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Effect of KNO_3-Priming on Germination Percentage and Interim of Serially Harvested Watermelon, Melon and Cucumber Seed Lots at Low and Optimum Temperatures

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Abstract :The effect of KNO_3 treatment(salt priming) on the germination of watermelon(*Citrullus lanatus* (Thunb.), Matsum & Nakai), melon (*Cucumis melo* L.) and cucumber (*Cucumis sativus* L.) seed lots harvested 21,28,35 and 42 DAA (Days After Anthesis) at sub-optimum (18°C) and optimum (25°C) temperatures was investigated. At 18°C, treated watermelon seeds showed 35,15,15 % higher total germination than control seeds when they were harvested 21,28,and 35 DAA. Whereas at 25 °C and 42 DAA the advantage of treatment was lost regarding total germination. But it was promotive on interim germination (percentage, 3rd day germination) regardless of temperature and harvests. Treatment was found to be deleterious in the first (21 DAA) and the last (42 DAA) harvests of melon which decreased total germination by 14,19 %, respectively, in melon at 18°C. Similar reductions at 25 °C were also observed as 40, 15 % in the corresponding harvests of melon.

In melon, treatment increased germination interim at 18 °C for all harvests (12, 96, 94 and 22 % higher at 21, 28, 35 and 42 DAA than control, respectively) while it was detrimental on interim germination of 21 and 42 DAA at 25 °C.

No benefit of treatment was observed in cucumber in which treated seeds regardless of harvest date and temperature showed lower total and interim germination percentages varying between 3 and 20 % and being more conspicuous at sub-optimal temperature and earlier than later harvests. Less mature watermelon seeds harvested until 42 DAA can get benefit from salt priming but melon seeds must rather be harvested around 30 DAA (28-35 DAA). Treatment with the present concentration and period was found to be detrimental for cucumber seed lots.

Key Words: Salt Priming, watermelon, melon, cucumber, germination, temperature

Değişik Dönemlerde Hasat Edilmiş Karpuz, Kavun ve Hıyar Tohumlarının Optimum ve Düşük Sıcaklıklarda Çimlenmesi Üzerine KNO_3-Priminginin Etkisi

Özet : Çiçeklenmeden 21, 28, 35 ve 42 gün sonra hasat edilen karpuz (*Citrullus lanatus* (Thunb.), Matsum & Nakai), kavun (*Cucumis melo* L.) ve hıyar (*Cucumis sativus* L.) tohumlarının optimumun altında (18°C) ve optimum (25°C) sıcalıkta çimlenmesi üzerine KNO_3 uygulamasının etkisi araştırılmıştır. 18°C sıcaklıkta uygulama yapılmış karpuz tohumları (21, 28 ve 35 günde hasat edilen) kontrol tohumlarına göre sırasıyla %35, %15 ve %15 daha yüksek oranda çimlenmişlerdir. 25°C sıcaklıkta 42 gün sonra hasat edilenlerde ise toplam çimlenmeye göre herhangi bir avantaj olmamıştır. Ancak çimlenme hızı (3. Gün çimlenme oranı) üzerine olumlu etkide bulunmuştur. Kavun tohumlarında uygulama 21 gün ve 42 gün sonra hasat edilenlerde 18°C sıcaklıkta sırasıyla %14 ve %19 oranında toplam çimlenmeyi azaltmıştır. 25°C sıcaklıkta ise bu azalma %40 ve %15 oranında olmuştur.

Kavunda tüm hasat dönemleri için 18°C'de uygulama kontrole göre çimlenme hızını artırmış (21 günde %12, 28 günde %96, 35 günde %94 ve 42 günde %22), 25°C sıcaklıkta ise 21 ve 42 gün sonra hasat edilen tohumlara yapılan uygulama çimlenme hızı üzerine olumsuz etkide bulunmuştur.

Hıyarda ise uygulamanın hiçbir olumlu etkisi gözlenmemiştir. Sıcaklık ve gün değerlere bakılmaksızın daha düşük toplam çimlenme oranı ve 3. gün çimlenme oranı (%3 ve %20 arasında değişmekte) elde edilmiştir. Sonuç olarak 42 günde hasat edilen kavun tohumları tuz priminginden daha fazla yararlanırken kavun tohumları çiçeklenmeden 30 gün (28-35 gün) sonra hasat edildikleri takdirde bu uygulamadan daha fazla yararlanabilmektedir. Uygulanan konsantrasyon ve periyodun hıyar tohumları üzerine ölümcül etkide bulundukları tespit edilmiştir.

Anahtar Kelimeler: Tuz primingi, karpuz, kavun, hıyar, çimlenme, sıcaklık

Introduction

Commercial seed lots of open pollinated vegetable species are comprised of both maturing and fully mature seeds due to destructive once over mechanical harvesting practices. Therefore, in most of the continuously flowering vegetable species seed lots contain differentially developed seeds. Obviously, this determines the overall performance of seed lots especially under stressful e.g. low temperature conditions. Those seeds which are less matured or over matured will tend to show lower performance compared to fully mature ones.

This is likely to occur in most of the vegetables including cucurbits. Priming treatments have been used in order to improve quality, for example e.g. repairing the damage that accumulated during storage (Ward and Powell 1983, Ellis and Butcher 1988), promoting rapid and uniform germination (Alvarado *et.al* 1987) promoting

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germination at low (Szafirowska et.al. 1981) and high temperatures (Cantliffe et.al. 1981). Priming treatments have also been shown to advance developmental processes in some species (Wiebe and Tiessen 1979, Welbaum and Bradford 1991). These studies show that less mature seeds might benefit from priming more as they would complete development while the priming process goes on.

Salt priming treatments have been used in cucurbits for: induction of low temperature germination (Sachs 1977, Nerson and Govers 1986); improvement of tetraploid variety germination (Nerson et.al. 1985); enhancing the germination response of heterogeneously matured seed lots (Welbaum and Bradford 1991) and repair of ageing (Oluoch and Welbaum 1996). Less mature muskmelon seeds (40 DAA) responded more positively to priming than mature ones (60 DAA) (Welbaum and Bradford 1991). Similarly, less matured seeds of watermelon, melon, and cucumber are likely to get more benefit from priming than full or over matured ones.

A differential response to priming among seed lots of varying maturity could contribute to the variability in results among developmentally heterogeneous seed lots. In turn, finding the best developmental period will help seed producers for determining the best harvest period to get the maximum benefit from priming treatments.

This work examines the responses to priming of seed lots harvested at 4 different periods after anthesis in watermelon, melon and cucumber by evaluating germination percentages and interim germination at low and optimum temperatures.

Material and Methods

Watermelon (*Citrullus lanatus* (Thunb.) Matsum & Nakai cv. Crimson Sweet), melon (*Cucumis melo* L. cv. Kırkagaç), and cucumber (*Cucumis sativus* L. cv. Beith Alpha) plants were grown in the Experimental Field of Department of Horticulture, Faculty of Agriculture ,University of Ankara between May and September 1998. Standard cultural practices were used during the growing period.

Full open flowers were tagged at anthesis on 7, 17 June, and 3 July, 1998 for cucumber, melon and watermelon, respectively, and 21, 28, 35 and 42 DAA (Days After Anthesis) fruits were harvested. Seeds were removed from the fruit on the same day of harvest, washed under tap water for 5 minutes and dried on top of paper towel at room temperature (20 ±2 °C) for 2 days until seed moisture was reduced to 6-7 %. Seed moisture content was determined by the high temperature oven method (130 °C, 1 h) (ISTA 1985). Seeds were then, stored in sealed glass jars at room temperature until the beginning of priming treatment (9 January 1999).

4-6 g of seeds of each harvest were put on top of filter paper moistened with 18 ml of 3 % KNO_3 and kept at 20 °C for 6 days in the dark in 9 cm petri dishes. During treatment dishes were covered with plastic film to prevent loss of liquid. At the end of the treatment, seeds were washed under tap water for 5 minutes and dried to the original moisture content at room temperature on top of filter paper. Total seed moisture was calculated from the weight that seed reached after treatment. Harvests were finished at the end of August 1998. Priming treatments were carried out in January 1999. Between these two dates seeds were kept in glass jars.

Four replicates of 25 seeds each were placed in 9 cm diameter petri dishes on two thicknesses of filter paper (Filtrak, Gmbh, Niederschlag, 9303 Post Borenstein Germany) moistened with 5 ml of deionised water. The seeds were incubated in the dark at 18 °C and 25°C. Countings were made 3, 6 and 9 days after incubation for cucumber and melon. One more counting was done after 14 days in watermelon. 2 mm long radicle was considered as germination criterion. Total germination was taken after 9 days in cucumber and melon but 14 days in watermelon. Interim germination was considered as 3rd day counting in all three species.

ANOVA was performed to test the differences between seed lots by using macustat (Oregon State University) and LSD values were calculated. Statistical analysis were carried out on angular transformed percentages but tables were constructed with actual values.

Results

Seed moisture contents of the seeds varied between 37.2 and 40.3 % in cucumber, 40.4 and 54.3 % in melon and 49.5 and 54.4 % in watermelon after treatment (Table 1). Watermelon seeds absorbed more water at the end of the treatment than the other two species despite similarity of the initial seed moisture contents (6.3-6.5 %). This effect was greatest at 21 DAA at which watermelon seeds had 13.9 and 17.1 % higher seed moisture content than melon and cucumber seeds, respectively.

The best overall advantage from treatment was gained in watermelon seeds. Regarding interim germination, seeds harvested 21, 28, 35 and 42 DAA showed 4, 19, 24 and 23 % superior germination, respectively, at 18 °C, corresponding percentages were found to be 35, 15, 15 and 0 for total germination. When performance of watermelon seeds at 25 °C is regarded advantage of the treatment was rather on interim germination (rate) than total. Treatment advanced 3rd day germination by 25, 5, 6, and 2 % at 21, 28, 35 and 42 DAA but differences in total germinations were not significant. Low temperature inhibited germination of watermelon seeds but that was gradually declined by the maturity. Seeds harvested (untreated) at 21, 28, and 35 DAA germinated 52, 61, and 79 % at 18 °C while corresponding total percentages at 25 °C were 96, 95, 92, respectively (Table 2). Seeds of 42 DAA germinated well regardless of temperature differences.

Table 1. Seed moisture contents (% fresh wt basis) of serially harvested cucurbit seeds after salt priming treatment

DAA	Cucumber	Melon	Watermelon
21	37.2	40.4	54.3
28	38.4	45.6	49.8
35	37.3	46.2	49.5
42	40.3	54.3	54.4
Initial m.c.	6.3	6.5	6.4

DAA : Days after anthesis

In melon, seed treatment was deleterious at early (21 DAA) and latest (42 DAA) harvests. Total germinations were reduced by 14 and 19% at 18 °C; 40 and 15 % at 25 °C in the earliest and latest harvests, respectively (Table 3). Contrarily, treatment was advantageous on interim germination at these two harvests at 18 °C but not 25 °C. Treatment gave no enhancement for total germination at both temperatures but its effect on interim germination was rather allocated for 18 °C at harvests of 28 and 35 DAA (Table 3). At this temperature 3rd day germination percentage was increased by 96 and 91 % whereas at 25 °C these were only 5 and 0% for 28 and 35 DAA.

Treated cucumber seeds showed inferior germination at all harvests and both temperatures. But the extent of inhibition was larger at 18 °C and earliest and latest harvests than 25 °C and interim harvests (Table 4). The largest inhibition occurred at 18 °C in seeds harvested 42 DAA with 20 % in interim and total germination percentages. At the same temperature the difference between treated and control seeds was in favour of control seeds with 12 and 9 % for total and interim germination of seeds harvested at 21 DAA. Differences between treated and control seeds were changed between 3 and 11 % in the rest of the observations (Table 4). One particular feature of cucumber seeds observed was that lowest germination percentage recorded was 75 %. However, in melon and watermelon much lower values such as 0, 2, 4 % were recorded especially in early harvests.

The effect of the treatment in general was more noticeable at sub-optimal temperature of 18 °C than 25 °C and was greater in interim germination (rate) than total. In melon it was detrimental on germination for early (21 DAA) and late (42 DAA) harvests and had none or very little effect on interim germination in mid harvests (28 and 35 DAA). Treatment was deleterious for cucumber seeds in all harvest and germination periods. The best advantages overall were obtained at both temperatures but being more prominent at 18 °C and in three early harvests of watermelon seeds.

Table 2. Effect of salt priming on 3rd day and total germination percentages of serially harvested watermelon seeds

Temp.(°C)		Germin.	DAA (days after anthesis) 21	28	35	42	LSD (p=0.05)
18	C	3rd day	0 A	1 A	4 A	12 A	2.1
		Total	52 A	61 A	79 B	100 C	15.3
	T	3rd day	4 A	20 B	28 C	35 D	4.1
		Total	87 AB	76 A	94 BC	100 C	12.8
25	C	3rd day	73 A	87 B	76 A	86 B	9.9
		Total	96 A	95 A	92 A	94 A	6.0
	T	3rd day	98 C	92 BC	82A	88 AB	7.1
		Total	100 B	94 AB	88 A	95 AB	9.0

Within rows values followed by different letters differ significantly
C = Control; T = Treatment

Table 3. Effect of salt priming on 3rd day and total germination percentages of serially harvested melon seeds.

Temp (°C)	Germin.		DAA (days after anthesis) 21	28	35	42	LSD (p=0.05)
18	C	3rd day	0 A	0 A	2 A	17 B	4.8
		Total	54 A	96 B	96 B	87 B	14.5
	T	3rd day	12 A	96 C	93 C	39 B	17.1
		Total	40 A	100 C	96 C	68 B	7.5
25	C	3rd day	73 A	95 C	96 C	83 B	7.5
		Total	79 A	95 B	96 B	87 AB	11.3
	T	3rd day	30 A	100 C	96 C	68 B	17.8
		Total	39 A	100 C	96 C	72 B	18.5

Within rows values followed by different letters differ significantly
C = Control; T = Treatment

Table 4. Effect of salt-priming on 3rd day and total germination percentages of serially harvested cucumber seeds.

Temp (°C)	Germin.		DAA (days after anthesis) 21	28	35	42	LSD (p=0.05)
18	C	3rd day	97 A	96 A	98 A	95 A	3.7
		Total	96 A	96 A	97 A	95 A	3.0
	T	3rd day	85 A	85 A	91 A	75 A	16.8
		Total	87 AB	91 B	91 B	75 A	14.2
25	C	3rd day	97 A	100 A	93 A	99 A	6.7
		Total	97 A	100 A	100 A	99 A	4.8
	T	3rd day	93 A	96 A	90 A	91 A	15.5
		Total	92 A	96 A	99 A	91 A	12.8

Within rows values followed by different letters differ significantly
C = Control; T = Treatment

Discussion

Results of this work showed that salt priming treatment was beneficial regarding total and interim germination percentages in watermelon seeds until seeds are 42 DAA while in melon benefit was only obtained from 28 and 35 DAA seeds. In cucumber, treatment was deleterious for all harvests between 21 and 42 DAA. Stimulative behaviour of salt priming (KNO_3) on seed germination and emergence at low temperatures in melon (Bradford 1985) and watermelon (Sachs 1977) seeds has been reported. Welbaum & Bradford (1991) showed that priming was more beneficial for 40 DAA than 60 DAA for low temperature and water potential germinations in muskmelon. The results reported here for watermelon agreed with that finding because the first three harvests got the best advantages particularly at 18 °C .

Salt priming in contrast to priming in Polyethylene Glycol or other organic molecules might pose toxicity problems as ions accumulate in seed tissues. Brocklehurst & Dearman (1984) showed a negative effect on germination in several vegetable crops primed in salts. It appears to be that cucumber seeds are very sensitive to salt accumulation however, in melon damage is related to developmental stage of the seed at which rather early and late harvests were inhibited. While the same negative effect was not observed in watermelon, two main reasons for that might be species differences, or desiccation effect after treatment. In some species there is a protective cap surrounds the embryo and plays an important role to control leakage and salt entrance (Taylor *et.al.*1998).

Salt priming treatments were found beneficial in melon (Bradford 1985) and watermelon (Sachs 1977) seeds. Very interestingly the dosage of salt was also the same as used in this experiment, (3 %). However, they used fully matured seed lots unlike this experiment. Some of the total harvest cucumber and melon seeds (2-3 %) germinated in the end of treatment. Despite those seeds that radicle emerged were eliminated from the lot, the rapid drying might still be damaging on the rest of the seeds in which germination processes started.

Moreover, watermelon seeds which showed more positive response to priming absorbed more solution than those of melon and cucumber. In all three, watermelon seeds had the highest moisture content after treatment. It appeared that watermelon shows a special response to salt priming. Since seeds of melon and cucumber might switch from developmental to germinative mode (some seeds germinated while under treatment) they can be easily damaged by drying while watermelon seeds might still be in developmental mode. Preliminary studies showed that watermelon seed maturation period is much longer than cucumber and melon. However, drying alone does not account for differences in germination of seed lots as suggested by Welbaum & Bradford (1991).

When seed development periods were compared among the three species, cucumber and melon seeds matured much earlier than watermelon. Cucumber seeds showed the maximum germination and dry weight by 32-39 DAA (Demir & Yanmaz 1997) similarly, melon seeds showed maximum germination by around 40 DAA (Welbaum & Bradford 1991). However, watermelon seeds need longer to reach maturity : they reached maximum dry weight and germination around 50 DAA (Unpublished Data). In this experiment only early harvests were considered to take account of likely benefit of priming effect on less mature seeds. Thus, 42 DAA seeds are at full maturity in cucumber and melon whereas just mature in watermelon.

Some of the previous results showed that salt priming can be used as a tool for low temperature germination of cucurbits especially in early spring sowings (Nelson & Sharples 1980, Nerson & Govers 1986). This agreed with the results reported here. The best advantage was obtained at 18 °C. But it seems to be that treatment should be applied more selectively for melon seeds to get the maximum benefit. In this species, seeds should be harvested between 28 and 35 DAA in order to get the benefit. On the other hand, watermelon seeds showed positive response until 42 DAA at which stage fruits are just starting to mature. These periods coincide with late fruit maturity in cucumber and melon but just the beginning in watermelon.

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