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VEGETABLE RESEARCH RESULTS 2007

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INTRODUCTION

This report summarizes the results of several vegetable studies conducted during 2007. We hope this type of information is of benefit to the vegetable industry in Ohio and the Great Lakes region. These reports are also available on the OSU Vegnet website at: http://vegnet.osu.edu. Your comments and suggestions for future efforts are always welcome.

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Special thanks and appreciation to Sean Mueller, Stan Gahn and the crew at the OARDC North Central Agricultural Research Station, Fremont, OH, for their help with plot establishment, maintenance, and harvesting.

Use of ABA (Abscisic Acid) and PEG 8000 (Polyethylene Glycol) to Control Vegetable Transplant Height -2007

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Introduction:

Vegetable transplants can become tall and leggy prior to field establishment, producing challenges for growers using mechanical transplanters to establish their crops. Preliminary greenhouse research in 2005 showed that the use of ABA reduced tomato transplant heights by as much as 67% compared to untreated control plants.

Materials and Methods:

Plug trays were seeded on April 26 with 'BHN 685' (seed source: SW) plum tomatoes (288-cell plug trays) and 'Wahoo' (seed source: SW) bell peppers (200-cell plug trays). ABA (abscisic acid) was applied as a drench application on May 23 (tomatoes) and May 30 (peppers) at a rate of 100, 200 or 400 ppm five days before transplanting and PEG 8000 (polyethylene glycol) was incorporated into the growing mix (Metro-Mix) at the rate of 20g/liter of mix prior to seeding plug trays to control transplant height in vegetable transplants. Plots were mechanically transplanted on May 30 (tomatoes) and June 5 (peppers) into raised beds spaced 5 feet apart with in-row plant spacing of 12 inches. Treatments were evaluated for their effect on transplant height control, field establishment, crop growth, and final marketable yield. Tomato plant height and stem diameter measurements were recorded prior to ABA application and 7 days after application (plant height only). Plant height, stem diameter, percent survival and dry weights were recorded 3 weeks after transplanting (tomatoes) and 2 weeks after transplanting (peppers). The same measurements plus plant height 6 weeks after transplant were recorded on peppers. Tomatoes were harvested on September 6 and peppers were harvested on August 15 and September 6.

Results:

PEG incorporated into the growing mix prior to seeding significantly reduced tomato plant height but not peppers prior to transplanting (Tables 1, 2). ABA applied at the rates of 100, 200 and 400 ppm significantly reduced tomato transplant height 7 days after application (DAA) compared to untreated control (Tables 1). No plant height differences were seen in peppers 7 days after application (Table 2). No differences in height were seen in peppers 2 weeks after transplanting or in tomatoes 3 weeks after transplant. There were no differences in final marketable yield in either crop. The use of ABA and PEG helped control tomato transplant height prior to transplanting without adverse effects on final yield. No differences were seen in height control for peppers (except for results with 200 ppm at 6 weeks after transplant), and there was no effect on final yield. Effects of ABA and PEG were more prominent in 2006 in both crops (Fig. 1, 2) and more research is needed to see the effect of these height controlling compounds on other vegetable crop species.

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- Special thanks to the *Ohio Vegetable and Small Fruit Research and Development Program* and the *OARDC Small Industry Grant Program* for their financial support of this research.
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- Thanks to Valent BioSciences for their donation of ABA for this project.
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Table 1. Use of ABA and PEG 8000 to Control Fresh Market Vegetable Transplant Height - 2007

TOMATOES 'BHN685'

Prior to ABA Application:

Treatment	Plant ht. (cm)	Stem diam (mm)
Untreated	17.5	2.8
PEG	16.2	2.5
LSD	0.80	0.10
p value	0.015	0.03
CV	4.9	5.9

	---7 days after ABA application--- (at transplant)	------3 wks after transplanting-------			
Treatment	Plant ht. (cm)	Percent survival	Plant ht. (cm)	Stem diam. (mm)	Dry wt of 5 plants (gm)
Control	19.2	99	22.4	7.05	37.90
ABA 100 ppm	17.7	98	21.5	7.25	39.31
ABA 200 ppm	17.5	99	22.8	7.90	41.08
ABA 400 ppm	15.5	93	21.7	7.28	37.25
PEG	16.7	98	20.1	7.28	38.84
LSD	1.17	3.8	NS	0.54	NS
p value	0.041	0.024	0.442	0.048	0.944
CV	8.2	3.6	9.0	6.4	19.9

Treatment	Red T/A	Cull T/A	Percent red fruit	Avg. fruit wt. (lbs)
Control	32.6	6.6	83	0.20
ABA 100 ppm	30.8	7.9	79	0.18
ABA 200 ppm	31.7	6.0	84	0.20
ABA 400 ppm	33.3	6.3	84	0.21
PEG	30.5	7.6	80	0.22
LSD	NS	NS	NS	NS
p value	0.984	0.174	0.181	0.065
CV	20.9	19.1	4.7	8.0

Table 2. Use of ABA and PEG 8000 to Control Fresh Market Vegetable Transplant Height - 2007

PEPPERS 'Wahoo'

Prior to ABA Application:

Treatment	Plant ht. (cm)	Stem diam (mm)
Untreated	11.9	2.8
PEG	11.0	2.9
LSD	NS	NS
p value	0.122	0.608
CV	6.4	6.2

Treatment	---5 days after ABA application-- (at transplant) Plant ht. (cm)	------2 wks after transplanting------- Percent survival	Plant ht. (cm)	Stem diam. (mm)	Dry wt of 5 plants (gm)	6 wks after transplanting Plant ht. (cm)
Control	11.5	92	16.5	4.45	3.9	29.4
ABA 100 ppm	10.8	99	16.3	4.48	4.1	28.2
ABA 200 ppm	11.3	99	15.2	4.33	3.8	26.5
ABA 400 ppm	10.6	98	16.1	4.30	3.7	28.9
PEG	11.5	100	15.7	4.35	3.9	29.0
LSD	NS	NS	NS	NS	NS	1.58
p value	0.666	0.435	0.438	0.569	0.891	0.014
CV	9.4	7.1	4.2	7.3	13.6	6.2

Treatment	Marketable T/A	Cull T/A	Avg. fruit wt. (lbs)
Control	7.3	2.7	0.63
ABA 100 ppm	8.2	2.4	0.63
ABA 200 ppm	8.8	2.0	0.67
ABA 400 ppm	8.3	2.6	0.65
PEG	7.8	2.8	0.68
LSD	NS	NS	NS
p value	0.777	0.707	0.409
CV	19.5	33.4	7.3

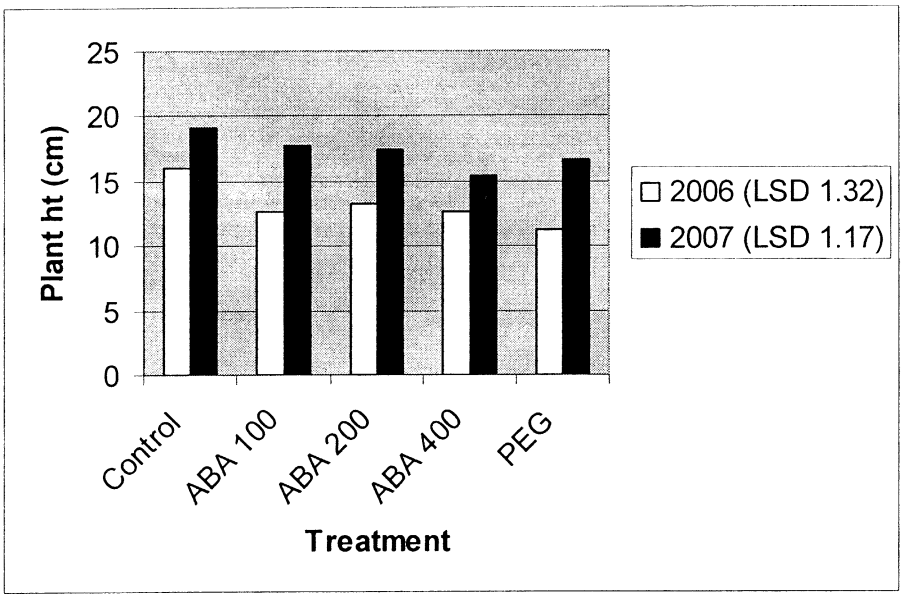

Fig. 1. Plant height 7 days (2006) and 5 days (2007) after ABA application on tomatoes 'BHN 685'.

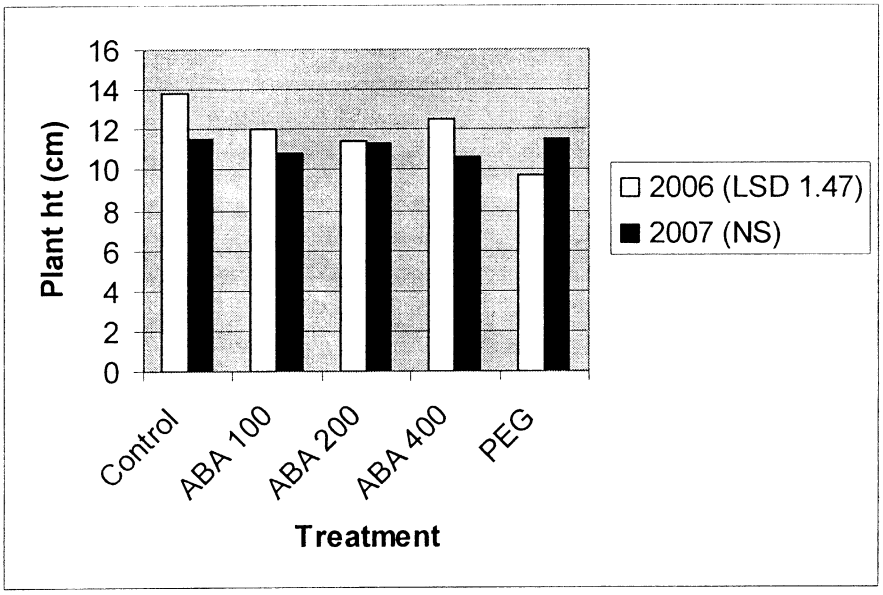

Fig. 2. Plant height 5 days after ABA application on peppers 'Wahoo'.

Use of ABA for Processing Tomato Transplant Height Control – 2007

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Objective: To investigate the use of ABA (abscisic acid) as a drench application of 200 and 400 ppm solutions (1,000 ml per plug tray) to control height in processing tomato transplants. Treatments will be evaluated for their effect on transplant height control, field establishment, crop growth and final marketable yield. In a greenhouse study conducted in 2005, preliminary studies found that ABA applied at 200 and 400 ppm controlled tomato ('Peto 696') transplant height by as much as 67% compared to untreated controls.

Materials and Methods: 'OX 325' and 'Gem 611' were seeded into 288-cell plug trays on April 26. Plants were grown under standard practices in the greenhouse. On May 23, the 4 week old seedlings were drench treated with 200 or 400 ppm ABA solutions (1,000 ml per plug tray). Untreated controls were also compared to ABA treatments. Plants were measured prior to ABA application and again 5 days later at field transplanting. Plants were established at the North Central Ag Research Station (Fremont, OH) in 3 replications on raised beds 5 feet apart with in-row plant spacing of 12 inches. Percent survival, plant height, stem diameter and dry weight of 5 plants was collected 3 weeks after transplanting. Plots were hand on August 30.

Results: Five days after the initial ABA application, there were no statistical (0.05 level) differences in plant height control with 'Gem 611' although transplants tended to be shorter (8-12% compared to the control). Height control in 'OX 325' was reduced by 2% (NS) and 21% with 200 and 400 ppm, respectively. No differences in percent survival, plant height or plant dry weight were found for either variety 3 weeks after transplant (WAT). There were differences in stem diameter in 'Gem 611' with 400 ppm ABA producing thicker stems. 'OX 325' stem diameter differences were not significant (Table 1). Marketable (red, green fruit) T/A, cull T/A, average fruit size and percent red fruit at harvest were not significantly influenced by ABA treatment for either variety. Marketable yields of 'Gem 611' ranged from 13.1 to 16.4 T/A. Marketable yields for 'OX 325' ranged from 20.8 to 23.0 T/A. Results this year show that ABA reduced plant heights 5 days after application for 'OX 325' tomato transplants but there were no differences (other than the 'Gem 611' stem diameter effect) after 3 weeks in the field (Table 1). ABA can be an effective height control strategy particularly when planting is delayed in the spring due to inclement weather at the time of field establishment. Cultivar responses to ABA in our 2007 research suggest that more study is needed to fine-tune this transplant height control strategy.

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- Special thanks to the *Mid-America Food Processors Association* for their financial support of this project
- Special thanks and appreciation to Sean Mueller, Stan Gahn, and the summer crew at North Central Ag Research Station for field maintenance, harvest, and transplant assistance
- Thanks to Dr. David Francis and Troy Aldrich for supplying seed
- Our appreciation is extended to Valent BioSciences for their donation of ABA

Table 1. Use of ABA for Processing Tomato Transplant Height Control - 2007

Prior to ABA Application:

Treatment	Plant ht. (cm)	Stem diam (mm)
'Gem 611'	13.5	2.8
'OX 325'	12.0	2.7

		5 days after ABA application (at transplant)	------3 wks after transplanting-------			
Cultivar	Treatment	Plant ht. (cm)	Percent survival	Plant ht. (cm)	Stem diam. (mm)	Dry wt of 5 plants (gm)
'Gem 611'	Control	15.0	100	22.1	7.8	31.9
'Gem 611'	ABA 200 ppm	13.8	100	21.8	8.8	34.3
'Gem 611'	ABA 400 ppm	13.2	100	20.1	9.3	35.3
LSD (0.05)		NS	NS	NS	1.11	NS
p value		0.078	-	0.552	0.045	0.458
CV		7.5	0	6.8	9.1	14.5
'OX 325'	Control	14.5	100	19.9	8.0	35.99
'OX 325'	ABA 200 ppm	14.2	100	20.4	8.0	35.75
'OX 325'	ABA 400 ppm	11.5	100	17.7	7.9	33.03
LSD		1.38	NS	NS	NS	NS
p value		0.003	-	0.05	0.989	0.829
CV		11.7	0	8.5	8.5	20.9

Cultivar	Treatment	Red T/A	Green T/A	Culls T/A	Avg. fruit wt (lb)	Percent red fruit
'Gem 611'	Control	13.1	3.1	1.9	0.15	72
'Gem 611'	ABA 200 ppm	16.4	2.8	2.8	0.14	75
'Gem 611'	ABA 400 ppm	14.5	2.8	1.9	0.14	75
LSD (0.05)		NS	NS	NS	NS	NS
p value		0.247	0.934	0.304	0.704	0.715
CV		17.6	34.5	36.8	4.10	5.7
'OX 325'	Control	23.0	7.4	1.2	0.14	73
'OX 325'	ABA 200 ppm	22.0	8.9	1.4	0.14	68
'OX 325'	ABA 400 ppm	20.8	9.9	2.4	0.14	63
LSD		NS	NS	NS	NS	NS
p value		0.803	0.674	0.745	0.729	0.309
CV		14.2	35.3	10.1	5.7	11.0

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Chemical Pinching of Processing Tomato Blossoms for Fruit Set and Yield Management - 2007

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Objectives:
To investigate the use of low rates of Ethrel on late vegetative/early reproductive phase of processing tomato plants for removal of early blooms and measurement of later bloom and fruit yield response compared to untreated and hand-thinned plants. This field study was in response to industry concerns about limited options in managing (1) fields of small plants which exhibit heavy flowering, and (2) split-set situations.

Materials and Methods:
Processing tomatoes 'Heinz 9704' and '7983' transplants were obtained from Chris McDonnall (McDonnall Greenhouses, Delta, Ohio). Plants were transplanted in the field on May 23 at the North Central Ag Research Station (NCARS) near Fremont, OH. Plots were 15 feet long and planted in three replications. Ethrel at two low rates (0.5, 1.0 pts/A) were applied to plants at 2 growth stages; first bloom (June 20) and three weeks after first bloom (July 11). Hand-thinning of blooms was done on June 20 as a mechanical check in addition to an untreated control. Marketable yield, percent red, and average fruit size were recorded at harvest. Plots were machine harvested on August 29. Marketable reds, greens, and culls were recorded along with average fruit weight and percent red fruit at harvest.

Results:
There were no differences in marketable red fruit for either cultivar. 'Heinz 9704' had significant differences in green and culled fruit and average fruit weight. Red fruit yields ranged from 17.3 to 25.6 T/A. Average fruit size was significantly smaller from control plots compared to the ethrel treatments and hand thinning (Table 1). There were no differences in green fruit or average fruit weight for '7983'. Red T/A yield ranged from 9.5 to 14.9. There were no differences in percent red fruit at harvest for either cultivar.

Acknowledgments:
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- Thanks to Chris McDonnall for supplying tomato transplants
- Our thanks to the crew at the North Central Ag Research Station for plot maintenance, spray applications, and harvest assistance.

Table 1. Chemical Pinching of Processing Tomato Blossoms for Fruit Set and Yield Management - 2007

Cultivar: 'Heinz 9704'

Treatment	Red T/A	Green T/A	Culls T/A	Avg. fruit wt (lbs)	Percent red fruit at harvest
Control	21.1	8.5	4.0	0.13	60
Hand thin @ first bloom	20.8	11.8	1.3	0.16	61
Ethrel .5 pts/A 3 wks after 1st bloom	17.3	8.4	3.7	0.14	58
Ethrel .5 pts/A @ 1st bloom	24.4	8.2	4.1	0.15	66
Ethrel 1 pts/A 3 wks after 1st bloom	25.6	7.9	3.9	0.14	67
Ethrel 1 pts/A @ 1st bloom	17.6	6.7	4.1	0.14	62
LSD (0.05)	NS	2.45	1.34	0.016	NS
p value	0.742	0.017	0.006	0.026	0.637
CV	32.7	22.5	33.3	8.5	10.8

Cultivar: ' '7983'

Treatment	Red T/A	Green T/A	Culls T/A	Avg. fruit wt (lbs)	Percent red fruit at harvest
Control	9.5	4.2	3.3	0.12	56
Hand thin @ first bloom	13.4	7.3	1.5	0.13	61
Ethrel .5 pts/A 3 wks after 1st bloom	14.9	3.7	3.0	0.12	70
Ethrel .5 pts/A @ 1st bloom	12.4	3.0	3.7	0.12	65
Ethrel 1 pts/A 3 wks after 1st bloom	13.0	3.6	2.4	0.12	67
Ethrel 1 pts/A @ 1st bloom	12.0	3.5	2.7	0.12	66
LSD (0.05)	NS	NS	0.84	NS	NS
p value	0.426	0.083	0.002	0.214	0.208
CV	25.0	46.8	32.1	6.0	10.5

fn: chemical pinching for proc toms 2007

Organic/Transitional Edamame (Vegetable Soybean) and Sweet Corn Seedling Establishment – 2007

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Introduction: This project focuses on the use of organic/biological seed treatments for optimum stand establishment of sweet corn and edamame. Traditional seed treatments, due to their composition, cannot be used in organic production systems. Use of untreated seed often reduces seed germination and field stands. Organic/biological treatments may be useful to organic and transitional farmers when direct seeding crops such as sweet corn and edamame. This project assessed establishment when sown under lab, greenhouse conditions and field seedling establishment to maximize agronomic and horticultural usefulness.

Materials and Methods: Sweet corn ('Xtra-tender 272A') and edamame ('Envy') seed was treated with various biological treatments: Champion, PlantShield® HC, and *Pseudomonas fluorescens* strain Delaw 1*(Pf1)* in 3 formulations (A, C, D) which differed only in the age and moisture content of the inoculum. All three formulations of *P. fluorescens* are suitable for organic production. Laboratory standard germination tests and cold tests (5 replications of 50 seeds) were performed on treated seeds and an untreated control. Seeds were also planted in plug trays in 4 replications of 50 seeds. Trays were put into a germinator at 60°F for 4 days (8 hours light, 16 hours dark). Trays were then transferred to a greenhouse bench and grown for an additional 7 days. Stand counts were recorded and 10 plants from each replication were sampled for dry weight accumulation. Field plots were also established at an organic grower site near Fremont, Ohio. Plots were mechanically seeded using five replications on June 11. Edamame seeds were planted in 30 inch rows at a population of 120 seeds per plot. Sweet corn was planted in 30 inch rows at a population of 60 seeds per plot. Each plot measured 20 feet. Stand counts were recorded on July 20. Statistical analysis was performed for data sets with missing data. Due to a planter malfunction, some treatments (in the field study only) are averaged over 2-4 reps.

Results: Sweet corn showed significant differences for standard germination, cold tests and plug tray emergence but not for seedling dry weights among the seed treatments (Table 1). *Pf1* formulations A and C were promising treatments in the sweet corn cold test and plug tray assessments. There were significant treatment differences for edamame ('Envy') plug tray emergence and seedling dry weights, but no differences among seed treatments for laboratory cold tests (Table 1).

Field results show no significant differences among seed treatments for either the sweet corn or edamame although the three *Pf1* formulations tended to perform best in field data comparisons for sweet corn emergence and seedling growth (Table 1). Percent field emergence was lower in general for edamame than for sweet corn, with the exception of the PlantShield HC treatment. Field emergence for sweet corn 'Xtra-tender 272A' ranged from 45-72% and for edamame 'Envy' from 30-52%. Future studies should also look at seed treatment effects on final yield.

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- Special thanks and appreciation to Mark Little for allowing us to plant this study on his farm.
- Thanks to Samuel Contreras for help with statistical analysis for field emergence.
- Special thanks to Matt Hofelich and the crew at the North Central Ag Research Station for assistance with planting and stand counts.

Table 1. Organic/transitional edamame (vegetable soybean) and sweet corn seedling establishment - 2007

Sweet Corn - 'Xtra-tender 272A'

			----------Plug tray study----------		
Treatment	Standard germ %	Cold test (% germ)	Emergence (% germ)	Seedling dry wt. (gm)	Percent field emergence
Untreated	98	68	97	0.32	58
PlantShield HC	95	63	88	0.29	51
Champion	92	82	84	0.29	45
P. fluorescens strain Delaw1-A	96	94	95	0.35	64
P. fluorescens strain Delaw1-C	96	95	95	0.39	69
P. fluorescens strain Delaw1-D	96	88	90	0.35	72
LSD (0.05)	3.2	6.7	3.8	NS	NS
p value	0.024	0.016	0.016	0.08	0.770
CV	3.0	16.5	6.4	16.3	

Edamame - 'Envy'

			----------Plug tray study----------		
Treatment	Standard germ %	Cold test (% germ)	Emergence (% germ)	Seedling dry wt (gm)	Percent field emergence
Untreated	97	90	86	1.39	34
PlantShield HC	92	90	85	1.47	52
Champion	92	90	84	1.29	37
P. fluorescens strain Delaw1-A	88	92	78	1.48	30
P. fluorescens strain Delaw1-C	98	90	92	1.37	38
P. fluorescens strain Delaw1-D	94	82	72	1.34	45
LSD (0.05)	NS	NS	10.2	0.12	NS
p value	0.061	0.165	0.015	0.025	0.350
CV	5.8	6.8	10.4	7.0	

Temperature During Seed Development Affects Size, Germinability and Storability of Lettuce Seeds.

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Introduction

- Seed germinability and storability are important aspects of seed quality determined by the genotype and environment of seed development.
- Lettuce is one of the most important vegetables in the USA and the world. The establishment of this species requires high quality seed, which may germinate at sub-optimal conditions (e.g. high temperature).
- The main objective of this study was to determine how temperature of the mother plant environment affects subsequent lettuce seed quality.

Material and Methods

Two experiments were performed to determine: i) effects of temperature on lettuce seed quality, and ii) critical moments during lettuce seed development for temperature effects.

Experiment 1, effects of temperature: Seeds of cv. 'Tango' were produced in growth chambers under one of two treatments: a) high temperature (HT), with day/night temperatures of 30/20°C, respectively, and b) low temperature (LT), with temperatures of 20/10°C. The experiment was replicated four times using plants from different sowing dates. Each replication was considered a block and consisted of 10 plants randomly assigned to each treatment. Several flower heads per plant were labeled during anthesis and harvested periodically to determine seed weight accumulation curves for each treatment. Final seed harvest was performed manually extracting only fully matured flower heads of each plant.

Seed evaluation. Seed dry weight, standard germination (normal seedlings after 7 days at 20C-light), and germination (radicle protrusion) at different conditions of temperature, light and water potential (PEG solutions) were evaluated on at least 100 seeds per replication. The germination index (GI) was calculated as the algebraic sum of the ratio of germinated seeds and days after sowing at the count moment. The accelerated aging (AA) test evaluated standard germination results achieved after 72 h of aging at 41°C and ~100%RH. Standard germination was also evaluated after 1, 2 and 3 months of storage at 30°C and 74% RH.

Experiment 2, critical moment determination. Flower heads of four plants from each temperature treatment were labeled on the day of anthesis. Labeling of flower heads at 30/20°C was performed 0, 4, 8 and 12 days before movement of the plants to 20/10°C, and plants at 20/10°C were labeled 0, 5, 10, and 15 days before being moved to 30/20°C. According with the moment of labeling and combination of temperatures, there were eight treatments: a) LOW (all the time at LT), b) 3/4 LOW- 1/4 HIGH (15 days at LT,

then HT), c) 2/4 LOW- 2/4 HIGH (10 days at LT, then HT), d) 1/4 LOW- 3/4 HIGH (5 days at LT, then HT), e) HIGH (all the time at HT), f) 3/4 HIGH- 1/4 LOW (12 days at HT, then LT), g) 2/4 HIGH- 2/4 LOW (8 days at HT, then LT), and h) 1/4 HIGH- 3/4 LOW (4 days at HT, then LT). Fully matured flower heads from each labeling moment were harvested manually.

Seed evaluation. Seed dry weight, dark germination at 30°C, germination at -5 bar, and percentage of normal seedlings after AA were evaluated on 4 sub-samples of 50 seeds per treatment.

Results and Discussion

Experiment 1. At 30/20°C seeds reached physiological maturity (PM), or max dry weight, 11 days after flowering (DAF), while seeds at 20/10°C reached PM at 15 DAF (Fig. 1). After PM seed desiccation was three times faster in seeds at 30/20°C than in those at 20/10°C (Fig. 1). Seeds from 20/10°C were heavier than seeds from 30/20°C (Fig. 1, Table 1), however the standard germination was similar for both treatments (Table 1).

When germinability was evaluated at sub-optimal conditions seeds produced at 30/20°C outperformed those from 20/10°C. For example, seeds from 30/20°C presented significantly higher dark germination at 18, 24 and 29°C (Table 1). Germination under light was similar for both treatments between 20 and 30°C, however between 30 and 40°C germination percentage and rates (expressed as germination index) were higher for seeds from 30/20°C (Fig. 2A). When germinated at osmotic potentials below -1.5 bar, seeds from 30/20°C also performed better (Fig. 2B).

The production of normal seedlings after accelerated aging (AA) was significantly higher for seeds from 30/20°C (Table 1). The AA test has been used to evaluate both vigor and storability of seeds. The reduced storability for lettuce seeds produced at 20/10°C was confirmed by the lower percentage of normal seedlings observed after different periods of seed storage at 30°C and 74%RH (Fig. 3).

Experiment 2. When the critical moments for temperature effects were studied, seed dry weight, dark germination at 30°C, and germination at low osmotic potential showed to be determined earlier during seed development, before 5 and 4 DAF for seeds from 30/20°C and 20/10°C seeds, respectively (Fig. 4). On the other hand, seed storability was determined at the end of seed development, after physiological maturity.

Our results indicate that lettuce (cv 'Tango') seed germinability is affected by the temperature of the mother plant environment during the first 4-5 days of lettuce seed development. Seeds that developed at higher temperatures (30/20°C) presented better germinability. The physiological mechanism governing this effect remains unclear and probably is related with some event happening early in seed development, as for example ABA accumulation on the seed.

In this study seed germinability was not correlated with seed storability (Fig. 4). The effect of temperature on seed storability was produced at the end of seed development, after physiological maturity. The time required for seed desiccation at 30/20°C was markedly lower than for seeds produced at 20/10°C (Fig. 1), and this could be a factor affecting lettuce seed performance after storage.

Because of the importance of lettuce seed germinability for proper establishment of the crop and storability for seed conservation and management of seed stocks, the mechanisms by which temperature affects these two aspects of seed quality should be further studied.

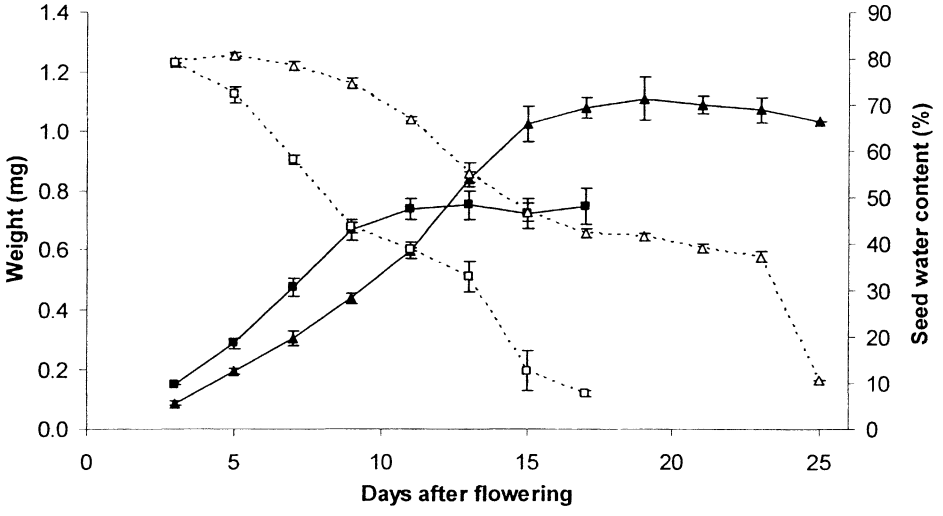

Figure 1. Seed dry weight (DW, solid line) and seed water content (WC, broken line) during development of lettuce seeds produced at 30/20°C (squares) and 20/10°C (triangles). Data are the average ±SE from four replications.

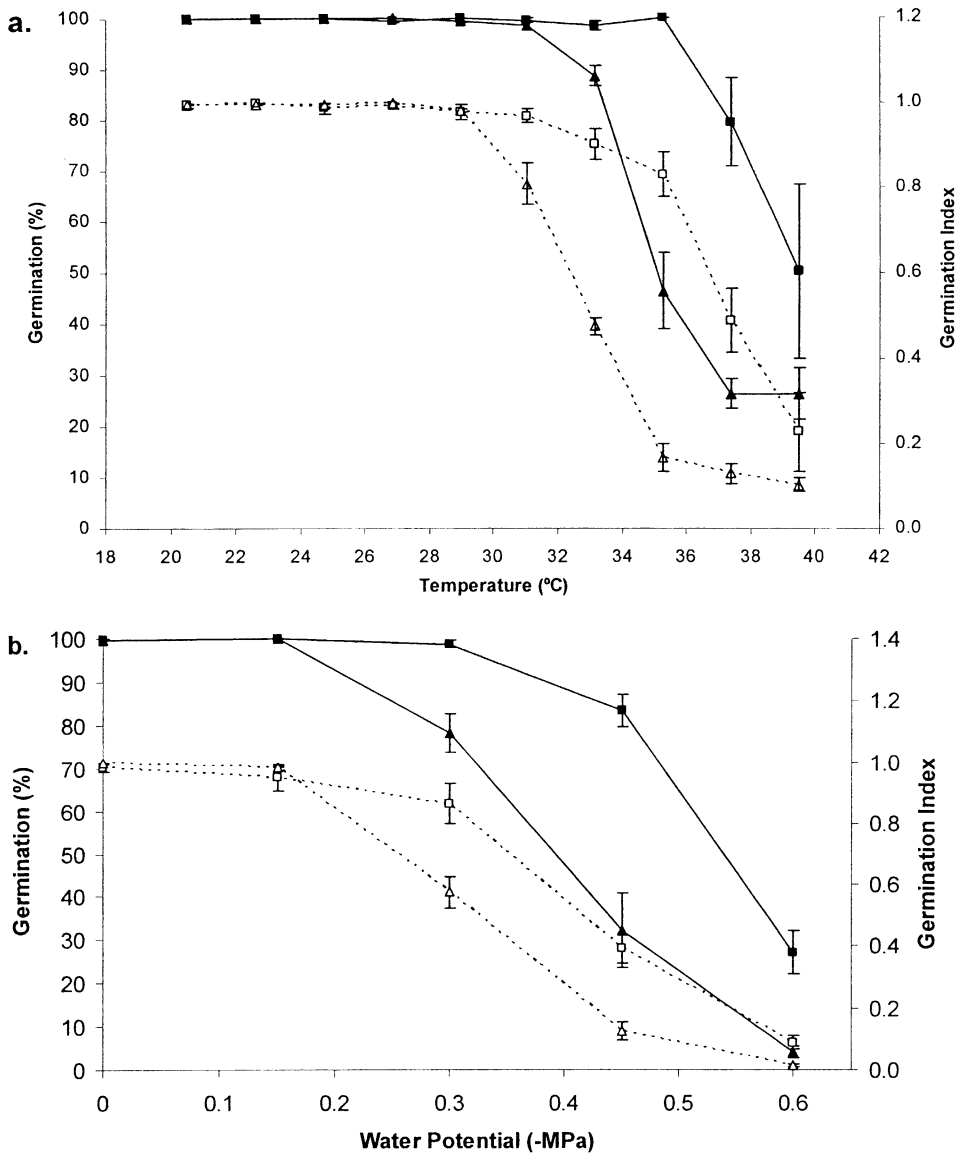

Figure 2. Germination percentage (solid lines) and germination index (broken lines) at different temperatures (A) and at 20°C and different water potentials (B) of lettuce seeds produced at 30/20°C (squares) and 20/10°C (triangles). Data are the average ±SE from four replications.

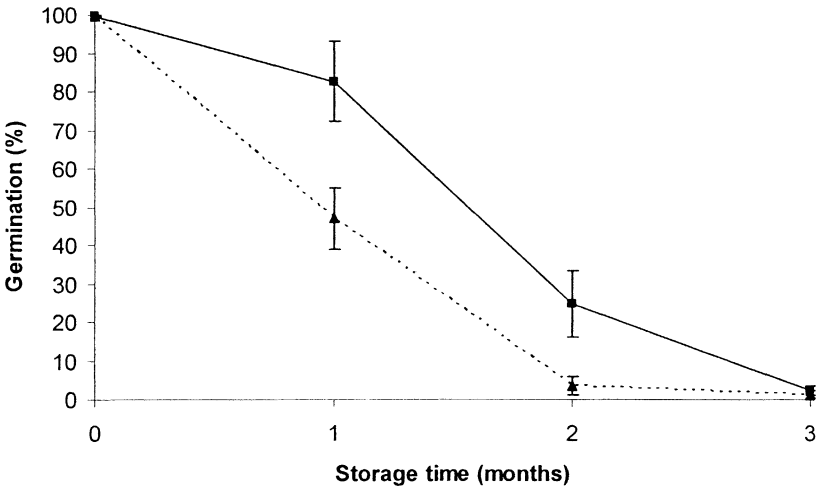

Figure 3. Germination (normal seedlings) after storage of lettuce seeds produced at 30/20°C (square) and 20/10°C (triangle). Data are the average ±SE from four replications.

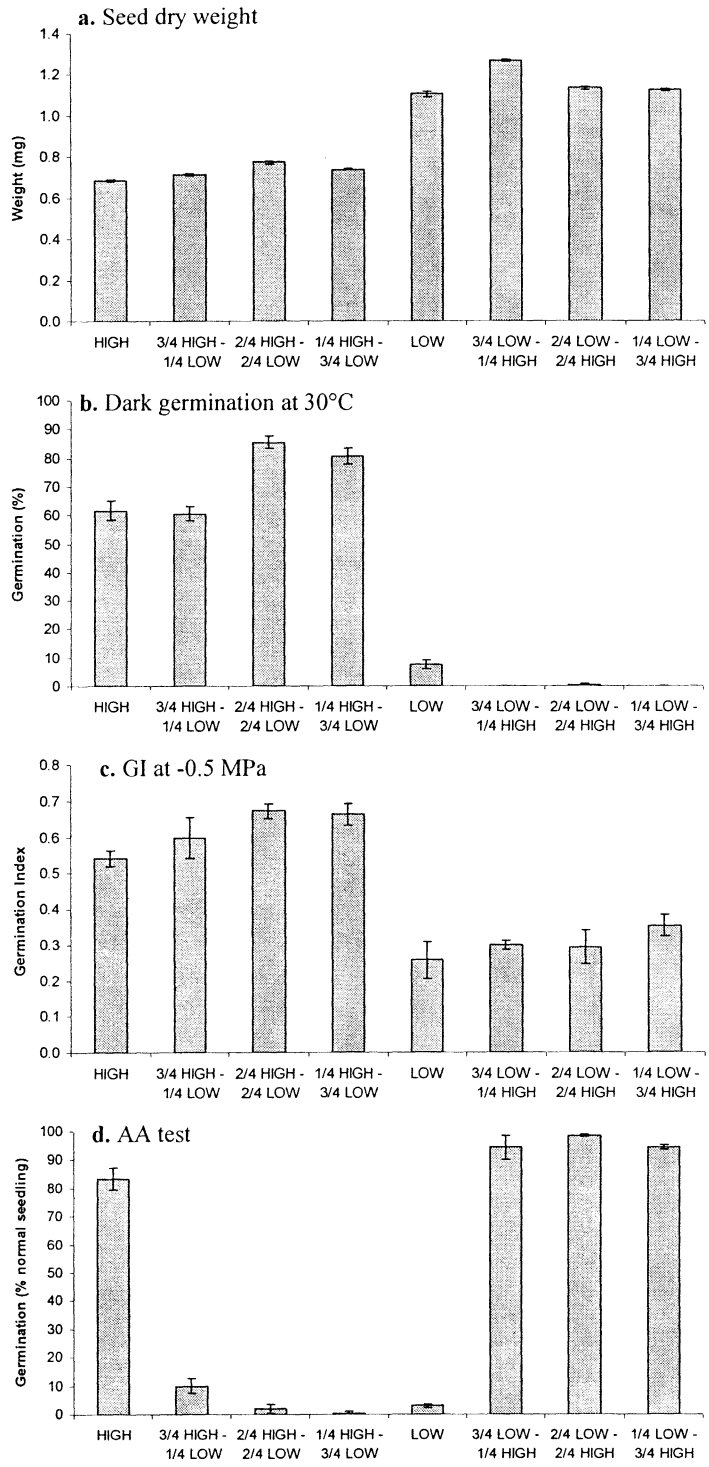

Figure 4. Seed dry weight (A), germination at 30°C (B), germination index at -5 bar (C), and normal seedlings after accelerated aging (D) of lettuce seeds produced at **LOW** (all the time at LT=20/10°C), **HIGH** (all the time at HT=30/20°C), **3/4 LOW- 1/4 HIGH** (15 days at LT, then HT), **2/4 LOW- 2/4 HIGH** (10 days at LT, then HT), **1/4 LOW- 3/4 HIGH** (5 days at LT, then HT), **3/4 HIGH- 1/4 LOW** (12 days at HT, then LT), **2/4 HIGH- 2/4 LOW** (8 days at HT, then LT), and **1/4 HIGH- 3/4 LOW** (4 days at HT, then LT). Data are the average ±SE from four sub-samples of 50 seeds.

Table 1. Parameters of quality for lettuce seed produced under high (30/20°C) and low (20/10°C) temperatures.

Parameter	Treatment		*p*-value[1]
	30/20°C	20/10°C	
Seed dry weight (mg/seed)	0.76	1.04	0.024
Normal seedlings at 20°C (%)	99.8	99.8	1.000
Normal seedlings after AA[2] (%)	59.5	1.8	0.001
Dark germination at 13°C (%)	97.0	87.0	0.086
Dark germination at 18°C (%)	100.0	86.0	0.006
Dark germination at 24°C (%)	97.0	68.0	0.004
Dark germination at 29°C (%)	50.0	14.5	0.022

(1): calculated from analysis of variance.
(2): Accelerated aging for 72 h at 41°C and ~100%RH. Normal seedling percentages 11 days after planting are reported.

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