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Review Article
MODERN AGRICULTURE PRACTICES: MICROWAVE SOLUTION

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Abstract

Agriculture in one of the major sector of foundation of Indian society & culture. Food and fiber are two basic need of any society for survival. Major challenge is to produce enough food for current population. So in modern era agriculture industry adopting new techniques & technology to fulfill the need of society. Mechanisation in agricultural is major transform. In various available techniques this paper give review of usage of microwave radiation to improve agriculture practice. This study based on possibility of exploring agriculture practice with the help of microwave radiation. This study identifies agriculture practice solutions in electromagnetic engineering by microwave frequencies

Keywords : Agriculture, Electromagnetic Wave, Microwave, Radiation.

Introduction

India is agricultural country where 58% of population depend on agricultural practice, even this sector provide approximately 50% employment. So its an important sector of Indian economy. Agriculture is one of domain which needs more attention because of change in environmental condition, water& food scarcity is major issue of our country with increase in population. As agriculture is one of core area of economic growth of our country. Government of India takes initiative to double income of farmers in next five years as major agenda, so this area needs more attention of scientist and researcher to find indigenous solutions. Cultivation with less water and decrease in germination time help in early growth of crop. To searching the solution it is noticed that due to unique features of traveling of EM wave does not require any material medium electromagnetic wave provide the a suitable solution. In continuation with the same is find that microwave which lies in the range of 300MHz to 300GHz of electromagnetic spectrum have numerous applications. In agriculture microwave used for chemical fumigation for controlling field & storage pests during transport in international market (Bisceglia *et al.*, 2009; Meggiolaro, 2014). Another major application microwave heating for shot exposure of seeds to microwave for early germination and weed control (Brodie *et al.*, 2009; Brodie *et al.*, 2012). For usage as cattle food microwave exposure of animal fodder help in digestion (Brodie *et al.*, 2010; Harris *et al.*, 20110). Extraction of essential oil from plant by microwave is one other application of these waves (Brodie *et al.*, 2011; Hoz *et al.*, 2011; Miletic *et al.*, 2009).

Application of microwave in agriculture based on dielectric properties of soil, crop and transmitting and receiving radiating antenna element used for biological samples as well as plant materials.

Dielectric characteristics

Dielectric constant and permeability are the parameter which required for propagation of EM waves in space. Permeability is almost same until and unless ferromagnetic material are not available so, dielectric properties are only change with the material. Table -1 show relative dielectric constant few material of which are directly or indirectly part of agriculture domain. So dielectric constant of biomaterial is the property which provide information about quality of agricultural goods without destructive method (Wee *et al.*, 2009; Yaw *et al.*, 2012). Different techniques are used to evaluate dielectric property and loss tangent. Microwave characterization of material permittivity done by free Space Method, Refection method, Transmission Line and Resonant Techniques. For feeding coaxial line, waveguide port, open-ended port, transmission model / reflection technique, microwave cavity & microstripline techniques are used. These all are widely used technique which has own limitations specially frequency at which measurement performed.

For non destructive measurement technique specially in soil/vegetable antenna is used for the measurement. In these materials it not possible to use dielectric probe/ cavity based resonator. In such cases a pair of horn antenna used for measurement of far-field model and free-space method. Than for measured reflection coefficients estimate the value of dielectric constant, permeability and loss tangent in terms of frequency. This method is used for precise, correct and reproducible measurement of material at environmental and complex EM environmental conditions. Composite materials like timber, soil and vegetable are anisotropic and lossy so cause depolarization of linear polarized EM field when they transmitted the material (Wee *et al.*, 2009). These composite materials are organic material as listed in table 1. These are mixture of water, air and

Table 1: Dielectric constant of materials

Material	Relative Permittivity
Amber	2.6-2.7
Alcohol, methyl (wood)	32.7
Alcohol, ethyl (grain)	24.55

Fat	16
Fiber	5
Flour (dry)	4.1-6.2
Cotton	1.3
Cellulose	3.7-7.5
Oil, linseed	3.4
Oil, mineral	2.1
Oil, olive	3.1
Soil	44
Soil Dry	2.4
Wood Dry	1.4-2.9

Solid materials has higher percentage of moisture content. Even some water molecules in relatively free state of liquid. This overall effect the dielectric property of material change with moisture content. Other than water content salt, temperature and material density of organic material also change dielectric property of material (Dinulović *et al.*, 2011; Nelson *et al.*, 2011).

Dielectric property of material depends on frequency parameter which given as:

$$\epsilon = \epsilon_{HF} + \frac{\epsilon_{LF} - \epsilon_{HF}}{1 + jw\tau} - j\frac{\sigma}{W \epsilon \text{ Free space}}$$

Where, τ= Relaxation time

σ Conductivity of material

Analysis of dielectric property of material change with embedded material like, organic material, water bound, free water, moist wood, grain, soil and moist object like insects.

Moisture Monitoring

Moisture is an important content in different sections of agriculture. Microwave application is simple because its dielectric dependent technique. As discussed in previous section dielectric property of material change with change in percentage of water content in it. Free space technique for moisture detection used to detect moisture in grain, cotton, sugar going for storage. This technique of monitoring moisture used in forestry and agriculture product like timber and grains. Microwave emission is another method for moisture detection in which remotely detects the moisture content. Power emission at EM spectrum for microwave range from soil are very small, radiometers can measure this brightness of earth surface from satellite. Routine examination of this give correct percentage of moisture in soil (Lakshmi, 2013). But this technique is very expensive. Radar is also used for measurement of moisture in soil by deploying these modules on agricultural machinery for real time analysis. This technique could be more beneficial if aerial and satellite radar used large area of site. Radar imaging is another technique to evaluate moisture content in by dielectric characteristics of agriculture material.

Dielectric property of material varies with exposure with microwave energy during transmission, absorption and reflection. So on basis of change of reflectivity appears in term of radar image. Studies available on usage of space born radar & ground penetration radar (Butnor *et al.*, 2009).

Material Analysis

Geographical survey of agricultural land is another application of microwave in agricultural area. This achieved by inducing the EM current to find conductivity of the bulk soil in depth. To evaluate conductivity of soil standard electromagnetic systems with fixed number of coil are used as in table-2.

Table 2: EM system for Geographical Survey

EM System	Frequency of Application	Inter-coil spacing
EM-31	9.8 kHz	3.66 m
EM-34	6.4KHz, 1.6KHz & 0.4KHz	10m,20m &40m
EM-38	14.6KHz	1m
EM-39	39.2KHz	50cm

Global Positioning system and geographic information system are two traditional method of geographic survey of agricultural land (Falade *et al.*, 2012).

Drying & Heating

Microwave drying is another application of microwave in agriculture for preservation of food material. This is an speedy technique of drying by keeping its nutrition value (Setiady *et al.*, 2009). Fast heating effect produce in microwave heating because of fast movement of moisture content. It directly related with dielectric property of material. Plants having higher water molecule have high dielectric constant so it more interact with microwave field. This technique is self limiting because reduction of water molecule reduces dielectric property of the organic material (Chen *et al.*, 2004). Microwave heating is viable solution over conventional technique of drying due to rapid drying as well as high throughput of moist organic material are desirable.

Microwave heating is one of major application of food industry in cooking, tempering, thawing, drying, baking, pasteurization, freeze-drying, reheating, sterilization and many more. Preferred because of fast processing in short time, space saving and energy efficient. It work on volumetric phenomena (Shaheen *et al.*, 2012; Shaheen *et al.*, 2013).

Insect and Weed Management

Major challenge of agriculture industry is minimization of spoilage of stored product. In this pest and insects are major threats they damage crop and wood product (Roberts 2010). Microwave are also use for detection and decaying of insects. For detection of decaying of insect based on movement and moisture content available in insects (Donskoy *et al.*, 2002; Ding *et al.*, 2008).

Radar are used for the detection of insects by technique:

1. Remote monitoring of larger flying insects for evaluating behavior of insect.
2. Detection by motion of insects

Traditionally mechanical & chemical techniques are used for weed management in cropping system but this destroys large number of plants. Even applying herbicide in soil can reduce the productivity of soil approximately 70%. In such condition microwave treatment of soil provide optimal solution for weed control, this also provide long term benefits against conventional herbicide technique. This microwave treatment increase germination rate of seed as well as protect against unwanted material (Brodie *et al.*, 2012). Microwave treatment can also used in quarantine and biosecurity application to replace harmful chemicals. By application of appropriate microwave applicator this could be done (Harris *et al*., 2011).

Animal Fodder

Transporting of food material by microwave treatment has benefit of long term storage also retain its nutrients. This treatment work on cell structures increase digestibility and moisture permeability in biomass, it also decrease mechanical strength and modifies complex protein (Dong *et al*., 2005). Modification of these proteins improves production efficiency of animal. This treatment also provide bio security to farmers.

Few effective applications of microwave techniques to enhance and improve the efficiency of crop quality as well as production are discussed in table-3.

Table 3 : Recent Studies

Work	Findings
Step-Frequency Ground Penetrating Radar for Agricultural Soil Morphology Characterization (Federico *et al*. 2019)	Analyzing the electrical properties of soil by GPR system show heterogeneity of soil in agricultural field. This impact number of physical characteristics of soil.
Microwave Weed and Soil Treatment in Rice Production (Muhammad et.al 2018)	The concept of superheating is use to kill weeds. This achieved by least energy to control weed. The experiment performed for three trial for energy level of approximately 400–500 J/cm^2 . This reduces approximately 70–80% reduction of weed tested agro-ecological area. With this treatment also improve 10 times nitrogen efficiency and 37% water efficiency in tested region. Also this treatment strategy is independent season & improve rice production in tested region.
Microwave Weed and Soil Treatment in Ag ricultural Systems (Brodie 2017)	The experiment based on heating effect of microwave for reduction of weeds. Test setup consist of four independent 2 kW generators operating at frequency of 2.45 GHz ground via waveguides and horn antennae. The overall conclusion of this work quoted this technique is better than fumigation because it's a routine practice.
Residue effect of microwave soil treatment on growth and development of wheat (Khan et.al 2017)	Is study is based on microwave irradiation in glass house area to in wheat cultivation. This irradiation kills weed seeds in cultivation area and improve production in second season.
Early-Time GPR: A Method to Monitor Spatial Variations in Soil Water Content during Irrigation in Clay Soils (Algeo *et al*. 2016)	This work is based on application of microwave Ground Penetrating Radar based system for monitoring of moisture content in soil.
open source software to simulate electromagnetic wave propagation for Ground Penetrating Radar (Warren *et al*.2016)	This simulation work is based on paython software to find new simulation platform for researcher working on GPR evaluate characteristics of soil.
Stabilizing effect of biochar on soil extracellular enzymes after a denaturing stress (Elzobair *et al*. 2016)	This work is based on bacterial communities of soil resistant towards microwave energy. Exposure to microwave energy at 800 J/g of soil decreases dehydrogenase enzyme activity in soil but at 3200 J/g increases functionality of soil.
Artificial and enhanced humification of soil organic matter using microwave irradiation (Kim *et al*.2013)	Irradiation at low energy by microwave improve physicochemical properties of organic matter of soil. Experiment results of this work explain that an exposure of forest soils for 10 min organic matter of soil becomeenhance aromatic and nonpolar, macromolecules organic compound and soil became more condensed.This technique also resultsuccessful groundwater remediation practice.

Future Aspect & Conclusion

Various technical aspects of applications of microwave discussed in this paper. Which justify the potential of microwave application in different domain of agriculture practices. It start from soil treatment, sowing seeds, help in irrigation practices in water scarcity world, weed management, analyze growth for crop and finally in storing the grains. The acceptability of microwave in agricultural practice need to evaluate technically. So this technology will be use widely for industrial & commercial purpose. The acceptability of microwave agricultural practice helps to improve production of food in the countries where food is big problem. In future this technique may also help to reduce growth time of crop with added above said benefits of microwave applications of microwave.

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