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ENHANCED SWEET CORN PROPAGATION: STUDIES ON TRANSPLANTING FEASIBILITY AND SEED PRIMING

Khalid E. ABD EL-HAMED[1], Mohammed W.M. ELWAN[1], Walied I. SHABAN[2]
[1]Department of Horticulture, Faculty of Agriculture,
Suez Canal University, 41522, Ismailia, Egypt
[2]Department of Agriculture Botany, Faculty of Agriculture,
Suez Canal University, 41522, Ismailia, Egypt

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Summary

Sweet corn hybrids with high-sugar genotypes (*sh*$_2$) has inherent problem of low seed emergence and stand in the field. This study was conducted to determine the effect of seed size, tray cell size and growing media components on sweet corn transplant transplanting. Other objectives were to evaluate the effect of priming sweet corn seeds on germination in the field. Bio-priming with *Trichoderma* and *Bacillus*, osmo-priming with KNO_3, and hydro-priming with H_2O have been tested. The results indicated that transplanting sweet corn is feasible with high quality transplants from seeds that germinate well in disease-free environment. Large sweet corn seeds, large tray cells, and vermiculite-based growing media proved to gave higher germination percentages. While same factors did not show pronounced effect on seedling performance in terms of root and shoot length and fresh weight. In the priming experiment, the bio-priming treatment showed the highest germination of seeds percentage among other priming treatments and the control. Sweet corn seeds treated with *Bacillus megaterium* germinated 50% higher than seeds treated with *Trichoderma* spp. as bio-control agents. *Aspergillus niger*, and *Penicillium* represented 65% of pathogens responsible for failure of sweet corn seed germination. The results of this study demonstrated the feasibility of enhanced sweet corn seed propagation through transplanting and seed priming to improve emergence and field stand.

key words: sweet corn, transplanting, seed size, tray cell size, seed priming, bio-priming, *Bacillus megaterium*, *Trichoderma* spp.

INTRODUCTION

Sweet corn (*Zea mays* L.) for fresh market, freezing and canning is an important commodity in many countries and becoming increasingly popular between consumers. However, sweet corn seeds germinate slowly and exhibit poor seedling vigor (Wolf *et al*. 1997). Poor germination is particular problem with early spring planting in cold soils. Seed priming, bio-priming, prehydration, coating and various fungicides treatments may

Corresponding author:
e-mail: Elwan_wasfy@yahoo.com
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improve the stand establishment of sweet corn (Bennett *et al*. 1991, 1992). Poor germination in sweet corn has been attributed to low seed vigor and susceptibility to seed and soilborne diseases. Injuries during imbibition has been identified as a major contributing factor to poor stand establishment in sweet corn resulting in increased leakage of electrolytes and carbohydrates (Schmidt & Tracy 1988, Wann 1986). The resulting leakage of electrolytes can stimulate pathogenic soilborne fungi. Also, low carbohydrate levels in seed adversely affect germination vigor (Styer & Cantliffe 1983, 1984).

1. Transplanting

On the other hand, transplanting provides optimal environmental conditions for seed germination and avoids planting seeds in disease-contaminated soil. Sweet corn has been transplanted experimentally in an attempt to improve stands and hasten maturity (Menasha & Tignor 2004, Menasha 2005, Di Benedetto *et al*. 2006, Miller 1972, Rattin *et al*. 2006, Wyatt & Mullins 1989). Similar attempts have been reported in field corn (Khehra *et al*. 1990, Pendleton & Egli 1969). Conversely, transplanting sweet corn remains a questionable practice because it increases production costs and often stunts plant development. Transplanting sweet corn is feasible because transplant technologies enable large-scale transplant production with minimal labor. However, little information is available on factors affecting transplanting such as seed quality, transplanting methods, growing media components and environmental conditions.

Since growers of fresh market sweet corn are interested in the earliest possible maturity for optimal prices, the approach of transplanting has been used. Transplanting sweet corn decreased time to harvest by 1 to 3 weeks depending the transplant age (Miller 1972, Wyatt & Mullins 1989). The effects on yield and mature plant characteristics have varied, depending on age of transplants and time of transplanting (Waters *et al*. 1990). Significant increase in stand counts and earliness were achieved through transplanting as compared with direct seeding (Dunwell *et al*. 1993). However, transplant produced a greater percentage of smaller, lower quality ears than did direct seeded plants which may nullify the benefits of improved stands obtained through transplanting (Welbaum *et al*. 2001). Corn does not transplant well because pruned roots do not branch and root replacement is generally poor compared with other crops such as tomato and cabbage. So, the inability of corn roots to regenerate after transplanting resulted in stunted plants that produced a greater percentage of cull ears (Welbaun *et al*. 2001). Further research on transplant production and planting should probably focus on the characteristics of root development and handling practices to protect roots from damage (Waters *et al*. 1990). Plug trays that minimize trauma to sweet corn roots may improve transplant field performance (Menasha & Tignor 2004, Menasha 2005, Rattin *et al*. 2006, Welbaum *et al*. 2001).

1.1. The effect of seed size

The development of the plant that emerges from a seed is influenced by the health and vigor of that seed

(Oexemann 1942). Seeds size is one of the most important characters of seed quality of a crop. Seed size and shape is controlled by the genetics of the parent plant (Voigt *et al*. 1966), but also influenced by environmental conditions during plant development and grain fill. Stresses such as high temperature, low soil moisture, or low fertility can reduce seed size. In corn placement of the seed on the ear also affects both size and shape. The sequential development of the corn ear from the base to the top causes a range in seed maturity and filling period, and affects the seed ability to compete for available photosynthate and space on the cob. Large-round seeds usually come from the base of the ear, flats from the center, and small round seed from the tip. Large seeds have advantage over small seeds because of the stock of nutrients at the disposal of the embryo (Giles 1990, Styer & Cantliffe 1984, Wann 1980).

In sweet corn, Cameron *et al*. (1962) found that seed size of hybrid varieties affect total percentage of germination, size of young plants, percentage of ear shoots which silk early and the number of ears ready for early market. Sweet corn seed size was shown consistently to influence early seedling dry weight (Bennett *et al*. 1988). In field corn, the relation between seed size and emergence, growth and yield has been extensively studied. There was a significant positive correlation between seed size (as indicated by 1000-seed weight) and plant vigor parameters under low temperature (Gubbels 1974). Seed size effect on field corn performance has shown a tendency for small seed classes to produce smaller plants than those from large size classes (Hicks *et al*. 1976). Also, in field corn initial plant size was larger when grown from large seed, but relative differences in plant size became smaller as the crop matured and there were no significant yield effect (Hawkins & Cooper 1979). On the other hand, seed size was not significant on maize seedling emergence and growth but significantly increased seedling height (large seed has taller seedlings as compared to small seed). Seed size did not influence seedling dry weight and number of leaves (Molatudi & Mariga 2009). Similar results have been achieved by Hunter and Kannenberg (1972).The same trend for the relationship between seed size and emergence, seedling growth and yield was found in broad array of plants including cabbage (Shanmuganathan & Benjamin 1992), broccoli (Heather & Sieczka 1991), tomato (Halsey 1969), onion (Gamiely *et al*. 1990), pea (Pyke & Hedley 1983).

1.2. The effect of tray cell size

Transplants are produced in a number of various sized containers or cells. Varying container size alters the rooting volume of the plants, which can greatly affect plant growth. Container size is important to transplant produces as they seek to optimize production space while transplant consumers are interested in container size as it relates to optimum post-transplant performance. A trend among many commercial transplants produces is toward more cells per tray (smaller containers) which increases the number of plants produced while reducing the need to develop more transplant production space and decreases propagation cost per plant. A major effect of

decreased container size is that it increases root restricting conditions (NeSmith & Duval 1998).

Plants undergo many physiological and morphological changes in response to reduced rooting volume. Plant development can be influenced by container size. Root restriction and container size can affect root and shoot growth, biomass accumulation, photosynthesis, leaf chlorophyll content, flowering and yield. The delicate balance between roots and shoots can be upset when the root system is restricted in a small rooting volume. Transplants with relatively large root systems generally suffer less post-planting shock and thus come into production earlier than plants with small root systems. Container grown plants in general have different root morphology than field seeded crops. These alterations in root morphology may be more pronounced with small container size and could predispose plants to drought stress since a significant reservoir of soil water resources goes unexplored. When root restricted seedlings are planted in the field they are often unable to compensate for evaporation even if they are well watered after transplanting (NeSmith & Duval 1998).

Shoot growth is greatly impacted by varying container size and root restriction. Similarly as rooting volume decreased, less leaf area is produced. The reduction in leaf area was due to both smaller and fewer leaves per plant. Reduced plant biomass under root restricting conditions could possibly be due to a lower photosynthetic rate. The flowering period was reduced due to increased root restriction in various species. Many morphological and physiological responses of plants to varying container sizes and root restricting conditions have been reported (Hall 1989, Maynard *et al*. 1996, Ruff *et al*. 1987). However, of most concern to the end user of the transplant is the post-planting performance of the seedling and of particular concern is crop yield resulting from transplants grown in different container sizes. Varying transplant container size has shown mixed results on harvested yield which have not been thoroughly explained (Cantliffe 1993, NeSmith & Duval 1998). In sweet corn, a grater percent germination was observed for seeds sown in the 49 ml/cell trays compared to the 19 ml/cell trays (Dunwell *et al*. 1993). Increased cell volume before transplanting significantly increased root surface area, average diameter, root volume, and shoot biomass after transplanting (Menasha & Tignor 2004, Menasha 2005). Similar results were obtained by Di Benedetto *et al*. (2006).

1.3. The effect of growing media

The transplant production process involves optimizing the many factors that govern both seedling production and post-plant performance (NeSmith & Duval 1998). Among these, perhaps the most important is the type of growing medium used. Due to the relatively shallow depth and limited volume of the container, growing media must be amended to provide the appropriate physical and chemical properties necessary for plant growth. Successful nursery production of container grown plants is largely dependent on these chemical and physical properties of the grown medium. An ideal medium should be free of dis-

eases and weed, light enough to facilitate handling and shipping. The media should also, be well drained and yet retain sufficient water to reduce the frequency of watering. Other parameters to consider include cost, availability, and stability over time. Selection of the proper media components is crucial to the successful production of transplants.

Peat is a very common organic component in nursery mixes. Peat is usually included in a mix to increase the water-holding capacity or to decrease the weight. In the last few years, coconut coir has been considered as a substitute for natural peat in growing media (Arenas *et al*. 2002). The particular structure of coconut fibers and their physical and chemical properties make them suitable for container media purposes. Coconut fiber has high water holding capacity and has been traditionally used to improve the physical and chemical properties of soils. Coconut coir has been tested as a horticultural medium for several ornamental crops with acceptable results. However, little work has been done with coconut coir as a medium component in vegetables transplant production. The relationship between transplant growth and coconut fiber should be investigated further (Arenas *et al*. 2002).

Both sand and vermiculite are some of the most commonly used amendments for the production of vegetable transplants. Medium and coarse sand particles provide optimum adjustments in media texture. Although sand is generally the least expensive of all inorganic amendments it is also the heaviest which may results in prohibitive transportation costs. On the other hand, vermiculite has a very high water holding capacity and aid in aeration and drainage. Vermiculite has excellent exchange and buffering capacities as well as the ability to supply potassium and magnesium. Although vermiculite is less durable than sand, its chemical and physical properties are very desirable for growing media. The time of in strawberry flowering was earlier in sand media than in media containing peat (Tehranifar *et al*. 2007). Tomato performed better when the sand content was proportionally higher in the growing medium mixture (Abo-Rezq *et al*. 2009).

2. Biological seed treatments and seed priming

Biological seed treatments for control of seed and seedling diseases offer the grower an alternative to chemical fungicides. A wide variety of microorganisms are currently used as seed treatments. The most intensively studied include bacteria of the genera *Pseudomonas*, *Enterobacter*, *Erwinia*, *Bacillus*; the fungi *Trichoderma* and *Gliocladium*; and the actinomycete *Streptomyces* (Callan *et al*. 1997, Lazarovits & Nowak 1997, Mathre *et al*. 1999). Bacterial antagonism, responsible for biological control may operate by antibiosis, competition or parasitism. Parasitism relies on lytic enzymes for the degradation of cell walls of pathogenic fungi (Chet *et al*. 1990). *Trichoderma* spp. are common inhabitants of the rhizosphere and are well recognized as biological agents of soilborne pathogens. A considerable amount of research has focused on the mycoparastic nature of *Trichoderma* and its contribution to plant health (Howell 2003). The application

of *Trichoderma* to the soil as a biological agent not only resulted in reduced disease severity but also enhanced plant growth. The potential of *Trichoderma* species as biocontrol agents of plant diseases was first recognized in early 1930s (Weindling 1932). The mechanisms employed by *Trichoderma* species to affect disease control includes mycoparasitism and antibiotic (toxin) production, competition through rhizosphere competence, production of enzymes such as chitinases and glucanases responsible for the suppression of plant pathogen by destroying cell wall integrity, induction of defense response in plant such as peroxidase activity (Harman 2000, Harman *et al*. 2008, Howell 2003). The biological seed treatments have been reported as an effective seed protection method in sweet corn using *Trichoderma* (Bjorkman *et al*. 1998, Bjorkman 2004, Harman *et al*. 1989, Parera & Cantliffe 1990), *Pseudomonas* (Callan *et al*. 1990, Callan *et al*. 1991, Cantliffe & Bieniek 1988, Mathre *et al*. 1995), *Gliocladium* (Hartz & Caprile 1995).

Seed priming is composed of a controlled moisturization period that does not allow radical emergence followed by a dry down period. Priming treatment promotes early germinative metabolic processes that result in a rapid and uniform emergence rate in the field. Sugars, salts, polyethylene glycol, or manitol are used to create soaking solutions with osmotic potentials that provide control of initial imbition rates (Bennett *et al*. 1992, Taylor & Harman 1990, Taylor *et al*. 1998). Several biochemical changes are occurring during priming (Khan 1992). Protein synthesis increases substantially during and following priming. Metabolic enzymes involved in storage reserve mobilization have been shown to increase, including α-amylase, malate dehydrogenase, and isocitrate lyase. Also, there is some evidence to suggest that cell wall properties of the seed cover change during priming (Hartmann *et al*. 1997, Varier *et al*. 2010). Basra *et al*. (1988) suggested that osmotic priming of maize seeds induced changes in embryo phospholipids and the benefits associated with osmo-priming may be at least partly due to an increased potential for ATP accumulation.

Several priming treatments have been tested in sweet corn including presoaking hydration (Bennett & Waters 1987 a,b, Gerber & Caplan 1989, Bennett *et al*. 1988, Gubbels 1975, Sabota *et al*. 1987), polyethylene glycol (PEG 8000) (Bennett & Waters 1987a,b, El-Saifi *et al*. 2010, Murray 1990); polymers (Sabota *et al*. 1987); mineral salts (El-Saifi *et al*. 2010); organic solvents (Hung *et al*. 1992), H_2O_2 (Gubbels 1975), sodium hypochlorite (Hartz & Caprile 1995, Parera & Cantliffe 1991) with varying results.

The objective of this investigation was to study the enhancement of sweet corn propagation through determine the effect of different seed priming techniques on seed emergence and stand establishment in the field. Besides, study the effects of seed size, tray cell size and growing media on germination and the growth performance of sweet corn transplants under the greenhouse condition.

MATERIALS AND METHODS

Germination experiment

This experiment was carried out at the transplants production greenhouse at the experimental farm of department of Horticulture, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt on the spring season of 2011. Eight treatments have been established as follows:

Two different sweet corn seed size:
- Large seeds (diameter >0.6 cm.) (100 seeds weight = 11gram).
- Small seeds (diameter <0.6 cm.) (100 seeds weight = 7gram).
- Two different seedling tray cell sizes:
- Large cells (58 cm^3).
- Small cells (18 cm^3).

Two different growing media mixture:
- Coconut fiber with vermiculite (2:1 v/v).
- Coconut fiber with sand (2:1 v/v).

Two replications were utilized each including 8 styrophoam trays with 84 seeds in large cell size treatments and 209 seeds in small cell size treatments. The seeds were visually graded to large and small then each grade was sieved using 6 mm pores sieve. Sweet corn kernels of cultivar 277A (sh_2) (Illinois Supersweet) were planted in the greenhouse on March 11, 2011. Early germination was recorded after 10 days of planting. Final germination was recorded when no more apparent germination was observed (approximately after 21 days). After germination evaluation, 10 seedlings from each treatment were collected randomly for more laboratory evaluation. Each seedling was cut at the point of growing media surface using sharp blade. Shoot length and shoot weight were recorded on the vegetative part of the seedling. The bottom part which includes root system and growing media was carefully washed using running tap water to completely remove the growing media surrounding the root system. Roots were air dried before root length and root weight were recorded. Then both shoot and root were placed in the oven under 70°C for 24 hours to allow for drying before dry weight of both were recorded. The experiment was statistically arranged in factorial design with three factors.

Seed priming experiment

A field experiment was conducted at the experimental farm of department of Horticulture, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt to test the effect of bio-priming, hydro-priming and osmo-priming on the germination of sweet corn kernels of cultivar 277A (sh_2) (Illinois Supersweet). The experiment was carried out in randomized complete block design with at least 4 replications (rows), each replicate was 10 m in length and 0.5 m in width containing approximately 35-40 seeds at a spacing of 25 cm within the row. The direction of rows was North-South and the seeds were cultivated directly on the third top of the slop ridges on the West direction. Experimental site soil texture was sandy (91% sand, 6% silt and 3% clay) with pH 8.27 and EC 0.47 $ds \cdot m^{-1}$, Ca 0.8 $meq \cdot L^{-1}$, Mg 0.6 $meq \cdot L^{-1}$, K 0.3 $meq \cdot L^{-1}$, Na 3.0 $meq \cdot L^{-1}$, Bicarbonate 1.6 $meq \cdot L^{-1}$, CL 3.0 $meq \cdot L^{-1}$,and Sulfate 0.1 $meq \cdot L^{-1}$. Before each planting, the soil of the experimental site was cleared, ploughed, harrowed and divided into rows. The experiment was conducted during the spring season of 2009 and was repeat-

ed in spring season of 2010 and 2011. Five treatments have been established as follows:

- Bio-priming with *Trichoderma*,
- Bio-priming with *Bacillus*,
- Osmo-priming with KNO_3 (5%),
- Hydro-priming with H_2O,
- Control (non-treated dry seeds).

For osmo- and hydro-priming treatments, sweet corn seeds were soaked in KNO_3 (5%) solution or in distilled water for 24 hours before planting. Seeds from all priming treatments and control were hand planted in rows in soil. Number of germinated seeds was recorded after 3 weeks of planting and when no more apparent germination was observed, percentage of germination was calculated as number of germinated seeds divided by the total number of planted seeds in each replicate.

Microbial cultures and seed inoculation

Trichoderma isolates were grown in molasses broth (molasses 30 g, yeast extract 5 g, distilled water 1000 ml) for 10 days at 27 ± 1°C. Subsequently broth cultures were homogenized using mixer grinder. The homogenized liquid cultures were formulated using talc as a carrier material (Talc: liquid broth culture of *Trichoderma* spp. at 2:1 w/v) with 10 g of carboxyl methyl cellulose (CMC) per kilogram of carrier material as adhesive agent.

Pure isolates of *Bacillus megaterium* were kindly obtained from Department of Microbiology of Soil, Water and Environment Research Institute, Agriculture Research Center (ARC), Giza, Egypt. *Bacillus megaterium* were grown in Sperber's broth (Sperber 1957), for 7 days at 27 ±1°C on a rotary shaker at 150 rpm. After incubation period bacterial cultures were formulated using talc as a carrier material (Talc: broth culture at 2:1 w/v) with 10 g CMC per kg carrier material as adhesive agent.

Seeds of sweet corn were first surface sterilized with sodium hypochlorite (1%), washed in distilled water and then were treated with talc based formulation of Trichoderma at 3 $g \cdot kg^{-1}$ seeds ($\approx 6 \times 10^7$ $cfu \cdot g^{-1}$) or 5 $g \cdot kg^{-1}$ seeds ($\approx 8 \times 10^9$ $cfu \cdot g^{-1}$) of *Bacillus megaterium* (Rudresh *et al*. 2005).

Isolation of the causal organism

Non-germinated seeds were randomly collected from the experimental site from all treatments to evaluate the pathogenic fungi associated with seed decay, Seeds with damping-off symptoms were picked up on PDA plates and purified for pathogen isolation and identification. Pure cultures were identified according to the description of Gilman (1957), Barnett and Hunter (1972).

Statistical analysis

Data were statistically analyzed using ANOVA/MANOVA of Statistica 6 software (Statsoft 2001, Tulsa, Ok, USA) with mean values compared using Duncan's multiple range with a significance level of at least $p \leq 0.05$.

RESULTS

Transplanting feasibility experiment

The main effect and interaction between media type, seed size and tray cell size on early and total seed germination of sweet corn are summarized in Table 1 and 2. The effect of each factor was different for early and final germination. Small sweet corn

kernels gave high early germination percentage while the large kernels provided the highest final and total germination percentage. In addition, the small tray cell size (18 cm^3) gave highest early germination compared to the large tray cell size (58 cm^3) which presented the highest final germination rate (Table 1). The growing mixture of coconut peat and sand promoted the early germination of seeds and accelerated the speed of germination since it granted higher early percentage of germination while the other growing mixture (coconut peat and vermiculite) gave the higher final percentage. The interaction between vermiculite based growing media with both large seed size and large tray cell size was associated with the highest percentage of final germination while the growing media with sand combined with large seed size and large tray cell size showed the lowest percentage of early and final germination (Table 2).

Table 1. The main effect of media type, seed size and tray cell size on early and total seed germination of sweet corn cv. 277A *sh*$_2$

Treatments		Early germination (%)	Final germination (%)
Media	Vermiculite	42.3	58.7
	Sand	46.1	47.3
Seed size	Large seeds	41.3	56.5
	Small seeds	47.1	49.5
Tray cell size	Large cells	42.2	54.9
	Small cells	46.2	51.1
Mean		44.2	53.0

Table 2. The interaction between media type, seed size and tray cell size on early and total seed germination of sweet corn cv. 277A *sh*$_2$

Media	Seed size	Tray cell size	Early germination (%)	Final germination (%)
Vermiculite	Large seeds	Large cells	39.3	86.9
		Small cells	40.4	50.5
	Small seeds	Large cells	47.6	48.8
		Small cells	41.9	48.5
Sand	Large seeds	Large cells	30.5	32.9
		Small cells	55.1	55.6
	Small seeds	Large cells	51.3	51.3
		Small cells	47.5	49.5

The effect of these three factors on shoot and root length, shoot and root fresh weight of germinated seedlings are summarized in Table 3 and 4. Growing media with sand gave the higher shoot and root length and weight comparing with media with vermiculite. Although large seeds gave significantly higher root length, the shoot length and root length and weight did not affected statistically by the size of sweet corn seeds. Similar trend was observed with the tray cell size given that it did not significantly

affect these traits with the observation that small tray cell size tend to offer non-significantly higher root length and weight while large tray cell size have a tendency to give slightly higher shoot length and weight (Table 3).

Table 3. The main effect of media type, seed size and tray cell size on both shoot and root length and fresh weight of germinated seedlings of sweet corn cv. 277A *sh*$_2$

Treatments		RL[1]	RFW[2]	SL[3]	SFW[4]
Media	Vermiculite	8.03a[5]	0.94b	3.04b	0.35b
	Sand	8.23a	1.13a	3.73a	0.50a
Seed size	Large seeds	9.17a	1.03a	3.36a	0.41a
	Small seeds	7.09b	1.03a	3.40a	0.44a
Tray cell size	Large cells	8.02a	0.98a	3.47a	0.44a
	Small cells	8.24a	1.08a	3.30a	0.42a
Mean		8.13	1.03	3.38	0.43

Note: [1]RL= Root Length (cm); [2]RFW= Root Fresh Weight (gram)
[3]SL= Shoot Length (cm); [4]SFW= Shoot Fresh Weight (gram)
[5]Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan's multiple range test

Table 4. The interaction effect between media type, seed size and tray cell size on shoot and root length, shoot and root fresh weight of sweet corn germinated seedlings cv. 277A sh

Media	Seed size	Tray cell size	RL[1]	RFW[2]	SL[3]	SFW[4]
Vermiculite	Large seeds	Large cells	9.27a[5]	0.97bc	2.72d	0.39cd
		Small cells	9.20a	0.91c	3.67b	0.34d
	Small seeds	Large cells	6.55b	0.88c	2.83d	0.34d
		Small cells	7.10b	0.98bc	2.92cd	0.34d
Sand	Large seeds	Large cells	9.13a	0.97bc	3.97b	0.45bc
		Small cells	9.07a	1.27a	3.09cb	0.46bc
	Small seeds	Large cells	7.14b	1.09abc	4.36a	0.57a
		Small cells	7.58b	1.18ab	3.50cb	0.52ab
Mean			8.13	1.03	3.38	0.48

Note: see Table 3

The interactions between the three factors are presented in Table 4. Even though there was no clear trend expressing the interaction between the three factors for studied traits, it can be noticed that the interaction between large sweet corn kernels and with either vermiculite or sand growing mixture regardless tray cell size gave better root length than the interaction between small seed size and both growing media types (Table 4). However, growing media mixture with sand interacted well with small seeds and large tray cells to give the highest significant shoot length and weight (Table 4).

Since the growth of the seedling to mature plant was correlated with the performance of both root and

shoot systems, the ratio of shoot/root is of considerable interest and is presented in Table 5 for length, fresh and dry weight. Growing media with sand and large tray cell size tend to give higher ratio for length and fresh weight while sand with small tray cells showed the higher shoot/root ratio for dry weight (Table 5).

Table 5. The ratio of shoot/root for length, fresh and dry weight of sweet corn germinated seedlings cv. 277A *sh*

Seed size	Media	Vermiculite		Sand	
	Tray cell size	Large cells	Small cells	Large cells	Small cells
Large seeds	SL/RL1	0.38	0.40	0.52	0.34
	SFW/RFW2	0.35	0.37	0.44	0.36
Small seeds	SL/RL	0.43	0.32	0.61	0.38
	SFW/RFW	0.39	0.40	0.52	0.46

[1]SL/RL = Shoot Length/ Root Length (cm)
[2]SFW/RFW = Shoot Fresh Weight/ Root Fresh Weight (gram)

Seed priming experiment

Results of the sweet corn seed priming experiment are shown in Table 6 and Figure 1. Sweet corn bio-primed seeds with *Bacillus megaterium* showed the highest significant percentage of germination and number of germinated seeds and the increase was 55% over the control treatment in the germination percentage (Table 6). Sweet corn seeds that were bio-treated with isolates of *Trichoderma* ranked second in germination percentage although not significantly different than the control non-treated seeds (Table 6). Both sweet corn seeds osmo-primed with KNO_3 or hydro-primed showed poor germination performance resulted in germination percentages lower than the control non-treated dry seeds. Isolations of fungi from infected dead or non-germinated seeds showed that *Aspergillus niger* was the dominant fungus with 33.8% frequency followed by *Penicillium* spp with 31.1% (Fig. 1). Both *Aspergillus niger* and *Penicillium* spp. accounted for two third of the causal organisms while the rest of isolated fungi (*Rhizopus stolonifer*, *Alternaria* spp. and *Fusarium* spp.) accounted for 17.6, 10.8, and 6.7% of the causal organisms respectively (Fig. 1).

Table 6. The effect of seed priming of sweet corn cv. 277A sh_2 on germination percentage and number of germinated seeds

Treatment	Germination %	No. germinated seeds
Bacillus megaterium	59.32a[1]	88.98a
Trichoderma spp	40.67b	61.0b
KNO_3	20.12c	30.18c
H_2O	17.56c	26.33c
Control	38.02b	57.02b
Mean	35.1	52.7

[1]Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan`s multiple range test

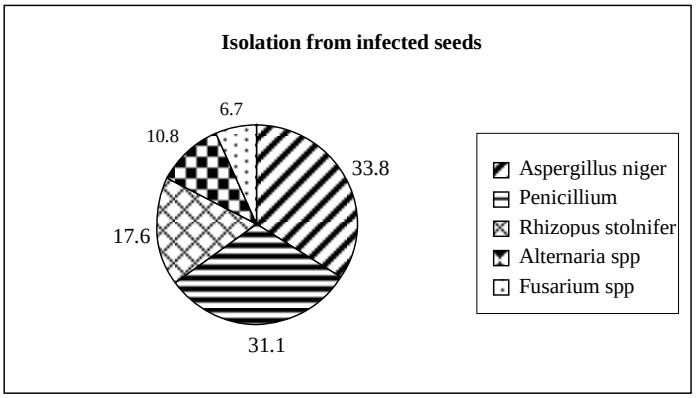


Fig.1. Frequency of fungi isolated from non-germinated seeds of sweet corn cv. 277A sh_2

DISCUSSION

Seed-borne and soil-borne fungi are the principal causes of sweet corn seed decay, and seedling blight, with stand reductions reaching 50% in localized areas. The most problematic fungi are *Fusarium*, *Rhizopus*, *Aspergillus* and *Penicillium*. The greatest damage from these pathogens occurs during the pre-emergence stage, causing poor germination of seeds or poor emergence of corn seedlings (Halfon-Meiri & Solil 1990). These fungi are common soil inhabitants in soils worldwide and have a broad host range. They survive between crops as dormant resting structures (oospores, sclerotia), in crop debris, saprophytically, and pathogenically on weeds and other hosts.

Beneficial bacteria and fungi provide promising alternatives or supplements to chemicals as seed treatments against soil borne pathogens. Beneficial fungi (*Trichoderma* spp.) and bacteria (*Bacillus* spp.) have been studied and selected for disease-suppressive properties. Bio-protectants are known to possess high degree of rhizosphere competence, and that protect seeds when added as a seed treatment. The present investigation confirms the earlier works in sweet corn (Bjorkman *et al*. 1998). It revealed that seed treatment with bio-agent strains improved seed germination and seedling stand over the control. Similar improvements of seed germination by bio-control means have been reported in maize (Mao *et al*. 1997). Beneficial bacteria and fungi increased synthesis of compounds which would have triggered the activity of specific enzymes that promoted early germination, such as α-amylase, which have brought an increase in availability of starch assimilation.

The efficacy of biological seed treatments can be affected by soil pH and iron concentration, moisture, temperature, and pathogen inoculums density (Callan *et al*. 1997). Efficacy can also be influenced by certain characteristics of the biological agent and of the seed treatment itself and these include the inoculum density on the bio-control agent on the seed, adjunct treatments such as priming, formulations and additives that enhance the activity and survival of the bio-control agent in the formulated product, crop and patho-

gen specifity of the biocontrol agent, and compatibility with other microbial inoculants or chemical fungicides (Callan *et al*. 1997).

The acidic nature of tomato seeds was suggested to be responsible for the relatively better protection of tomato by the more acid-tolerant Trichoderma than Enterobacter cloacae (Harman & Taylor 1988). Consequently, the sugary nature of sweet corn seeds may be responsible for the differences of biocontrol agents effectiveness against one pathogen than another. The array of pathogens isolated from the decayed and non-germinated sweet corn seeds may explain the difference observed between *Trichoderma* and *Bacillus* in our experiments due to the production of pathogen-specific antibiotics.

Bigger seed germination translates to healthy seedlings. If seed is large the emerging seedling has a larger food source depending on before it gets established. Maize seedlings from bigger seeds tend to emerge more successfully and are more vigorous both at the start of and throughout of their whole life (Boctes & Girardin 1994). Vigorous seedling are also, likely to be less affected by weeds and diseases. The larger seeds allow a better tolerance on unfavorable conditions also during early growth (Heather & Sieczka 1991). Taylor and Ten Broeck (1988) demonstrated that the amount of seedling emergence force expended increased linearly as seed size increased for an array of small- to large-seeded vegetable crops. However, an inverse relation existed between the capacity of seeds to use reserve materials and small-sized seeds were more efficient in using this reserve materials than large ones (Bremner *et al*. 1963, Taylor & Ten Broeck 1988). In our experiment the small seeds showed higher early germination than large seeds (Table 1) which can be explained by the rapid imbibition of moisture which accelerate both physiological and chemical process of germination. It is conceivable that smaller seeds require less water for germination, since they have less volume (Muchena & Grogan 1977). Roots of large seeds have much higher penetrating potential than those of small seeds which of great importance for the establishment of the plant and its competitive survival amongst other plants (Gelmond 1978).

Transplanting sweet corn was investigated as a method to improve stand establishment and hasten maturity. Transplanting sweet corn has been reported to produce significantly higher emergence percentage than direct seeded (Welbaum *et al*. 2001) and significantly reduced days required for emergence comparing to direct seeded (Water *et al*. 1990). It is obvious from the obtained results that the average final germination percentage was improved in the transplanting experiment (53%) compared to when seeds were directly cultivated in the field (35%). The superior germination percentage obtained when large sweet corn seeds were planted in large tray cells filled with vermiculite-based media in the transplanting experiment (86.9%) (Table 2) was much higher than the superior germination percentage obtained with *Bacillus*-treated seeds in priming experiment (59.3%) (Table 6). This may be justified by the numerous benefits of plug transplant-

ing. Transplanting using plugs offers the ease of transplanting, improved plant survival, avoid of soilborne diseases (Durner *et al*. 2002, Ratten *et al*. 2006). In plug production system there is little likelihood of plugs becoming infected with soilborne pathogens. Plugs keep most root hairs that quickly absorb water and nutrients. This active root system allows more uniform and faster plant growth.

Transplants produced in speedling trays are largely dependent on the chemical and physical properties of the growing media and the selection of the proper media components is critical to the successful production of transplants. Vermiculite with its platelike structure holds large quantities of water and positive charged nutrients like K, Mg, and Ca. This can be correlated to the higher final germination percentages associated with vermiculite-based growing media (Table 1). Sand is typically selected as a media component to improve the drainage. The coarse sand particles with loose texture allow faster penetrating potential and growth of roots which can explain the significantly higher root length, fresh weight (Table 3) associated with sweet corn seeds grown in sand compared to vermiculite. The better root system development with sand allowed for water and nutrients and nutrients absorption which reflected in significantly higher shoot length and fresh weight (Table 3) compared to the vermiculite.

Transplants grown in large tray-cell sizes generally are taller and have greater leaf area and shoot dry weight than those grown in small tray-cell sizes (Cantliffe 1993). Better seedling performance obtained when larger seedling containers were used may be partially due to beneficial effect arising from favorable physical properties of the planting media and availability of fertilizer since the amount of each was proportional to container size. Moreover, hormones synthesized in the root apex and reallocated to shoots would be reduced when the root growth was obstructed by the container base (Di Benedetto *et al*. 2006).

Plant responses to reduced soil volume have been reported for a wide range of crops (NeSmith & Duval 1998). On the other hand, higher production efficiency is obtained if multicell trays with the smaller cell volume are used. Container geometry can have a pronounced effect on seedling morphology. More narrow cells caused seedling height to decrease (Liptay & Edwards 1994). In this experiment small tray cells favor the root growth (length and weight) while large tray cells favor the shoot length and weight (Table 3). These conflicting results can be explained by the difference between both tray cell depths. The small cell are narrow and deep which promoted the root length while the large cell contained more media with high levels of aeration and water holding capacity that allowed for better growth of shoot (Table 3). Relation between plants growth and container size that affect levels of aeration and water availability is well documented (Milks *et al*. 1989, Bilderback & Fonteno 1987).

In conclusion, the results of this study suggested that transplanting can be an alternative method of sweet corn propagation compared with direct seeding. Plug cell trays felled with suitable growing media and the use of large sweet corn seeds would

produce better transplants. Bio-priming is suggested to enhance sweet corn low germination in contaminated soils and further improve seedling establishment. Additional research is needed to test other beneficial organisms combined with various chemical and physical seed treatments.

REFERENCES

Abo-Rezq H.M., Albaho M., Thomas B. 2009. Effect of sand in growing media on selected plant species. European Journal of Scientific Research 29 (4): 618-623.

Arenas M., Vavrina C.S., Cornell J.A., Hanlon E.A., Hochmuth G.I. 2002. Coir as an alternative to peat in media for tomato transplant production. HortScience 37(2): 309-312.

Barnett H.L., Hunter B.B. 1972. Illustrated Genera of Imperfect Fungi. Burgess Publ. Co., Minnesota, USA. 241pp.

Basra A.S., Bedi S., Malik V.B. 1988. Accelerated germination of maize seeds under chilling stress by osmotic priming and associated changes in embryo phospholipids. Annals of Botany. 61(5): 635-639.

Bennett M.A., Waters L. 1987a. Seed hydration treatments for improved sweet corn germination and stand establishment. Journal of the American Society for Horticultural Science 112(1): 45-49.

Bennett M.A., Waters L. 1987b. Germination and emergence of high sugar sweet corn is improved by presowing hydration of seed. HortScience 22(2): 236-238.

Bennett M.A., Waters L., Curme G.H. 1988. Kernel maturity, seed size, and sweet hydration effects on the seed quality of a sweet corn inbred. Journal of the American Society for Horticultural Science 113(3): 348-353.

Bennett M.A., Callan N.W., Fritz V.A. 1991. Seed treatments for disease control. HortTechnology 1(1): 84-87.

Bennett M.A., Fritz V.A., Callan N.W. 1992. Impact of seed treatments on crop stand establishment. HortTechnology 2(3): 345-349.

Bilderback T.E., Fonteno W.C. 1987. Effects of container geometry and media physical properties on air and water volumes in containers. J. Environ. Hort. 5(4): 180-182.

Bjorkman T., Blanchard L.M., Harman G. 1998. Growth enhancement of shrunken-2 (sh2) sweet corn by *Trichoderma harzianum* 1295-22: effect of environmental stress. Journal of the American Society for Horticultural Science 123: 35-40.

Bjorkman T. 2004. Effect of Trichoderma colonization on auxin-mediated regulation of root elongation. Plant Growth Regulation 43: 89-92.

Boctes T.C., Girardina P. 1994. Effects of seed size on maize growth from emergence to silking. Maydica 39: 213-218.

Bremner P.M., Eckersal R.N., Scott R.K. 1963. The relative importance of embryo and endosperm size in causing the effects associated with seed size in wheat. J. Agr. Sci. 61: 139-145.

Callan N.W., Mathre D.E., Miller J.B. 1990. Bio-priming seed treatment for biological control of *Pythium ultimum* preemergence dampening-off in sh_2 sweet corn. Plant Disease 74 (5): 368-372.

Callan N.W., Mathre D.E., Miller J.B. 1991. Field performance of sweet corn seed bio-primed and coated with *Pseudomonas fluorescens* AB254. HortScience 26(9): 1163-1165.

Callan N.W., Mathre D.E., Miller J.B., Vavrina C.S. 1997. Biological seed treatments: factors involved in the efficacy. HortScience 32 (2): 179-183.

Cameron J.W., Cole D.A., Van Maren A. 1962. Seed size effects on hybrid sweet corn in coachella valley. California Agriculture 16(6): 6-7.

Cantliffe D.F., Bieniek M. 1988. Improved plant stands of super sweet corn by seed treatment. Proc. Fla. State Hort. Soc. 101: 372-376.

Cantliffe D.J. 1993. Pre-and postharvest practices for improved vegetable transplant quality. HortTechnology 3(4): 415-418.

Chet I., Ordentlich A., Shapira R., Oppenheim A.B. 1990. Mechanisms of biocontrol of soil-borne plant pathogens by Rhizobacteria. Plant and Soil 129(1): 85-92.

Di Benedetto Molinari A.J., Rattin J. 2006. The effect of transplant in sweet maize (*Zea mays* L.) II. Container root restriction. International Journal of Agricultural Research 1(6): 555-563.

Dunwell W., Wolfe D., Maksymowicz W., Slone D. 1993. Producing sweet corn transplant in a float system greenhouse. HortScience 28 (4): 275.

Durner E.F., Poling E.B., Maas J.L. 2002. Recent Advances in strawberry plug transplant technology. HortTechnology 12(4): 545-550.

El-Saifi S.K., Ahmed H.M.I., Morsi M.M., Hassan S.M., El-Shatoury R.S. 2010. An attempt to improve sweet corn seed germination under low temperature conditions by using seed priming. J. Plant Production 1(2): 171-181.

Gamiely S., Smittle D.A., Mills H.A., Banna G.I. 1990. Onion seed size, weight, and elemental content affect germination and bulb yield. HortScience 25 (5): 522-523.

Gelmond H. 1978. Problems in crop seed germination. In: Crop Physiology. pp. 1-78. Oxford and B. H. Publishing Co. New Delhi.

Gerber J.M., Caplan L.A. 1989. Priming sweet corn seed for improved emergence. HortScience 24 (5): 854.

Giles B.E. 1990. The effects of variation in seed size on growth and reproduction in the wild barley (*Hordeum vulgare* ssp. *spontaneum*). Heredity 64: 239-250.

Gilman J.C. 1957. A Manual of Soil Fungi. The Iowa State College Press, Ames, Iowa, USA. 450 pp.

Gubbels G.H. 1974. Growth of corn seedlings under low temperatures as affected by genotype, seed size, total oil, and fatty acid content of the seed. Canadian Journal of Plant Science 54: 425-426.

Gubbels G.H. 1975. Emergence, seedling growth and yield of sweet corn after pre-germination at high temperature. Canadian Journal of Plant Scienc. 55: 995-999.

Halfon-Meiri A., Solil Z. 1990. Factors affecting seedling blight of sweet corn caused by *Pinicillium oxalicum*. Plant Disease 74: 36-39.

Hall M.R. 1989. Cell size of seedling containers influences early vine growth and yield of transplanted watermelon. HortScience 24(5): 771-773.

Halsey L.H. 1969. Seed size and planting depth effects on two tomato cultivars. Proc. Florida State Horticultural Society 82: 118-120.

Harman G.E., Taylor A.G. 1988. Improved seedling performance by integration of biological control agents at favorable pH levels with soild matrix priming. Phytopathology 78 (5): 520-525.

Harman G.E., Taylor A.G., Stasz T.E. 1989. Combining effective strains of *Trichoderma harzianum* and solid matrix priming to improve biological seed treatments. Plant Disease 73 (8): 631-637.

Harman G.E. 2000. Myths and dogmas of biocontrol, changes in perceptions derived from research on *Tricho-*

derma harzianum T-22. Plant Disease 84 (4): 377-393.

Harman G.E, Bjorkman T., Ondik K., Shoresh M. 2008. Changing paradigms on mode of action and uses of *Trichoderma* spp. for biocontrol. Outlooks on Pest Management 19(1):1-6.

Hartmann H.T., Kester D.E., Davies F.T., Geneve R.L. 1997. Plant Propagation: Principles and Practices. Prentice Hall, Upper saddle River, N.J. U.S.A. 770 pp.

Hartz T.K., Caprile J. 1995. Germination of sh_2 sweet corn following seed disinfection, solid-matrix priming, and microbial seed treatment. HortScience 30(7): 1400-1402.

Hawkins R.C., Cooper P.J.M. 1979. Effects of seed size on growth and yield of maize in the Kenya highlands. Experimental Agriculture 15: 73-79.

Heather D.W., Sieczka J.B. 1991. Effect of seed size and cultivar on emergence and stand establishment of broccoli in crusted soil. Journal of the American Society for Horticultural Science 116(6): 946-949.

Hicks D.R., Peterson R.H., Lueschen W.E., Ford J.H. 1976. Seed grade effect on corn performance. Agronomy Journal 68(5): 819-820.

Howell C.R. 2003. Mechanisms employed by *Trichoderma* species in the biological control of plant diseases: the history and evolution of current concepts. Plant Diseases 87: 4-10.

Hung P.E., Fritz V.A., Waters L. 1992. Infusion of shrunken-2 sweet corn seed with organic solvents: effects on germination and vigor. HortScience 27(5): 467-470.

Hunter R.B., Kannenberg L.W. 1972. Effect of seed size on emergence, grain yield, and plant height in corn. Canadian Journal of Plant Science 52: 252-256.

Khan A.A. 1992. Preplant physiological seed conditioning. Hort. Rev. 13: 131-181.

Khehra A.S., Brar H.S., Sharma R.K., Dhilon B.S., Malhotra V.V. 1990. Transplanting of maize during the winter in India. Agronomy Journal 82(1): 41-47.

Lazarovits G., Nowak J. 1997. Rhizobacteria for improvement of plant growth and establishment. HortScience 32: 188-192.

Liptay A., Edwards D. 1994. Tomato seedling growth in response to variation in root container shape. HortScience 26(6): 633-635.

Mao W., Lewis J.A., Hebbar P.K., Lumsden R.D. 1997. Seed treatment with a fungal or bacterial antagonist for reducing corn damping-off caused by species of Pythium and Fusarium. Plant Disease 81 (5): 450-454.

Mathre D.E., Johnston R.H., Callan N.W., Mohan S.K., Martin J.M., Miller J.B. 1995. Combined biological and chemical seed treatments for control of two seedling diseases of sh_2 sweet corn. Plant Disease 79 (11): 631-637.

Mathre D.E., Cook R.J., Callan N.W. 1999. From discovery to use, traversing the world of commercializing bio-control agents for plant disease control. Plant Disease 83 (11): 972-983.

Maynard E.T., Vavrina C.S., Scott W.D. 1996. Containerized muskmelon transplants: Cell volume effects on pre-transplant development and subsequent yield. HortScience 31(1): 58-61.

Menasha S.R. 2005. The effects of plug transplant container volume and root substrate composition on *Zea mays* L. root architecture, yield and quality. M.S. Thesis, University of Vermont, USA.

Menasha S.R., Tignor M.E. 2004. Plug tray cell volume effects on sweet

corn transplant root architecture and biomass accumulation. HortScience 39(4): 865.

Milks R.R., Fonteno W.C., Larson R.A. 1989. Hydrology of horticultural substrates: III. Predicting air and water content of limited volume plug cells. Journal of the American society for Horticultural Science 114(1): 57-61.

Miller R.A. 1972. Forcing sweet corn. HortScience 7(4): 188- 424.

Molatudi R.L., Mariga I.K. 2009. The effect of maize seed size and depth of planting on seedling emergence and seedling vigor. Journal of Applied Sciences Research 5 (12): 2234-2237.

Muchena S.C., Grogan C.O. 1977. Effects of seed size on germination of corn (*Zea mays*) under simulated water stress conditions. Canadian Journal of Plant Science 57, 921-923.

Murray G.A. 1990. Priming sweet corn seed to improve emergence under cool conditions. HortScience 25(2): 231.

NeSmith D.S., Duval J.R. 1998. The effect of container size. HortTechnology 8 (4): 495-498.

Oexemann S.W. 1942. Relation of seed weight to vegetative growth differentiation, and yield in plants. American Journal of Botany 29: 72-81.

Parera C.A., Cantliffe D.J. 1990. Improved stand establishment of shrunken-2 sweet corn by seed treatments. Proc. Fla. State Hort. Soc. 103: 153-157.

Parera C.A., Cantliffe D.J. 1991. Improved germination and modified imbibition of shrunken-2 sweet corn by seed disinfection and solid matrix priming. Journal of the American society for Horticultural Science 116(6): 942-945.

Pendleton J.W., Egli D.B. 1969. Potential yield of corn as affected by planting date. Agronomy Journal 61(1): 70-71.

Pyke K.A., Hedley C.L. 1983. The effect of foliage phenotype and seed size on the crop growth of *Pisum sativum* L. Euphytica 32: 193-203.

Rattin J., Di Benedetto A., Gornatti T. 2006. The effects of transplant in sweet maize (*Zea mays* L.) I. growth and yield. International Journal of Agricultural Research 1(1): 58-67.

Rudresh D.L., Shivaprakash M.K., Prasad R.D. 2005. Effect of combined application of *Rhizobium*, phosphate solubilizing bacterium and *Trichoderma* spp. on growth, nutrient uptake and yield of chickpea (*Cicer aritenium* L.). Applied Soil Ecology 28: 139-146.

Ruff M.S., Krizek D.T., Mirecki R.M., Inouye D.W. 1987. Restricted root zone volume: Influence on growth and development of tomato. Journal of the American Society for Horticultural Science 112(5): 763-769.

Sabota C., Beyl C., Biedermann J.A. 1987. Acceleration of sweet corn germination at low temperatures with Terra-Sorb or water presoaks. HortScience 22(3): 431-434.

Schmidt D.H., Tracy W.F. 1988. Endosperm type, inbred background and leakage of seed electrolytes during imbibition in sweet corn. Journal of the American Society for Horticultural Science 113: 269-272.

Shanmuganathan V., Benjamin L.R. 1992. The influence of sowing depth and seed size on seedling emergence time and relative growth rate in spring cabbage (*Brassica oleracea* var. *capitata* L.). Annals of Botany 69: 273-276.

Sperber J.I. 1957. Solubilization of mineral phosphates by soil bacteria. Nature 180: 994-995.

Statsoft Inc. 2001. STATISTICA for Windows Version 6. http://www.statsoft.com.

Styer R.C., Cantliffe D.J. 1983. Changes in seed structure and composition during development and their effect

on leakage in two endosperm mutants of sweet corn. Journal of the American Society for Horticultural Science 108: 721-728.

Styer R.C., Cantliffe D.J. 1984. Dependence of seed vigor during germination on carbohydrate source in endosperm mutants of maize. Plant Physiology 76: 196-200.

Taylor A.G., Ten Broeck C.W. 1988. Seedling emergence forces of vegetable crops. HortScience 23(2): 367-369.

Taylor A.G., Harman G.E. 1990. Concepts and technologies of selected seed treatments. Annu. Rev. Phytopathol. 28: 321-339.

Taylor A.G., Allen P.S., Bennett M.A., Bradford K.J., Burris J.S., Misra M.K. 1998. Seed enhancements. Seed Science Research 8: 245-256.

TehranifarA., Poostchi, M., Arooei H., Nematti H. 2007. Effects of seven substrates on qualitative and quantitative characteristics of three strawberry cultivars under soilless culture. Acta Hort. 761: 485-488.

Varier A., Vari A.K., Dadlani M. 2010. The subcellular basis of seed priming. Current Science 99(4): 450-456.

Voigt R.L., Gardner C.O., Webster O.J. 1966. Inheritance of seed size in sorghum, *Sorghum vulgare* Pers. Crop Science 6 (6): 582-586.

Wann E.V. 1980. Seed vigor and respiration of maize kernels with different endosperm genotypes. Journal of the American Society for Horticultural Science 105: 31-34.

Wann E.V. 1986. Leaching of metabolites during imbibition of sweet corn seed of different endosperm genotypes. Crop Science 26 (4): 731-733.

Waters L.J., Burrows R.L., Bennett M.A., Schoenecker J. 1990. Seed moisture and transplant management techniques influence sweet corn stand establishment, growth, development and yield. Journal of the American Society for Horticultural Science 115 (6): 888-892.

Weindling R. 1932. *Trichoderma tignorum* as a parasite of other fungi. Phytopathology 2: 837-845.

Welbaum G.E., Frantz J.M., Gunatilaka M.K., Shen Z. 2001. A comparison of the growth, establishment and maturity of direct-seeded and transplanted *sh*$_2$ sweet corn. HortScience 36 (4): 687-690.

Wolf D.W., Azanza F., Juvik J.A. 1997. Sweet corn. pp. 461-478. In: The Physiology of Vegetable Crops. (H.C. Wien, ed.) CAB International. USA.

Wyatt J.E., Mullins J.A. 1989. Production of sweet corn transplants. HortScience 24(6): 1039.

ROZMNAŻANIE SUPER SŁODKIEJ KUKURYDZY CUKROWEJ: BADANIA NAD KONDYCJONOWANIEM NASION ORAZ PRODUKCJĄ Z ROZSADY

Streszczenie

Uprawa mieszańców kukurydzy cukrowej z genotypami o wysokiej zawartości cukru (*sh*$_2$) jest utrudniona ze względu na słabe wschody nasion. Badania przeprowadzono w celu określenia wpływu wielkości nasion, wielkości komórek w paletach rozsadowych i komponentów podłoży uprawowych na młode rośliny kukurydzy cukrowej. Drugim celem badań była ocena wpływu kondycjonowania nasion kukurydzy cukrowej na kiełkowanie nasion w polu. Zastosowano bio-priming przy użyciu grzybów *Trichoderma* i bakterii *Bacillus*, osmo-priming w roztworze KNO_3 oraz hydropriming w H_2O. Badania wykazały, że przesadzanie kukurydzy cukrowej jest możliwe pod warunkiem zastosowania wysokiej jakości rozsady uzyskanej z nasion dobrze kiełkujących w wol-

nym od chorób środowisku. Duże nasiona, duże komórki w paletach rozsadowych oraz podłoża na bazie wermikulitu sprzyjały kiełkowaniu nasion kukurydzy cukrowej. Natomiast te same czynniki nie wykazały wyraźnego wpływu na wzrost sadzonek pod względem długości korzeni i pędów oraz świeżej masy. W doświadczeniu z kondycjonowaniem nasion traktowanie mikroorganizmami dało najwyższy procentowy udział kiełkujących nasion w porównaniu do pozostałych zabiegów kondycjonowania i kombinacji kontrolnej. Nasiona traktowane bakteriami *Bacillus megaterium* kiełkowały o 50% lepiej niż nasiona traktowane grzybami *Trichoderma* spp.

Aspergillus niger i *Penicillium* stanowiły 65% patogenów odpowiedzialnych za porażenie nasion kukurydzy cukrowej. Wyniki badań wykazały możliwość rozmnażania super słodkiej kukurydzy cukrowej z rozsady oraz wykorzystanie kondycjonowania nasion dla poprawy wschodów oraz obsady roślin na polu.