INFLUENCE OF PROHEXADIONE-CALCIUM INCORPORATED INTO PRIMING SOLUTION ON GERMINATION AND EMERGENCE OF MUSKMELON AND WATERMELON SEEDS AT LOW TEMPERATURE

Saman Saber ALI

Master's Thesis

Department of Horticulture

Supervisor: Assist. Prof. Dr. Nusret ÖZBAY

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REPUBLIC OF TURKEY
BİNGÖL UNIVERSITY
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This master's thesis was accepted by the following committee on 18.05.2017 with the vote unity.

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I confirm the result above

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Director of the institute

PREFACE

I would like to thank ‘Allah’ for giving me the power to start and complete. I would like to express my sincere thanks and appreciation to my supervisor Dr. Nusret ÖZBAY, professor of vegetable crops, Department of Horticulture, Faculty of Agriculture, and University of Bingöl for his supervision, ingenious and kind guidance, encouragement, and positive criticism during the course of this investigation and writing of the thesis. I would like to thank to my wife Rezan who supported and powered me for completing this thesis successfully. I appreciate my parents who enhanced me in this difficult way. I would like to make this paper as a gift for my two sweet children (Raz and Randy). In addition it is pleasure to thank my two sisters and my brother for their assistance. Finally, I would like to thank my friends (Abdulstar Abdulla Omar; Master in Plant Biotechnology; Directorate of Agriculture Research-Erbil-Iraq) who gave me advice from the start to the end of this study. Thanks for all people who taught and sustained me throughout my life.

Saman Saber ALI

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CONTENTS

LIST OF SYMBOLS

°C	: Celsius Degree
%	: Percentage
µM	: Micrometer
ABA	: Abscisic acid
ASA	: Acetyl salicylic acid
$CaCl_2$	: Calcium Chloride
cm	: Centimetre
DAA	: Day after anthesis
dsm^{-1}	: Decisiemens per meter
E_{10-90}	: Emergence synchrony
EI	: Emergence percentage
FEP	: Final emergence percentage
FGP	: Final germination percentage
G_{10-90}	: Germination synchrony
G_{50}	: The time to reach 50% germination
GA_3	: Gibberellic Acid
GI	: Germination index
h	: hour
HCl	: Hydrochloric acid
K_2SO_4	: Potassium Sulphate
KH2PO4	: Potassium Dihydrogen Phosphate
KNO3	: Potassium Nitrate
L	: liter
M	: mole
MeJA	: methyl jasmonate
MET	: Mean emergence time
mg	: milligram

MGT : Mean germination time

mL : milliliter

mM : Millimole

mm : millimeter

Mol : mole

MPa : Mega Pascal

NaCl : Sodium chloride

$NaHClO_3$: Sodium hypochlorite

NaOCl : Sodium hypochlorite

PEG : Polyethylene glycol

Pro-Ca : Prohexadione Calcium

SA : Salicylic acid

V : Volume

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PRİMİNG ÇÖZELTİSİNE PROHEXADIONE-CALCIUM İLAVESİNİN KAVUN VE KARPUZ TOHUMLARININ DÜŞÜK SICAKLIKTA ÇİMLENME VE ÇIKIŞI ÜZERİNE ETKİSİ

ÖZET

Bu tez çalışmasında priming çözeltilerine ilave edilen Prohexadione-Calcium (Pro-Ca) dozlarının kavun (*Cucumis melo* cv. 'Kırkağaç 637') ve karpuz (*Citrullus lanatus* cv. 'Charleston Gray PS') tohumlarının düşük sıcaklık ve yüksek sıcaklıkta çimlenme ve fide çıkış performansları üzerine etkileri araştırılmıştır. Tohumlar 0, 25, 75 ve 100 $mg.^{-1}$ Pro-Ca içeren 1-.5 Mpa KNO_3 ve KH_2PO_4 solüsyonları içerisinde, karanlıkta 25 °C'de kavuniçin 4 gün, karpuz için 6 gün süreyle prime edildi. Priming işleminden sonra tohumlar saf su ile yıkanıp filtre kâğıdı üzerinde 20 ºC sıcaklıkta 24 saat kurutulduktan sonra 15 ºC ve 20 ºC'de çimlenme ve çıkış testlerine tabi tutulmuşlardır. Uygulama görmemiş kontrol tohumlarına göre, bitki büyüme düzenleyicilerinin gerek varlığında ve gerekse yokluğunda gerçekleştirilen priming uygulamaları genel olarak kavun ve karpuz tohumlarında düşük sıcaklıkta, çimlenme yüzdesi (FGP), ortalama çimlenme süresi (MGT), çimlenme indisi (GI), çıkış yüzdesi (FEP) ve ortalama çıkış süresi (MET) ve çıkış indisinde önemli iyileşme sağlamıştır. Sonuçlar priming ortamına ilave edilecek Pro-Ca'un, tatlı biber tohumlarının düşük ve yüksek sıcaklıktaki performanslarını arttırmada başarılı bir şekilde kullanılabileceğini ortaya koymuştur.

Anahtar Kelimeler: Kavun, karpuz, priming, prohexadione-calcium, çimlenme, çıkış, düşük sıcaklık.

INFLUENCE OF PROHEXADIONE-CALCIUM INCORPORATED INTO PRIMING SOLUTION ON GERMINATION AND EMERGENCE OF MUSKMELON AND WATERMELON SEEDS AT LOW TEMPERATURE

ABSTRACT

This thesis study was conducted to investigate effects of incorporating Prohexadione-Calcium (Pro-Ca) into the priming solutions on low temperature germination and emergence percentage performance of muskmelon *(Cucumis melo* cv. 'Kırkağaç 637') and watermelon (*Citrullus lanatus* cv. 'Charleston Gray PS') seeds. Priming was accomplished by imbibing muskmelon and watermelon seeds for 4 and 6 days, respectively at 25 °C in darkness in solutions of KNO_3 or KH_2PO_4, each at -1.50 MPa, containing 0, 25, 50, 75, or 100 $mg.L^{-1}$ Pro-Ca. After priming treatment, seeds were washed with distilled water and dried at 20 ºC temperature on filter paper for 24 h, then the seeds were subjected to germination and emergence tests at 15 and 20 °C. Priming muskmelon and watermelon seeds in the presence or absence of plant growth regulators in general improved final germination percentage (FGP), mean germination time (MGT), germination index (GI), final emergence percentage (FEP), and mean emergence time (MET), emergence index (EI) compared to non-primed seeds at both temperatures. The results of the study indicated that inclusion of Pro-Ca into the priming solutions can be used as an effective method to improve low temperature germination performance muskmelon and watermelon seeds.

Keywords: Muskmelon, watermelon, priming, prohexadione-calcium, germination, emergence, low temperature.

1. INTRODUCTION

The *Cucurbitaceae* family comprises more than 700 species of herbaceous crops plants with about 90 genera. They provide vegetables, fruits, oils, and several other useful products. The fruits are a pepo (fleshy berry-like structures with a rind and spongy seed interiors), but sometimes a papery, bladdery pod. The seeds are usually flat and plate-like.

Cucurbits are preferred warm climate rather than cold and they are not adaptable to frost and cold environment while mostly require high temperature relatives in the germination stage (Nerson 2007). Watermelon and muskmelon are classified as very tender, warm-season crops and are native to the Old World tropics and subtropics (tropical and southern Africa) (Bates and Robinson 1995). Watermelon belongs to Cucurbitaceae family and it is one of the prostrate useful vegetables. Watermelon (*Citrullus lanatus* (Thumb.) Matsum.and Nakai) was formerly known as *Citrullus vulgaris*. Commercial cultivars are classified as *Citrullus lanatus* var. lanatus, and wild accessions are *Citrullus lanatus* var. citroides (Decoteau 2000). It is sweet and contains a high percentage of sugar. As watermelon requires whether that is more likely hot in summer, there are variable of places that can be watermelon grown in it. Watermelon grown in different climatic zones in the world, but its origin land may tropical Africa and United States (Decoteau 2000). It is clear that watermelon grown in most of the countries in the word, however, in some places watermelon cannot be grown in the open field while greenhouses cover that and produce huge amount of it. Watermelon complete cycle growth is approximately 17 weeks if there is no frost (Decoteau 2000).

Muskmelon has been placed in the same family of watermelon, despite the fact that both are similar in vegetative and morphological characteristics. It is believed that Iran is the origin of Muskmelon however, there are some records of planting it in the United States in 1494 (Decoteau 2000). Muskmelon prefers arid and semi-arid weather for gaining the best yield. For optimum germination and high yield muskmelon also require

enforce to gain that.

Temperature is one of the most factors that plant relies on it for its growth. It is important that germination and plant growth conduct under optimum condition of temperature and humidity. For optimum result for the researchers it will be useful to know temperature range, which seed germinate in higher percentages and in short time. At the stage where the germination mark as highest speeds that will be the optimal temperature (Hakansson et al. 2002). The proper temperature has a higher effect on controlling germination (Nerson 2007). Researchers are needed to know the minimum, maximum and optimum for regulating growth in plant (Kurtar 2010). Optimum temperatures lead to most accelerating of seed germination and plant growth High temperature (25–28°C) is the best temperature for desirable germination of seed and seedling emergence of watermelon (Demir and Mavi 2004).

Melons are not germinating well at supra and sub-optimal temperatures (Farooq et al. 2007). Many researchers conducted studies on salt as for priming and some of them obtained useful results. (Korkmaz et al. 2005) reported that KNO_3 with one of MeJA or with spermine can be used as one of the best method for high germination without any effect on the yield. In regards to osmotic solution, 1.30 MPa osmotic potential is effective for priming seed in muskmelon (Nascimento 2003).

Researchers investigated lots of methods for improving germination seeds in different production. (Wittwer and Bukovac 1957) are the first researchers introduced the idea of using plant growth regulators (PGRs) to accelerate the germination seed of vegetables under suboptimal temperatures. Exogenous is one of the applications for to gain advanced germination in melon seed (Nelson and Sharples 1980). Germination and seedling emergence are vital stage during plant growth (Singh et al. 2015). Absence of specific requirement is the reason that seeds in cucurbits not germinated (Nerson 2007). For optimum and desirable germination and growth result many scientists have tried to find better methods. Before sowing there some priming treatments for seed (osmoconditioning, osmopriming, osmotic priming) that involves exposing seeds in a low external water potential that controls hydration (Nascimento 2003)

Priming is a technique to control seed, water uptake by incubation the seed in ingredients

such as salt or polyethylene glycol. Seed priming is a process before sowing seeds which include the controlled hydration of seeds that help pre-germinated metabolic events to take place but it is not enough to let radicle rupture the seed coat (Pill 1995).

Recently many seed priming techniques have developed, such as hydropriming (soaking in water), halopriming (soaking in inorganic salt solutions), osmopriming (soaking in solutions of different organic osmotica), thermopriming (treatment of seed with low or high temperatures), solid matrix priming (treatment of seed with solid matrices), and biopriming (hydration using biological compounds) (Ashraf and Foolad 2005). Each treatment has positive and negative influence and might have varying impacts depending on varieties, the growth of plant life cycle plant species, concentration/dose of priming agent, and the incubation period. There are many ingredients used in priming to improve germination and other aspects in plants, but some of them are often used. Recently, KNO_3 is often used than other salts to improve germination, uniformity of seedling and emergence ratio of seeds in many crops in stress environments (Mustafa et al. 2007). Priming is often used for optimum result in germination and seedling emergence for most crop species (Hosseini and Koocheki 2007). In using 5priming media KNO_3 was the most effective for increasing germination, germination rate and plume (Armin et al. 2010). In using KNO3 with methyl jasmonate (MeJA) for priming watermelon seeds is gained optimum result for effective methods in improving low temperature performance in watermelon seed (Korkmaz et al. 2004). (Salk et al. 2008) have found that minimum temperature for seed germination in melon and watermelon is 10 °C while 25-30 °C is optimum. In a study of some cucurbits including melon and watermelon germination percentage and germination speed were increased at suboptimal temperature while decreased at supra-optimal temperature (Kurtar 2010). Priming under 15°C temperature watermelon seed germination was improved by using priming with using and without using regulators for plant growing compared to untreated seeds which was not emergence (Korkmaz et al. 2004).

This thesis study was conducted to investigate effects of incorporating Prohexadione-Calcium (Pro-Ca) into the priming solutions on low temperature germination and emergence percentage performance of muskmelon *(Cucumis melo* cv. ‘Kırkağaç 637’) and watermelon (*Citrullus lanatus* cv. ‘Charleston Gray PS’) seeds.

2. LITERATURE REVIEW

There are some seeds that are facing difficulties to germinate due to the lack of moisture reaching inside seed. Low percentage of germination of some seeds is a common circumstance dissatisfactory temperatures that is making it to make concerns particularly in the late winter and the beginning of spring in many regions in the world. Basically, the optimum seed germination and seedling early growth happens at high temperatures such as (20–30°C) that include several crops for example, tomato, eggplant, bean, watermelon, cucumber, and melon (Tzortzakis 2009). Further to the previous information, chilling injury happens at temperature ranged (0-10 °C) (Lyons 1973; Levitt 1980). Chilling injury has been examined by many researchers (Khani et al. 2010; Chachalis et al. 2008).

Seed germination of numerous plant species face difficulties and suffer through facing chilling injury which usually happens in tropical or subtropical environments by suffering above freezing temperature (low temperature) which is one of the cases that has negative impacts on seed germination and yield. There are several factors that are affect chilling injury in seeds which are: type of species or cultivar, temperature, initial seed water content, the duration of chilling process and seed germination period process during the time which chilling injury is happening. The process of chilling injury is related to stress. The imbibition period of seeds is the period when the sensitivity of stress starts as well as chilling temperature. Thus, the imbibitional chilling injures can be defined as sensitivity to a combination of low water content of seeds and imbibition at period of cold temperature. In addition, the mode of chilling injury in seeds is not similar with chilling injury of tissues that contain enough moisture (Bedi and basra 1993).

Temperature is one of the most essential factors affecting growth and development of many plants. Optimum watermelon and melon seed germination and seedling emergence occur at relatively high temperatures (25-28 °C). Poor germination and emergence are common phenomenon at sub-optimal temperatures which is a great concern of growers

that grow melon and watermelon seedlings early spring in Turkey (Demir and Mavi 2004). One of the methods used to eliminate or reduce the negative effect of low temperature on germination and emergence of seeds is priming application. This technique has been used to improve germination and emergence performances of vegetable seeds, such as germination rate, total germination and seedling uniformity, mainly under unfavorable environmental conditions. Different priming methods are applied for this purpose. The seed priming methodology depends on the species, and the osmotic solution, temperature, and duration vary with plant species.

Seed priming is nowadays being extensively used to improve seed germination and seedling emergence in a wide range of plant species (Hosseini and Koocheki 2007). Seed priming treatments using different salts such as KNO_3 have been effective in improving watermelon germination under low temperature conditions (Demir and Van de Venter 1999).

(Sachs 1977) reported that priming watermelon seeds in polyethylene glycol (PEG) and salt solutions improved germination at low temperature.

(Sachs et al. 1980) conducted a research to accelerate seed germination of pepper seeds cv. ‘Early Calwonder’ under low temperature. The seeds were treated by deionized water for 0, 12, 24, 48 hours at 30 °C or primed with KNO_3 (3%) for 0, 3, 6, 9, 12 days at 20 °C, then germinated at 15 °C. Researchers reported that in aerated KNO3 solutions for 6 or 8 days, or, imbibition at 30 °C for 48 h in water, enhanced the germination at 15 °C when the seeds we're not re-dried after treatment.

In a research conducted by (Edelstein and Kigel 1990), mean time of germination (MTG) and total germination of two melon accessions (Noy Yizre'el and Persia 202) in response to various temperatures between 7 and 47 °C were investigated. The germination tests showed marked differences between the two accessions. 'Persia 202' germinated fully (> 85%) at a wider range of constant temperatures (13- 41 °C) than ‘Noy Yizre'el' (19-35 °C). Researhers also reported that untreated 'Noy Yizre'el' seeds were unable to germinate at 14 °C, but germination was much improved by seed coat removal, exposure to gibberellin, or initial imbibition at 25 °C.

(Hall et al. 1989) reported that water-imbibed watermelon seeds provided faster crop establishment than dry seeds at temperatures below the optimum (15.7 °C).

In a research conducted by (Dhillon 1995) seeds of muskmelon male sterile lines were subjected to salt priming treatments in order to improve the germination and emergence at low temperature. He reported that the best priming treatment was 2.5 % KNO_3 for 16 h in darkness in terms of germination. Emergence studies in a field experiment confirmed the effectiveness of the priming treatment for low temperature germination of muskmelon seeds.

(Singh et al. 2001) conducted an experiment to determine the optimum temperature for testing watermelon seeds for cold germination ability and to find out whether there were genetic differences among cultivars for cold germination ability. Four temperatures (10, 14, 18, 22 °C) were used in the study. They reported that maximum germination percentage (84% and 83%) was observed at 22 and 18 °C, respectively. The minimum germination percentage (44%) was observed at 14 °C. As for genetic differences for cold, 'Charleston Gray' had 71 % germination compared to 64% for 'Petite Sweet'.

In an earlier research, (Korkmaz 2002) investigated whether abscisic acid (ABA) would mitigate chilling damages in the watermelon, a chilling-sensitive plant. 'Crimson Sweet' watermelon seedlings were grown in a greenhouse with a temperature regime of 25 °C (day) and 20 °C (night). Five-day-old seedlings were sprayed with 10-4 M cis, trans-abscisic acid 15 hours prior to being exposed to 1.5 ± 0.5 °C for 24 hours in a dark incubator. The watermelon seedlings were visually inspected and rated in order to estimate the extent of chilling injury, and their shoot and root fresh and dry weights were determined one and two weeks after the chilling exposure. The researcher reported that the chilling caused significant visual damage on the plants that were not sprayed with ABA. Plants that were not treated with ABA had significantly lower shoot and root fresh and dry weights compared to plants sprayed with ABA prior to chilling exposure.

(Nascimento 2003) reported that muskmelon (*Cucumuis melo*) seeds from priming treatments had a better germination rate and seedling development under 17 and 25 °C.

(Demir ve Mavi 1999) evaluated the effects of osmo-priming using solution of potassium nitrate for 6 days at 24 °C and hydro-priming using distilled water at 30 °C for 18 days on germination of watermelon seeds under 3 different temperatures (15, 25, and 38 °C. They come to the conclusion that both osmopriming and hydropriming treatments significantly increased seed germination at 15 °C. On the other hand, the researchers also indicated that there was no significant impact of osmo-priming on seed germination at 25 and 38 °C.

In previous study conducted by (Demir and Mavi 2004), the influence of salt priming (KNO3, 3%, 6 day, 20 °C) on greenhouse seedling emergence, emergence rate, seedling weight and hypocotyl length of watermelon seeds grown in two production sites and harvested 20, 30 and 40 days after anthesis (DAA) was investigated. Author reported that the maximum benefit of priming was observed in seeds of 20 DAA for all criteria. Primed seeds of this harvest had 19 and 22% higher seedling emergence percentages, 60 and 96 h faster emergence rate, 68 and 82mg heavier seedling weights, and 2 and 4mm longer hypocotyls compared to control ones in sites 1 and 2, respectively. They suggested that Salt priming can be used to increase watermelon emergence and produce well-developed seedlings particularly in early spring sowings at low temperatures in greenhouse conditions.

(Korkmaz et al. 2004) reported that watermelon seeds were primed in 2.5% (0.25 M) KNO3 solution for 6 days at 25 °C in darkness containing one of the following: 1, 3 or 5 µM methyl jasmonate (MeJA), or 1, 3 or 5 mM spermine. The seeds were then subjected to germination and emergence tests at 15 °C. Priming watermelon seeds in the presence or absence of plant growth regulators significantly improved germination percentage and rate at 15 °C compared to untreated control seeds, which failed to germinate. The seeds primed in KNO3 solution containing 1 or 3 µM of MeJA had significantly higher germination percentages (96 and 85 %, respectively) compared to seeds primed in KNO_3 only (69%).

(Farooq et al. 2005) reported that priming four varieties of tomato seeds were soaked in -1.1 MPa aerated solution of polyethylene glycol (PEG-8000), NaCI and KN03 for 24 h. compared with control treatment, all treatments resulted in improved germination and

seedling vigor by dormancy breakdown. The lowest mean germination time was showed in seeds primed with KN03 in all four cultivars. The highest final germination percentage and germination index were showed in seeds primed with KN03 in all the cultivars.

In a research carried out by (Korkmaz 2005), sweet pepper seeds were treated with 3% KNO3 solution in darkness under 25 °C for 6 days adding four level of methyl jasmonate (MeJA) 1, 3, 5 and 10mM or 0.05, 0.1, 0.5 and 1 mM acetyl salicylic acid (ASA). Following priming, the seeds were subjected to germination and emergence tests at 15±0.5 °C. Priming muskmelon seeds in the presence or absence of plant growth regulators significantly improved germination percentage, rate and synchrony at 15 °C compared to untreated control seeds. The researchers suggested that priming in 1 µM of MeJA or 3 mM spermine incorporated into the KNO3 solution can be used as an effective method to improve low temperature performance of muskmelon seeds.

(Mavi et al. 2006) reported that tomato rootstock seeds were primed with 2% KNO3, 1% NaCl, and 500 ppm GA_3 at 20 °C for 4 days in the darkness. The results of the study showed that priming reduced germination time rather than subsequent relative growth rate and is a valuable tool to improve seedling quality in rootstock tomato seedling production. KNO_3 was best prime in this study for growth and reducing time of emergence.

A laboratory study was carried out to evaluate the possibility of improving germination and enhancing seedling growth by osmopriming in melon. Melon seeds were soaked in aerated 1, 2 and 3% solutions of $CaCl_2$ and KNO_3 for 24 h. Priming in KNO3 gave better results than in $CaCl_2$. Priming in KNO_3 solutions improved the germination rate and uniformity, and early seedling growth, being the best with its lowest concentration. None of the priming treatments improved seedling fresh weight; however, improvement in seedling dry weight was observed from seeds primed with 1% KNO_3 solution (Farooq et al. 2007).

Sugar beet were treated in 3% KNO3 solution under 25 for 6 days in darkness containing one of the following 0, 0.05, 0.1, 0.5, or 1 mM acetyl salicylic acid (ASA) or 1, 3, 5 or 10 µM methyl jasmonate (MeJA). A non-primed treatment was also included in the experiment. Priming seeds in the presence or absence of plant growth regulators in

general improved final germination percentage (FGP), germination rate (G_{50}) and germination synchrony (G_{10-90}) at 15 degrees C compared with non-primed sugar beet seeds. Researchers suggested that priming sugar beet seeds in 0.05 mM of ASA or 3 µM MeJA incorporated into the KNO_3 solution can be more effective than KNO_3 alone to improve low temperature germination performance of seeds and subsequent seedling growth (Govahi et al. 2007).

(Ilias et al. 2007) reported that seeds of okra [*Abelmoschus esculentus* (L.) Moench] cultivars 'Pileas', 'Psalidati', and 'Clemson Spineless' were subjected to exogenous hormones [gibberellic acid-(GA_3) and Prohexadione-Ca] applied as foliar spray. Stem and leaf dry masses and stem length were significantly increased by the application of exogenous GA_3, but Pro-Ca inhibited growth. Control and Pro-Ca treated okra plants took more time to bloom than did GA_3 treated plants.

(Abbas et al. 2009) investigated effect of growth regulator "Atonik" on seed germination and growth of watermelon seeds. . The seeds treated with by plant growth regulator 'Atonik' solution gave higher speed and percentage of germination compared with unprimed as control.

In a research conducted by (Mohammadi 2009), soybean seeds were treated with 1% solution each of ammonium, calcium, potassium, sodium nitrate, non-primed control and hydro-primed under 20 °C for one day. Germination tests were conducted under four temperatures (5, 15, 25, 35 °C). In accordance with the result obtained from the laboratorial study, germination percentage and rate were ameliorated when temperature was increased up to 25 °C. In both filed and laboratorial studies priming with KNO_3 solution gave maximum germination percentage and germination rate in all determined traits. The results of this study showed that priming can be used as fruitful method to accelerate seed performance and traits of plant in late spring seed of soybean.

Seeds of Fennel (*Foeniculum vulgare*) were primed by hydro-priming with distilled water, osmopriming with $K2SO_4$ at four levels, NaCl at four levels, and PEG6000 at four levels. Unprimed seeds were used as a control treatment. Priming treatments significantly affected germination performances of the seeds. Maximum germination was obtained by PEG6000 (- 0.9 MPa) and minimum germination was seen in control treatment. Highest

germination rate was obtained from the K_2SO_4 (-0.3MPa) treatment while minimum was by -0.3 MPa NaCl (Neamatollahi et al. 2009).

(Tzortzakis 2009) reported that the endive and chicory seeds were pre-treated with ment gibberelic acid (GA3; 25 and 250μM), 6-benzylaminopurine (BAP; 25 and 250μM), KNO3 (50 and 150mM), methyl jasmonate (MJ; 50 and 500μM), dittany of Crete (Origanum dictamnus L.) essential oil (Dict.; 50 and 500μM (extracted by hydro-distillation) and NaHClO3 (5% v/v available chlorine for 15 and 45 min) solutions for (24 h, 23 ±2 °C, dark). Control was maintained using distilled water. This study KNO3 and GA3 (250) mM it could be one of choices for improving rapid of uniformity in seedling emergence and plant development of nursery and greenhouse.

(Tzortzakis 2009) investigated effects of pre-sowing treatments using hydropriming, osmopriming and halopriming on seedling emergence, seedling weight and plant growth of endive and chicory in laboratory and/or nursery conditions. Halopriming (KNO_3) or growth regulators (gibberelic acid; GA3) improved the rate of germination of chicory and endive, and reduced the mean germination time. Thirty-minute pre-sowing treatment with $NaHClO_3$, methyl jasmonate and dictamus essential oil decreased seed germination as well as seed radicle length in vitro condition. In the nursery tests, pre-sowing treatments had in some extent impact on the upper part (especially fresh weight) of the seedling, while no major changes were observed for leaf number and root fresh weight. The author suggests that KNO_3 and secondly GA3 treatments may improve rapid and uniform seedling emergence and plant development in nurseries and/or in greenhouses, which is easily applicable by growers with economic profits.

Priming studies were conducted by using 0.1 N HCL, 1.5 N NaCl, 3% PEG 6000, and 3%, KNO_3 and non-primed as control in watermelon. Priming increased watermelon emergence, emergence rate, and plumule length. No significant differences were found to exist on plumule dry weight and radicle length. Priming with PEG and NaCl negatively affected the rate and growth of emerged seedling. Among the tested priming agents, KNO_3 had the most effective impact on emergence and seedling growth. Compared with the non-primed control seeds, priming with KNO_3 increased the germination, germination rate and plumule length of watermelon seeds by 17.87%, 18.65%, and 4.68%,

respectively (Armin et al. 2010).

In a research conducted by (Dursun and Ekinci 2010), parsley seeds were primed 2, 4, 6 and 8 day with (-0.5 MPa , -1MPa and -1.0MPa) of Polyethylene glycol, (0.30 and 0.35 mol/L) of KNO_3 and (0.50 and 0.60 mol/L) of Mannitol, hydro-priming hours (12, 24, 36, 48 h) and untreated (control) for germination percentage at 5, 10, 15, 20 and 25 °C. Germination percentages at different temperatures were significantly affected by priming treatments. The parsley seeds hydroprimed (12, 24 and 36 h) and in mannitol 0.60 mol/L at 2 day generally had the higher germination percentages as compared with PEG and KNO_3 treatments.

(Ghassemi-Golezani et al. 2010) reported that laboratory tests and a field experiment were carried out to evaluate the effects of salt priming (0.8% NaCl with electrical conductivity of 15.3 dsm^{-1} and 0.8% KNO_3 with electrical conductivity of 12.5 $dsm^{-1}$for 8 h at 20 ± 1 °C) on seed invigoration and field performance of three winter rapeseed cultivars. Compared with non-primed seeds, salt priming, particularly KNO_3 priming, decreased mean time to germination and increased seedling size. Although response to salt priming varied among rapeseed cultivars, seed priming generally increased grain yield per unit area through enhancing rate and percentage of seedling establishment, pods per plant and grains per plant. The highest improvement in grain yield per unit area was observed for seeds primed with KNO_3 (31.5%).

A research was carried out in order to study the effect of seed priming on germination, seedling emergence and seedling electrolyte leakage of snake melon (*Cucumis melo* var. *flexuosus*). The Seeds were primed in -1 MPa solution of polyethylene glycol (PEG 6000), KNO_3 and NaCl in darkness. The results of the study showed that priming the snake melon seeds with KNO_3 was more effective than other priming treatments. The study revealed that snake melon seed priming with KNO3 decreased MGT and increased seedling dry weight under salinity stress compared to other priming treatments (Shahi-Gharahlar et al. 2010).

(Arin et al. 2011) reported that onion seeds (*Allium cepa* L.) of short-day cultivars (‘Aki’and ‘Alix’) and long-day cultivars (‘Banko’ and ‘Suluova’) were primed with different concentrations of polyethylene glycol (PEG6000) in inorganic salts (KNO_3 and

KH_2PO_4) for different periods of time (3 and 6 days) at 15 °C. After the priming treatments, the effects of priming on seedling emergence were evaluated at optimal (20 °C) and suboptimal (11 °C) temperatures under field conditions. Priming in both KNO_3 and KH_2PO_4 reduced the days to emergence without significant loss in emergence ratio. In contrast, seed priming with PEG was ineffective. They also reported that seeds primed with KNO3 and KH_2PO_4 emerged approximately four days earlier than the control seeds in variety 'Alix', regardless of the sowing date.

Seeds of tomato cultivars ('Nagina' and 'Pakit') were pretreated with aerated solutions of 10, 25 and 50 mM NaCl and KNO_3 for one day. Halo-priming with 25 mM KNO_3 for 24 h increased final germination percentage and germination index of both tomato cultivars as compared to all pre-sowing seed treatments including control. It also significantly reduced the time taken to 50% emergence and mean emergence, increased final seedling emergence percentage and seedling growth. Results indicated that halopriming with varying concentrations of KNO_3 improved germination potential and seedling establishment of both cultivars and it proved better option than NaCl which resulted in poor emergence and seedling growth. Maximum improvement was recorded in seeds primed with 25 mM KNO_3 (Nawaz 2011).

In an earlier study (Zhang et al. 2011), influence of eggplant seed germination and seedling emergence at low temperature by seed priming with incorporation salicylic acid into KNO_3 solution was investigated. The eggplant seeds were primed with 3% KNO_3 solution in different level of 0.05, 0.1, 0.5 and 1 mM (SA) under 25 °C for 6 days, respectively. After the priming, seeds were either immediately used for germination and emergence tests at 15 °C or stored at 4°C for 1 month and then for the germination test. In general, the priming eggplant seeds improved the final germination percentage (FGP), germination rate (G50), and germination synchrony (E10–90) at 15 °C compared with non-priming seeds.

(Cokkizgin et al. 2013) treated seeds of six varieties of cotton with KNO_3 and distilled water to increase cold stress tolerance of the varieties under controlled environmental conditions. Primed and unprimed seeds were germinated at 18 °C during for seven days. The height germination index was observed at the distilled water treatment and KNO_3

(4%) treatment. The researches indicated that the results of the study further supported the idea of that potassium nitrate or distilled water are effective in cotton cold tolerance improvement.

(Sahib et al. 2014) reported that okra seeds were treated with $KH_2PO_4$4 (1.5 and 3%) and hydro-priming, distilled water as control at 25°C and 30 °C of temperature for 4 hours. Maximum seed germination percentage, germination speed index, and seedling vigor index were observed when the seeds primed by KH_2PO_4 3% for 4h and at 20 and 30 ºC.

(Ozbay and Ergun 2015) evaluated four concentrations of 0, 50, 100, or 150 mg L^{-1} of prohexadione-calcium (Pro-Ca) on the growth and quality of eggplant (*Solanum melongena*) seedlings in a greenhouse experiment. All Pro-Ca concentrations significantly reduced shoot height and internode length, when compared to the control. The concentrations of 50, 100, and 150 mg L^{-1} Pro-Ca reduced shoot height by 27, 32, and 38%, respectively.

(Ozbay and Susluoglu 2016) reported that sweet pepper were treated in 3% KNO_3, 2% KH_2PO_4, and 10% PEG solutions containing 0, 25, 50, and 100 mg.L^{-1} Pro-Ca in darkness at 25 °C for 3 days. Priming pepper seeds, in the presence or absence of plant growth regulator, improved final germination percentage, mean time to germination, and germination index, final emergence percentage, and mean time to emergence compared to non- primed seeds. The highest final germination percentage and the lowest mean time to germination were obtained from KH_2PO_4 + 25 mg.L^{-1} Pro-Ca treatment.

3. MATERIAL AND METHODS

This study was conducted during 2016 at the Vegetable Physiology Laboratory, Department of Horticulture, Faculty of Agriculture, and University of Bingöl, Turkey.

3.1. Plant Material

Melon (*Cucumis melo* L.) seeds of 'Kırkağaç 637' (Bursa Seed Company, Bursa, Turkey) and and watermelon (*Citrullus lanatus* var. *lanatus*) seeds of 'Charleston Gray PS' variety (Seminis Vegetable Seeds Inc. St. Louis, Missouri, USA) were used in the experiments.

Figure 3.1. 'Kırkağaç 637' melon variety

Open pollinated 'Kırkağaç 637' melon variety melon variety with vigorous plants that set large and round fruits (3-4 kilograms). Side branches are long and have many leaves. The

flesh is white and very sweet. It is suitable for storage and transport due to thick rind. Average yield is 30 tons/hectare.

Figure 3.2. ‘Charleston Gray PS’ watermelon variety

Watermelon ‘Charleston Gray PS’ is the classic oblong watermelon. It has red, fibreless flesh and a tough, medium-thick gray-green rind. At one time this was the predominant watermelon in home gardens and markets. Resistant to fusarium wilt, anthracnose and sunburn. Ready for harvest 87 days after sowing. The variety has fruits averaging (12-14 kilograms), good shipper and good shelf life.

The initial seed moisture was 6 % (dry weight basis). Moisture contents were determined according to the standardized laboratory test for moisture content has the oven method (ISTA 1996). The standard germination test of melon and watermelon were conducted on the seeds and their initial germination percentage was determined as 90% and 93%, respectively. The seeds were stored in a sealed container at 10 °C and 45% relative humidity until used.

3.2. Growing Media

The mixture of peat moss and perlite [4:1 (v/v)] was used in the experiments. Peat moss is the most commonly used soilless medium. It is widely available and relatively inexpensive (Kueper 2010).

Figure 3.3. Two growing media used in the experiments

Peat moss is formed from sphagnum mosses in very acid bog conditions which preserve most of the plant fiber structure. It is lightweight, relatively pathogen free, and has a high water holding capacity (Meche 2017). Perlite is a volcanic rock that is heated and expanded to become a lightweight material. Because it is heated to 760-1090 °C, it is sterile. Perlite improves drainage and aeration by creating tiny air tunnels that allow water and air to flow freely to the roots. Perlite can hold 3-4 times its weight in water, yet will not become soggy (Kueper 2010; Meche 2017). All growing media materials were purchased from E-Tartes Company (İzmir, Turkey). No pre-plant fertilization was included in the media.

3.3. Priming Treatments

Based on results of the preliminary experiments, KNO_3 and KH_2PO_4 were chosen as priming agents. The priming agents were supplemented with 0, 25, 50, 75, or 100 $mg.L^{-1}$

Prohexadione Calcium (Regalis, BASF 125 10W containing 10% Prohexadione-Ca as the active ingredient). For all the treatments, the seeds were surface disinfested in 1% (active ingredient) sodium hypochlorite (NaOCl) for 10 min to eliminate seed-borne microorganisms. After disinfestation, they were washed under running tap water and surface moisture was removed by placing them between sterile paper towels for 30 min at room temperature.

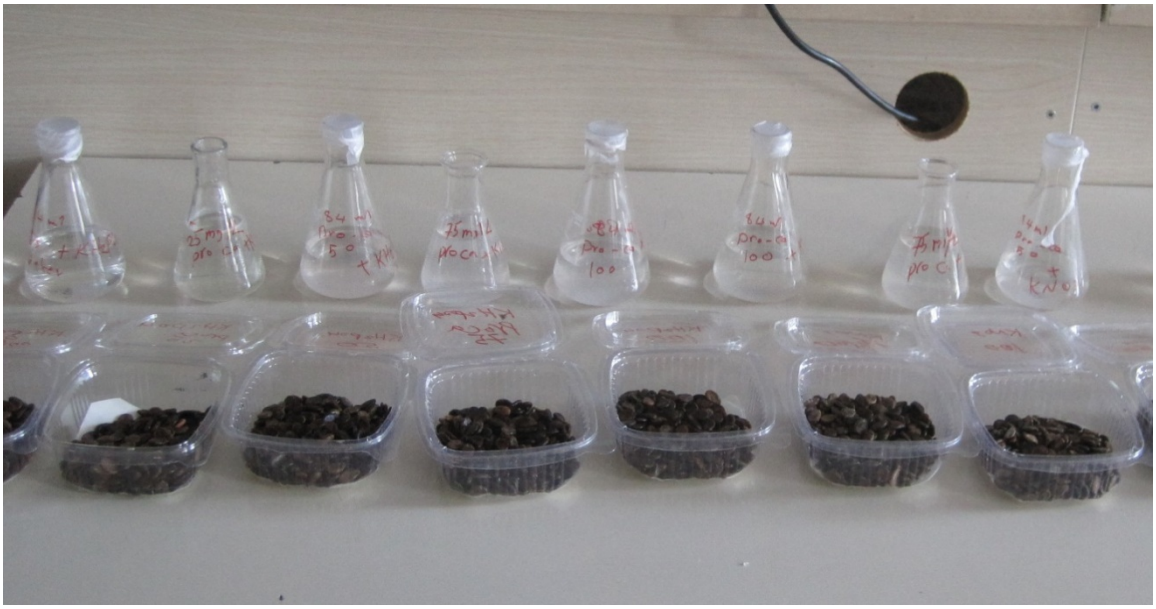

Figure 3.4. The boxes used during priming process

Priming was accomplished by imbibing melon and watermelon seeds for (4 and 6 respectively) days at 25 °C in darkness in solutions of KNO_3 or KH_2PO_4, each at -1.50 MPa, containing 0, 25, 50, 75, or 100 $mg.L^{-1}$ Pro-Ca. The melon and watermelon seeds were placed in covered plastic germination boxes (10 × 10 × 4 cm) on double layers of filter paper (Whatman #1) saturated with 8 mL priming solution (Figure 3.4). Following priming, the seeds from each box were washed in a sieve and rinsed under running tap water to remove priming chemicals and left to surface dry on drying papers placed in petri dishes under room conditions (20 °C and 45% relative humidity) for 24 h. Untreated dry seeds were taken as control.

3.4. Germination and Emergence Tests

Germination and emergence tests were carried out in a growth chamber (Model ICE 256, Memmert, Germany) at 15 and 20 °C. Melon and watermelon seeds were placed on two layers of filter paper moistened with 2 mL of distilled water in sterile standard 90 x 15.7 mm (diameter x height) petri plates (Figure 3.5). Treatments were arranged in a completely randomized design with four replications of 25 seeds (Figure 3.5). The filter papers were moistened with distilled water as needed.

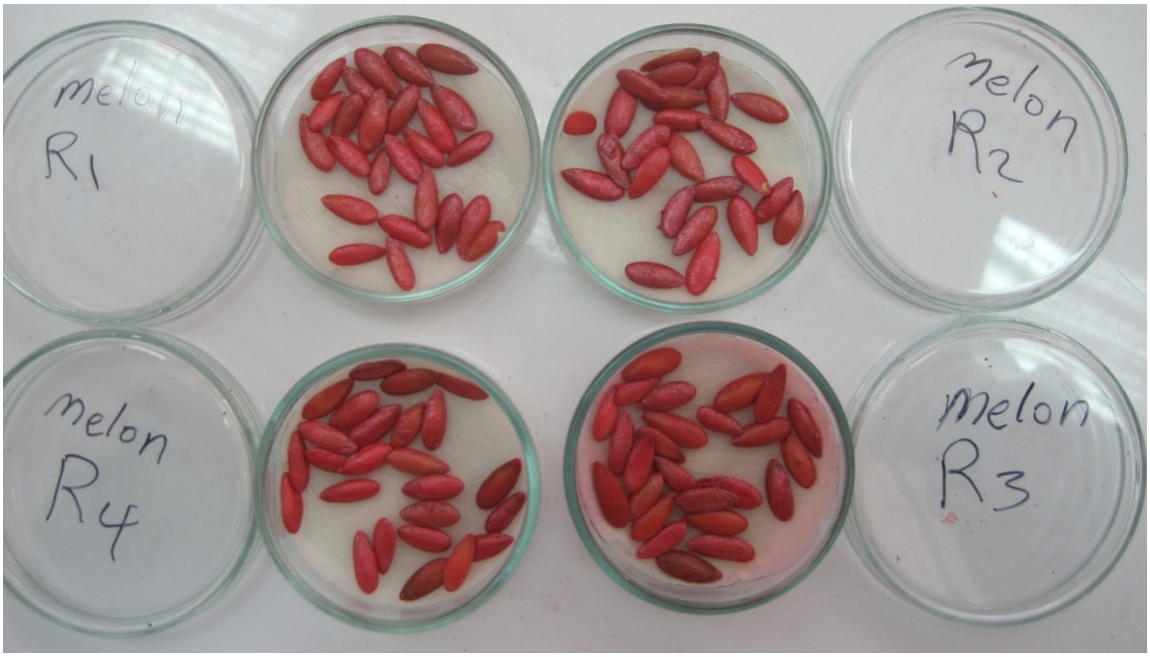

Figure 3.5. Melon seeds germinated in petri plates

Germination throughout the paper is defined as visible radicle protrusion through the seed coat and pericarp (Figure 3.6). The numbers of the germinated seeds were recorded daily until no further germination occurred (18 d). From the total number of seeds germinated, final germination percentage (FGP) and its angular transformation (arcsine$\sqrt{FGP}$), mean time to germination (MTG), and germination index (GI) were calculated (Ellis and Roberts 1981).

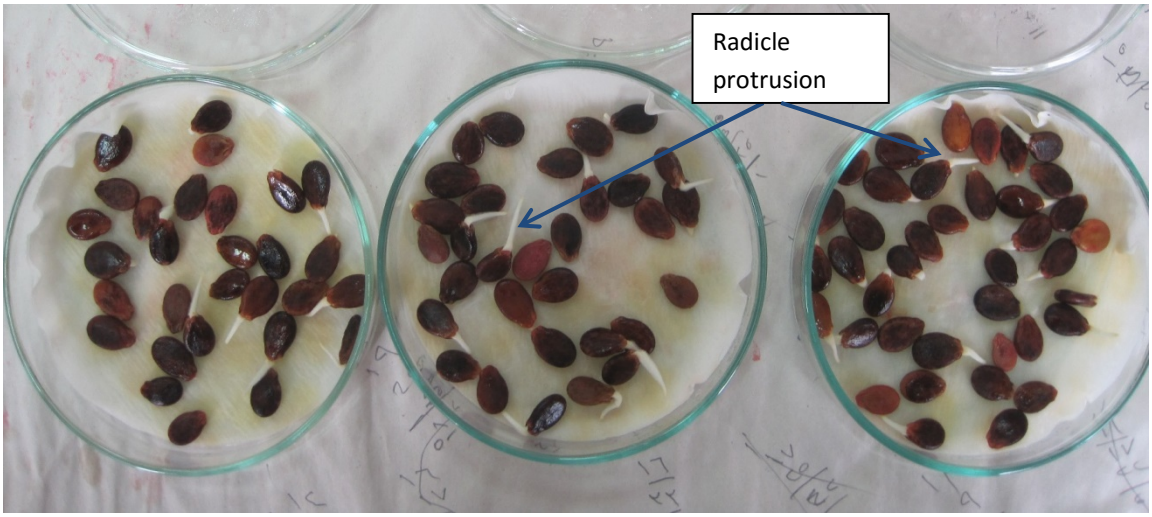

Figure 3.6. Visible radicle protrusion through the seed coat and pericarp

For emergence test, seeds were primed as described above and 25 seeds from each treatment were planted into 1.5 cm depth in 7 × 5 cm (diameter × height) round plastic cups filled with growth medium consisting of peat and perlite in the ratio of 4:1 (Figure 3.7.).

Figure 3.7. Round plastic cups used in the emergence tests.

The cups were watered and placed in the same growth chamber used in germination test. The cups were moistened with distilled water as needed. Seedling emergence was recorded daily for 18 days. The seedlings were counted as emerged when the hypocotyls appeared above the surface of the growing media (Figure 3.8.). Final emergence percentage (FEP) and its angular transformation (arcsine√FEP), mean time to emergence (MTE), and emergence index (EI) were calculated.

Figure 3.8. Emerging melon seedlings.

4.5. Germination and Emergence Parameters

4.5.1. Final germination percentage [FGP (%)]:

$$FGP = \frac{\text{Number of germinated seeds after 18 days}}{\text{Total number of seeds tested}} \text{ X } 100 \qquad (4.5.1)$$

It was calculated according to the germination count taken after 18 days and expressed as percentage according to the following equation described by (Ellis and Roberts 1981) and (Ruan et al. 2002).

4.5.2. Mean time to germination (MTG): It was calculated to the following equation of (Ellis and Roberts 1981).

$$MGT = \frac{\sum Dn}{\sum n} \quad (4.5.2)$$

Where n is the number of seeds, which were germinated on day D, and D is number of days counted from the beginning of germination.

4.5.3. Germination index (GI): It was calculated as described in the Association of Official Seed Analysts (AOSA 1983) by following formula:

$$GI = \sum \left(\frac{GT}{Tt}\right) \quad (4.5.3)$$

Where GI is the germination index, G is the number of seeds, which were germinated on day T, t is number of days counted from the beginning of germination.

4.5.4. Final emergence percentage (FEP): It was calculated according to the emergence count taken after 18 days and expressed as percentage according to the following equation described by (Ellis and Roberts 1981) and (Ruan et al. 2002).

$$FEP = \frac{\text{Number of emerged seeds after 18 days}}{\text{Total number of seeds tested}} \text{ X } 100 \quad (4.5.4)$$

4.5.5. Mean time to emergence (MTE): It was calculated to the following equation of (Ellis and Roberts 1981).

$$MET = \frac{\sum (Dn)}{\sum n} \quad (4.5.5)$$

Where n is the number of seeds, which were emerged on day D, and D is number of days counted from the beginning of emergence.

4.5.6. Emergence index (EI): It was calculated as described in the Association of Official Seed Analysts (AOSA 1983) by following formula:

$$EI = \sum(\frac{ET}{Tt}) \quad (4.5.6)$$

Where EI is the emergence index, E is the number of seeds, which were emerged on day T, t is number of days counted from the beginning of emergence.

3.7. Experimental Design and Statistical Analysis

The experiments were arranged according to completely randomized design with three replicates, each replicate having 25 seeds. The experiments were repeated twice. Mean values of the germination and emergence parameters were statistically analyzed by SAS ANOVA procedure to evaluate the significant effects of the priming and Pro-Ca doses. Means were separated by using Duncan's Multiple Range Test (DMRT) at a significance level of $P \leq 0.05$.

4. RESULTS

4.1. Melon Results

4.1.1. Final Germination Percentage (FGP)

Data regarding Effect of priming treatments on final germination percentage (FGP) of melon seeds at low temperatures (15 and 20 °C) is given in table 4.1.1. In the priming treatments, the FGP of melon seeds ranged from 5.33% to 28% at 15°C, and from 53.33% to 82.67% at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on mean time of germination of melon seeds at both temperatures.

Table 4.1.1. Effects of priming treatments on final germination percentage [FGP and angular transformation (in brackets)] of melon seeds at 15 and 20 °C

Priming treatments		**FGP (%)**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	24.00 [29.33] ab	77.33 [61.67] ab
	25	28.00 [31.67] a	77.33 [61.67] ab
	50	24.00 [29.33] ab	82.67 [65.67] a
	75	18.67 [25.66] bc	74.67 [60.00] ab
	100	25.33 [30.00] ab	82.67 [65.00] a
KH_2PO_4	0	10.67 [18.67] de	58.67 [50.00] c
	25	14.67 [22.33] cd	69.33 [56.67] b
	50	14.67 [22.33] cd	69.33 [56.67] b
	75	8.00 [16.00] ef	57.33 [49.33] c
	100	5.33 [13.33] f	58.67 [49.67] c
Nonprimed seeds		9.33 [17.33] ef	53.33 [46.67] c
$LSD_{0.05}$		4.81	6.18
Significance		***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

Results showed that priming treatments significantly improved FGP of melon seeds as

compared to control treatment (non-primed seeds). The seeds primed with KNO_3 supplemented with Pro-Ca had higher FGP than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds in both temperatures (Table 4.1.1). In the germination test conducted at 15°C, the highest FGP (28%) was obtained from the seeds primed in KNO_3 with 25 $mg.L^{-1}$ Pro-Ca followed by the treatments of KNO_3 with 0 and 50 $mg.L^{-1}$ Pro-Ca (24%) in the same statistical group. KH_2PO_4 supplemented with 75 and 100 $mg.L^{-1}$ Pro-Ca or non-primed seeds resulted in the lowest FGP (8.00%, 5.33% and 9.33%, respectively) at 15°C. There was no statistical difference among the treatments of KNO_3 supplemented with Pro-Ca levels in terms of FGP at 20°C. KH_2PO_4 supplemented with 75 and 100 $mg.L^{-1}$ Pro-Ca or non-primed seeds resulted in the lowest FGP (57.33%, 58.67% and 53.33%, respectively) at 20°C, which is similar to the results obtained at 15°C.

4.1.2. Mean Germination Time (MGT)

Data regarding effect of priming treatments on mean germination time (MGT) of melon seeds at low temperatures (15, 20 °C) is given in table 4.1.2 In the priming treatments, the MEG of melon seeds ranged from 11.13 to 15.00 days at 15°C, and from 7.69 to 11.42 days at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on mean germination time of melon seeds at both temperatures.

Results of the current study showed that priming treatments were more effective on MGT, and significantly improved MGT of melon seeds as compared to control treatment (non-primed seeds). At 15 °C, the control treatment had highest MGT (15.00 days) among the treatment and it was significantly different from other treatments (Table 4.1.2). The priming treatments decreased the MGT in melon seeds at 15°C compared to the non-primed seeds. In other words, they shortened the mean germination time compared to the control (non-primed seeds).

At temperature of 20°C, melon seeds primed with KNO_3 supplemented with Pro-Ca (except for 100 mgL^{-1} dose) had lower MGT than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds (Table 4.1.2). KNO_3 supplemented with 0. 25, and 50 mg L^{-1} Pro-Ca gave the lowest MGT values (7.72, 8.26 and 7.69 days, respectively). KH_2PO_4 supplemented with 100 mg L^{-1} Pro-Ca gave the highest MTG

value (11.42 days), which means that the melon seeds primed with it took longer time to germinate compared to treatments.

Table 4.1.2. Effects of priming on mean germination time [MGT] of melon seeds at 15 and 20 °C

Priming treatments		**MGT (Days)**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	13.31 bc	7.72 d
	25	11.13 f	8.26 d
	50	11.55 def	7.69 d
	75	11.39 ef	9.28 c
	100	12.47 bcdef	10.17 bc
KH_2PO_4	0	12.61 bcde	10.10 bc
	25	11.95 cdef	9.84 bc
	50	12.69 bcde	10.38 b
	75	13.66 bc	10.16 bc
	100	12.83 bcd	11.42 a
Nonprimed seeds		15.00 a	9.52 bc
$LSD_{0.05}$		1.43	0.90
Significance		***	***

*** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

4.1.3. Germination Index (GINDEX)

Data regarding effect of priming treatments on germination index (GINDEX) of melon seeds at low temperatures (15, 20 °C) is given in table 4.1.3. In the priming treatments, the GINDEX of melon seeds ranged from 0.10 to 0.65 at 15°C, and from 1.47 to 3.17 at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on GINDEX of melon seeds at both temperatures.

Results showed that some priming treatments significantly improved GINDEX of melon seeds as compared to control treatment (non-primed seeds). The seeds primed with KNO_3 supplemented with Pro-Ca had higher GINDEX than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds at both temperatures tested (Table 4.1.3).

Table 4.1.3. Effects of priming on germination index [GINDEX] of melon seeds at 15 and 20 °C

Priming treatments		GINDEX	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	0.47 bc	2.83 ab
	25	0.65 a	2.64 b
	50	0.54 ab	3.17 a
	75	0.43 bcd	2.47 b
	100	0.53 ab	2.43 b
KH_2PO_4	0	0.22 efg	1.81 cd
	25	0.31 cde	2.00 c
	50	0.29 def	1.90 cd
	75	0.14 fg	1.56 de
	100	0.10 g	1.47 e
Non-primed seeds		0.16 efg	1.72 cde
$LSD_{0.05}$		0.15	0.41
Significance		***	***

*** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

The results showed that, at temperature 15°C, KNO_3 supplemented with 25 mg L^{-1} Pro-Ca gave the highest GINDEX value with 0.65 (Table 4.1.3). This treatment was followed by the KNO_3 supplemented with 50 and 100 mg L^{-1} Pro-Ca treatments (0.54 and 0.53, respectively). At temperature of 20°C, KNO_3 supplemented with 50 mg L^{-1} Pro-Ca gave the highest GINDEX value with 3.17 (Table 4.1.3). This treatment was followed by the KNO_3 alone treatment (2.83). KH_2PO_4 supplemented with 100 mg L^{-1} Pro-Ca gave lowest GINDEX value which is 1.47 at 20°C (Table 4.1.3).

4.1.4. Final Emergence Percentage (FEP)

Data regarding effect of priming treatments on final emergence percentage (FEP) of melon seeds at low temperatures (15 and 20 °C) is given in table 4.1.4. In the priming treatments, the FEP of melon seeds ranged from 9.33% to 34.67% at 15°C, and from 44.00% to 74.67% at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) at temperature 15°C and had a significant effect ($P \leq 0.01$) at temperature 20°C on Final Emergence Percentage of melon seeds.

According to the Table 4.1.4, in general, while priming treatments of KNO_3 supplemented with Pro-Ca significantly improved FEP of melon seeds KH_2PO_4

supplemented with Pro-Ca (except for 25 and 50 mg.L^{-1}) decreased FEP as compared to control treatment (non-primed seeds). The seeds primed with KNO_3 supplemented with Pro-Ca had higher FEP than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds in both temperatures (Table 4.1.4). However, there was no statistical difference among the treatments of KNO_3 supplemented with Pro-Ca levels in terms of FEP at both temperatures. Even though there were no significant differences among the KNO_3 treatments in terms of FEP at 15°C, the highest FEP value (34.67%) was obtained from the treatment of KNO_3 supplemented with 25 $mg1^{-1}$ Pro-Ca.

Table 4.1.4. Effects of priming treatments on final emergence percentage [FEP and angular transformation (in brackets)] of melon seeds at 15 and 20 °C

Priming treatments		**FEP (%)**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	30.67 [33.33] ab	65.33 [54.33] abcd
	25	34.67 [36.00] a	60.00 [50.67] bcd
	50	29.33 [32.33] ab	74.67 [59.67] a
	75	25.33 [30.00] bc	70.67 [57.33] ab
	100	28.00 [31.67] ab	62.67 [52.33] abcd
KH_2PO_4	0	10.67 [18.67] e	56.00 [48.67] cde
	25	20.00 [26.67] cd	60.00 [50.67] bcd
	50	16.00 [23.67] d	68.00 [56.00] abc
	75	10.67 [18.67] e	56.00 [48.33] cde
	100	9.33 [17.33] e	53.33 [46.67] de
Nonprimed seeds		16.00 [23.67] d	44.00 [41.67] e
$LSD_{0.05}$		4.53	7.94
Significance		***	**

** Significant at P<0.01, *** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

As for FEP at 20°C, the highest FEP value (74.67%) was obtained from the treatment of KNO_3 supplemented with 50 $mg1^{-1}$ Pro-Ca (Table 4.1.4).

4.1.5. Mean Emergence Time (MET)

Data regarding effect of priming treatments on mean emergence time (MET) of melon seeds at low temperatures (15, 20 °C) are given in table 4.1.5. In the priming treatments, the MEG of melon seeds ranged from 13.05 to 16.71 days at 15°C, and from 9.35 to 11.83 days at 20°C. Data analysis showed that priming treatments had a significant effect

($P \leq 0.001$) at temperature 15°C and significant effect ($P \leq 0.05$) at temperature 20°C on mean time of Germination of melon seeds at both temperatures.

Results of the current study showed that priming treatments were more effective on MET and significantly improved MET of melon seeds as compared to control treatment (non-primed seeds). At 15 °C, the control treatment had highest MGT (16.71 days) among the treatment and it was significantly different from other treatments (Table 4.1.5). This means that the melon seeds primed with it took longer time to germinate compared to treatments. The priming treatments decreased the MET in melon seeds at 15°C compared to the non-primed seeds. In other words, they shortened the mean emergence time compared to the control (non-primed seeds).

Table 4.1.5. Effects of priming on mean emergence time [MET] of melon seeds at 15 and 20 °C

Priming treatments		**MET (Days)**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	14.04 bcd	9.77 b
	25	13.93 bcd	10.74 ab
	50	14.79 b	9.35 b
	75	14.25 bc	9.52 b
	100	13.77 bcd	9.57 b
KH_2PO_4	0	14.44 bc	10.49 ab
	25	13.57 cd	10.10 b
	50	14.03 bcd	10.51 ab
	75	14.38 bc	10.84 ab
	100	13.05 d	11.79 a
Nonprimed seeds		16.71 a	11.83 a
$LSD_{0.05}$		1.12	1.54
Significance		***	*

* Significant at P<0.05, *** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

Even though there were no significant differences among the KNO_3 priming treatments, at temperature of 15°C, KNO_3 supplemented with 50 mg L^{-1} Pro-Ca gave the highest MET value (14.79 days). Similarly, although there were no significant differences among the KH_2PO_4 treatments, KH_2PO_4 supplemented with 75 mg L^{-1} Pro-Ca gave the highest MET value (14.38 days).

4.1.6. Emergence Index (EINDEX)

Data regarding effect of priming treatments on emergence index (EINDEX) of melon seeds at low temperatures (15, 20 °C) is given in table 4.1.6 In the priming treatments, the EINDEX of melon seeds ranged from 0.18 to 0.63 at 15°C, and from 1.05 to 2.14 at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on Emergence index of melon seeds at both temperatures.

According to the Table 4.1.6, in general, priming treatments of KNO_3 supplemented with Pro-Ca significantly improved EINDEX of melon seeds as compared to control treatment (non-primed seeds) and the treatments of KH_2PO_4 at both temperatures (4.1.4). However, there were no statistical differences among the treatments of KNO_3 supplemented with Pro-Ca levels (except for 100 $mg1^{-1)}$ in terms of EINDEX. Even though there were no significant differences among the KNO_3 treatments in terms of EINDEX at 15°C, the highest EINDEX value (0.63) was obtained from the treatment of KNO_3 supplemented with 25 $mg1^{-1}$ Pro-Ca. As for EINDEX at 20°C, the highest EINDEX value (2.14) was obtained from the treatment of KNO_3 supplemented with 50 $mg1^{-1}$ Pro-Ca (Table 4.1.6).

Table 4.1.6. Effects of priming on emergence index [EINDEX] of melon seeds at 15 and 20 °C

Priming treatments		**EINDEX**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	0.55 ab	1.84 abc
	25	0.63 a	1.96 ab
	50	0.50 ab	2.14 a
	75	051 ab	1.74 abc
	100	045 bc	1.54 cd
KH_2PO_4	0	0.18 e	1.48 cd
	25	0.38 cd	1.6 bcd
	50	0.29 de	1.79 abc
	75	0.19 e	1.46 cde
	100	0.18 e	1.28 de
Nonprimed seeds		0.25 de	1.05 e
$LSD_{0.05}$		0.124	0.412
Significance		***	***

*** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

4.1.7. Relationships between Germination and Emergence properties of Melon Seeds at 15 °C

The extrovert correlation analysis showed that there were numerous significant correlations among variables used in germination and emergence properties of melon seeds at temperature 15 °C (Table 4.1.7).

The data showed strong positive correlation between FGP and GI (r =0.979). Similarly, FEP exhibited strong positive correlation with the EI (r = 0.987). Mean germination time (MGT) had positive correlation coefficients with mean emergence time (MET) of primed seeds (r=0.431).

Table 4.1.7. Pearson correlation coefficients of the germination and emergence properties of melon seeds at 15 °C

	FGP	MGT	GI	FEP	MET	EI
FGP	1.00					
MGT	-0.498**	1.00				
GI	0.979**	-0.596**	1.00			
FEP	0.918**	-0.461**	0.907**	1.00		
MET	-0.103	0.431*	-0.142	-0.055	1.00	
EI	0.923**	-0.505**	0.924**	0.987**	-0.182	1.00
Numbers followed by * significant at P≤0.05, ** significant at P≤0.01,						

The results of the current study revealed negative correlations between MGT and GI (r= -0.596). The result showed strong positive correlation between FGP each one FEP (r =0.918) or EI (r=923). Mean germination time had negative correlation between each one of the GI (r=0.596) or FEG (r=461) or EI (r=0.505). The data showed strong positive correlation between GI each one of FEP (r =0.907) or EI (r=924).

4.1.8. Relationships between Germination and Emergence properties of Melon Seeds at 20 °C

The correlation analysis showed that there were numerous significant correlations among variables used in germination and emergence properties of melon seeds at temperature 20 °C (Table 4.1.8).

Table 4.18. Pearson correlation coefficients of the germination and emergence properties of melon seeds at 20 °C

	FGP	MGT	GI	FEP	MET	EI
FGP	1.00					
MGT	-0.512**	1.00				
GI	0.881**	-0.827**	1.00			
FEP	0.715**	-0.330	0.622**	1.00		
MET	-0.559**	0.442*	-0.548**	-0.506**	1.00	
EI	0.740**	-0.419*	0.675**	0.953**	-0.727	1.00
Numbers followed by * significant at P≤0.05, ** significant at P≤0.01						

The data showed strong positive correlation between FGP and GI (r =0.881). Similarly, FEP exhibited strong positive correlation with the EI (r = 0.740). Mean germination time (MGT) had positive correlation coefficients with mean emergence time (MET) of primed seeds (r=0.442). The result showed positive correlation between FGP each one FEP (r =0.715) or EI (r=740). The FGP has negative correlation with MET (r=0.559). Mean germination time had negative correlation between each one of the GI (r=0.596) or FEG (r=461) or EI (r=0.505). The data showed strong positive correlation between GI each one FEP (r =0.907) or EI (r=924).

4.2. Watermelon Results

4.2.1. Final Germination Percentage (FGP)

Data regarding effect of priming treatments on final germination percentage (FGP) of watermelon seeds at low temperatures (15 and 20 °C) is given in Table 4.2.1. In the priming treatments, the FGP of watermelon seeds ranged from 9.33% to 64.00% at 15°C, and from 30.67% to 88.00% at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on mean time of germination of watermelon seeds at both temperatures.

Results showed that priming treatments significantly improved FGP of watermelon seeds as compared to control treatment (non-primed seeds). The seeds primed with KNO_3 supplemented with Pro-Ca had higher FGP than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca at both temperatures (Table 4.2.1). The seeds primed with KH_2PO_4 supplemented with Pro-Ca decreased the FGP of watermelon seeds compared to

the non-primed seeds at both temperatures tested (Table 4.2.1).

Table 4.2.1. Effects of priming treatments on final germination percentage [FGP and angular transformation (in brackets)] of watermelon seeds at 15 and 20 °C

Priming treatments		FGP (%)	
Priming Agent	Pro-Ca (mg l^{-1})	15°C	20°C
KNO_3	0	50.67 [45.33] b	88.00 [70.00] a
	25	60.00 [50.66] ab	80.00 [63.33] b
	50	61.33 [51.66] ab	77.33 [61.66] b
	75	64.00 [53.33] a	68.00 [55.66] c
	100	60.00 [50.66] ab	62.67 [52.33] c
KH_2PO_4	0	9.33 [17.33] e	38.67 [38.66] d
	25	13.33 [21.33] de	37.33 [37.66] de
	50	16.00 [23.00] de	33.33 [35.00] de
	75	18.67 [24.66] d	30.67 [33.33] e
	100	20.00 [26.66] d	36.00 [36.66] de
Non-primed seeds		33.33 [35.55] c	77.33 [61.66] b
$LSD_{0.05}$		6.43	5.18
Significance		***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

In the germination test conducted at 15°C, the highest FGP (28%) was obtained from the seeds primed in KNO_3 with 75 $mg.L^{-1}$ Pro-Ca. This treatment was followed by the treatments of KNO_3 with 25, 50 and 100 $mg.L^{-1}$ Pro-Ca (60.00%, 61.3 and 60.00%, respectively) in the same statistical group. KH_2PO_4 alone treatment resulted in the lowest FGP (9.33%) at 15°C.

There was no statistical difference among the treatments of KNO_3 supplemented with Pro-Ca levels in terms of FGP at 20°C. KH_2PO_4 supplemented with 75 and 100 $mg.L^{-1}$ Pro-Ca or non-primed seeds resulted in the lowest FGP (57.33%, 58.67% and 53.33%, respectively) at 20°C, which is similar to the results obtained at 15°C.

At 20°C, all priming treatments with KH_2PO_4 and the treatments of KNO_3 supplemented with 75 or 100 $mg.L^{-1}$ Pro-Ca decreased FGP of watermelon compared to the control treatment. The highest FGP (88.00%) was obtained from the KNO_3 alone treatment.

4.2.2. Mean Germination Time (MGT)

Data regarding effect of priming treatments on mean germination time (MGT) of watermelon seeds at low temperatures (15 and 20 °C) is given in Table 4.2.2. In the priming treatments, the MEG of watermelon seeds ranged from 13.25 to 16.67 days at 15°C, and from 6.03 to 10.38 days at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.05$) at 15°C and a significant effect ($P \leq 0.001$) at 20°C on mean germination time of watermelon seeds.

Results of the current study showed that priming treatments were more effective on MGT and significantly improved MGT of watermelon seeds as compared to control treatment (non-primed seeds). At 15 °C, the control treatment had highest MGT (16.67 days) among the treatment and it was significantly different from other treatments (Table 4.2.2). The priming treatments decreased the MTG in watermelon seeds at 15°C compared to the non-primed seeds. In other words, they shortened the mean germination time compared to the control (non-primed seeds). There was no statistical difference among the treatments of KNO_3 and KH_2PO_4 supplemented with Pro-Ca levels in terms of MGT at 15°C (Table 4.2.2).

Table 4.2.2. Effects of priming treatments on watermelon germination time [MGT] of watermelon seeds at 15 and 20 °C

Priming treatments		**MGT (Days)**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	14.03 b	6.03 e
	25	14.90 ab	8.02 d
	50	13.93 b	9.00 bcd
	75	14.95 ab	9.42 abc
	100	13.30 b	9.65 abc
KH_2PO_4	0	13.50 b	9.46 abc
	25	13.25 b	9.97 ab
	50	13.39 b	8.78 cd
	75	14.50 b	9.72 abc
	100	14.15 b	10.38 a
Nonprimed seeds		16.67 a	8.8 cd
$LSD_{0.05}$		1.97	1.08
Significance		*	***

* Significant at P<0.05, *** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

At temperature of 20°C, some priming treatments, especially KH_2PO_4 supplemented with 100 mg L^{-1} Pro-Ca levels increased the MGT compared to the non-primed control, which means that they extended the MGT of watermelon seeds. KNO_3 supplemented with 0 mg.L^{-1} Pro-Ca had lowest MGT value (6.03 days). In other words, it shortened the mean germination time compared to the other treatments (Table 4.2.2).

4.2.3. Germination Index (GINDEX)

Data regarding effect of priming treatments on germination index (GINDEX) of watermelon seeds at low temperatures (15, 20 °C) is given in table 4.2.3. In the priming treatments, the GINDEX of watermelon seeds ranged from 0.17 to 1.16 at 15°C, and from 0.84 to 4.20 at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on GINDEX of watermelon seeds at both temperatures.

Table 4.2.3. Effects of priming on germination index [GINDEX] of watermelon seeds at 15 and 20 °C

Priming treatments		**GINDEX**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	0.98 a	4.20 a
	25	1.01 a	2.84 b
	50	1.11 a	2.64 b
	75	1.07 a	2.04 c
	100	1.16 a	1.80 c
KH_2PO_4	0	0.17 c	1.25 d
	25	0.26 c	1.07 de
	50	0.29 bc	1.15 de
	75	0.32 bc	0.91 de
	100	0.35 bc	0.84 e
Non-primed seeds		0.51 b	2.48 b
$LSD_{0.05}$		0.23	0.39
Significance		***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

Results showed that some priming treatments significantly improved GINDEX of watermelon seeds as compared to control treatment (non-primed seeds) at both temperatures. The seeds primed with KNO_3 supplemented with Pro-Ca had higher GINDEX than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-

primed seeds at 15°C (4.2.3). However, there were no statistical differences among the treatments of KNO_3 supplemented with Pro-Ca levels in terms of GINDEX at 15°C (Table 4.2.3). At 15°C, the treatments of KH_2PO_4 supplemented with various Pro-Ca levels did not have any positive or negative effect on GINDEX of watermelon seeds compared to the control treatment (Table 4.2.3).

At 20°C, all priming treatments with KH_2PO_4 and the treatments of KNO_3 supplemented with 75 or 100 mg L^{-1} Pro-Ca decreased GINDEX of watermelon compared to the control treatment. The highest GINDEX value (4.20) was obtained from the KNO_3 alone treatment (Table 4.2.3).

4.2.4. Final Emergence Percentage (FEP)

Data regarding the effect of priming treatments on final emergence percentage (FEP) of watermelon seeds at low temperatures (15 and 20 °C) is given in Table 4.2.4. In the priming treatments, the FEP of watermelon seeds ranged from 50.67 to 86.67% at 15°C, and from 74.67 to 90.67% at 20°C.

Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) at temperature 15°C and had a significant effect ($P \leq 0.01$) at temperature 20°C on FEP of watermelon seeds.

According to the Table 4.2.4, the priming treatments (except for KH_2PO_4 supplemented with 0 and 50 mg.L^{-1} Pro-Ca) significantly improved FEP of watermelon seeds. The seeds primed with KNO_3 supplemented with Pro-Ca had higher FEP than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds at 15 °C (Table 4.2.4). In terms of FEP of watermelon seeds at 15°C, the highest FEP values (82.67 and 86.67%) were obtained from the treatment of KNO_3 supplemented with 75 and 100 mg1^{-1} Pro-Ca, respectively. On the other hand, the lowest FEP value (50.67%) was obtained from the control treatment (non-primed seeds) at 15 °C (Table 4.2.4).

Table 4.2.4. Effects of priming treatments on final emergence percentage [FEP and angular transformation (in brackets)] of watermelon seeds at 15 and 20 °C

Priming treatments		FEP (%)	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	66.67 [55.00] de	90.67 [72.66] a
	25	73.33 [59.00] cd	81.33 [64.33] bc
	50	76.00 [60.66] bc	84.00 [66.00] b
	75	82.67 [65.00] ab	80.00 [63.33] bcd
	100	86.67 [68.66] a	77.33 [61.66] cd
KH_2PO_4	0	57.33 [49.00] fg	80.00 [63.33] bcd
	25	58.67 [50.00] fg	77.33 [61.66] cd
	50	62.67 [52.33] ef	74.67 [59.66] d
	75	62.67 [52.33] ef	76.00 [60.66] cd
	100	64.00 [53.33] ef	78.67 [62.33] bcd
Non-primed seeds		50.67 [45.33] g	80.00 [63.33] bcd
$LSD_{0.05}$		4.70	4.15
Significance		***	***

*** significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

As for FEP at 20°C, the highest FEP value (90.67%) was obtained from the treatment of KNO_3 alone treatment (Table 4.2.4). Rest of the priming treatments and non-primed seeds gave the similar FEPs and there were statistically in the same group.

4.2.5. Mean Emergence Time (MET)

Data regarding effect of priming treatments on mean emergence time (MET) of watermelon seeds at low temperatures (15 and 20 °C) are given in Table 4.2.5. In the priming treatments, the MET of watermelon seeds ranged from 14.71 to 18.80 days at 15°C, and from 8.17 to 11.06 days at 20°C. Data analysis showed that priming treatments had a significant effect ($P \leq 0.001$) on MET of watermelon seeds at both temperatures.

Results of the current study showed that priming treatments were more effective on MET and significantly improved MET of watermelon seeds as compared to control treatment (non-primed seeds). At 15 °C, the control treatment had highest MGT (18.80 days) among the treatment and it was significantly different from other treatments (Table 4.2.5). This means that the watermelon seeds primed with it took longer time to germinate compared to treatments. The priming treatments decreased the MET in

watermelon seeds at 15°C compared to the non-primed seeds. In other words, they shortened the MET compared to the control (non-primed seeds). Even though there were no significant differences among the KNO_3 priming treatments, at temperature of 15°C, KNO_3 supplemented with 25 and 100 mg L^{-1} Pro-Ca gave the lowest MET values (14.75 and 14.87 days, respectively). Similarly, although there were no significant differences among the KH_2PO_4 treatments, KH_2PO_4 supplemented with 100 mg L^{-1} Pro-Ca gave the lowest MET value (14.71 days).

Table 4.2.5. Effects of priming treatments on mean emergence time [MET] of watermelon seeds at 15 and 20 °C

Priming treatments		**MET (Days)**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	15.98 b	8.17 g
	25	14.75 d	8.60 f
	50	15.47 bcd	9.25 e
	75	15.30 bcd	9.82 d
	100	14.87 d	10.46 bc
KH_2PO_4	0	15.44 bcd	9.86 d
	25	15.77 bc	10.70 ab
	50	15.37 bcd	9.86 d
	75	14.99 cd	10.02 d
	100	14.71 d	11.06 a
Non-primed seeds		18.80 a	10.15 cd
$LSD_{0.05}$		0.81	0.38
Significance		***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

At 20 °C, KNO3 alone had lowest MET value (8.17) among all treatments and this treatment was followed by the treatments of KNO_3 supplemented with 25 and 50 mg.L^{-1} Pro-Ca (8.60 and 9.25 days respectively).

4.2.6. Emergence Index (EINDEX)

Data regarding effect of priming treatments on emergence index (EINDEX) of watermelon seeds at low temperatures (15 and 20 °C) is given in table 4.2.6. In the priming treatments, the EINDEX of watermelon seeds ranged from 0.68 to 1.47 at 15°C, and from 1.79 to 2.78 at 20°C. Data analysis showed that priming treatments had a

significant effect ($P \leq 0.001$) on EINDEX of watermelon seeds at both temperatures.

According to the Table 4.2.6, at 15 °C, all priming treatments significantly improved EINDEX of watermelon seeds as compared to non-primed seeds (4.2.6). Except for KNO_3 alone treatment, the treatments of KNO_3 supplemented with Pro-Ca had higher EINDEX values compared to the treatments of KH_2PO_4 supplemented with Pro-Ca at 15 °C (Table 4.2.6). Among the all treatments KNO_3 supplemented with 75 and 100 $mg1^{-1}$ Pro-Ca gave the highest EINDEX values (1.36 and 1.47, respectively) while the control treatment had the lowest EINDEX value (0.68).

Table 4.2.6. Effects of priming treatments on emergence index [EINDEX] of watermelon seeds at 15 and 20 °C

Priming treatments		**EINDEX**	
Priming Agent	**Pro-Ca (mg l^{-1})**	**15°C**	**20°C**
KNO_3	0	1.06 cd	2.78 a
	25	1.25 b	2.38 b
	50	1.24 b	2.31 b
	75	1.36 ab	2.06 c
	100	1.47 a	1.86 de
KH_2PO_4	0	0.94 d	2.05 c
	25	0.94 d	1.82 e
	50	1.02 cd	1.90 cde
	75	1.05 cd	1.91 cde
	100	1.09 c	1.79 e
Non-primed seeds		0.68 e	1.99 cd
$LSD_{0.05}$		0.12	0.16
Significance		***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Fisher's Least Significant Difference (LSD) test.

As for EINDEX at 20°C, except for KNO_3 supplemented with 75 and 100 $mg1^{-1}$ Pro-Ca, the treatments of KNO_3 supplemented with Pro-Ca had higher EINDEX values compared to control and also the treatments of KH_2PO_4 supplemented with Pro-Ca at 20 °C. The highest EINDEX value (2.78) was obtained from the treatment of KNO_3 alone treatment (Table 4.2.6).

4.2.7. Relationships between Germination and Emergence properties of Watermelon Seeds at 15 °C

The correlation analysis showed that there were numerous significant correlations among variables used in germination and emergence properties of watermelon seeds at temperature 15 °C (Table 1).

Table 4.2.7. Pearson correlation coefficients of the germination and emergence properties of watermelon seeds at 15 °C

	FGP	MGT	GI	FEP	MET	EI
FGP	1.00					
MGT	0.222	1.00				
GI	0.969**	0.013	1.00			
FEP	0.715**	-0.122	0.740**	1.00		
MET	-0.071	0.429*	-0.130	-0.474**	1.00	
EI	0.633**	-0.218	0.669**	0.969**	-0.670**	1.00
Numbers followed by * significant at P≤0.05, ** significant at P≤0.01,						

The data showed strong positive correlation between FGP and GI (r =0.969). Similarly, FEP exhibited positive correlation with the EI (r = 0.969). Mean germination time (MGT) had positive correlation coefficients with mean emergence time (MET) of primed seeds (r=0.429). The data showed strong positive correlation between GI each one of FEP (r =0.740) or EI (r=669). The result showed positive correlation between FGP each one FEP (r =0.715) or EI (r=633).

4.2.8. Relationships between Germination and Emergence properties of Watermelon Seeds at 20 °C

The correlation analysis showed that there were numerous significant correlations among variables used in germination and emergence properties of melon seeds at temperature 20 °C (Table 4.2.8). The data showed strong positive correlation between FGP and GI (r =0.936). Similarly, FEP exhibited positive correlation with the EI (r = 0.883). Mean germination time (MGT) had positive correlation coefficients with mean emergence time (MET) of primed seeds (r=0.823). However, results of the current study revealed strong negative correlations between MGT and GI (r= -0.843).

Table 4.2.8. Pearson correlation coefficients of the germination and emergence properties of watermelon seeds at 20 °C

	FGP	MGT	GI	FEP	MET	EI
FGP	1.00					
MGT	-0.639	1.00				
GI	0.936**	-0.843**	1.00			
FEP	0.660**	-0.689**	0.779**	1.00		
MET	-0.664**	0.823**	-0.808**	-0.601**	1.00	
EI	0.744**	-0.843**	0.888**	0.883**	-0.902**	1.00
Numbers followed by * significant at P≤0.05, ** significant at P≤0.01						

The result showed positive correlation between FGP each one FEP (r =0.660) or EI (r=744). The FGP has negative correlation with MET (r=0.664). Mean germination time had negative correlation between each one of the GI (r=0.843) or FEG (r=689) or EI (r=0.843). The data showed strong positive correlation between GI each one of FEP (r =0.779) or EI (r=888) and GI had a negative correlation between MET (808). MET had negative correlation between each one FEP (r=-0.601) and EI (r=-0.902).

5. DISCUSSION

Results showed that priming treatments significantly improved FGP of and watermelon melon seeds as compared to control treatment (non-primed seeds). This finding confirms the findings of (Korkmaz 2005), who reported that priming treatments significantly improved FGP and germination rate of pepper seeds at low temperature. The results of the current study were also in agreement with those of (Ozbay and Susluoglu 2016). The seeds primed with KNO_3 supplemented with Pro-Ca had higher FGP than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds in both temperatures. This result agrees with those of (Singh et al. 2012), who reported faster and higher total germination of sorghum using KNO_3 solution.

When the mean germination times were evaluated, it was found that primed seeds were more effective on mean germination time than control at low temperature. These results are compatible with some previous studied such as sugar beet (Govahi et al. 2007), muskmelon (Korkmaz et al. 2005), eggplant (Zhang et al. 2011) reported that the primed seeds in solution KNO3 with supplemented with any one of (MeJA, ASA, Spermine, salicylic acid) had lowest mean time of germination at low temperature. It was also reported that the best treatment to seed of muskmelon for germination and emergence at low temperature was 2.5% KNO3 for 16 h in dark (Dhillon 1995). (Demir et al. 1994) reported that GA3 and KNO3 treatments influenced on eggplant seed germination and rate of germination respect comparing that of the control. On the other hand, in some studies, there are also reports that the priming did not have an effect on the mean time of germination. For example, in a study carried out by (Başay et al. 2004), it is stated that PEG and KNO3 solution in Kandil variety pepper seeds increase germination but not in mean time of germination.

Results showed that priming treatments significantly improved germination index of melon seeds as compared to control treatment (non-primed seeds). The current study

results were also in agreement with those of (Ozbay and Susluoglu 2016).

Results showed that priming treatments significantly improved FEG of melon seeds as compared to control treatment (non-primed seeds) at low temperatures. The seeds primed with KNO_3 supplemented with Pro-Ca had higher FEP than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds in both temperatures. This finding confirms the findings of (Korkmaz 2005), who reported that priming treatments significantly improved FEP and emergence rate of pepper seeds at low temperature. In another previous study, (Korkmaz et al. 2005) reported that priming muskmelon seeds with the solution of KNO_3 supplemented 1 µM MeJA and 1 mM spermine improved low temperature emergence of muskmelon seeds compared to untreated seeds and seeds primed in KNO3 solution alone. The researchers al so reported that inclusion of 1 µM MeJA and 3 mM spermine into the priming solution led to the highest emergence percentages with 90 % and 85 %, respectively, while priming in KNO3 solution in the absence of plant growth regulators resulted in significantly lower emergence percentage (31 %). The results of the current study were also in agreement with those of (Ozbay and Susluoglu 2016).

When the mean germination times were evaluated, it was found that primed to seeds was more effective on mean germination time than control at both temperatures. Some of the priming treatments decreased MET compared to the control. This result is in agreement with (Korkmaz 2005) who investigated the effects of adding plant growth regulators to priming solution on the germination and exit percentage of low-temperature sweet pepper (*Capsicum annuum* 'Demre') before and after storage. However, these results are not in agreement with those obtained on tomato rootstock (Mavi et al. 2006) and tomato (Farooq et al. 2005). They reported the primed seeds reduced mean time of emergence.

Results showed that priming treatments significantly improved germination index of melon and watermelon seeds as compared to control treatment (non-primed seeds). The seeds primed of solution KNO3 supplemented with Pro-Ca had highest Germination index than either the seeds primed with KH_2PO_4 supplemented with Pro-Ca or non-primed seeds at temperature 15°C. This result agrees with those of (Farooq 2005), who reported maximum germination index of tomato was obtained using KNO_3 solution. In a

study carried out by (Sivritepe and Şentürk 2011), priming and drying applications with water and salt solutions were compared for the physiological improvement of pepper seeds. However, these results seem to be consistent with (Parera and Cantliffe 1992), which founded that pre-sowing seed applications significantly increased the exit index (value vigor seeds)in maize.

The correlation analysis showed that there were numerous significant correlations among variables used in germination and emergence properties of watermelon seeds at temperature 15 and 20°C. At 15°C, there was a strong positive correlation between FGP and GI (r =0.969). Similarly, FEP exhibited positive correlation with the EI (r = 0.969). Mean germination time (MGT) had positive correlation coefficients with mean emergence time (MET) of primed seeds (r=0.429). These results are in agreement with (Bradford et al. 1990; Demir et al. 2008) who reported that there was a positive association between MGT and MET. However, results of the current study revealed strong negative correlations between MGT and GI (r= -0.827). These results are in line with those of (Kausar et al. 2009) who have reported that highly negative correlation was found between MGT and GI of primed sunflower seeds.

6. CONCLUSION

Temperature is one of the most factors that plant relies on it for its growth. It is important that germination and plant growth conduct under optimum condition of temperature and humidity. For optimum result for the researchers it will be useful to know temperature range, which seed germinate in higher percentages and in short time. At the stage where the germination mark as highest speeds that will be the optimal temperature.

Melon and watermelon are the important horticultural crops cultivated mostly in arid and semi-arid regions of the world. Poor germination and emergence are common phenomenon at sub-optimal temperatures which is a great concern of growers that grow melon and watermelon seedlings early spring. Various seed pretreatments have been suggested for low-temperature germination of these vegetable seeds. One of the methods used to eliminate or reduce the negative effect of low temperature on germination and emergence of seeds is priming application.

This thesis study was conducted to investigate effects of incorporating Prohexadione-Calcium (Pro-Ca) into the priming solutions on low temperature germination and emergence percentage performance of muskmelon and watermelon seeds.

The results of present experiment showed that the improvement of the percentage of germination and emergency of melon and watermelon seeds at the low temperatures, especially 15°C, was related with priming treatments. Incorporation of Pro-Ca into the priming agents especially treatments of KNO_3 further increased the percentage of germinating and emerging melon and watermelon seeds at 15 and 20°C.

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RESUME

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