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Influence of ultrasonic waves and storage period under field condition on germination of four vegetable seeds

Sanaa Mohammad-Salih Rasheed Hojeen Majid Abdullah

E-Mail: Sanaa_76_2006@yahoo .com siyarduhoki97@yahoo.com

Department of Horticulture- College of Agricultur- University of Duhok, Kurdistan Region- Republic of Iraq

Abstract

A laboratory experiment in 2014 was carried out in the Central Laboratory of Research, College of Agriculture, University of Duhok. The aim was to investigate the effect of ultrasonic waves and stored period under field condition on germination percentage of four vegetable seeds : Cress, Celery, Swiss chard and Garden Rocket. The factors studied were ultrasonic waves power (30 and 60 w) with time of (0,5, 10, and 15 min) of ultrasonic waves and storage period (1 and 2 years). Completed Randomized Design with four replicates was used. Results showed all studied factors and its interactions had significant effect on germination percentage of studied vegetable seeds, expect the effect of storage period on germination percentage of Garden Rocket. The results indicated that there were a significant three way interaction effect of ultrasonic waves power 30 w, duration zero and 1 year storage period on germination percentage of Cress , Swiss Chard and Garden Rocket (99.3, 100.0 and 100.0%) respectively, compared most interactions. Also, found three way interaction significant effect mention on germination percentage of Celery (73.0 %) when exposed to ultrasonic duration 10 min as compared to other interactions.

It can be concluded that ultrasound led to improve germination vegetables studied, but the duration of storage led to reduce over time. It can be recommended to treated the seeds with ultrasonic waves at 30 w for zero

min in Cress , Swiss Chard and Garden Rocket and for 10 min in Celery to improve the germination percentage of seeds stored for one year.

Keywords**:** Ultrasonic waves, Seed germination, seeds storage, Vegetable seeds.

Introduction

Vegetable seeds are mostly imported by agricultural companies and sold to farmers, some farmers may use part of the seeds to grow their crops and keep the rest for the next season. Seeds may be stored under controlled conditions for crop production. It's an important to test seed at regular intervals to make sure from its viability and vigor Wiesner (19). The influence of physical factors as microwave and laser radiation, magnetic field and ultrasound treatment is an alternative of soil additives and fertilizers. The application of Ultrasonic waves to biotechnological process has been recently a driving force of some research group. Ultrasound influence can be seen mainly through a phenomenon called cavitations. Cavitations is the formation, growth and sometimes the implosion of micro bubbles created in a liquid when ultrasound waves propagate through it Suslick (17). For many years ultrasonic waves has been found to be use in engineering, science and medicine etc., therefore it has great importance. Recently the research work is still in progress to study the effect of ultrasonic waves in chemical, physical, biological, mechanical and industrial fields Zhu *et al*. (23).

Ultrasonic wave has high efficiency, saving energy, improved biological activity, mass transfer enhancement and shortening process time which are the main positive effects of such treatments Kouchebagh and Mirshekari (12). Ultrasound has been used in conjunction with seeds for many purposes. In biotechnology processes and food industry. Ultrasonically stimulated seed germination and increasing percentage of germination offers the possibility of increased productivity for large scale farm crops and for more general horticulture; Ultrasonic irradiation used in the seeds of tomatoes

Abramove (1) and radishes Shimomura (15).

Germination is an economical and simple method for improving the nutritive value and several studies have reported use for higher yield and effective growth of plant Ali *et al.* (5) and Shirgave and Ramteke (16). Different plant cultures were subjected to ultrasonic stimulation: Liu *et al.* (13) on pepper, tomatoes and cucumbers, Goussous *et al.* (10) on corn, Florez (9) on chickpea, wheat, pepper, and watermelon, Aladjadjiyan (4) on ornamental trees and Yaldagard *et al.* (20, 21 and, 22) on barley . Carbonell *et al.* (7) found that treatment with a static magnetic field with induction of 0.08, 0.1 and 0.17 time increased the germination of tomato seeds by 5 to 25 %. Similar results for rice, sunflower were reported by Carbonell *et al.* (7) and maize by Florez (9). Aladjadjiyan (2) studied the effect of ultrasound with a frequency of 22 kHz and a power of 150 W on the germinating energy and germination of carrot seeds (*Daucus carota* L.), cv. Nantes, he found that the maximum effect was observed in 5 min treatment. The objective of this study was to investigate the effect of power and duration of ultrasonic waves on germination of some vegetable seeds which stored for one or two years under field condition.

Materials and Methods

A laboratory experiment was conducted in Central Laboratory research, College of Agriculture, University of Duhok in 2014. Effect of ultrasonic wave, power (30 and 60 w), duration (0, 5 ,10 and 15 min) and storage period (1 and 2 years) were tested through germination percentage of four spices of vegetable seeds Cress *(lepidium sativum*), Celery (*Apium graveolens*___var dules), Garden Rocket (*Eruca sativa*) and Swiss Chard *(Beta vulgaris*) which locally produced.

The ultrasonic device was purchased from local market, this device produce level of power (intensity) 30 and 60 w, with timer. Cooling system for this device was modified by building external water cooling to control the high temperature during ultrasonic. The seeds were soaked for 12 h in water at the temperature 20°C then exposed to ultrasonic wave, after that the treated seeds were put in germinator at temperature 25°C to study the germination percentage.

The Samples of 100 seeds for each observation were germinated in Petri dish on filtered paper in a germinator at temperature 25°C. Complete Randomized Design (CRD) was used with four replications. Data analyzed according to the analysis of variance (ANOVA) using SAS software Means were tested according to Duncan's Multiple range at level 5% AL-Rawi and Khalaf Alah (6).

Results

The results in Table (1) illustrated that significant effect of ultrasonic power and duration on cress germination, 30w power gave highest germination percentage (83.13%). Exposure duration of ultrasonic waves 15 min gave highest germination percentage (70.58%) compared with 0 min (65.75%), but there was non significant difference with 5 or 10 min (69.50 and 69.50 % respectively). Storage period for 1 year gave highest germination percentage (78.79%) compared with 2 years (58.88%).

Interaction between storage period 1 year and power 30w gave highest germination percentage (99.58%) compared to others. Interaction between storage period and duration (1 year and 10 min) gave highest germination percentage (82.50%) compared with others but there was non significant difference with 5 or 15 min and 1 year (81.33 and 80.00% respectively).

Interaction between power and exposure duration of ultrasonic waves and storage period (30w, 5min and 1 year) gave highest germination percentage (100.00%) compared with others, but there was non significant difference with 30 w power and 0 or 10 or 15 min and 1 year (99.33, 99.67 and 99.33%) respectively.

Table (2) shows significant effect of ultrasonic power, duration and storage period on germination percentage of celery seeds, highest germination percentage (33.13 %) was obtained in 30w power, exposure duration of ultrasonic waves 10min gave highest germination percentage (22.50) compared to others. Storage period for 1 year gave highest germination (32.58%) in comparison with 2 years (2.67%).

Interaction between storage period 1 year and 30w power significantly increased germination percentage which reached (61.17%) compared to others. Interaction between storage period and duration(1 year and 10 min) gave highest germination percentage (41.00%) compared to others. Interaction between power and exposure duration 30w and 10 min gave highest germination percentage (40.17%) compared to other interactions.

Interaction between storage period, power and exposure duration (1 year, 30w and 10min) gave highest germination percentage (73.00%) compared to other interactions.

Results in Table (3) shows the effect of ultrasonic waves and storage period on germination percentage of Garden Rocket. Highest germination percentage (98.42%) in 30w power, 10 min exposure duration gave germination percentage(89.58 %).

Table 1. Effect of power and duration of ultrasonic waves and storage period on germination of cress seeds.

Storage period (year)	Power (w)	Duration (min)				S*P	Means of storage period (year)
		0	5	10	15		
1	30	99.33 a	100.00 a	99.67 a	99.33 a	99.58 a	78.79 a
	60	43.33 d	62.67 c	65.33 bc	60.67 c	58.00 c	
2	30	73.00 b	68.00 bc	65.33 bc	60.33 c	66.67 b	58.88 b
	60	47.33 d	47.33 d	47.67 d	62.00 c	51.08 d	
S *D	1	71.33 b	81.33 a	82.50 a	80.00 a	means of power	
	2	60.17 c	57.67 c	56.50 c	61.17 c		
P * D	30	86.17 a	84.00 a	82.50 ab	79.83 b	83.13 a	
	60	45.33 e	55.00 d	56.50 cd	61.33 c	54.54 b	
Means of duration		65.75 b	69.50 a	69.50 a	70.58 a		

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level.

Table 2. Effect of power and duration of ultrasonic waves and storage period on germination of celery seeds.

Storage period (year)	Power (w)	Duration (min)				S*P	Means of storage period (year)
		0	5	10	15		
1	30	51.33 c	54.67 c	73.00 a	65.67 b	61.17 a	32.58 a
	60	0.00 f	7.00 d	9.00 d	0.00 f	4.00 b	
2	30	2.33 ef	7.67 d	7.33 d	3.00 e	5.08 b	2.67 b
	60	0.00 f	0.00 f	0.67 ef	0.33 ef	0.25 c	
S *D	1	25.67 c	30.83 b	41.00 a	32.83 b	means of power	
	2	1.17 e	3.83 de	4.00 d	1.67 ef		
P * D	30	26.83 c	31.17 b	40.17 a	34.33 b	33.13 a	
	60	0.00 e	3.50 d	4.83 d	0.17 e	2.13 b	
Means of duration		13.42 d	17.33 b	22.50 a	17.25 c		

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level.

there was significant effect of storage period on germination percentage.

Two way interaction indicated that there was significant effect on germination percentage of Garden Rocket seeds. Interaction between storage period and power (1 year and 30w) significantly increased germination percentage which reached (100.00%) compared to others. Interaction between storage period and exposure duration (2 year and 0 min), gave highest germination percentage (96.00%) compared to others, and interaction between power and duration significantly affected on germination percentage, 30 w power and 10 min duration gave highest germination percentage (99.00%), but not differ from interaction between (30 w and 0min or 5 min) (98.83 and 98.50% respectively) .

Significant superiority effect was found of three way interaction 30 w power for (zero, 5, 10 and 15 min) duration of ultrasonic waves and 1 year of storage period on germination percentage (100.00, 100.00, 100.00 and 100.00 %) respectively compared to others.

Results in Table (4) indicated that there was significant effect of ultrasonic waves on germination percentage of Swiss Chard seed , 30 w power significantly increased germination percentage which gave (99.88%), highest germination percentage in 10 min exposure duration (88.17%). Storage period (1year) significantly increased germination percentage (84.21%) compared to 2 years storage which had lower percentage (82.42%).

Interaction between storage period 1year and power 30w gave highest germination percentage (100.00%) but non significant different for the interaction of 2 years and 30w (99.75) .

Table 3.Effect of power and duration of ultrasonic waves on germination of Garden Rocket seeds on two storage time.

Storage period (year)	Power (w)	Duration (min)				S*P	Means of storage period (year)
		0	5	10	15		
1	30	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a	83.71 a
	60	56.33 h	73.33 f	73.00 f	67.00 g	67.42 d	
2	30	97.67 b	97.00 b	98.00 b	94.67 c	96.83 b	89.29 a
	60	94.33 c	66.67 g	87.33 d	78.67 e	81.75 c	
S *D	1	78.17 d	86.67 bc	86.5 bc	83.50 c	Means of power	
	2	96.00 a	81.83 d	92.67 b	86.67 d		
P * D	30	98.83 ab	98.5 ab	99.00 a	97.33 b	98.42 a	
	60	75.33 c	70.00 d	80.17 c	72.83 d	74.58 b	
means of duration		87.08 a	84.25 b	89.58 a	85.08 b		

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

Table 4.Effect of power and duration of ultrasonic waves and storage period on germination of Swiss Chard seeds.

Storage period (year)	Power (w)	Duration (min)				S*P	Means of storage period (year)
		0	5	10	15		
1	30	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a	84.21 a
	60	61.33 f	69.00 e	74.33 cd	69.00 e	68.42 b	
2	30	100.00 a	100.00 a	100.00 a	99.00 b	99.75 a	82.42 b
	60	54.00 g	70.00 de	78.33 c	58.00 gf	65.08 c	
S *D	1	80.67 c	84.50 b	87.17 ab	84.50 b	means of power	
	2	77.00 d	85.00 b	89.17 a	78.50 d		
P * D	30	100 a	100 a	100 a	99.50 b	99.88 a	
	60	57.67 f	69.50 d	76.33 c	63.50 e	66.75 b	
means of duration		78.83 c	84.75 b	88.17 a	81.50 c		

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range tests at 5% level

Interaction between storage period and duration significantly induce germination percentage, highest germination percentage (89.17%) gave between storage period 2 year and 10 min duration compared to others, but non significant differences for the interaction between (1year and 10min) (87.17%). Interaction between power and duration of ultrasonic waves indicated significant effect and the highest germination percentage in 30 w power with (0.5,and 10 min) exposure duration which gave (100.00, 100.00 and 100.00%) respectively.

Three way interaction indicated significant differences on germination percentage , interaction between storage for 1 year with 30 w and duration (0, 5, 10 and 15 min) and 2years with 30 w and duration of (0, 5 and 10 min) had the same highest germination percentage (100.00%) compared to others.

Discussion

In this study, estimation was made for the effect of ultrasonic waves with power of 30 and 60 w in four duration on the germination of some vegetable seeds under laboratory conditions. The study included new seeds with lower power of ultrasonic stimulation caused an increased of the germination of vegetable seeds. It's suggested that the sonication process accelerates the imbibitions of water through the pericarp, sonication may create or enlarge fissures in the protective coating surrounding the seed and pericarp, the superiority of sonication may be due to a higher holding capacity and higher porosity, which increase oxygen availability. These results may be attributed to mechanical effects due to ultrasonically induced cavitations increasing water uptake by the cell walls. The most probable mechanism for ultrasonic enhancement of germination is the interior of the cell wall structure,

the collapse of cavitations bubbles near cell walls would be expected to produce cell disruption together with good penetration of water into the cells, through the ultrasonic jet, The method considerably reduced the time required to initiate the germination of seeds Toma *et al.* (18). It could be concluded that the use of ultrasonic treatments also played the role of plant stimulation factor. These results are in harmony finding with Hebling and Silva (10) on Corn, and ornamental trees. Aladjadjiyan and Goussous *et. al*.(9) on Chickpea, Wheat, Pepper, and Watermelon. Kouchehagh and Mirshekari (11) found that the physical priming techniques as laser, magnetic field and ultrasonic waves enhanced seed germination of Tomato plant.

Conclusion

According to the results, it can be concluded that 30 w of ultrasonic waves led to improve germination percentage of studied vegetable seeds, but 60 w led to deteriorate it regardless of exposure duration of ultrasonic waves and storage period. Also, all studies exposure duration of ultrasonic waves at 30 w made no difference on germination percentage of studied vegetable seeds that stored for one year under field conditions except Celery. In addition storage period period under field condition led to decrease germination percentage of studied vegetable seeds through time. It can be recommended treats seed with 30 w of ultrasonic waves for zero min for Cress, Swiss chard and Garden Rocket and for 10 min for Celery to improve seed germination percentage that stored for one year under field conditions. Also, to make an experiment on vegetable seeds to investigate effect of ultrasonic waves on germination and its related traits, growth, yield and quality.

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تأثير الموجات فوق الصّوتية و مدة الخزن تحت الظروف الحقلية على انبات اربعة بذور الخضراوات

سناء محمد صالح رشيد السيد هوزين ماجد عبدالله

Sanaa_76_2006@yahoo .com siyarduhoki97@yahoo.com

قسم البستنة- كلية الزراعة - جامعة دهوك – اقليم كردستان – جمهورية العراق

المستخلص

نفذت تجربة مختبرية عام 2014 في مختبر المركزي للبحوث - كلية الزراعة- جامعة دهوك، بهدف دراسة تاثير تأثير الموجات الفوق الصوتية و مدة الخزن تحت ظروف الحقل على نسبة انبات بذور اربعة خضراوات (الرشاد، الكرفس، السلق والجرجير). العوامل المدروسة هي قوة الموجات فوق الصوتية 30و60 واط بمدة تعرض 0، 5، 10 و 15 دقيقة لبذور مخزونة 1و2 سنة. استعمل تصميم تام وباربعة مكررات. اظهرت النتائج ان العوامل المدروسة و تداخلاتها قد اثرت معنويا في نسبة الانبات لبذور الخضراوات المدروسة باستثناء تأثير مدة الخزن على نسبة انبات بذور الجرجير. وجد تفوق معنوى لتاثير التداخل الثلاثي للموجات فوق الصوتية بقوة 30 واط ومدة تعرض صفر دقيقة ومدة خزن لسنة واحدة في نسبة انبات بذور الرشاد والسلق والجرجير (99.3 ، 100.0و100.0 %) على التتابع، مقارنة مع اغلب التداخلات الاخرى. كذلك وجد تفوق معنوي شبه مشابه لتأثير التداخل الثلاثي اعلاه على نسبة انبات بذور الكرفس (73.0 %) عندما كانت مدة التعرض للموجات فوق الصوتية 10 دقيقة مقارنة مع التداخلات الاخرى.

يمكن الاستنتاج ان الموجات فوق الصوتية تؤدي الى تحسين نسبة الانبات الخضراوات المدروسة، ولكن مدة الخزن تؤدي الى خفضها بمرور الوقت. يمكن التوصية بمعاملة البذور بالموجات فوق الصوتية بقوة 30 واط لمدة صفر دقيقة في الرشاد و السلق والجرجير ولمدة 10 دقيقة في الكرفس لتحسين نسبة انبات البذور المخزونة لمدة سنة واحدة.

كلمات دالة:- موجات فوق الصوتية، نسبة انبات، مدة خزن البذور، بذور الخضراوات.