, and on some crops, this may pay for itself relatively quickly.

The issue of annual costs relates to maintenance both during and after the season, and re-installation costs in annual crops. Here the variation in cost between products lies with differing labor requirements and the need for dealer or outside support.

Growers need to also consider the potential water saving and productivity gains that may accompany the use of the equipment. However, these benefits will only be achieved if the grower understands the equipment and its limitations, uses the equipment appropriately and interprets the information correctly.

There are suppliers that allow products to be rented for a period of time such as the growing season. This may offer an alternative for irrigators that don't want to buy the equipment outright or have short term crops. [3]

B. Question 2: How much maintenance will it need?

A number of devices may require particular maintenance or have particular difficulties in servicing, and these have to be considered during your selection process.
Look at mid-season and end of season maintenance requirements. Can you maintain it, or is dealer servicing required? Does it need to be sent away, and if so, how long for and who pays?

Does the product come with adequate dealer support? Back-up service is crucial. If the product needs to be sent away, is a replacement product available? What is the likely turn around for product repairs? Is the equipment "plug and play" (that is if you plug it in it will work without any additional configuration) or will in field configuration be required? [3]

C. Question 3: Does soil type affect my choice of device?

Soil type can affect which device you should choose, as some devices may be inaccurate in some soil types. For example, gypsum blocks in sand and capacitance probes in cracking clays may give inaccurate readings. Salinity may also affect the accuracy of some sensors.

Different types of soil type do usually occur across the farm or paddock. Farmers need to check that you have enough soil moisture monitoring sites to get representative data or data for each sector of different soils for the area being irrigated at that time. As a minimum farmer should ensure the most representative soil type is covered or the basically the sensor are covering all the farming land as send data for each sector properly. This is linked to the amount of funding you wish to commit to this type of equipment and the level of precision you are trying to achieve. There is a tradeoff between the number of probes installed (how representative the data is), the cost of the equipment and the accuracy or precision you require. [3]

D. Question 4: Does my irrigation system I use limit my choice?

The characteristics of the irrigation system should help determine what device is chosen and how it is installed.
Surface irrigation may impede access for manual readings and may also cause problems by inundating sensors or access tubes, so waterproofing is important.

The distribution uniformity of a system affects how sensors may be placed. Drip and micro irrigation in particular require correct selection of representative monitoring sites. It is important that the spacing between the probe and the emitter or drip line is considered. [3]

E. Question 5: Does crop type limit my choice of device?

The profile and placement of the device must match the requirements of the crop at the monitored site.
Deep-rooted plants may need more sensors, or single sensors giving readings at multiple depths as it necessity to check every layer of the soil. It may be sensible to do a soil pit to identify the soil characteristics at different depths and any layers that may limit plant growth. Doing this may help identify the ideal placement of sensors at multiple depths and for recording or collecting the data.

For annual crops, sensors may have to be installed after emergence and removed at the end of the season before harvest.

F. Question 6: What other factors affect my choice?

The importance of probe installation cannot be overstated. There are many things that can influence the quality of data, installation being a key factor. Therefore, it is critical that the installation of the probe is done by a qualified person.
Reading sensors manually could damage some crops and compact the soil around the sensor site. Automatically logged devices maybe a better choice for these situations.

How is the device powered? Is this power available, and can the power source be protected in the field or in transit?
Soil Moisture Monitoring devices provide additional information that can help guide and improve irrigation decisions, but they should always be used in conjunction

with other tools such as weather data, field observations of the crop and soil moisture, shovel etc.

G. *Question 7: Technology Available in the market?*

Frequency Domain Reflectometry (FDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the operating frequency of an oscillating circuit.

Time Domain Transmission (TDT) and Time Domain Reflectometry (TDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the speed of propagation along a buried transmission line.

Neutron moisture gauges: The moderator properties of water for neutrons are utilized to estimate soil moisture content between a source and detector probe.

Soil resistivity: Measuring how strongly the soil resists the flow of electricity between two electrodes can be used to determine the soil moisture content.

Galvanic cell: The amount of water present can be determined based on the voltage the soil produces because water acts as an electrolyte and produces electricity. The technology behind this concept is the galvanic cell.

H. *Question 8:What are the barriers to adoption?*

Adoption of soil moisture monitoring systems by

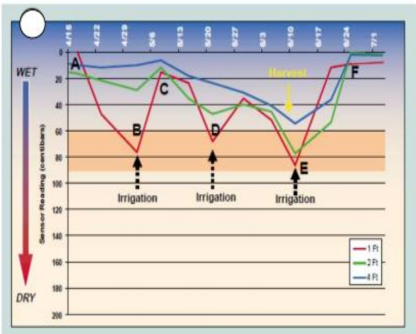

Figure 3. Plots of soil moisture tension data at three depths, and recommended tension threshold values (*adapted from Orloff et al., 2002*)

farmers has been limited by lack of information and training, difficulties in installing and calibrating the sensors in the field and difficulties involved in downloading and interpreting the data. Cost can also be an issue for some of the systems, although there are some very affordable system available. Another problem has been that sensors installed in the field can interfere with farming operations.

Understanding Soil Moisture Data:

When using soil moisture tension sensors, the lower threading the higher the soil moisture content and vice-versa. When the soil is near field capacity, after rain or irrigation, the sensor reading is low and commonly in the range of 5-10 centibars. Assoil moisture is depleted, the sensor readings increase gradually. Plotting moisture tension data on graphs helps growers visualizing what is happening in the soil root zone, providing them with clear picture of the soil moisture status and about how fast the soil is drying as a result of water uptake by roots. Figure 3 presents typical plots of soil moisture tension at three different depths (1-ft, 2-ft and 3-ft deep) along the soil profile, with the identification of tension range values where irrigation should occur and trends that indicate adequate irrigation management. Figure 4 shows soil moisture tension graph at 6” and 18” depth generated by a data logger over the entire irrigation season, with clear indication of under-irrigation and inadequate frequency and amounts of irrigation applications.

IV. FINDINGS

The survey brought to the forefront the following:

- Adequate irrigation management could be a difficult task to farmers, due to harvest schedules and to uncertainties related to soil water relationships. The use of soil moisture monitoring can therefore provide very useful and cost-effective information to farmers for ground-trotting their irrigation decisions, fine-tuning irrigation practices, and allow avoiding under and over-irrigation, which causes adverse impacts, from yield loss, to water-related diseases, higher energy and water cost, nutrient losses, leach-outs and environmental concerns. Such information is critical in day-to-day irrigation decisions to aim at maximum yields and at optimal water and energy use, especially during periods of limited or unreliable water supply.
- The survey shows that the most important aspect is the lack of knowledge and wide spread of the information about the soil moisture measuring device amongst the farmers and hence less use of the devices
- Industry interaction has only begun and has a long way to go. And having research projects are important areas where interaction has not yet caught up.

V. CONCLUSION

There is various soil moisture monitoring methods for irrigation scheduling. While each one has advantages and disadvantages, proper installation and calibration can make them effective tools. Soil moisture monitoring complements knowledge of plant water usage, soil moisture storage capacity, and root zone depth and characteristics to improve irrigation management. Optimizing irrigation by timely, adequate – but not excessive — irrigation applications promotes water conservation and profitability

There are positives and negatives associated with all of the tested devices with no one likely to meet all requirements. By their very nature, in-situ devices or those that rely on an access tube, can only be located at one geographic point and yet are expected to adequately represent the moisture environment of a much larger area. If a high level of accuracy is required, then the solution is to increase replication, but this brings with it additional capital and maintenance costs.

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