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Research Article

Dielectric properties of wheat samples

Shabnum Shabbir, Afsheen Zehra, Riaz Hashmi*, M Ishaq Khan, Javed Zaki, Syed EhtashamUl Haque, Altaf Hussain*, Afsheen Tariq, Rabia Badar, and Samina Begum.

Department of Botany, University of Karachi, Karachi, Pakistan -75270.

ABSTRACT

Dielectric properties of wheat treated with homeopathic drug (Rhus Toxicodendron) of different potencies have been studied over a wide frequency range (10^{-2} – 10^{5} Hz) at two growth stages. The results of electrical studies are supported by the botanical findings. It may be concluded that increase in plant growth due to homeopathic treatment is perhaps due to the increased dynamic electrical energy supplied to the plants by the energized homeopathic drugs.

Key words: Dielectric, Rhus Toxicodendron, wheat, homeopathic drug

INTRODUCTION

Dielectric spectroscopy is an analytical technique, which is suitable for investigation of the electrical conduction/polarization process in different types of non-conducting materials under given conditions [9-10, 14]. This technique has also found application in the study of pharmaceutical systems [5, 2]. There are several reports on the use of dielectric spectroscopy for the study of living material samples [7-8, 11, 4, 20, 19]. Many plant species response have been studied under the influence of various dielectric treatments [22, 18].

In this paper we present the results of electrical studies of wheat seeds treated with homoeopathic drugs and dried flag leaves of the plants grown from these seeds. The main objective of these studies was to understand the dielectric response of plant grown from the drug infused seeds.

Under the influence of a time varying electric field, the charge transport through a sample depends mainly upon it intrinsic properties giving rise conductivity. The current through the sample is limited by its impedance which in its complex form is related to the complex capacitance by,

$$Z^* (\omega) = 1/ \{i \omega C^*\} \qquad (1)$$

Where I represents imaginary unit.

The complex capacitance C* (ω) is expressed by,

$$C^* (\omega) = C' (\omega) - iC'' (\omega)$$
$$= C^* (\omega) - iG(\omega)/ \omega \qquad (2)$$

Where C' (ω) and G (ω) are capacitance and conductance of the sample respectively.

Dielectric study comprises measurements of capacitance and conductance of the sample. The material under test is generally placed between two electrodes forming a capacitor. The capacitance of the sample depends upon it geometrical configuration and permittivity which is a characteristic of the material. Te relation between capacitance and permittivity is given by

$$C^* (\omega) = \{\varepsilon' (\omega) - i\, \varepsilon'' (\omega)\}. A/d = c^* (\omega).A/d$$

Where A is the area of the electrodes, d is the distance between the electrodes and c* (ω) is the complex dielectric permittivity given by

$$c^* (\omega) = \varepsilon' (\omega) - \varepsilon'' (\omega)$$

The quantity of ε' (ω) is the real part of the complex dielectric permittivity and ε" (ω) is the loss factor.

When a polar substance is subjected to a static electric field the dipoles tend to align along the field direction and after removal of the field they return to their original orientation. Alignment of dipoles in the field direction gives rise to electric polarization while the time delay in return back of dipoles to the original orientation is referred to as relaxation.

Under the application of an alternating field, dipoles attempt to re-orient at the same rate as the frequency of the applied field thus establishing polarization current. Debye developed the theory for the polarization process in pure materials [6]. Although, the Debye theory formed the basis of microscopic understanding of relaxation process in dielectric materials, the response of very few materials can be described by Debye law. In contrast with the Debye law, the observed dielectric response of most solid materials can best be described by two laws depending on the polarization mechanism [12, 16].

1) The dielectric response of polar materials is characterized by two fractional power laws corresponding to high and low frequency[16].

$C^* (\omega) = \{C' (\omega) - C_{inf}\} \{\cot (n\pi/2)\} \alpha\ \omega^{(n-1)}; \omega >> \omega_p$ (4-a)

$C^* (\omega)\ \alpha\ \omega^m\ \&\ C' (\omega) = \text{constant}; \omega >> \omega_p$ (4-b)

Both exponents m and n lie between 0& 1.

2) The behavior of carrier dominated systems at high frequencies is similar to that of dipolar ones with $n=n_1$ close to unity. The low frequency behavior below some critical frequency ω_c shows a strong dispersion following a second power law of the same form but with a much smaller value of the exponents $n = n_2$ close to zero. Such a behavior is regarded as low frequency dispersion [1].

MATERIALS AND METHODS

Effect of homoeopathic medicine on wheat was studies at two different stages i.e. dried seeds treated with different potencies of homoeopathic medicine Rhus Toxicodendron and dried leaf of the plants grown from the treated seeds.

Alcoholic solutions of four potencies 6, 30, 200 and 1000 of Rhus Toxicodendron (Willmar Schwabe, Germany) were prepared by mixing 0.5ml of the remedies in 100 ml of distilled water. Thirty surface sterilized seeds of wheat (*Triticum aestivum* cv. Chakwal-86) were soaked in each solution. After three hours of soaking, the seeds were air dried and used for dielectric studies. One sample termed as control was prepared by soaking the seeds into a solution of 0.5ml ethanol and 100ml distilled water for comparison with other measured results.

The treated seeds were sown in the fields of Department of Botany, University of Karachi, with 30cm drill distance and five replicated rows with ten plants per row. The plants were divided into categories according to the given potency. Each plant in each category received treatment of 10ml solution of the respective potency through roots after every thirty days of growth for a total growing period of 100 days. Plants were then uprooted and the total shoot length was measured. Fully expanded flag leaves from such 10 different plants were dried in a muffle furnace at 80^oC for half an hour, chopped into small pieces and used for dielectric studies.

For both types of samples a self designed hollow cylinder of Teflon, at each of which electrode in the form of metallic gauze can be inserted, as shown in fig 1, was used as sample holder. The leaves were encapsulated in the cylinder and the electrodes were inserted gently at the ends with no extra pressure applied so that any effect arising due to pressure may be minimized. To connect the sample with the measuring system, two thin wires with BNC plugs and that of the thin wire was matched with that of the internal impedance of the measuring equipment.

The frequency response was measured on a fully computerized dielectric spectrometer consisting of a solution 1255 frequency response analyses (FRA), a Chelsea dielectric interface, an Opus computer, a DXY 800 plotter and an Epson LQ-500 printer. A block diagram of the measuring technique is shown in fig 2. Using this system, the dielectric properties of any material can be investigated in the frequency range from 10^{-4} to 10^7 HZ provided the loss tangent tan lies between 10^{-3} and 10^3. All the measurements were made with 0.1V ohms and zero DC bias.

RESULT AND DISCUSSION

Frequency dependent dielectric response of dried wheat seeds treated with different potencies of Rhus Toxicodendron is shown in figure 3.The real and imaginary components of the complex capacitance C'(ω) and C'''(ω) are plotted on common axes and to avoid overlapping, individual set is displaced vertically by two divisions i.e. by two decades. Response of untreated sample (control) is also shown for comparison. It can be seen that the response of all samples, with the exception of C_{1000}, are qualitatively similar, and becomes strongly frequency dependent at low frequencies. For analysis the entire response can be divided into three regions depending upon frequency. An almost flat C (ω) at high frequencies, an overlapped region at intermediate frequencies where C' and C'' overlap each other, and finally a dispersive region below 1HZ. The transition from one region to another occurs almost at same frequency for all samples. For C_{1000} sample the flat C' (ω) extends to relatively much lower frequencies and the overlapping region occurs at quite low frequencies.

For dried flag leaf samples, dependence of the complex capacitance on frequency is shown in figure 4, on logarithmic scale. Both C' (ω) and C'' (ω) are plotted on common axes and individual set of data is displaced vertically by two decades for clarity. From these plots it is clearly evident that the response corresponding to all potencies comprises of two regions: an overlapped region 1KHZ, in which both C' (ω) and C'' (ω) are almost parallel. However, the C'' (ω) curves for all samples are almost parallel to each other which indicate s that the transport mechanism is not affected by the change in potency of the medicine, only the rate of process is changes. For clarification of this view, the individual plots are normalized and shown in figure 5, where the data presented in figure 4, are replotted to obtain a master curve by translating the individual set of data along the horizontal axis until the best overlap over the maximum frequency range is obtained. The loci of a reference point denoted (**.**) are also marked in figure 5, which show the relative shift of the individual set of data. A simple horizontal shift of the reference point suggests that the increase in potency of the medicine only varies the rate of change transports in the sample. As the potency increases from zero (untreated) to C_{1000} the reference point shifts towards low frequencies except for C_{200} for which the reference point shifts toward high frequency. This implies that an increase in potency reduces the rate of conduction process, except for C_{200} for which it becomes faster. Variation in conduction with increasing potency is also clear from table 1 where the conductance of both types of samples i.e. seeds and crushed dried leaves are reproduced at decade of frequencies. It is quite obvious from the table that for seed samples the conductance first increases with the increase in potency and then above a certain potency it shows a decrease whereas, for leaf samples a continuous rise with relatively lower rate of increase at higher potencies, is observed except for C_{200} which exhibits a dip. This periodic nature in the behavior is one of the important characteristic of homoeopathic drugs [17, 3, 13].

A comparison of figure 3 and 4 shows that at high frequencies the constancy in C'' (ω) is no longer present in figure 4. An overlap region in the intermediate frequency range followed by a dispersive region in figure 3 is similar to the response of figure 4 and suggests that the overall response of leaf samples has shifted to high frequency region.

The capacitance plots for both types of samples consist of more than one region. Presence of more than one region in C*(ω) plots indicates that there are more than one process. To obtain further information, the capacitance data is transformed into complex impedence plots i.e. Z*- plots. Impedance plots corresponding to figure 3 and 4 are given in figure 6 and 7 respectively. It can be seen that Z-plots of all seed samples are composed of two/three distinct parts. At high frequencies an inclined straight line appears which gradually turns downwards and eventually becomes a skewed semicircle at low frequencies. The turning in the straight line gives indication about the commencement of second part characterized by a nearly semi-circular component. The semicircle does not interest the real axis and continues to rise even at much lower frequencies.

The complex Z-plots for all leaf samples, shown in figure 7, consist of two components. At high frequencies the data falls on a distorted skewed semi-circle is followed by a circular arc of relatively large radius at low frequencies. This implies that there are two elements in series with each other. In Z-plane, an inclined line corresponds to a dispersive capacitor and skewed semi-circle corresponds to a dispersive capacitor C_n in parallel with a resistor R, respectively. The diameter of the semicircle gives the values of the resistance and the angle of skewness is a measure of the amount of dispersion in the capacitor. Numerically, the value of capacitive element can be obtained from the peak frequency f_p of the semicircle by the relation $Cp = 1/ \{2\pi f_p R$. Table II gives the parameters calculated from impedance plots. The values of resistance and capacitance are calculated at peak frequency from the impedance plots.

To analyze the impedance plots for leaf samples, we propose an equivalent circuit comprising of two parallel combinations in series that each combination consists of a capacitor in parallel with a resistor. An arrangement of these circuit elements is shown in figure 8(a). These parallel combinations suggests two frequency dependent physical processes, bulk-interfacial, existing in series with each other. Generally, at high frequencies the parallel combination of a weakly dispersive capacitor C_{n1} and a high resistance R_1 is attributes to the contribution from the bulk of the sample whereas, at low frequencies the parallel combination of a strongly dispersive capacitor C_{n2} and a small resistance R_2 corresponds to interfacial or electrode effect. The increase in conductance with potency may arise due to the accumulation of charge near the electrode surface thus producing a layer which obstructs the flow of charge. Increase in potency enhances the blocking effect thus forming a capacitor like situation. Since the layer formed is not sufficiently thick, as an appreciable amount of charge carries can still pass through, thus a conduction element can be associated with a blocking element. A parallel combination of C_{n2} and R_2 may therefore be described by the suggested behavior at the electrodes. Similarly, the proposed equivalent circuit for seed samples is shown in figure 8(b). Here the relatively weakly dispersive capacitor C_{n3} represents the bulk response of the sample whereas, the parallel combination of C_{n4} and R_4 may account for the grain-grain contact at the surface. A slight change in the resistance and capacitance values is observed. Similar behavior has been reported in case of fresh leaves (5).

CONCLUSION

Homoeopathic medicine Rhus Toxicodendron Significantly affects the electrical properties of wheat seeds. These effects are also transferred to the plants grown from the same seeds. The variation in the potencies of Rhus Toxicodendron affects the rate of charge transport while the transport mechanism remains same. Our results are consistent with the growth studies of vegetative and reproductive parts of the plants as shown in figure 9. In this figure comparative studies of shoot length and dry weight of ear are presented in the form of bar graph. It is evident from figure 9, that both the agricultural parameters increase with the increase in potency of the drug except for sample treated with C_{200}, where both parameters show a decrease.

Figure 10 is the photograph of the plants grown from wheat seeds treated with the drug taken after 100 days of growth. This photograph also supports the above discussion. Since, the metallic electrodes were placed at the two opposite faces of the sample so it implies that the bulk of the samples make a major contribution to the response which is further supported by the corresponding complex impedance plots. The natures of energy in homeopathic drugs are dynamic and this dynamic penetrates into every cell, every particle and even the atoms of the living cells [22]. Thus, it is quite evident from the results of the present study that increase in plant growth due to homeopathic treatment is perhaps due to the increased dynamic energy supplied to the plants by the potentized homeopathic drug. As shown by fig 4. The C”(ω)=G/ ω does not follow a slop[e of exactly -1 manifesting that the charge transport is not a simple D.C conduction in which the conductance does not show any frequency dependence while C” (ω) varies inversely with frequency.

The leaf samples, fig 4, show stronger low frequency dispersion compared with seed samples. Fig 3, pointing towards the influence of drugs. Magnitude of C’ (ω) and C” (ω) also show a considerable increase of about six decades. Variation of conductance with frequency, for both types of samples is also shown in table 1.

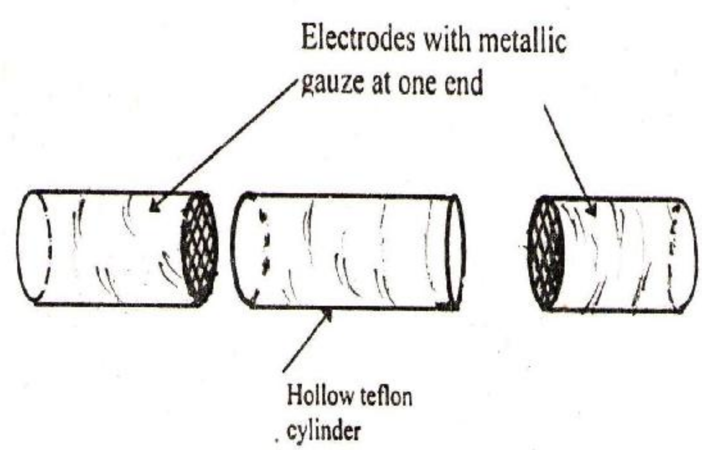

Fig 1.
Design of sample holder

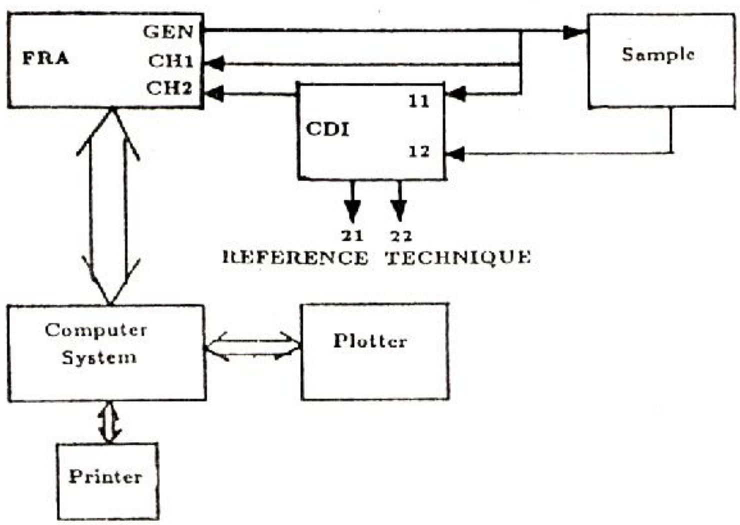

Fig 2.
Block diagram of the frequency domain measuring system

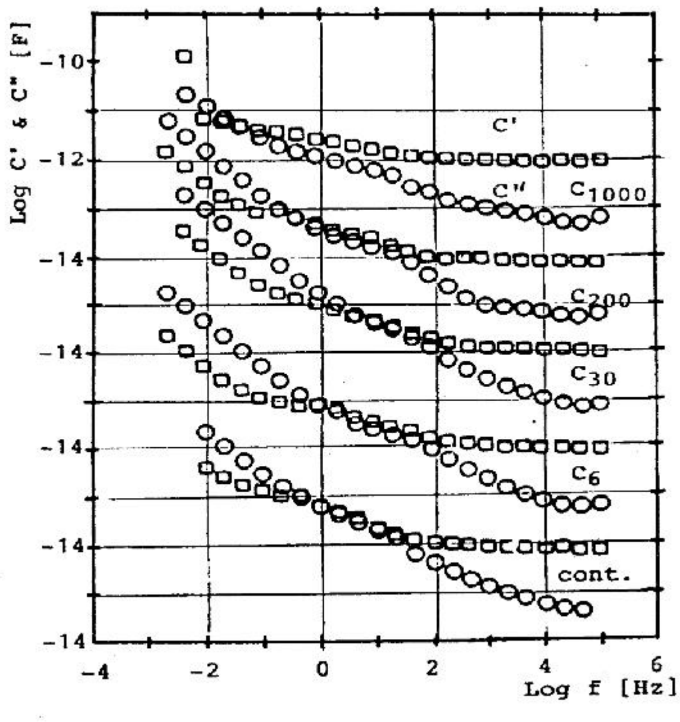

Fig.3.
Frequency dependence of C' (ω) and C" (ω) for Wheat seeds treated with different potencies of Rhus Toxicodendron

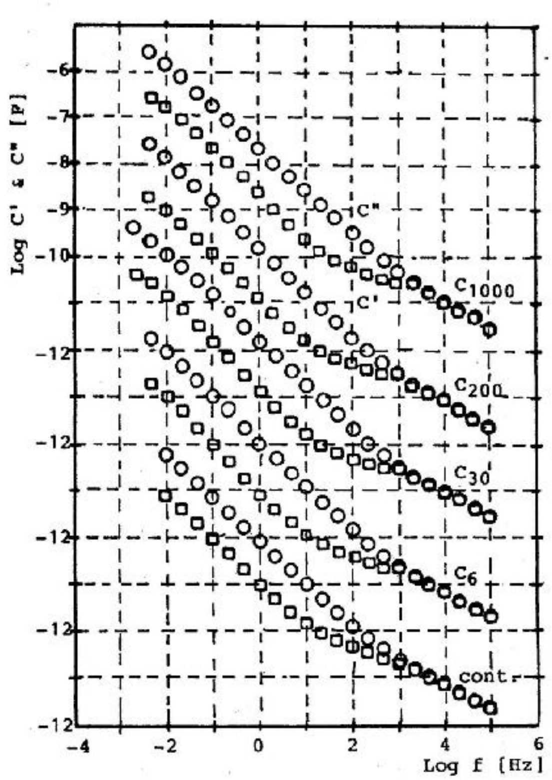

Fig.4.
Variation of complex capacitance with frequency for dried flag leaf samples grown from wheat seeds treated with Rhus Toxicodendron

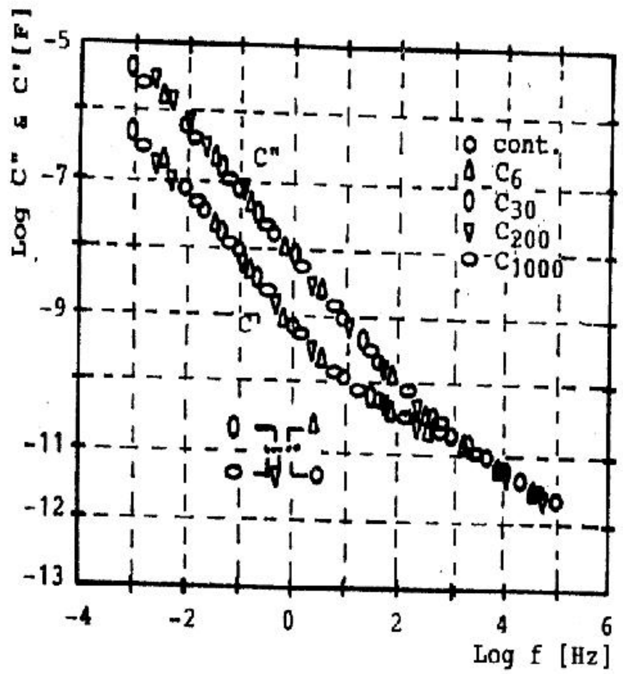

Fig.5.
Normalized plot of data presented in figure 4

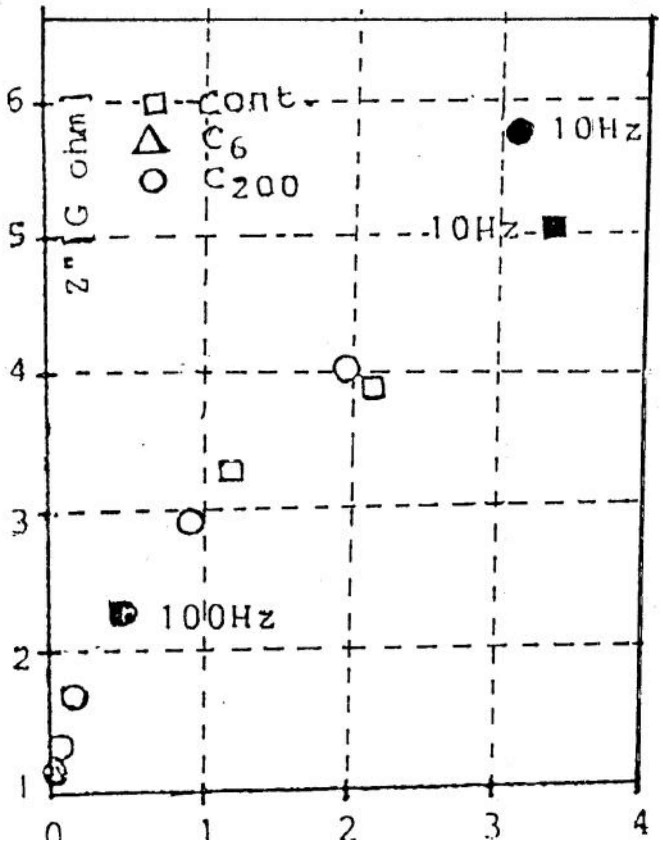

Fig. 6(a).
High frequency region of impudence plots corresponding to data of Figure 3. filled symbols represent points at decade frequencies.

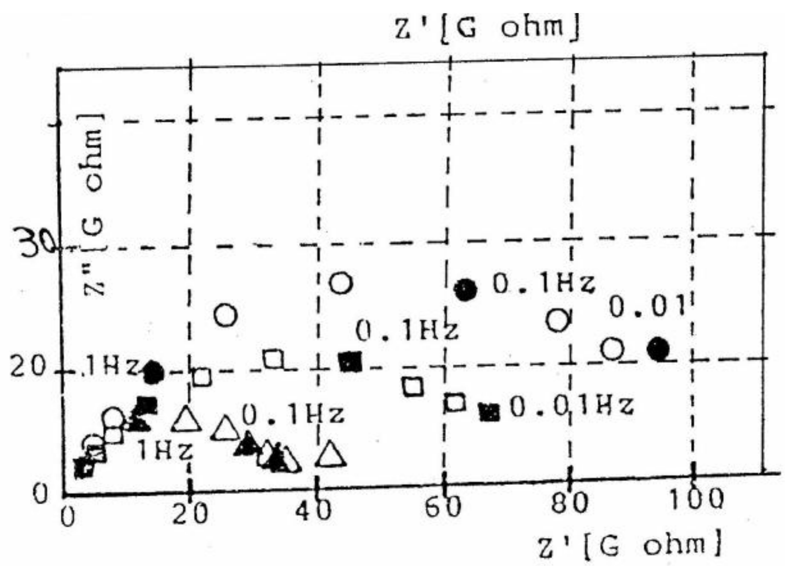

Fig. 6(b).
Low frequency region of the same plots. Two different scales are used for low and high frequencies data better resolution

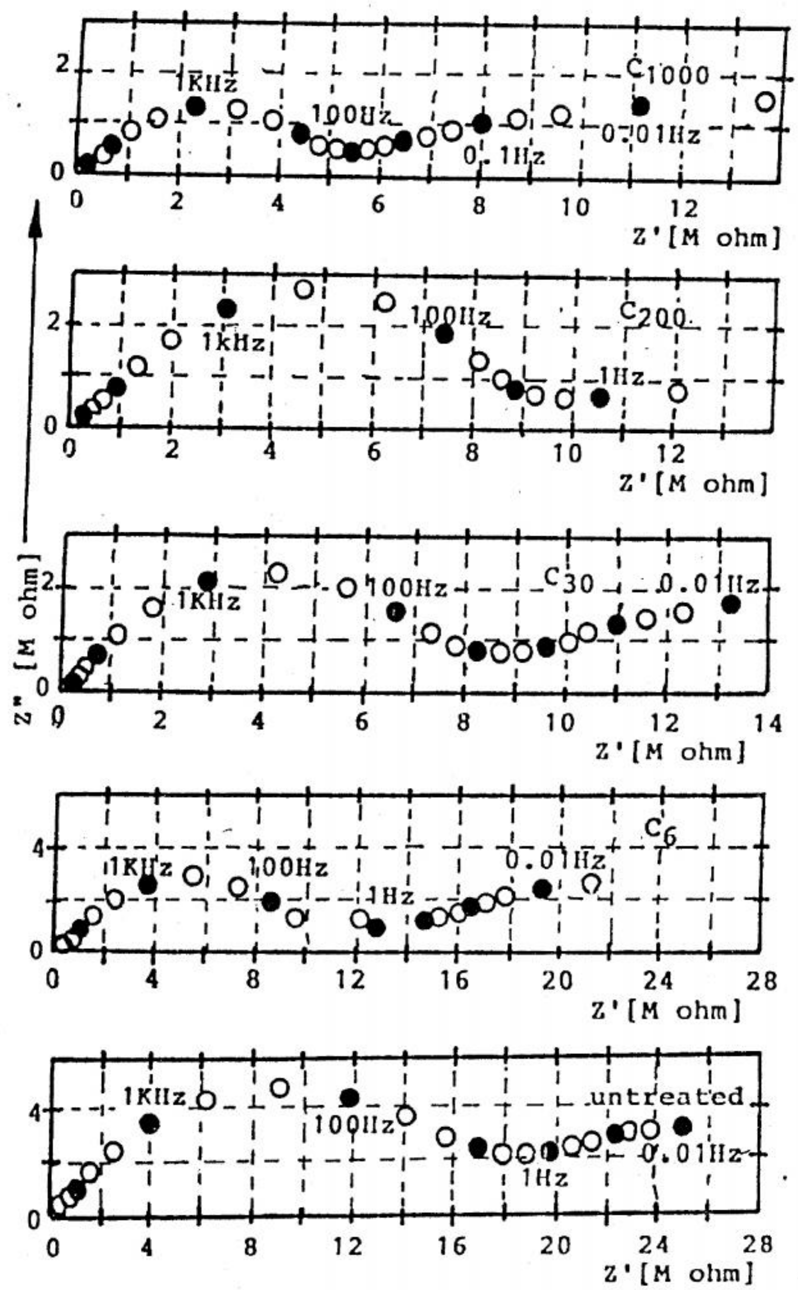

Fig.7.
Impedence plots for dried flag leaf samples (data of figure 4)

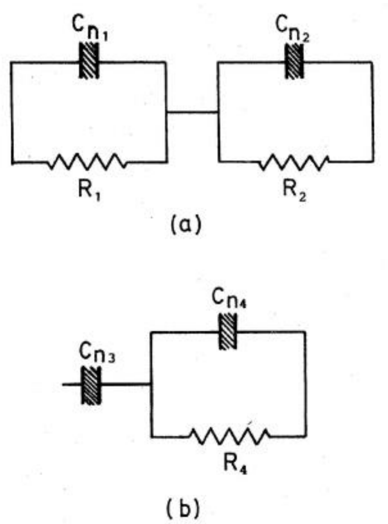

Fig.8.
Proposed equivalent circuits for (a). Dried flag leaf samples (b) Dried seed samples

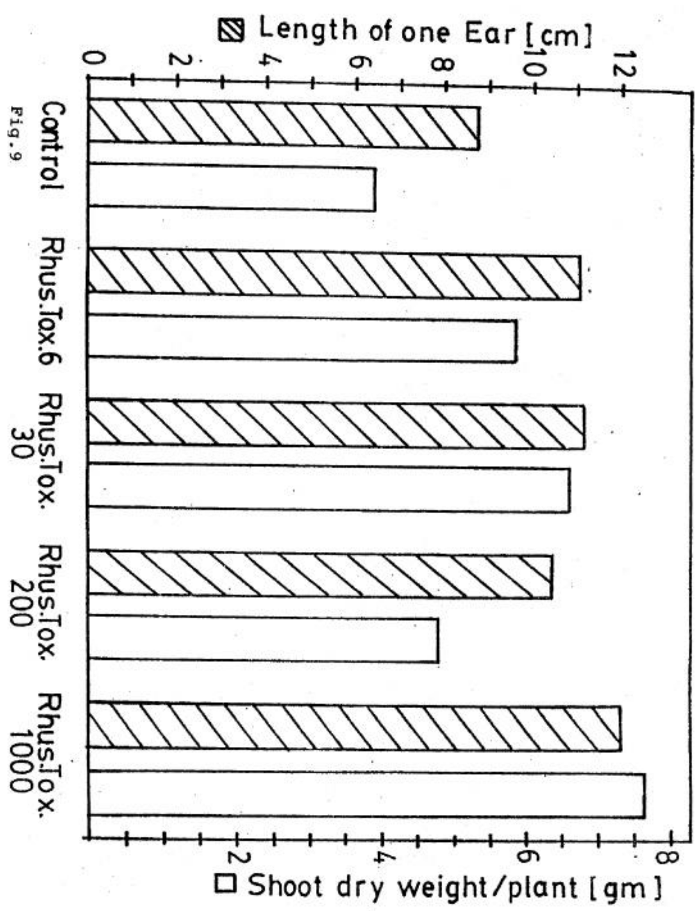

Fig.9.
Effect of Rhus Toxicodendron potencies on the shoot dry weight and ear length of wheat (*Triticum aestivum* cv Chakwal-86) after 100 days of growth in the field

Fig. 10.
Effect of Rhus Toxicodendron potencies on the growth of above ground parts of *Triticum aestivum* cv Chakwal-86 after b100 days of growth under natural conditions

Table 1
Conductance (mho)

Frequencies	Potencies				
	control	C 6	C 30	C 200	C 1000
	Seed Samples				
10 kHz	3.28E- 9	4.37E- 9	6.24E- 9	4.41E- 9	3.65E- 9
1 kHz	7.62E- 10	1.17E- 9	1.62E- 9	5.72E- 10	6.02E- 10
100 Hz	2.69E- 10	5.08E- 10	7.45E- 10	2.63E- 10	1.32E- 10
10 Hz	1.23E- 10	1.40E- 10	2.55E- 10	9.92E- 11	3084E- 11
1 Hz	3.58E- 11	4.44E- 11	1.08E- 10	2.53E- 11	7.65E- 12
0.1 Hz	1.83E- 11	3.17E- 11	8.17E- 11	1.25E- 11	1.76E- 12
	Dried Leaf Samples				
10 kHz	4.43E- 7	5.02E- 7	6.71E- 7	5.70 E- 7	8.05 E- 7
1 kHz	1.38E- 7	1.74E- 7	2.24E- 7	2.03 E- 7	3.21 E- 7
100 Hz	7.31E- 8	1.08E- 7	1.42E- 7	1.25 E- 7	1.26 E-7
10 Hz	5.75E- 8	7.70E- 8	1.19E- 7	1.12 E- 7	1.81 E-7
1 Hz	4.97E- 8	6.72E- 8	1.03E- 7	1.06 E- 7	1.51 E- 7
0.1 Hz	4.38E- 8	5.98E- 8	8.94E- 8	1.03 E- 7	1.22 E -7

Table II
Parameters from impedence plots

Potencies	R_2 (ohm)	C_{n2} (F)	f_p (Hz)
	Seed Samples		
Cont	8.00 E-10	4.20 E-11	4.64 E-2
C 6	3.12 E-10	1.19 E-11	4.26 E-1
C 30	1.60 E-10	1.21 E-10	7.32 E-2
C 200	1.12 E-11	2.14 E-11	6.65 E-2
C 1000	1.44 E-12	1.88 E-11	5.87 E-3
	Dried Leaf samples		
	R_4 (ohm)	C_{n4} (F)	f_p (Hz)
Cont	22.0 E-6	3.36 E-10	2.15 E-0
C 6	14.0 E-6	2.45 E-10	4.64 E-1
C 30	9.20 E-6	1.14 E-10	1.52 E-2
C 200	11.0 E-6	1.76 E-10	8.21 E-1
C 1000	7.00 E-6	4.920 E-10	4.64 E-1

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