Variation in Dielectric Behaviour of Soil of Indo-Gangetic Region of Haryana (India) with Fertilizers at 5 GHz

Rajeev Kumar[1] and Anupamdeep Sharma[2]

[1]*Punjab Technical University, Jallandhar, India*
[2]*Department of Physics, SBBS college of Engineering and Technology, Jallandhar, India*
E-mail: [1]rajivandphysics@rediffmail.com, [2]dr.anupamdeep@yahoo.com

Abstract—*The paper presents the experimental results of measurement of complex dielectric constant of mixture of different fertilizers and soil of Indo-gangetic region of Haryana (India) at 5 GHz. Four samples of unfertilized soils are collected from different parts of Indo-Gangetic region of Haryana. The variation in the real part ($\in'$) and imaginary part ($\in''$) of complex dielectric constant of mixture of moist soil (moisture content 8% and 16%) and fertilizers are studied at 5 GHz. It is found experimentally that the values of $\in'$ and $\in''$ both increases with fertilizer content. The technique used for the measurement of complex dielectric constant is waveguide cell technique. The microwaves are allowed to be incident on the sample. A part of incident signal reflects and superimpose with incident signal to give rise to standing wave pattern. The dielectric constant is measured by using the shift in minima of standing wave pattern that takes place due to the change in guide wavelength on the introduction of sample in the waveguide. Different fertilizers used are Urea, Potash, DAP (Di-Ammonium Phosphate). The results obtained are useful in agriculture and in various remote sensing applications.*

1. INTRODUCTION

All plants need nutrients to survive. Nutrients can be '**macronutrients**'–because these are needed in greater quantities–such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S) and magnesium (Mg) or '**micronutrients**' such as zinc (Zn), copper (Cu), iron (Fe), boron (B), and molybdenum (Mo) because they are needed in lesser quantities. Crops get most of their nutrient requirements from the soil. However, many soils do not provide all the nutrients in quantities needed by the crops. Soil nutrients are commonly removed by continuous cropping and must be replaced through the addition of nutrient sources, such as fertilizers [1]. In the presence of some Electromagnetic (EM) field, the behavior of a dielectric material is entirely different from that in presence of a direct current field. In EM field the material gets polarized and its degree of polarization depends upon permittivity and permeability of the material. Several workers have studied the variation in dielectric properties of dry and moist soil at microwave frequencies. Ahire D.V. et. al. [2] studied the variation in dielectric behavior of black soil of Maharashtra at C-Band and show that dielectric constant and dielectric loss increases with fertilizer content in soil. Wang J. R. and Schmugge T. J. [3] showed that the dielectric constant is directly proportional to pore- space of soil. Yadav V. et al. [4] report that, the grains of the crops get the sufficient space for growth due to more pore space , so fertility of soil is increased, they also report that dielectric constant, dielectric loss, a.c. conductivity and relaxation time increase with increase in the concentration of fertilizers in the soil. Navarkhele V. V. et al. [5] and Shaikh A. A and Navarkhele V. V. [6] have also studied the dielectric properties of black soil with inorganic and organic matters at X-band microwave frequencies. Gadani D. H. et al. [7] have studied the dielectric properties of fertilized soils at radio frequencies and report that dielectric constant and dielectric loss increase with the increase in concentration of fertilizers in the soil.

2. EXPERIMENTAL DETAILS

2.1 Sample Preparation

Haryana State lies between 27°39' -30° 55' N latitude and 74°28' -77°36' E longitudes[8]. Samples of soil are collected from indo-gangetic region of Haryana from four districts - Ambala, Yamunanagar, Kurukshetra and Panchkula in zigzag pattern across the area. The samples of soil collected first sieved and coarse particles are removed. The fine particles obtained are then oven dried for several hours to remove moisture completely and make it dry. Now to prepare moist soil samples measured quantity of distilled water is added to dried soil. The gravimetric soil moisture content in percentage term is calculated using the following relation :

$$w_c(\%) = \frac{w_w - w_d}{w_d} \times 100$$

where w_w is the weight of wet soil and w_d is the weight of dry soil.

The wilting point of the soil is also calculated using Wang and Schmugge Model. [9]

W = 0.06774–0.00064 × (Sand %) + 0.0478 × (Clay %)

Now to prepare soil samples, mix different concentrations of fertilizers in moist soil (8% and 16% moisture content). These samples are then allowed for few hours to facilitate internal drainage, homogenous mixing and settlement. The concentration of the fertilizers are varied from 0 to 0.1% for Urea, DAP and Potash.

2.2 Measurement of dielectric constant and dielectric loss

In the present work, technique used for the measurement constant is waveguide cell technique [10]. A microwave bench operating at C-Band is used at 5 MHz in TE_{10} mode with Gunn source at room temperature. The microwaves are allowed to be incident on the sample. A part of incident signal reflects and superimpose with incident signal to give rise to standing wave pattern. The dielectric constant is measured by using the shift in minima of standing wave pattern that takes place due to the change in guide wavelength on the introduction of sample in the waveguide. The complex dielectric constant can be calculated using the following relations:

$$\in' = \frac{g_\in + \left[\frac{\lambda_{gs}}{2a}\right]^2}{1 + \left[\frac{\lambda_{gs}}{2a}\right]^2} \text{ and } \in'' = \frac{-b_\in}{1 + \left[\frac{\lambda_{gs}}{2a}\right]^2}$$

where $g_\in$ and $b_\in$ are real and imaginary parts of admittance, λ_{gs} is wavelength in air filled guide,

a = inner width of rectangular waveguide.

The physical and chemical analysis reports of four samples are presented in Table 1. The Physical parameters are percentage of sand, percentage of silt, percentage of clay, WP, BD. The chemical parameters are pH, EC, percentage of K, percentage of organic carbon, presence of Zn (ppm).

Table 1: Physical and chemical parameters of samples from indo-gangetic region of Haryana

Property		Area			
		A	B	C	D
Texture	Sand(%)	62	65	58	56
	Silt (%)	20	23	26	31
	Clay(%)	18	12	16	13
WP		0.1141	0.0835	0.1071	0.0940
BD		1.46	1.53	1.47	1.50
pH		6.9	6.8	7.1	7.2
EC(dS/m)		0.27	0.25	0.29	0.33
Zn(ppm)		0.8	0.7	0.7	0.9
K(Kg/ha.)		525	600	550	625
OC(%)		0.24	0.16	0.22	0.18

A-Yamunanagar B-Kurukshetra

C-Ambala D-Panchkula

3. RESULTS AND DISCUSSION

The values of dielectric constant of unfertilized soil samples at 8% moisture content for Ambala, Kurukshetra, Panchkula and Yamunanagar districts are 5.6, 6.1, 5.3 and 5.9 respectively whereas the values of dielectric loss of unfertilized soil samples at 8% moisture content for Ambala, Kurukshetra, Panchkula and Yamunanagar districts are 0.89, 1.00, 0.99 and 1.00 respectively. Further the values of dielectric constant of unfertilized soil samples at 16% moisture content for Ambala, Kurukshetra, Panchkula and Yamunanagar districts are 16.4, 17.0, 16.3 and 16.5 respectively whereas the average value of dielectric loss of unfertilized soil samples at 16% moisture content for Ambala, Kurukshetra, Panchkula and Yamunanagar districts is 2.3. In the present study it is found that the values of both dielectric constant and dielectric loss increases with the increase in fertilizer content in the soil. The variations in $\in'$ and $\in''$ for moist soil (having 8% and 16% moisture content) for four samples with fertilizer content are plotted in Fig. 1 -16. The plots clearly show that both $\in'$ and $\in''$ increases with fertilizer content almost linearly. It is also obvious that rate of increase of $\in'$ and $\in''$ for different fertilizer content is highest for Urea and lowest for Potash. Also the rate of increase of $\in''$ with fertilizer content is more than the rate of increase of $\in'$ with fertilizer content for all fertilizers under study. With the increase in Fertilizer content any soil, pore space increases. Due to increase in pore space, dielectric constant increases and also increases fertility. Due to the addition of fertilizers, physical and chemical properties of soil changes.

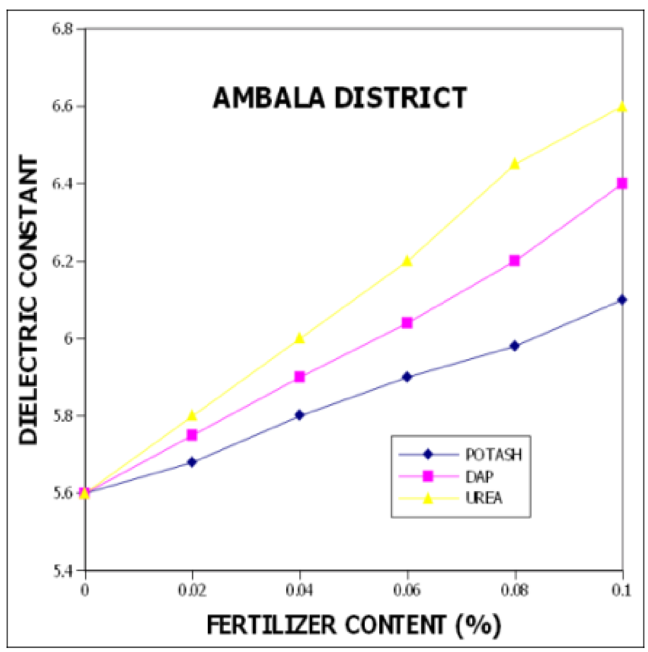

Fig. 1: Variation in Dielectric constant of soil (8% moisture content) of Ambala District with fertilizer content

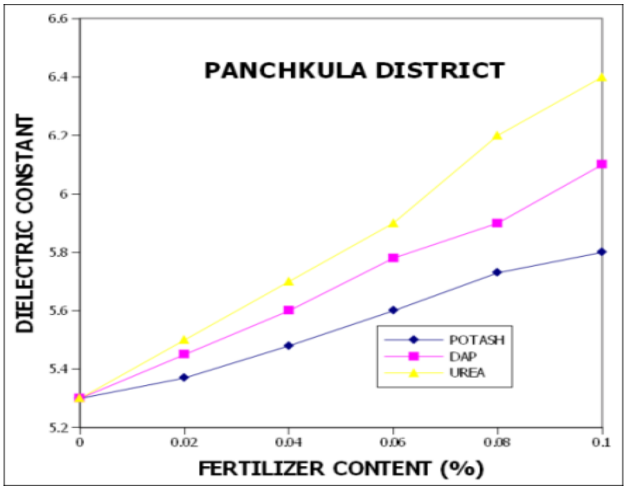

Fig. 2: Variation in Dielectric constant of soil (8% moisture content) of Panchkulala District with fertilizer content

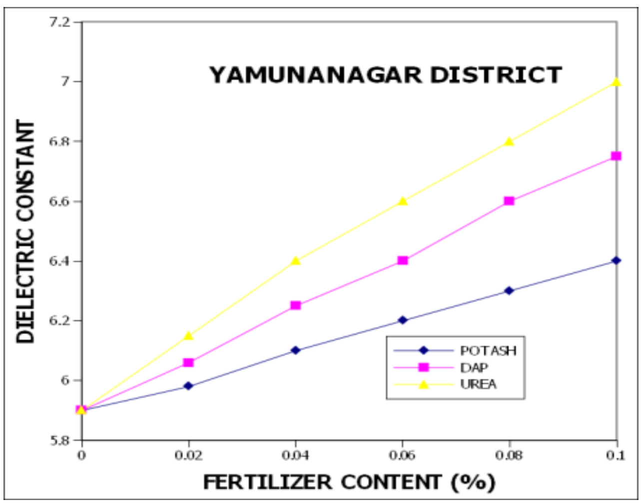

Fig. 3: Variation in Dielectric constant of soil (8% moisture content) of Yamunanagar District with fertilizer content

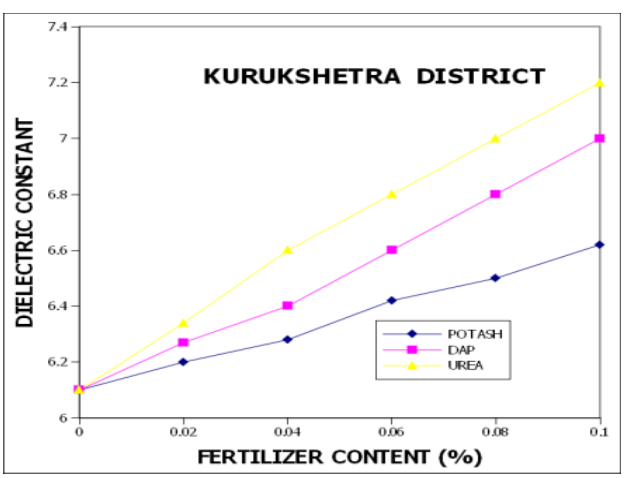

Fig. 4: Variation in Dielectric constant of soil (8% moisture content) of Kurukshetra District with fertilizer content

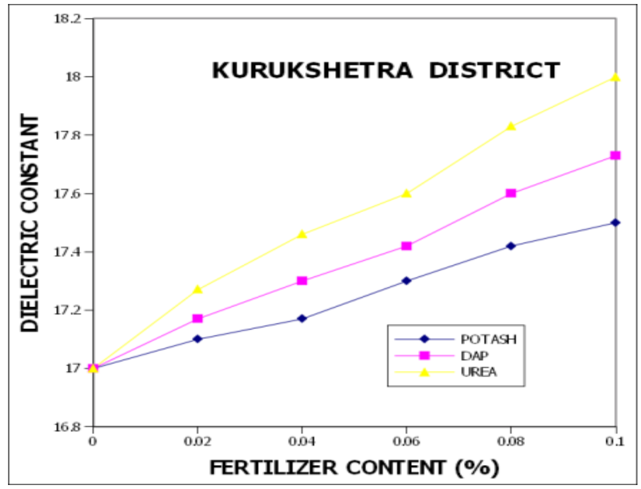

Fig. 5: Variation in Dielectric constant of soil (16% moisture content) of Kurukshetra District with fertilizer content

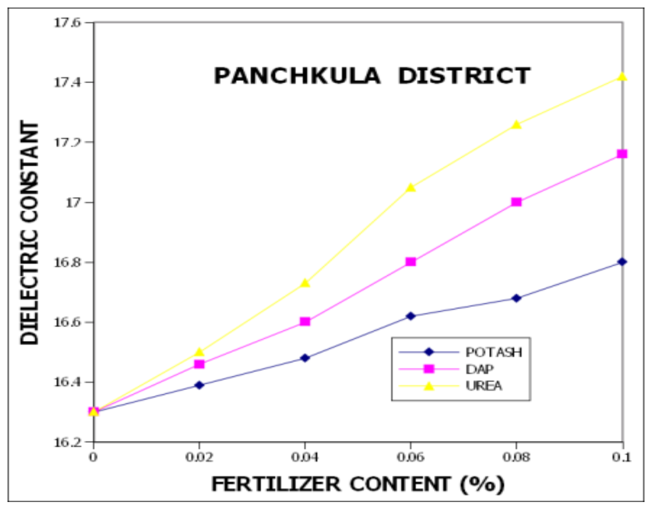

Fig. 6: Variation in Dielectric constant of soil (16% moisture content) of Panchkula District with fertilizer content

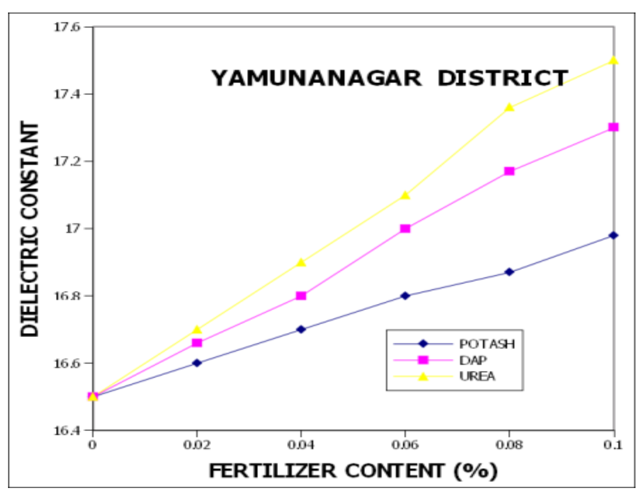

Fig. 7: Variation in Dielectric constant of soil (16% moisture content) of Yamunanagar District with fertilizer content

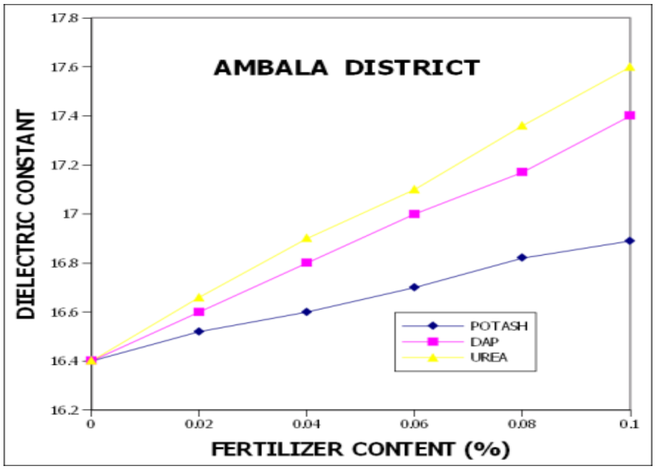

Fig. 8: Variation in Dielectric constant of soil (16% moisture content) of Ambala District with fertilizer content

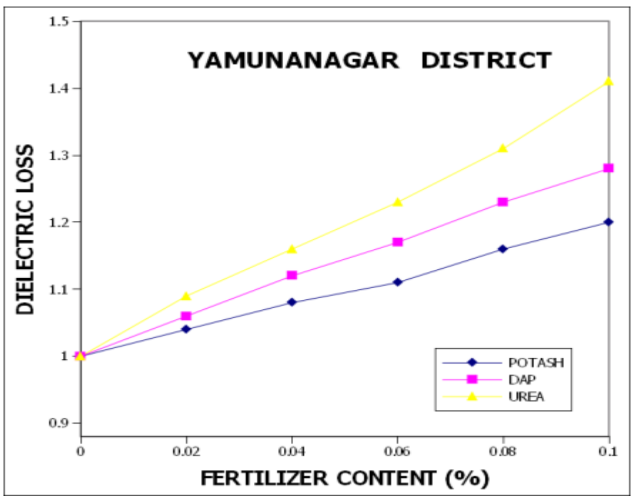

Fig. 9: Variation in Dielectric loss of soil (8% moisture content) of Yamunanagar District with fertilizer content

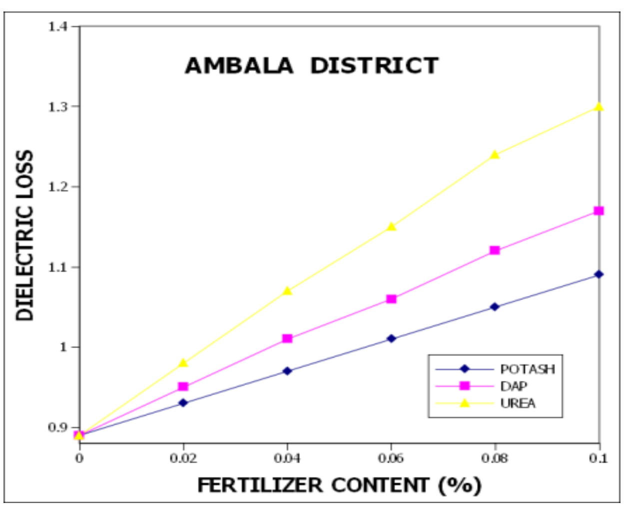

Fig. 10: Variation in Dielectric loss of soil (8% moisture content) of Ambala District with fertilizer content

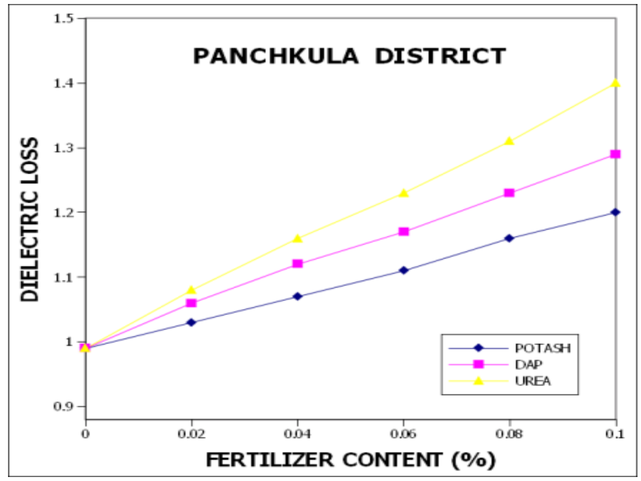

Fig. 11: Variation in Dielectric loss of soil (8% moisture content) of Panchkula District with fertilizer content

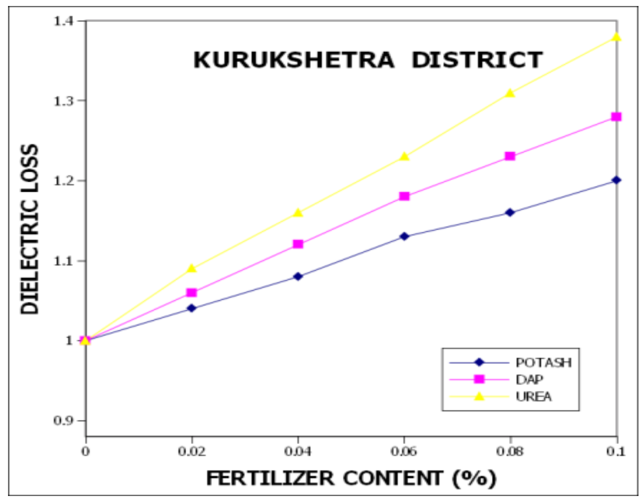

Fig. 12: Variation in Dielectric loss of soil (8% moisture content) of Kurukshetra District with fertilizer content

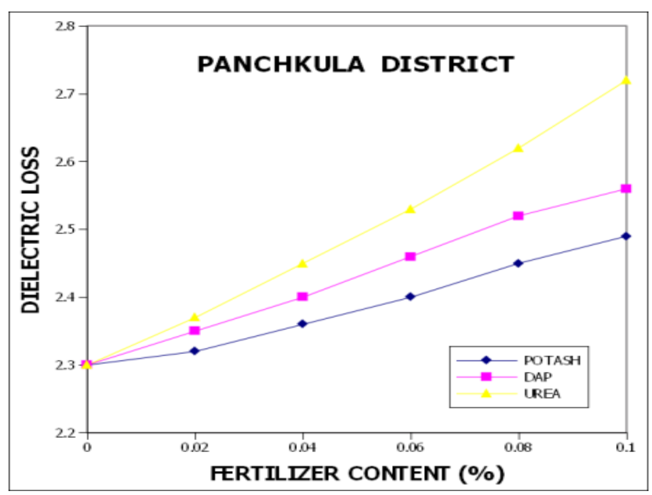

Fig. 13: Variation in Dielectric loss of soil (16% moisture content) of Panchkula District with fertilizer content

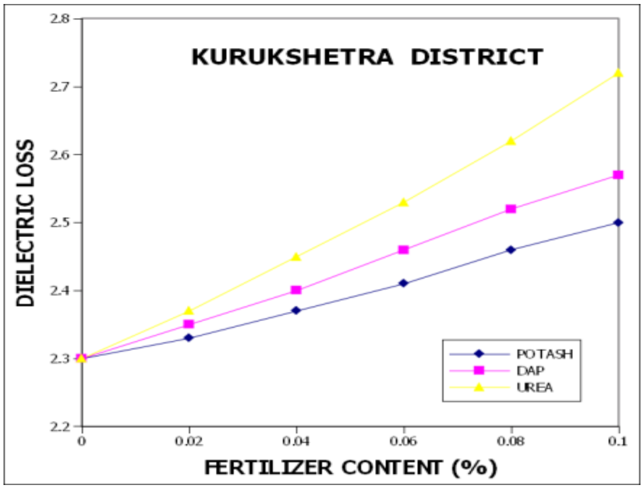

Fig. 14: Variation in Dielectric loss of soil (16% moisture content) of Kurukshetra District with fertilizer content

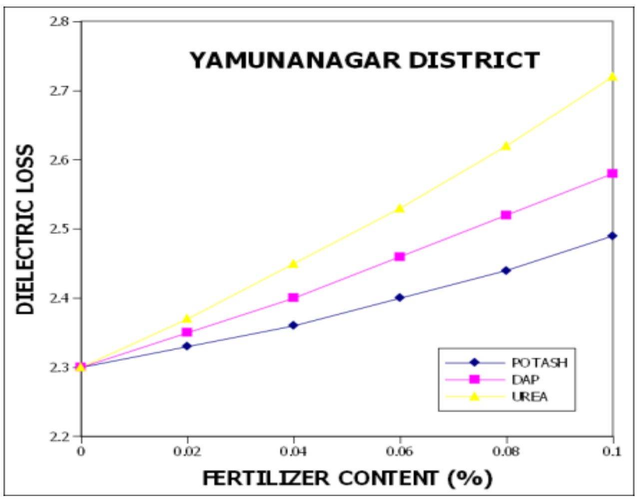

Fig. 15: Variation in Dielectric loss of soil (16% moisture content) of Yamunanagar District with fertilizer content

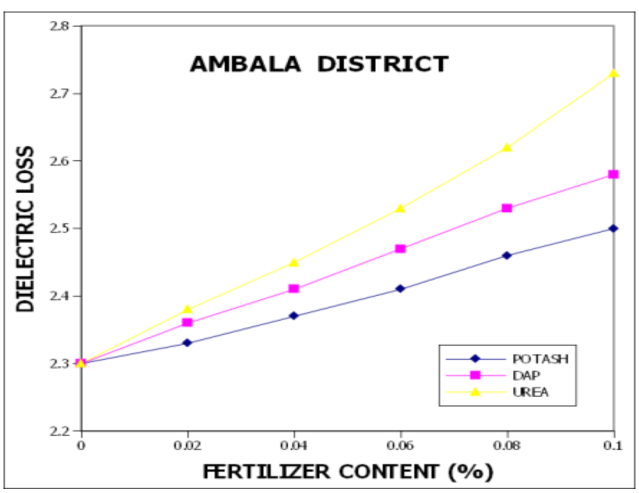

Fig. 16: Variation in Dielectric loss of soil (16% moisture content) of Ambala District with fertilizer content

4. CONCLUSION

Study of properties of moist and fertilized soil of Indo-Gangetic region of Haryana (India) at 5 GHz is useful in agriculture and other remote sensing applications. The study is useful to understand the behavior of fertilized soil and to improve the fertility of soil. Study shows that dielectric constant and dielectric loss of soil increases with the increase in fertilizer content. The rate of increase of both dielectric constant and dielectric loss with fertilizer content is highest for Urea and lowest for Potash.

When fertilizers are added in soil, pore space increases and hence dielectric constant and fertility. The study is also very useful to make best choice of fertilizer for soil of known physical and chemical properties.

REFERENCES

[1] http://www.fertilizer.org/AboutFertilizers

[2] Vidya D Ahir, D.V. Ahire and P.R. Choudhari, "Dielectric constant and emissivity of dry and wet black soils at C-Band microwave frequency," in *Journal of Chemical, Biological and Physical Sciences;* vol1.2 no. 2 February2012 pp 937-946

[3] Wang J. R. and Schmugge T. J., *IEEE Trans. Geosci. Remote sens.*,vol. 18, 1980, pp 288- 295.

[4] Yadav, V., Anil Kumar, A. Sharan, S. Sinha, A.K. Yadav, M. Gupta, V.K. and Jangid, R. A., *Journal of Agricultural Science*, vol.42, 2009, pp 42-49.

[5] Navarkhele, V. V. Shaikh, A. A. and Ramshetti, R. S., (2009), *Indian J. of Radio and Space Physics*, vol. 38, 2009, pp112-115.

[6] Shaikh A. A. and Nawarkhele V. V., Frontiers of Microwaves and Optoelectronics, *Proceedings of International Conference on Microwaves and Optoelectronics, Anamaya Publishers, New Delhi, India*, 2008, p879.

[7] Gadani D. H., Vyas A. D. And Rana V. A., *Indian J. of Radio and Space Physics*, vol. 52, 2014, pp399-410.

[8] http://en.wikipedia.org/wiki/Haryana

[9] Wang J R and Schmugge T J, "An empirical model for complex dielectric permittivity of soils as a function of water content," in *IEEE Transactions on Geoscience and Remote Sensing* (USA), 18, (1980) pp288-295

[10] Sucher M and Fox J, *The handbook of microwave measurements, Vol II* (John Wiley, New York, 1963)