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Effect of Ultrasonic Treatment on Seed Germination and Seedling Emergence in Seven Vegetable Species

Ultrasonik Uygulamasının Yedi Sebze Türünde Tohum Çimlenmesi ve Fide Çıkışına Etkisi

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EFFECT OF ULTRASONIC TREATMENT ON SEED GERMINATION AND SEEDLING EMERGENCE IN SEVEN VEGETABLE SPECIES

ABSTRACT:

This research was performed to determine the effect of ultrasonic treatment on seed germination, seedling emergence and mean germination and emergence times in seeds of watermelon, melon, leek, pepper, carrot, tomato and aubergine. Ultrasonic treatment (US) was applied at a dose of 50 kHz for 30 minutes, hydropriming treatment (HP) was carried out using distilled water, and untreated seeds were used as control (C). Mean germination percentages were 85% in US treated seeds, 82% in HP and 78% in C. Corresponding values for seedling emergence were 83, 75 and 72% respectively. The maximum advantages obtained from US in germination were observed in watermelon (13%), carrot (11%), pepper (13%), leek (10%), and pepper (7%) compared to C and HP seeds, respectively. Advantages in seedling emergence obtained by US were greatest in watermelon (20%), leek (22%) and tomato (13%) compared to C and for pepper (14%), tomato (12%), melon (11%), watermelon (10%) and leek (10%) compared to HP. US treatment reduced both germination and emergence times. Results showed that US treatment was more positive effect on seedling emergence than germination. It has been determined that US treatments have the potential to increase the germination and seedling quality of vegetable seeds.

Keywords: *Seed priming, Mean germination time, Seed quality*

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ULTRASONİK UYGULAMASININ YEDİ SEBZE TÜRÜNDE TOHUM ÇİMLENMESİ VE FİDE ÇIKIŞINA ETKİSİ

ÖZ:

Bu araştırma, karpuz, kavun, pırasa, biber, havuç, domates ve patlıcan tohumlarında ultrasonik uygulamanın tohum çimlenmesi, fide çıkışı ve ortalama çimlenme ve çıkış süreleri üzerine etkisini belirlemek amacıyla yapılmıştır. Ultrasonik uygulama (US) 30 dakika boyunca 50 kHZ dozunda uygulanmış, hidropriming uygulaması (HP) distile su kullanılarak yürütülmüş, uygulama yapılmayan tohumlar ise kontrol (C) olarak kullanılmıştır. Ortalama çimlenme yüzdeleri US uygulanmış tohumlarda %85, HP'de %82 ve C'de %78 olmuştur. Fide çıkış oranları için karşılık gelen ortalamalar sırasıyla %83, 75 ve 72 olarak kaydedilmiştir. US uygulamasının C'ye göre maksimum avantaj oluşturduğu türler karpuz (%13), havuç (%11), ve biber (%13) HP'ye göre ise pırasa (%10) ve biber (%7) olmuştur. Fide

çıkışında US uygulamasının C tohumlarına göre en avantajlı olduğu türler karpuz (%20), pırasa (%22) ve domates (%13), HP'ye göre ise biber (%14), domates (%12), kavun (%11), karpuz (%10) ve pırasa (%10) olmuştur. US uygulaması hem çimlenme hem de fide çıkış zamanını azaltmıştır. Sonuçlar US uygulamasının fide çıkışı üzerinde çimlenmeye göre daha olumlu bir etkisi olduğunu göstermiştir. US uygulamasının sebze tohumlarının çimlenme ve fide kalitesini artırma potansiyeline sahip olduğu ortaya konulmuştur.

Anahtar Kelimeler: *Tohum uygulamaları, Ortalama çimlenme zamanı, Tohum kalitesi*

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1. INTRODUCTION

Rapid germination is an important feature for successful transplant production in vegetable seeds. Slow and erratic germination may cause non-uniform and small sized seedlings. Various pre-treatment techniques including priming are used to accelerate germination (Farooq et al., 2019) and obtain well-developed transplants from vegetable seeds (Demir, 2002). Seed priming techniques involve physiological methods which consist of imbibing seeds until verge of radicle emergence (Mavi and Demir, 2004; Ermis et al., 2016; Dutta, 2018). During priming, seeds are allowed to imbibe the targeted priming media, which may consist of macro and micro nutrients, growth regulators, osmoticum or water, for a certain amount of time (Farooq et al., 2019).

There are some other physical seed-enhancing methods used in seed technology such as ultrasound waves. This treatment involves the application of sound frequencies in the inaudible range (20-100 kHz) to interact with material/seeds in air or water. Ultrasound treatment is used to inactivate microorganisms in food technology (Pingret et al., 2013) and to stimulate germination in various crop seeds (Rinaldelli, 2000; Yaldagard et al., 2008; Gossous et al., 2010; Miano et al., 2015; Miano et al., 2016; Moosavi et al., 2018). Ultrasound treatment generates microscopic tiny voids in a liquid medium resulting in bubbles containing water or gas. These bubbles expand and then implode. This is called cavitation and is responsible for most of the ultrasonic effect. Ultrasound treatments are considered environmentally friendly with high potential for quality improvement in seeds (Yaldagard et al., 2008). Gossous et al. (2010) found that treated pepper and watermelon seeds had higher seed moisture than untreated ones. Mechanical stress originating from the ultrasonic vibration promoted germination in cucumber and rice seeds (Takahashi et al., 1991). Miano et al. (2016) also found positive effects on germination of barley seeds. The objective of this study was to investigate the effects of ultrasonication on germination and vigour of watermelon, melon, pepper, tomato, carrot, leek and aubergine seeds.

2. Material and Methods

Seeds of watermelon (*Citrullus lanatus* Matsum and Nakai cv. Crimson Sweet), melon (*Cucumis melo* L. cv. Kırkagac), carrot (*Daucus carota* L. cv. Maestro F1), leek (*Allium porrum* L. cv. Inegol), tomato (*Solanum lycopersicum* L. cv. H2274), pepper (*Capsicum annuum* L. cv. Sera Demre), and aubergine rootstock (*Solanum melongena* L cv. Vista F1.) were obtained from commercial companies. Seed moisture content was determined according to ISTA rules (ISTA, 2016). Seed moisture contents ranged between 5.2 and 7.5%. Seeds were kept at 5 °C in airtight laminated foil packets until use.

Ultrasonic treatment (US) was carried out on 300 seeds in each species. Seeds were weighed and placed in perforated mash cloths, dipped into distilled water and treated with 50 kHz ultrasonication for about 30 minutes at 20 °C in dark. Then seeds were left for 24 hours in the water without sonication before being dried at room temperature for about 24 hours until the initial weight was reached. The other 300 seeds in each species were kept in distilled water for 24 hours at 20 °C without sonication and were considered HP (hydroprimed). Untreated seeds were evaluated as control (C).

Standard laboratory germination tests (SG) were conducted on three replicates of 50 seeds for control, HP and US treated seeds. Seeds were placed between damp filter paper (Filtrak, Germany). Germination tests were carried out at 20 °C for carrot and leek, and 25 °C for watermelon, melon, pepper and aubergine in the dark. Two mm radicle emergence was calculated in daily counts. Normal germination (seedlings with developed root and shoot structures) percentages were evaluated after 14 days for watermelon, leek, aubergine, tomato pepper, and carrot and after 8 days for melon.

The mean germination/emergence time (MGT/MET) was calculated based on frequent daily radicle emergence counts using the formula

$$MGT/MET = \Sigma\, n.t \,/\, \Sigma n$$

where n = number of seeds newly germinated (2 mm radicle emerged) or seedlings emerged at time t; t = days from planting, Σn = final germination/emergence

The seedling emergence (SE) test was determined by sowing seeds 3 cm deep in seedling trays with compost (Plantaflour, GmbH, Germany). The trays were placed in a growing cabinet where the temperature was maintained at 22±2 °C. Light was provided 16 hours per day (72 μMm-1second-1). Daily emergence (appearance of cotyledons to surface) was counted for calculation of MET values but normal seedling percentages (well-developed root and shoot structures) were counted after 20 days. The experiment was conducted with a completely randomised design and means were compared using the Duncan Multiple Range test with the SPSS program at 5% level.

3. Result and Discussion

Ultrasonication increased germination percentages in watermelon, carrot, and pepper significantly different compared to control ($P<0.05$). The difference between hydropriming and ultrasonic treatments was not significant ($P>0.05$) for all species, except leek. The highest germination percentages in hydroprimed seeds are in aubergine, carrot, tomato and melon seeds with 94, 90, 86 and 85 %, respectively, while corresponding values in the same species were 97, 90, 86 and 90% with ultrasonic treatment (Table 1). Overall mean values were highest for ultrasonic treatment at 85%, followed by HP at 82% and lowest in control at 78%.

The variation in response to ultrasonication for germination percentages that we observed in our work was also reported by earlier reports. Goussous et al. (2010) reported that treatment was effective on wheat, chickpea and watermelon but not on pepper seeds. Miano et al. (2015) found ultrasound treatments did not have any significant effect on some barley seed lots. Treatment enhanced seed vigour and seedling growth in switch grass seeds (Chen et al., 2012). This shows that ultrasonication effect based on species differences. It may be linked to seed coat structures because energy densities are deposited at the site of impact causing physical impacts in plant cells during ultrasonication (Yaldagard et al., 2008). Seed coat surface and structures may also be influential on US effect. Some vegetable seed surfaces can be hard and do not allow oxygen and water absorption (Demir, 1997) or the pericarp may contain some substances inhibiting germination (Leskovar et al., 1999) that ultrasonic waves eliminate.

Seedling emergence percentages showed that ultrasonic treatment increased germination percentages significantly compared to control in four species (watermelon, leek, tomato, pepper). US seeds had higher seedling emergence but were not significant for the other species (Table 2). Ultrasonic treatment stimulated seedling emergence in five species compared to HP treatment. Except aubergine and carrot seeds, the differences in emergence between ultrasonic and hydroprimed seeds were significant ($P<0.05$) and were 10% and higher in the other species. The highest difference was observed in pepper seeds at 14%. Tomato and melon seeds followed at 12 and 11%, respectively. For melon and pepper seeds, HP seeds had lower emergence than control seeds at 5 and 8%. Seedling emergence percentages changed between 37 and 91% for C, 49 and 94% for HP, and 59 and 94% for US seeds. Leek seeds had the lowest and aubergine seeds had the highest emergence in all three cases. The mean values for C, HP and US seeds were 72, 75 and 83%, respectively (Table 2). The higher effect of ultrasonic treatment on seedling emergence showed that treatment was more effective on seed vigour than germination (Tables 1 and 2). Emergence conditions in most cases are less optimum than for germination and seed performance under nonoptimal conditions is related to seed vigour features (Ozden et al., 2019). The effect of ultrasonication on seed vigour was also confirmed in earlier reports about seeds from different species (Gossous et al., 2010; Shekari et al., 2015).

Time to germination (MGT) was significantly reduced by ultrasonic treatment ($P<0.05$) compared to both HP and C seeds (Table 3). The fastest germinating species were melon and aubergine in all three cases. Watermelon, leek, carrot and pepper were slow germinators. Mean seedling emergence time was also longest in leek, pepper, carrot and watermelon in all cases (Table 4). Similar to germination time, aubergine and melon seeds had the shortest emergence time among the species. Leek seeds were the slowest with 9.4 and 11.4 days emergence time, while melon seeds were the fastest emerging in 4.3 and 5.6 days. Goussous et al. (2010) found the stimulating results in watermelon and pepper seedling emergence potential.

Table 5 shows the advantages of ultrasonic treatment compared to HP and C. Ultrasonic treatment was beneficial for both germination and seedling emergence compared to C and HP seeds. The advantage of US was higher for seedling emergence (SE) than germination. Total advantages of US were 52 and 25% germination and 72 and 57% seedling emergence compared to C and HP seeds, respectively. The highest total advantage of US was obtained in pepper, leek and watermelon seeds at 40, 45 and 43% in all four cases. The lowest advantage of US was obtained in aubergine seeds with 6% in total.

Reduced time to germination and emergence shown by lower MGT and MET values due to ultrasonication can be valuable and is related to successful transplant size of vegetable seeds (Demir et al., 2008). Faster germination is related to transplant size or field emergence potential in diverse vegetable species seeds (Demir et al., 2008; Mavi et al., 2010; Ozden et al., 2019). From that point of view, ultrasonication is considered an easy, cheap and convenient treatment to achieve faster emergence and obtain well-developed seedlings in modules and field sowing conditions. The extra benefit of ultrasonication (US) compared to hydropriming (HP) indicated that the treatment provided advanced benefit compared to than HP (Table 2). This is valuable data for successful transplant production. In the meantime, different treatment times and seeds from other vegetable species need to be investigated.

Table 1. Changes in germination percentage (%) of control (C), hydroprimed (HP) and ultrasound (US) vegetable seeds.

Species	C	HP	US
Watermelon	58^{b}	71^{a}	71^{a}
Melon	85^{a}	85^{a}	90^{a}
Carrot	79^{b}	90^{a}	90^{a}
Leek	71^{a}	64^{b}	74^{a}
Tomato	81^{a}	86^{a}	86^{a}
Pepper	75^{b}	81^{ab}	88^{a}
Aubergine	95^{a}	94^{a}	97^{a}
Mean	78	82	85

* *Means with different letters in the same line were significantly different at 5%.*

Table 2. Changes in seedling emergence (%) of control (C), hydroprimed (HP) and ultrasound (US) vegetable seeds.

Species	C	HP	US
Watermelon	61^{c}	71^{b}	81^{a}
Melon	83^{ab}	78^{b}	89^{a}
Carrot	77^{a}	81^{a}	81^{a}
Leek	37^{c}	49^{b}	59^{a}
Tomato	69^{b}	70^{b}	82^{a}
Pepper	85^{b}	77^{c}	91^{a}
Aubergine	91^{a}	94^{a}	94^{a}
Mean	72	75	83

* *Means with different letters in the same line were significantly different at 5%.*

Table 3. Changes in mean germination time (MGT, day) of control (C), hydroprimed (HP) and ultrasound (US) vegetable seeds.

Species	C	HP	US
Watermelon	5.4^{b}	5.3^{b}	4.6^{a}
Melon	1.6^{b}	1.7^{b}	1.3^{a}
Carrot	4.7^{b}	4.6^{b}	3.9^{a}
Leek	4.4^{c}	3.8^{b}	3.2^{a}
Tomato	2.9^{b}	3.6^{c}	2.0^{a}
Pepper	3.7^{b}	3.6^{b}	3.0^{a}
Aubergine	1.9^{c}	1.5^{b}	1.3^{a}

* *Means with different letters in the same line were significantly different at 5%.*

Table 4. Changes in mean emergence time (MET, day) of control (C), hydroprimed (HP) and ultrasound (US) vegetable seeds.

Species	C	HP	US
Watermelon	8.7[b]	8.5[b]	7.5[a]
Melon	5.6[c]	4.5[b]	4.3[a]
Carrot	9.1[a]	9.4[b]	9.2[a]
Leek	11.4[c]	9.4[a]	10.5[b]
Tomato	6.2[b]	5.9[b]	5.7[a]
Pepper	10[b]	9.5[a]	9.4[a]
Aubergine	6.0[b]	5.1[a]	5.2[a]

** Means with different letters in the same line were significantly different at 5%.*

Table 5. Advantage of US treatment for germination percentage (GP) and seedling emergence (SE) compared to control (C) and HP treatment. The values were obtained by subtracting C (US-C) and HP (US-HP) values from US.

Species	US-C		US-HP	
	GP	SE	GP	SE
Watermelon	13	20	0	10
Melon	5	6	5	11
Carrot	11	4	0	0
Leek	3	22	10	10
Tomato	5	13	0	12
Pepper	13	6	7	14
Aubergine	2	1	3	0
Total	52	72	25	57

4. CONCLUSION

This study showed that ultrasonic treatment advanced seed germination and seedling emergence in seven different vegetable species. This is reflected not only in total percentages but also in germination and emergence time. The effect varied among the species. However, the beneficial effect was more for emergence than germination in most of the species. The present data is valuable for successful transplant production. Moreover, ultrasonic treatment can be used as a cheap and easy method for other vegetable seeds.

Conflict of interests

The authors declare that they have no conflict of interest

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