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Sensor Based Smart Farming for Fenugreek Farmers in Sikar Division of Rajasthan

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Abstract: ***This study deals with the sensor based smart farming of fenugreek. Rajasthan state is among top producers of fenugreek. Fenugreek is a multiuse plant. Seeds and leaves are used commonly in household as spice whereas the plant has variety of medicinal uses. Indian medical system Ayurveda highlights its importance in treatment of disease like diabetes and cancer. The Sikar division of Rajasthan state is uprising as producer of vegetables, flowers and medicinal plants of different verities. The farmers of this area are progressive and adaptive to new technology in agriculture. Real time monitoring of soil moisture, air flow in soil and farm air temperature with remotely controlled irrigation system for high yield of fenugreek crop has been studied. This is helpful for the farmers who contributes in development of the country and are providing employment to more than half of the workforce of India.***

Keywords: Smart farming, Fenugreek, Medicinal, Soil moisture, Sensor, Real time monitoring.

I. INTRODUCTION

The farming play significant role in the development growth and economy of the country. Around 55% of the total workforce in India is involved in agriculture and allied sector activities at present. Indian population is engaged in agriculture, contributing about 18% of the country's GDP. According to present projections the Indian agriculture sector is growing at the rate of 3.5 % [1]. The agriculture sector is witnessing a technological transformation today. The government has initiated the fourth wave of revolution in this sector by introducing technological advancements in farms to improve yields and to improve the economic conditions of the Farmers countrywide. The conventional methods of farming are being replaced by smart farming to achieve the goals of efficiency and high productivity and overall to increase the income of farmers in India. Application of sensors and Artificial Intelligence enabled systems for improvement in farming are some of the key features of government policies and initiatives for marginal farmers. Sensor based smart farming helps the farmers in real time monitoring of farmlands and ensure that individual subpart of the farm and individual crop in multi-crops case get precisely the inputs they need for optimum yield.

For high yield smart farming using sensors such as air temperature sensor, humidity sensor, soil moisture sensor, soil pH sensor, light intensity sensor are used to collect data in all aspects starting from soil bed preparation, sowing, crop growth, and harvest. Compared with smart farming, the traditional farming of spices including fenugreek which relies on a lot of manpower and uses simple agricultural tools and machinery has gradually shown its disadvantages. Smart farming [2] uses the Internet of Things and sensor technology to provide precise crop growth data for formulating scientific planting programs. It also helps the farmers in saving labor, optimizing crop varieties, and improving their crop quality and higher yield. India is now a country with highest population in the world. Indian spices have great demand worldwide. Due to reasons like population growth, climate change, and reduced rainfall the farming is being negatively impacted and this is leading to changes in cultivation methods. To improve crop yields and collect accurate data from whether to crop harvest, it is crucial to adopt modern and precision agricultural practices and install various types of sensors using new and state-of-the-art technology. Environmental concerns are addressed in development of green packaging technology for biosensors and microelectronic systems [3]. India is main producer and exporter of grain and spices therefore it is the solution and meet the endless and growing needs of the above eight billion world population. Precision agriculture sensors are highly efficient for farmers because they transmit data that helps farmers not only to monitor their crop but also to improve quality of their products and keep abreast of changes in the farm and the ecosystem. Using smart farming marginal farmers can now record their crops and keep an eye on their effectiveness remotely. They can easily address crop pests and take swift action to protect their crops from any risk to the abrupt metrological change.

Fenugreek (Sanskrit name – Methika, Local Name – Methi, Botanical Name - *Trigonella foenum-graecum* L.) is an annual, self-pollinated herbaceous crop belonging to the family Fabaceae. The plant can grow up to a height of about 30–60 cm, depending on the variety. Diverse fenugreek genotypes differing in growth habits, morphology and seed quality are grown in different parts of the world. The plant has trifoliate and pinnate leaves, the stems are slender and branching, roots with nodules, white or yellow flowers in pairs or solitary, 3–15 cm long pods bearing 10–20 small, yellow-brown hard seeds.

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This plant has ability to tolerate drought and is able to grow well in the areas with moderate to low rainfall. The temperature required is in the range of 10–20 °C for better yield. The water availability affects its yield the most. For Indian climate, early sowing of seeds in the second week of October month gives higher yields. Fenugreek plant can be grown under diverse climatic conditions and different soil types, making it cultivable all around the world. Fenugreek is cultivated in in many countries in Africa, America, Asia, Europe, and also in some parts of Australia. It shows excellent growth in semi-arid climate with well-drained soil and requires regular watering specially in growing season. These conditions are satisfied in the Sikar division of Rajasthan. Four districts namely Churu, Jhunjhunu, Neem ka Thana and Sikar are covered under Sikar division of Rajasthan. This division is expanded from Aravali Hills Range to the Great Indian Desert Thar. Climate is semi arid and soil variety exists in this geographical part. Low water availability is the key climatic feature of this area and this affects its yield the most. The farmers cultivate different varieties of fenugreek in this area. RMt 1, Hissar Sonali, Prabha, Nagauri Pan Methi, Methi No - 47, Kasuri and Early Co -1Punching are popular varieties in this area.

II. PROMINENT USES OF MEDICINAL AND NUTRIENT PLANT - FENUGREEK

Fenugreek is used as a food ingredient, flavoring agent, herb, or spice for human consumption, and as green fodder and medicine for animals. Fenugreek is a medicinal plant used as an herbal remedy in many traditional healing systems. Fenugreek seeds and leaves are used as a spice in many cuisines, particularly in Indian and Middle-Eastern dishes. The seeds are also used to make fenugreek tea. It is used as an adhesive, emulsifier, as a food stabilizer, and gum. Fenugreek is used to produce various types of bakery and extruded products. In heritage cities of Rajasthan it has been used in Lime plaster work for drinking water storage units. Fermented fenugreek water and fermented unrefined sugar were the preferred admixtures used to improve workability, water resistance, hydration of plaster and to improve the mortar strength [4].

Fenugreek (Sanskrit name - Methika) is a well-known and useful herb in Ayurveda. Ayurvedic research extracts of Sushruta Samhita, Sarangadhar Samhita, and Bhavaprakasha highlights fenugreek as an effective herb against cough and early diabetes. It is useful in obesity and reduces lipid status of blood. It connects the increase in the level of low-density lipoprotein cholesterol (LDL-C) and insulin resistance. It correlates these parameters in the prognosis of abdominal obesity, Type 2 diabetes mellitus, atherosclerotic cardiovascular disease [5]. Fenugreek has phenolic acids, flavonoid conjugates, saponins, and fatty acids. Fenugreek seed is a good antioxidant. It has hypolipidemic, hypoglycemic, antioxidant, and immunomodulatory effects on human body. Fenugreek seeds contain the amino acid 4-hydroxy isoleucine which increases insulin secretion. The raw germinated fenugreek plants are packed with health supplements and are useful for health and fitness-conscious people. Diosgenin is the most important bioactive compound in fenugreek. It is used as the raw precursor for the large-scale synthesis of oral contraceptives, steroids and hormones such as testosterone, norethisterone, glucocorticoids, and progesterone. It has antidiabetic, antifertility, anticancer, antimicrobial, antiparasitic, lactation stimulant, and hypocholesterolemic effects. The fenugreek plant is good example of “microgreens” [6]. It is rich in micro-nutrient iron, minerals potassium, calcium and sodium and phytochemicals. The extract of fenugreek seeds is anti-fungal and therefore these are commonly used as organic bio-pesticides [7]. Seed extracts have been reported to improve bone and brain health also.

Fenugreek seed contains carbohydrates up to 60 % and proteins up to 30 %. The ingredients are listed below in Table 1;

TABLE I
FENUGREEK SEED CONTENTS

Nutrients	Specification
Carbohydrates	Mucilaginous fiber with galactomannans
Proteins	lysine and tryptophan
Oils	b-pinene, neryl acetate, caryophyllene
Alkaloids	Trigonelline, choline, gentianine, carpaine, fenugreekine
Flavonoids	Apigenin, luteolin, orientin, quercetin, vitexin, and isovitexin
Free amino acids	4-hydroxyisoleucine, arginine, histidine, and lysine
Saponins	Diosgenin, yamogenin, tigogenin, neotigogenin
Vitamins	A, B1, C
Minerals	Calcium, silicon, sodium, and iron

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Fenugreek is used for different domestic and commercial purposes. Uses of fenugreek seeds, leaves, stem and straw are given in Table 2;

TABLE 2
FENUGREEK USES (DOMESTIC AND COMMERCIAL)

Specific Use	Plant Product
Bread making	Seed
Food gum	Seed
Dyes	Seed
Syrups	Seed
Alcoholic beverages	Seed
Emulsifying agent	Seed
Stabilizer and adhesive	Seed
Insect repellent	Seed oil
Perfumes	Seed oil
Food (General)	Seed and Leaf
Flavouring agents	Seed, and Leaf
Paper industries	Seed and Leaf
Paints	Seed and Leaf
Cosmetics	Seed and Leaf
Fumigant	Leaf
Functional food	Seed, Leaf and Stem
Forage	Leaf and Straw
Vegetable	Leaf and Stem



Fig. 1 Fenugreek leaves and seeds from farms in Sikar division

III.FENUGREEK CULTIVATION IN INDIA

In India, fenugreek is cultivated mainly in Madhya Pradesh, Rajasthan, Gujarat, Haryana, Uttaranchal, Uttar Pradesh, Maharashtra, and Punjab. In Rajasthan raw green leaves and seeds are sold in vegetable markets and grocery shops for their countless medicinal benefits. According to the report of National Horticulture Board (NHB), total fenugreek production in India was 226 thousand MTons in 2023, up from an average of 220 thousand MTons during the previous decade. State-wise production of fenugreek for the top producer states in India is depicted in Table 3;

TABLE 3
STATE-WISE FENUGREEK CROP AREA AND PRODUCTION

State	Crop area (Hectares)	Yield (Kg/Ha)	Production in 2022 (MTons)	Production in 2023 (MTons)	% Change
Madhya Pradesh	66000	1363	126750	90000	- 29
Rajasthan	40800	1245	90400	50800	- 44
Gujarat	24450	1390	41550	34000	- 18

Frost during flowering and early grain formation phase is vulnerable for fenugreek production. Clear sky climate with moderate cool and frost free conditions is favorable for excellent plant growth. Extreme cold and frost in Rajasthan state has significantly lowered the production and depressed the fenugreek farmers' income.

IV. SENSORS FOR SMART FARMING OF FENUGREEK

There are various types of sensors used in smart farming of crops. Optical sensors use the light to evaluate soil materials. The optical sensors can be positioned on automobile machinery, drones, or robots to enable the soil to reflect and the gathering and processing of fenugreek plant leaves color data during crop period. Optical sensors also have the ability and capacity to condition the clay, natural matter, and humidity of the soil and irrigation requirement for precise growth of crop. Electrochemical sensors are used for soil nutrient detection before sowing. The electrochemical sensors aid in the collection, processing, and mapping of the chemical data of the soil. They are usually mounted on specially designed sleds. They supply accurate details required for agriculture. This includes the nutrient of the soil levels and pH. The soil samples are then sent out to a soil testing lab and standard procedures can be carried out for treatment of farm soil. The soil pH is determined with accuracy by using ion-selective electrode. These electrodes notice the pursuit of specified ions, such as hydrogen, nitrate, and potassium in the soil. Location sensors also known as agricultural weather stations are positioned at different places throughout the fields. Similarly electronic sensors usually installed on farm-machinery like tractors and other automotive field equipment to check equipment operations. Data are transmitted via mobile communication systems to computers or mailed to individuals directly. The farmer can access the information on their mobile phones.

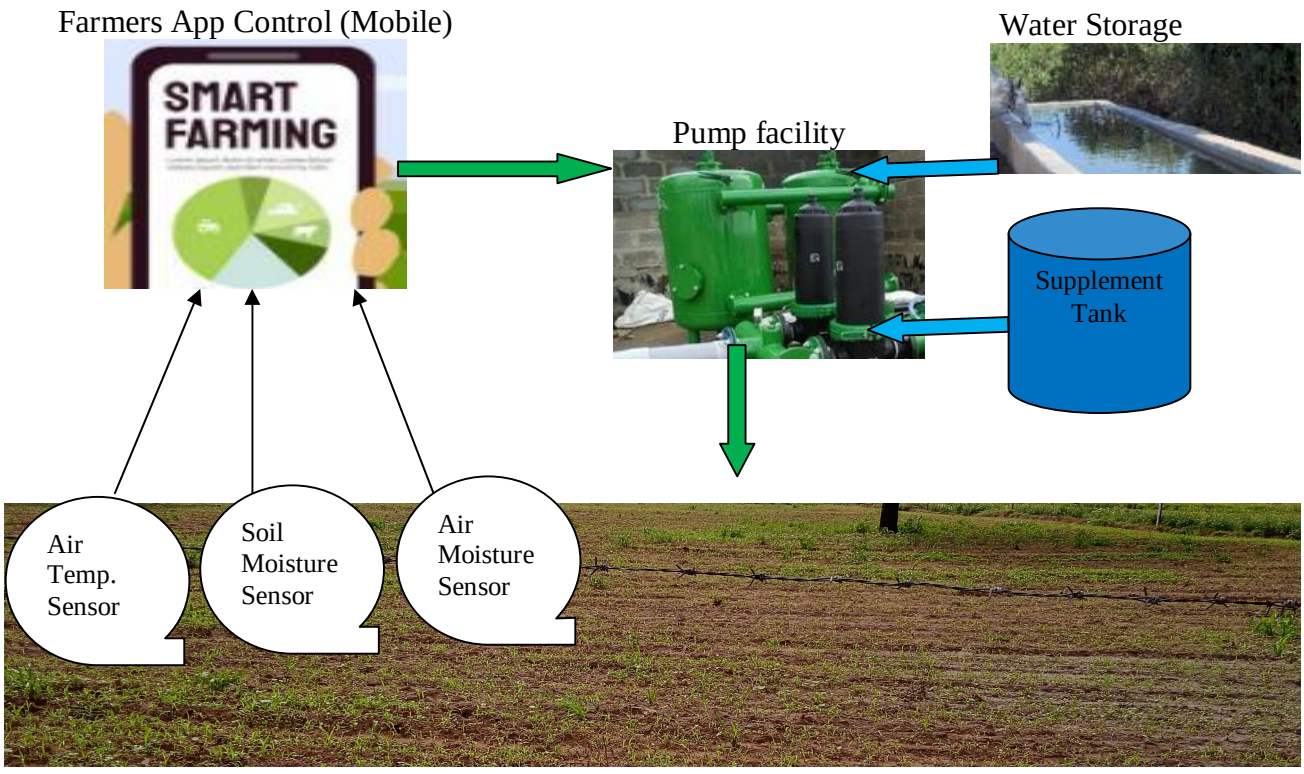


Fig. 2 Schematic of sensor based smart farming

V. REAL TIME SENSING FOR SMART FARMING

The temperature, soil moisture and air moisture are important parameters for fenugreek farming. For high yield soil moisture must be maintained during plant growth period and during regular subsequent cutting of leaves. The smart connectivity between the real-time monitored data of soil and air moisture and mobile controlled pump facility maintains the moisture precisely for excellent growth of crop. With help of optical sensors supplement requirement to crop are determined and supplements are irrigated time to time with water supply. When moisture up to plant root depth is high/moderate then pump facility is kept off. On low moisture sensing by soil moisture sensors around roots the irrigation through pump is turned on. The soil moisture sensors calculate the moisture levels in the soil with help of a dielectric constant. The dielectric property of farm beds before sowing for adding substitutes depending on the moisture content in the soil. During crop period the moisture content in soil is regularly watched through this moisture sensor. Post cultivation moisture sensors are used to determine the dryness of fenugreek seeds for storage.

Airflow sensors play vital role in smart farming of crops. Airflow sensors measure soil air penetration in different varieties of soil. The properties like moisture levels, soil type, compaction and structure are calibrated to access the airflow signature of farm soil.

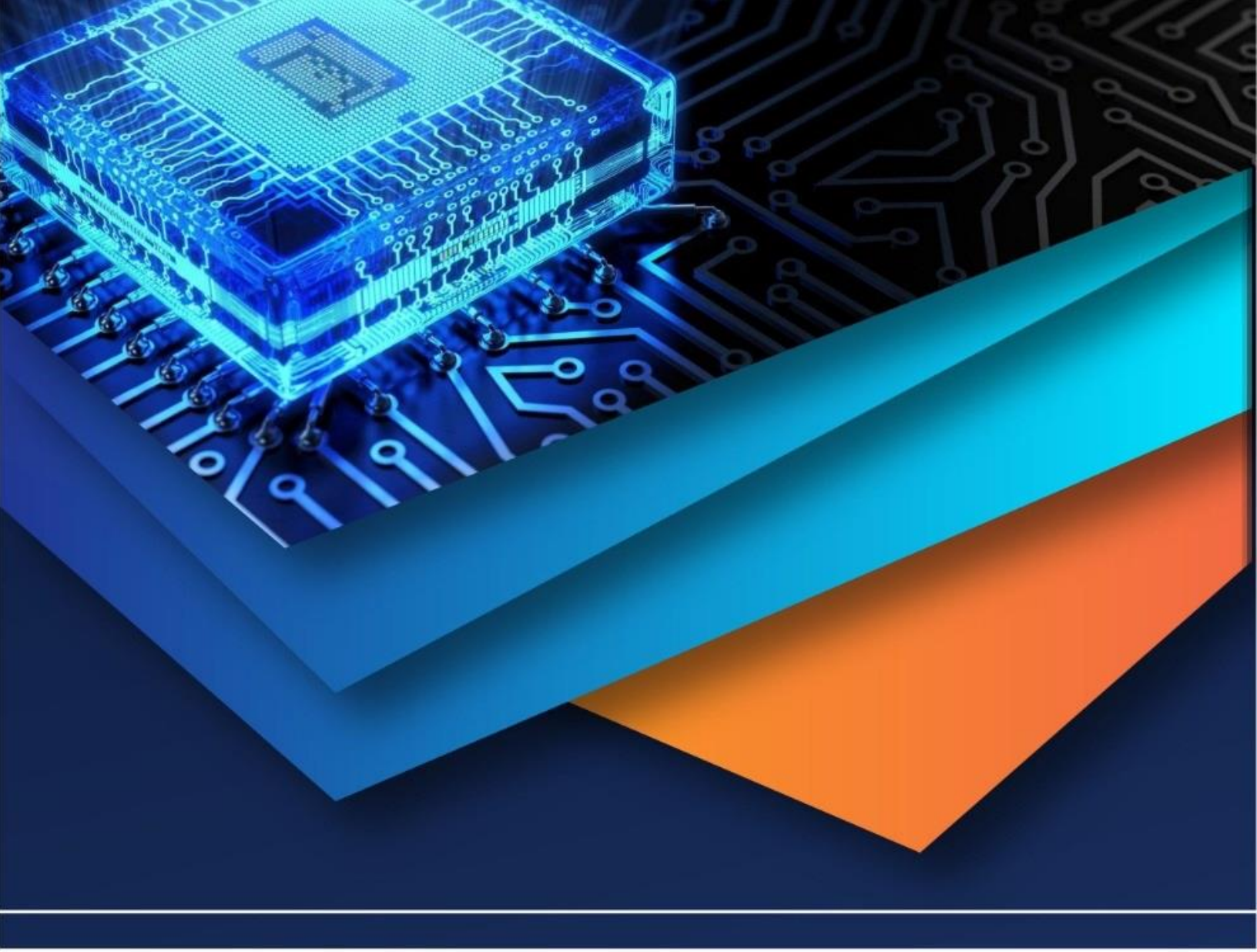
The sensors provide real-time information of the crops and the fields. These are important for obtaining high yield. The information include air temperature, soil temperature at various depths, rainfall, leaf wetness, wind speed, dew point temperature, wind direction and relative humidity.

VI. CONCLUSION

India is a fast growing economy in the world at present and agriculture is contributing significantly in the economy. Indian agro-products especially the species are in demand globally. Use of technology in conventional farming maximise the crop yield and reducing burden of uncertainty of farmers' income. Fenugreek is a multi-use agro-product. Its medicinal properties and acceptance as a popular 'micro green' are proportionally related to its market demand. Sikar division of Rajasthan is situated in zone of low rain fall and farmers' income falls in lower to middle income group. Smart farming of fenugreek is helpful in obtaining high yield with optimal utilization of resources and hence minimizing the disparity among the income of farmers. Rajasthan state is known for highest population of live stocks in India and farmers are spending their time in care to their live stocks as well as care to crops on the farms. The installation of mobile controlled sensors in farms enables the farmers of the region towards real time monitoring of crop from remote locations as well.

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