The Use of Microwave as Physical Method for Plant Growth Stimulation

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ABSTRACT

Different chemical additives are used for rising productivity of plants. Their application causes the contamination of raw materials of food production with toxins that is dangerous for consumer's health. On-farm safety for fresh production needs developing and implementing new methods for quality assurance. Experiments were conducted to investigate the effects of microwave radiation on germination and growth rate in seeds. In the present paper, the bioeffects of 2.45GHZ with 900W output power have been used. Chickpea seeds experimented for different exposure time (10, 20, 30,60seconds). Average length of plant recorded and compared with control seeds. Average length increase with exposure time increase up to 30sec. compared with control seeds.

Keywords: Microwave Radation, Growth Stimulation, Chickpea Seed

استخدام الامواج المايكروية كطريقة فيزياوية لتحفيز نمو النباتات

الخلاصة

تستخدم الكثير من المواد الكيمياوية المضافة لزيادة انتاجية النباتات,وقد تؤدي هذه الاضافات الى زيادة المواد السامة في الاغذية المنتجة.لذلك دعت الحاجة الى ايجاد طرائق بديلة لزيادة الانتاجية وتكون آمنة.تم في هذا البحث اختبار تاثير الموجات المايكروية على معدل النمولأحد النباتات.واستخدم لهذا الغرض موجات بتردد 2.45غيغاهيرتز وطاقة900 واط. استخدمت بذور الحمص بعد تعريضها الى الموجات المايكروية بازمان تعرض مختلفة(10 و 20 و 30 و 60 ثانية). أوضحت النتائج زيادة أطوال النباتات بزيادة زمن التعرض مقارنة ببذور مجموعة الكنترول.

INTRODUCTION

The growing needs of ecological agricultural products together with the increased demand of vegetable raw materials for food production as well for other branches of industry imposes the necessity for searching new, safer decisions for raising the agricultural production. Anthropogenic changes of the soil, waters, and atmosphere due to the use of different chemical additives for raising plants productivity led to searching alternative ways. Safe methods for increasing the yield include the reasonable use of chemicals and substitution of some of them by appropriate physical treatment. The use of controlled influence of physical factors on biological behavior during development of different cultures is a modern trend in combining the intensification of plant technologies with the ecological requirements.

Physical methods for increasing the vegetable production are based on the use of physical factors for plant treatment, particularly on the dill seeds with the major goal of increasing the yield and accelerating plant growth and development. Most perspective factors are the treatment with electromagnetic waves, particularly optical emission, magnetic field as well as the ultrasound and microwave radiation [1, 2, 3, 4, and 5].

Microwaves are non ionizing radiations and are part of electromagnetic (EM) spectrum [6]. The characteristic of EM field is mainly described by its energy content, which is related to its frequency by E=*hf*, where E *Electric* field, h plank constant and f *frequency.* All EM wave consists of electrical E and magnetic *H* field compone- nts vibrating in phase and perpendicular to direction of propagation. EM waves differ depending upon frequency or wavelength. Frequency or corresponding wavelength defines the characteristics of EM wave. Frequency *f* and wavelength λ are connected by $\lambda=C/F$ where $c = 3 \times 10^8$ m/s is the speed of EM wave in vacuum. All the waves can be described mathematically by the following equation [7]:

$$Y(x,t) = A\cos(2pt/T - 2px/l + f_o)$$

Where *A* is the amplitude of the wave, *T* its time period, λ *is* its spatial wavelength and ϕ_o is a reference phase. The existence of electromagnetic wave, presumes time varying electric and magnetic fields connected in a way such that one creates other in a degree proportional to the rate of variation. The Maxwell's equation relates the electric and magnetic fields in different conditions.

A common way to describe the absorption of EM field in matter is to calculate the specific absorption rate (SAR). SAR is the measure of the absorption of non-ionizing EM radiation by living tissue. Mathematically it is defined as

$$SAR=\sigma E^2/\rho \qquad W/Kg$$

Where σ the specific conductivity (S/m) of the body, *E* is the Electric field intensity within the body (v/m) and ρ is the density of the living tissue (kg/m^3) [8].

The aim of present work is to enlarge previous experiments on stimulation effect of microwave on seeds by investigat its influence on the early stage development of chick pea seed (Cicer arietinum L.).

MATERIALS & METHODS

The influence of microwave irradiation with wavelength 12 cm on seeds of Chick-Pea (Cicer arietinum *L.*) has been investigated. A microwave oven with frequency of radiation 2.45 GHz and maximum output power 900 W according to supplier's data has been used as microwave source. Maximum density of irradiation has been estimated at 45 kW/m^3. The estimation has been obtained by dividing the output power of the device (900 W) to the working volume having dimensions 0.19×0.33×0.32 m^3. Chick-Pea seeds have been preliminarily soaked in distilled water for 1 hour, presuming that the imbibed water plays an important role in the absorption of the energy of microwave radiation.

Seeds for the experiment have been distributed in four groups each containing 10 seeds. The variants differ by the time of exposure to the microwave radiation. Seeds have been exposed to the microwave radiation for 0 s (control), 10 s, 20 s, 30 s and 60s. The experiments have been performed in the July 2011 under laboratory conditions. The natural light cycle was 14 h – light / 10 h – darkness and the daily

temperature 27 ± 2 ºC, night temperature 23 ± 2 ºC. Groups of 30 seeds were subjected to each microwave treatment, for chosen exposure times and analogous group were used as control. The Chick-Pea seeds were cultured then in small plastic pots (Ø = 7.5 cm and h = 8.8 cm), 10 seeds in each pot, in good soil. The average length of plant calculated and plotted vs. time of growth.

RESULTS & DISCUSSION

Table (1) summarizes the experimental results for seeds during whole 14 days. It is clear that the 4th day show the first germination sign (Except for 60 sec. it dies out). The divergence in average length starts in day 5 and continues at this pattern for day 14.60 sec. seeds neglected and the other average length plotted vs. exposure time.

Figure (1) shows linear curves and the slopes of

these curves presents the growth rate, as in Figure (2). Figure (3) shows the 60sec. is 100% lethal it means that the exposure time is very critical parameter and if we exceed the range seeds die out (burning) and that what happened to 60sec. seed.

There are several factors that can affect germination process. Over watering can prevent the plant to get enough amount of oxygen. If seed is deeply planted in soil, then it can make to use all the stored energy before reaching soil surface. Dry conditions can prevent germination, as seed doesn't get enough moisture. Some seeds have so hard seed coats that oxygen and water get through it. If soil temperature is extremely low or high, then it can affect or prevent germination process.

Process of germination occurs in different stages. When seed absorbs water and seed coat gets burst. It is the first sign of germination. There is an activation of enzymes, increase in respiration and plant cells get duplicated. A chain of chemical changes starts which leads to development of plant embryo. Chemical energy stored in the form of starch is converted to sugar, which is used during germination process. Soon, embryo gets enlarged and seed coat burst opens. Growing plant emerges out. Tip of root first emerges and helps to anchor the seed in place. It also allows embryo to absorb minerals and water from soil. Some seeds require special treatment of temperature, light or moisture to start germination [9].The accelerated germination and improved germinating energy could be due to the eventual disturbance of the seed coat under the influence of the microwave electromagnetic treatment, which facilitated water penetration into the seeds and the start of the initial development stages. We can also add another effect of microwave on seed water, Vibration of water molecule dipoles induced by microwave radiation gives thermal effect, which according to van't Hoff's rule and Arrhenius law affects reaction rate in biological processes. Increase in the rate of biochemical changes may result in accelerated or intensified production of auxins and glutathione, which are growth activators. Formation of growth activators initiates germination process. Additional factors affecting germs biomass growth may include circulation and supplying buds with spare substances necessary to commence germination process, also connected with the rate of biochemical changes.

CONCLUSIONS

On the basis of the results obtained in the present investigation of the stimulation effect of microwave treatment on seed development, we concluded that the electromagnetic radiation (microwave) enhance seeds germination by decreasing time required to development. Exposure time is very important factor and exceeding the critical value lead to negative effect and die out.

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Table (1) the results of average plant length of Pretreated samples.

TIME(DAYS)	AVERAGE LENGTH OF PLANTS				
	control	10sec	20sec	30sec	60sec
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0.65	1.2	1.4	3.33	0
5	1.26	2	4	5	0
6	2.51	3.59	7.7	10.22	0
7	3.15	6	8	12	0
8	6.69	8.1	9.9	15.5	0
9	8.8	14.09	16.91	19.26	0
10	9.837	16.21	18.24	23.57	0
11	10.8	20.28	23.65	27.1	0
12	13.02	23.33	26.47	28.741	0
13	14.217	24.542	28.671	32.441	0
SLOP	1.5408	2.7218	3.0234	3.3101	0

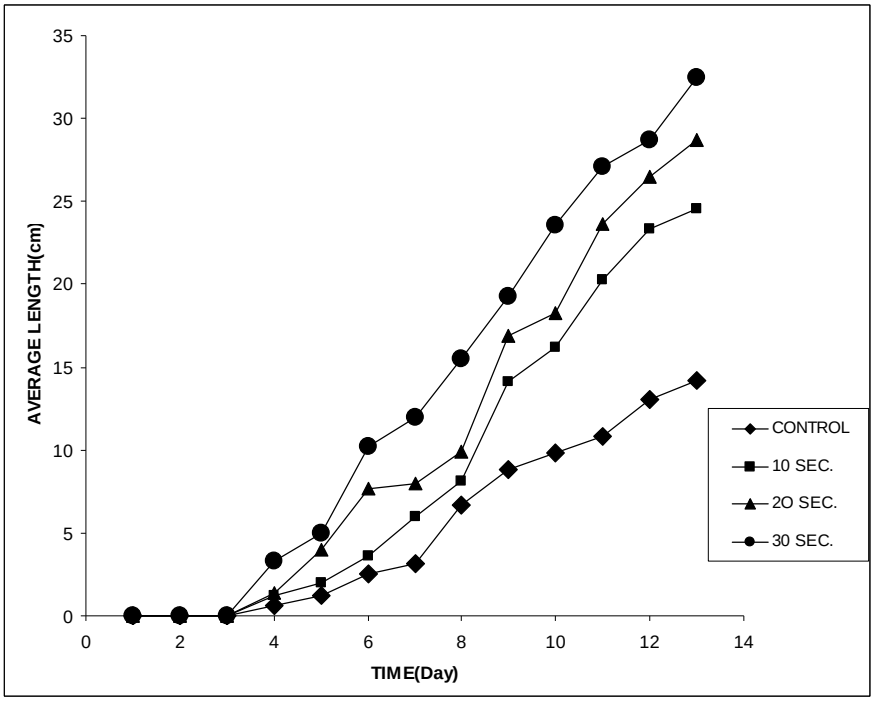

Figure (1) Development of plants versus through time for four samples.

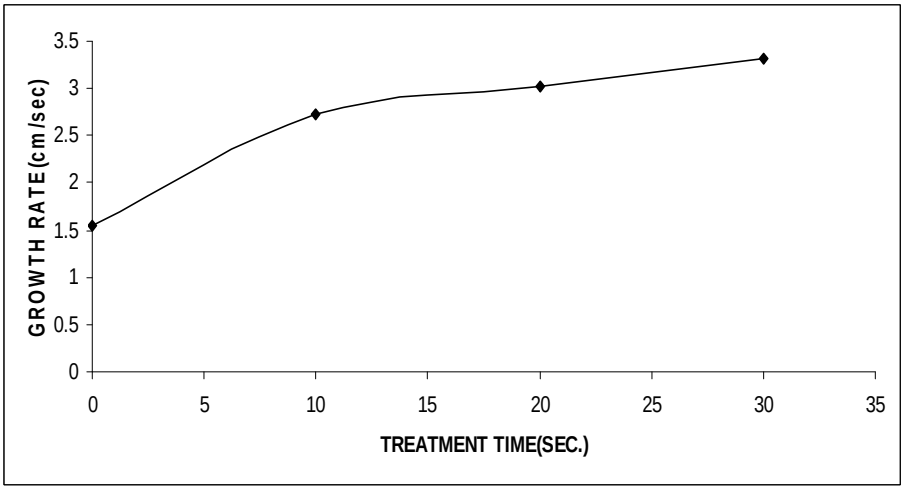

Figure (2) shows the development of growth Rate versus treatment time.

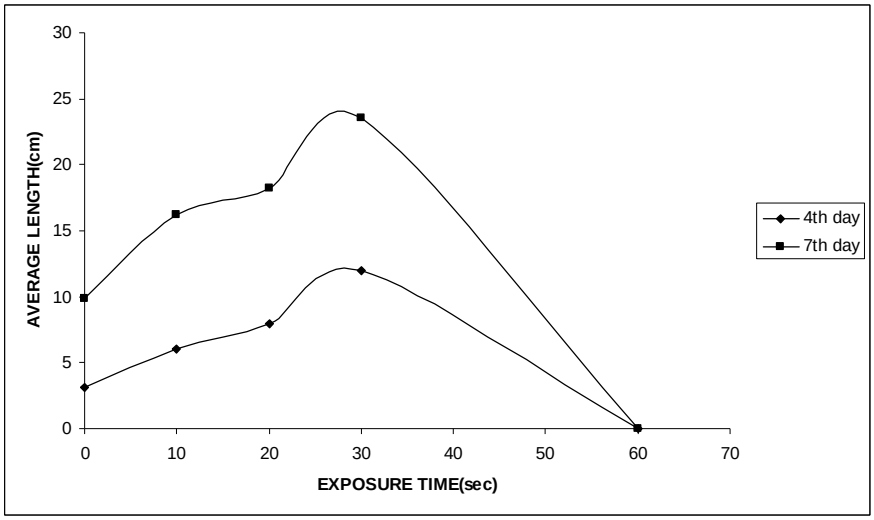

Figure (3) Development of plants versus time for five samples.