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Optimizing Greenhouse Corn Production: Materials and Methods

Robert Eddy

Purdue University, robeddy@purdue.edu

Daniel T. Hahn

Purdue University, dhahn@purdue.edu

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Purdue Methods:

Optimizing Greenhouse Corn Production

MATERIALS AND SUPPLIERS

Root Media

Fafard Mixes: Conrad Fafard, Inc., Agawam, MA

Metro-Mixes, Redi-earth Mix, Perlite and Vermiculite: Sun Gro Horticulture, Bellevue, WA

Pro-Mixes: Pro-Mixes: Premier Horticulture, Quakertown, PA

Turface MVP and Profile Greens Grade calcined clay: Profile Products LLC, Buffalo Grove, IL

Eco-lite zeolite: Earth Works Natural Organic Products, Easton, PA

Expanded Shale: Diamond Pro / TXI, Dallas, TX

Fertilizers

Excel 15-5-15 Cal-Mag, Excel 21-5-20, Peters 20-20-20, and Miracid 30-10-10: The Scotts Company, Marysville, OH

Greencare 16-3-15: Greencare Fertilizers, Kankakee, IL

Multicote-4 14-14-16 slow release fertilizer: Sun Gro Horticulture, Bellevue, WA

Ca chelate (9.5%), Liquid Calcium Chloride (13% Ca), Zn chelate (14%): Hydro-Gardens, Colorado Springs, CO

CaNO₃ 15-0-0 fertilizer (19% Ca): Yara North America, Inc., Tampa, FL

MgSO₄ "Epsom salt" (MgSO₄-7H₂O): Kroger, Cincinnati, OH

Pots, Tray-inserts and Trays

Pots, tray-inserts and trays: ITML-brand 5-inch standards, 5.5-inch azalea, 6.5-inch azalea, 3-inch square, 4-inch square, 8-inch standard, 4-gallon nursery container, Elite 1200 nursery container, 1020 trays: Myers Industries Lawn & Garden Group, Akron, OH

Pots, tray-inserts: 6-inch standards, 606 tray-insert, 1204 tray-insert: Landmark Plastic Corporation, Akron, OH

Sub-irrigation trays: "White Display Trays", T.O. Plastics, Clearwater, MN

Clear watering saucers: Woodstream Corp., Lititz PA

Decorative pot covers: Hummert International, St. Louis, MO

Equipment

Computer environment controls: Priva, Vineland Station, Canada

Plant growth chambers: Conviron (model E8 and E15), Winnipeg, Canada and Percival Scientific, Inc. (model AR-75L), Perry Iowa

Ultra-sonic cleaning bath: Cole-Parmer (Model B3-R, output 55 KHz +/-6%), Vernon Hills, IL

Garden irrigation timer: Model 62015 Hose Faucet Timer, Orbit Irrigation Products, Inc., North Salt Lake, UT

Irrigation Drippers: Chapin Watermatics Inc., USA, Water Town, NY

Chlorophyll Meter: Model Spad-502, Konica Minolta Sensing Americas Inc., Ramsey, NJ

Chemicals

Uniconazole plant growth regulator: Sumagic, Valent U.S.A. Corporation, Walnut Creek, CA

Floral preservative: Floralife, Inc., Walterboro, SC

93% Sulfuric acid: Brenntag, Henderson, KY

Pest Control

Phytoseiulus persimilis: MGS Horticultural, Inc., Leamington, Canada

Yellow Sticky Traps: Whitmire Micro-Gen, St. Louis, MO

METHODOLOGY

Experiment 1

Effect of Root Medium and Automatic Irrigation on Growth and Seed Yield of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

In this initial study, corn grown in calcined clay granules is compared to a standard root media for growing greenhouse corn, and hand-watering compared to an automated drip system.

Seed of a corn inbred line known for weak growth and marginal yield were grown in two root media for comparison. One was a root medium commonly used for containerized corn: Metro-Mix 360 peat-based soilless potting mix augmented with field soil at 5% final volume. The other was calcined clay granules made for the athletic field industry, trade name Turface MVP. Twelve pots of each media were sown, the nursery containers having a diameter of 30 cm (12 inches) and a volume of 14.8 liters (4 gal). Each root media was further divided into groups of four pots for watering method comparison. One set received hand-watering with a hose as need was determined by staff to avoid water stress. A second set was watered with drip irrigation on a timer, activating every six hours for two minutes, or 4 times daily. The final set had a similar drip irrigation system activated every 2 hours, or 12 times daily. Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Plant height at pollination, days to pollination, leaf number and chlorophyll content (Spad 502 chlorophyll meter) were recorded. Seeds per ear were counted at termination of the crop.

Experiment 2

Effect of Root Medium on Early Vegetative Growth of Greenhouse-Grown Corn

Derek Gambrel, Rob Eddy and Dan Hahn

Young corn plants were compared after being grown in various commercial soilless mixes and augmented mixes.

On 2 February 2004, seed of corn hybrid Pioneer 34M95 were sown in 15 cm (6-inch) diameter round "standard" plastic pots. Five seeds were sown per pot, later thinned to three seedlings following germination one week later. Six pots of each of the following media were filled:

Metro-Mix 360 coir-based potting mix
5.5:1 Metro-Mix 360 coir, Turface calcined clay (by volume)
2:1 Metro-Mix 360 coir, Turface

Metro-Mix 360 peat-based potting mix
5.5:1 Metro-Mix 360 peat, Turface
2:1 Metro-Mix 360 peat, Turface

Metro-Mix 366-P coir-based potting mix
5.5:1 Metro-Mix 366-P coir, Turface
2:1 Metro-Mix 366-P coir, Turface

Metro-Mix 200 coir-based potting mix
5.5:1 Metro-Mix 200 coir, Turface
2:1 Metro-Mix 200 coir, Turface

Metro-Mix Redi-Earth peat-based potting mix
5.5:1 Metro-Mix Redi-Earth, Turface
2:1 Metro-Mix Redi-Earth, Turface

Metro-Mix 560 coir-based potting mix
5.5:1 Metro-Mix 560 coir, Turface
2:1 Metro-Mix 560 coir, Turface

Turface
2:1 Turface, medium vermiculite
1:1 Turface, medium vermiculite
1:2 Turface, medium vermiculite

The pots were placed in a growth room with 22°C day / 18°C night (72°F / 64°F) temperature. Since this was a short-term experiment, the pots were not spaced apart. Supplemental lighting of approximately 150 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using a combination of metal halide and high pressure sodium fixtures for 16 hours per day.

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Irrigation was performed by a drip irrigation system on a garden timer activated for 2 minutes every 4 hours, or six times daily. Observations of color and vigor were made weekly for four weeks.

Experiment 3

Effect of Root Medium on Early Vegetative Growth of Greenhouse-Grown Corn, Part II

Derek Gambrel, Rob Eddy and Dan Hahn

Young corn plants were compared after being grown in various soilless mixes and augmented mixes. Vermiculite was extensively studied, as it was most cost effective. Pot size was larger than previous study.

On 19 March 2004, seed of corn hybrid Pioneer 34M95 were sown in 28 cm (11-inch) diameter “Elite 1200” nursery containers with a volume of 11.3 liters (3 gal). The pots were lined with a 20-cm (8-inch) clear saucer to contain the smaller-particle media that would otherwise flow through the drainage holes. Four seeds were sown per pot, later thinned to a two seedlings following germination one week later. Forty-two total pots were sown. Three single pot replicates of each of the following media were filled:

Vermiculite, medium grade
Vermiculite, coarse grade
Vermiculite, extra coarse grade
Perlite
Profile
Turface
2:1 Vermiculite medium, Turface (by volume)
2:1 Vermiculite medium, Profile
2:1 Vermiculite coarse, Turface
2:1 Vermiculite coarse, Profile
2:1 Vermiculite extra coarse, Turface
2:1 Vermiculite extra coarse, Profile
2:1 Perlite, Turface
2:1 Perlite, Profile

The pots were placed in a glass greenhouse with 24°C day / 19.5°C night (75°F / 67°F) temperature setpoints. Since this was a short-term experiment, the pots were not spaced apart. Supplemental lighting of approximately 150 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using a combination of metal halide and high pressure sodium fixtures for 16 hours per day.

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Irrigation was performed by a drip irrigation system on a garden timer activated for 2 minutes every 4 hours, or six times daily. Observations of color and vigor were made weekly for four weeks.

Experiment 4

Effect of Root Medium, Irrigation Frequency and Pot Drainage Method on Growth and Seed Yield of Greenhouse-Grown Corn

Westin Rink, Rob Eddy and Dan Hahn

Corn was grown to harvest in the best two root media from earlier studies, with differing irrigation frequencies and perched water tables examined.

On 25 June 2004, seed of corn hybrid Pioneer 34M95 were sown in 28 cm (11-inch) diameter “Elite 1200” nursery containers with a volume of 11.3 liters (3 gal). Two pots were stacked together with a slit decorative pot cover between them to act like a screen containing the smaller-particle media that would otherwise flow through the drainage holes. Half the pots were lined with a clear plastic saucer, which would hold a 3 cm column of water even after the pot drained following irrigation. This artificial “perched water table” would ensure the roots

always had access to water, while the upper portion of the soil column would not be saturated. Four seeds were sown per pot, later thinned to a one seedling following germination one week later. Seventy-two total pots were sown. Three single pot replicates of each of the following treatments were filled:

Profile calcined clay, Drained pot, 48 hour irrigation frequency
Profile, Drained pot, 8 hour irrigation frequency
Profile, Drained pot, 2 hour irrigation frequency
Turface calcined clay, Drained pot, 48 hour irrigation frequency
Turface, Drained pot, 8 hour irrigation frequency
Turface, Drained pot, 2 hour irrigation frequency
Profile, Perched pot, 48 hour irrigation frequency
Profile, Perched pot, 8 hour irrigation frequency
Profile, Perched pot, 2 hour irrigation frequency
Turface, Perched pot, 48 hour irrigation frequency
Turface, Perched pot, 8 hour irrigation frequency
Turface, Perched pot, 2 hour irrigation frequency

The pots were placed in a glass greenhouse with 27°C day / 21°C night (80°F / 70°F) night temperature setpoints. Supplemental lighting of approximately 150 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using a combination of metal halide and high pressure sodium fixtures for 16 hours per day.

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Irrigation was performed by a drip irrigation system on garden timers, one timer per watering frequency. Days to pollination, final plant height, seed per ear and dry seed weight were recorded. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Experiment 5

Effect of Container Size and Plant Number Per Container on Vegetative Growth of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Corn was grown with the best root media and irrigation frequency from earlier studies, but in differing pot sizes and number of plants per pot.

On 17 September 2004, seed of corn hybrid Pioneer 34M95 were sown in pots containing Turface calcined clay granules in varying sized pots. Forty total pots were sown. Eight single pot replicates of each of the following treatments were filled:

20-cm (8-inch) diameter pot, one plant
16.5-cm (6.5-inch) “azalea” pot, one plant
15-cm (5.5-inch) “azalea” pot, one plant
20-cm diameter pot, two plants
20-cm diameter pot, three plants

The pots were placed in a glass greenhouse with 27°C day / 21°C night (80°F / 70°F) temperature setpoints. Supplemental lighting of approximately 150 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using a combination of metal halide and high pressure sodium fixtures for 16 hours per day.

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Irrigation was performed by a drip irrigation system on garden timers, one timer per watering frequency. Weekly observations were made during vegetative phase.

Experiment 6

Effect of Photoperiod and Root Medium on Vegetative Growth of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Corn was grown three root media, one containing a zeolite amendment, and under three photoperiods.

On 7 December 2005, seed of corn hybrid Pioneer 34M95 were sown in 15-cm (6-inch) diameter “standard” pots containing one of three root media:

- 1:1 (by volume) of Turface and Pro-Mix BX
- 1:1 of Profile and Pro-Mix BX
- 1:1 of Eco-lite zeolite product and Pro-Mix BX

Nine pots of each were sown with two seeds each, later thinned to one seedling following germination. Twenty-seven total pots were sown. Three single pot replicates of each root media were then exposed to the one three photoperiods: Natural day (winter), ND with 16 hour supplementation, and ND with 24 hour supplementation.

The pots were placed in a glass greenhouse. The supplemental lighting of approximately 100 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using a combination of metal halide and high pressure sodium fixtures.

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Irrigation was performed every 8 hours by a drip irrigation system on garden timers. Weekly observations were made during vegetative phase.

Experiment 7

Comparing Acidic versus Basic Fertilizer Formulation on Vegetative Growth of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Early vegetative growth was compared between plants grown in three root media, one containing a zeolite amendment, and using two different fertilizer solutions.

On 7 December 2005, seed of corn hybrid Pioneer 34M95 were sown in 15-cm (6-inch) diameter “standard” pots containing one of three root media:

- 1:1 (by volume) of Turface and Pro-Mix BX
- 1:1 of Profile and Pro-Mix BX
- 1:1 of Eco-lite zeolite product and Pro-Mix BX

Eight pots of each were sown with two seeds each, later thinned to one seedling following germination. Twenty-four total pots were sown. Four single pot replicates of each root media were then irrigated at each irrigation with one of the following fertilizers:

15-5-15 (basic) fertilizer, 200 ppm N
Miracid 30-10-10, 200 ppm N

The pots were placed in a glass greenhouse. The supplemental lighting of approximately 100 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided for 16 hours per day using a combination of metal halide and high pressure sodium fixtures.

Plants were fertilized at each irrigation. Irrigation was performed every 8 hours by a drip irrigation system on garden timers. Weekly observations were made during vegetative phase.

Experiment 8

Effect of Pollination Technique on Seed Yield of Greenhouse-Grown Corn

Adam Leonberger, Rob Eddy and Dan Hahn

Seed yields were compared between open-pollination, hand pollination, plant shaking, and fan-assisted pollination.

On 24 February 2006, seed of corn hybrid Pioneer 34M95 were sown in 120- 20.3 cm (8-inch) diameter round "standard" plastic pots. Root media consisted of a 1:1 mixture of Pro-Mix BX and Profile Greens-Grade calcined clay granules. A paper towel was placed in the bottom of the pot to hold in the media until it could be wetted. Two seeds were planted per pot, later thinned to one plant following germination. Planting depth was approximately 2.5 cm.

Plants were kept in white display trays without holes. Irrigation solution was kept in the trays continuously to keep the root media moist. Irrigation solution consisted of 15-5-15 fertilizer at a concentration of 200 ppm N. Plants were grown in a glass greenhouse with 24°C day / 19.5°C night (75°F / 67°F) setpoints and a photoperiod of 16 hours provided by high pressure sodium and metal halide fixtures providing 100 $\mu\text{mol}/\text{m}^2/\text{s}$ supplemental light. On 20 April, plants were moved to another greenhouse with polyethylene film roof but same environmental conditions. The fertilizer solution was applied with a drip irrigation system activated three times daily for a period of five minutes. Plastic sheeting was put up between treatment groups to contain a majority of pollen within each group.

On 5 May, pollination techniques began and continued until 16 May unless pollen was no longer present on tassels. One set was hand pollinated by collecting pollen in tassel bags and pouring over silks. Silks were covered by ear bags when not being pollinated. Another set was pollinated by use of a fan suspended approximately 46 cm (18-inches) above the tassels, pointed downward. The fan was used from 10AM to 12AM each morning. A third set was pollinated by manually shaking stems for 6-7 seconds. A fourth set was not pollinated by any technique, and bags kept over ears during shaking, hand-pollinating and fan operation period of other treatments.

On 13 June, ears were measured for length, circumference and number of seed. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Experiment 9

Effect of Container Size on Vegetative Growth of Greenhouse-Grown Corn

Adam Leonberger, Rob Eddy and Dan Hahn

Corn growth was compared between three pot sizes, to see if there was a limit to how small the container could be.

On 24 February 2006, seed of corn hybrid Pioneer 34M95 were sown in four sizes of plastic pots: 20.3 cm (8-inch) diameter round “standard” pots; 14 cm (5.5-inch) diameter round “azalea” style pots; 10.3 cm (4-inch) diameter square pots; and 7.6 cm (3-inch) diameter square pots. Twelve pots of each size were planted, except for the largest size, which were used in another study simultaneously consisting of 120 pots. Root media consisted of a 1:1 mixture of Pro-Mix BX and Profile Greens-Grade calcined clay granules. A paper towel was placed in the bottom of the largest size pot to hold in the media until it could be wetted. Two seeds were planted per pot, later thinned to one plant following germination. Planting depth was approximately 2.5 cm. Plants were kept in white display trays without holes. Irrigation solution was kept in the trays continuously to keep the root media moist. Irrigation solution consisted of 15-5-15 fertilizer at a concentration of 200 ppm N. Plants were grown in a glass greenhouse with 24°C day / 19.5°C night (75°F / 67°F) setpoints and a photoperiod of 16 hours provided by high pressure sodium and metal halide fixtures providing 100 $\mu\text{mol}/\text{m}^2/\text{s}$ supplemental light.

Plant height and leaf unfolding stage were recorded weekly through vegetative stage.

Experiment 10

Effect of Glass- versus Polyethylene-glazed Greenhouse on Seed Yield of Corn

Adam Leonberger, Rob Eddy and Dan Hahn

Corn was pollinated under two glazing materials to test the hypothesis that increased UV light that penetrates polyethylene would improve seed yield.

Twelve corn plants growing in large nursery containers were obtained from an Indiana research company in May 2006. They were approximately 120-cm (4-feet) in height. Purdue researchers did not know the root medium and fertilization practice at the original facility, or the identity of the inbred line.

Plants were moved into two locations at Purdue University, one a glass greenhouse and the other with a polyethylene film roof and polycarbonate sidewalls. Temperature setpoints in both locations were 24°C day / 19.5°C night (75°F / 67°F) under natural day length. Irrigation solution consisted of 15-5-15 fertilizer at a concentration of 200 ppm N. Hand pollination was performed on all plants over seven days to each set.

On 20 July, ears were measured for length, circumference and number of seed. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Experiment 11

Effect of Husk Tip Removal on Seed Yield of Greenhouse-Grown Corn

Adam Leonberger, Rob Eddy and Dan Hahn

Seed set was compared with and without removal of the ear tip to create a “brush” of silks one day prior to pollination.

Twelve corn plants growing in large nursery containers were obtained from an Indiana research company in June 2006. They were approximately 120-cm (4-feet) in height. Purdue researchers did not know the root medium and fertilization practice at the original facility, or the identity of the inbred line.

Plants were moved into two locations at Purdue University, one a glass greenhouse and the other with a polyethylene film roof and polycarbonate sidewalls. Temperature setpoints in both locations were 24°C day / 19.5°C night (75°F / 67°F) under natural day length. Irrigation solution consisted of 15-5-15 fertilizer at a concentration of 200 ppm N. Hand pollination was performed on all plants over seven days to each set.

One day prior to start of pollination, half of plants in each environment had husk tips cut. The upper 2-3 cm were removed, so that silks would emerge in a “brush,” a common practice for research corn production to improve pollination. The first silks had begun to emerge prior to the cut on each plant. The other six plants did not have husk tips cut. Hand pollination was performed on all plants on 20 July to 27 July to each plant. Ear bags covered the silks in between pollinations.

On 14 August, ears were measured for length, circumference and number of seed. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Experiment 12

Effect of Root Medium on Early Vegetative Growth of Greenhouse-Grown Corn Under Constant Sub-Irrigation

Rob Eddy and Dan Hahn

Early vegetative growth was compared between plants grown in six root media, including an expanded shale product, kept under constant sub-irrigation.

On 23 January 2008, seed of corn hybrid Pioneer 34M95 were sown in 13-cm (5-inch) diameter “standard” pots containing one of six root media:

Turface calcined clay granules
Profile calcined clay granules
Coarse vermiculite
Pro-Mix BX
Profile/Coarse vermiculite layered
Expanded shale

Six pots of each were sown with two seeds each, later thinned to one seedling following germination. Thirty-six total pots were sown. The pots were placed in a glass greenhouse. The supplemental lighting of approximately 100 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using a combination of metal halide and high pressure sodium fixtures.

Plants were irrigated and fertilized continuously with 15-5-15 fertilizer at a concentration of 200 ppm N. A tray was kept filled with the solution daily. Observations were made weekly for four weeks. Visual rankings of chlorosis was made on 18 February, with “0” representing dark green leaves and “5” representing a plant with leaves that were nearly completely yellow.

Experiment 13

Effect of Root Medium, Growth Regulator Application and Tassel Storage of Growth and Seed Yield of Greenhouse-Grown Corn

Craig Schluttenhofer, Jeannie Ross, Tyler Mason, Rob Eddy and Dan Hahn

Earlier comparisons of root media were compared using more replicates and with plants grown to seed harvest. Growth regulator was applied to one group to reduce height. A tassel storage technique to improve pollination was validated.

On 1 May 2009, seed of corn hybrid Pioneer 34M95 were sown. Three sets of 20 pots were each filled with differing root media for comparison. Turface calcined clay granules was the root media we hypothesize to improve growth. The other two root media were examples of typical mixes used at university and corporate research greenhouses for corn, both relying on the incorporation of field soil. The first was a mixture consisting of a fine-grade commercial potting mix (Fafard’s Superfine Germination Mix) and a locally dug field soil at a ratio of 9:1 Fafard mix: field soil ratio. The second was a 1:1 mix of the same field soil and a medium grade potting mix (Metro-Mix 510). The field soil had been dried and ground prior to mixing, and has been used successfully in container studies of agronomic crops by the Life Science Greenhouse complex on Purdue campus. Three seeds were sown per pot, later thinned to one seedling following germination on week later.

Sixty additional pots were filled with calcined clay for use in the growth regulator and tassel storage treatment groups, one twenty-pot set for each of those treatments and a third set for combination of growth regulator and tassel storage. For all pots in this study using calcined clay granules, a method was devised to keep the granules from leaking out the drainage holes of the pots. Two pots were nested, the lower one with approximately 500 cc of Metro-Mix 510 in the bottom to cover the drainage holes of the upper pot without sealing. There are other methods to accomplish this, but we wanted to use materials readily available at most greenhouses and methods easily adapted and scaled to larger production.

The pots were placed in a greenhouse with polyethylene film room and polycarbonate sidewalls with 25.5°C day / 21°C night (78°F / 70°F) temperature setpoints. Each treatment group was configured into two twin-rows, 75-cm (30-inches) apart. Within the twin rows, individual plants were approximately 30-cm (12-inches) apart. Treatment groups were by approximately 1.6-m (66-inches) apart to ensure similar sun exposure to each group.

Because we were comparing cultivation “systems” rather than individual components, the root media containing field soil were sown in 11.3 liter (3 gal) nursery pots and watered with a hose by the greenhouse team. The pots containing Turface were sown in 20-cm (8-inch) diameter pots and irrigated automatically as described below.

Pots were irrigated with clear water using a hose at sow date. No further irrigation was required until 6 May, when automated irrigation programming was initiated on the Turface pots. The Turface pot programming was achieved with Priva microprocessor climate control

initiating a drip irrigation system with two drippers per pot. The programming simulated what could be done with a battery-operated timer, so that conditions of study could be repeated by any grower. The program came on every two hours for two minutes. Total volume for the 12 cycles per day was approximately 4.8 liters per pot per day. The programming had been shown to be detrimental to the other soil types in earlier studies, so the 9:1 mix and 1:1 mix were watered as needed by hose for the duration of the study, approximately once per week for the first five weeks, twice per week during the rest of vegetative growth, and three times per week during reproduction. Each irrigation by hose was with approximately 2.5 liters fertilizer solution.

Fertilizer solution was used for every irrigation event beginning 6 May. Irrigation solution consisted of 15-5-15 fertilizer at a concentration of 200 ppm N. The solution pH was adjusted to approximately 6.1 using 93% sulfuric acid.

Observations were made on pests in the differing root media. Weeds were removed growing in pots with incorporated with field soil on 18 May and as needed for duration of study. Yellow sticky traps were placed on surface of 4 representative pots of each root media on 20 May to survey insects later that same day. Potato slices of approximately 5 cm diameter were placed, face down, approximately 1.3 cm into 5 representative pots of each root media on 22 May for survey of larval insects under surface five days later.

As study progressed, Two-Spotted Spider Mite pests were controlled by a combination of removal of lowest 2-3 leaves, hosing off plants three times weekly with clear water and an application of approximately 1500 Phytoseiulus persimilis predatory mites over the entire crop.

Plant heights and seed counts of ear commenced on week of 29 July. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Growth Regulator Application

On 19 May, application of 1 ppm uniconazole plant growth regulator were made to two sets of pots containing calcined clay granules, according to a technique described by Craig Schluttenhofer of the Cary Mitchell lab in the Horticulture & Landscape Architecture department of Purdue (publication pending). Plants were at V4-V5 leaf stage. Irrigation system was deactivated for a period starting 36 hours prior to the application until 24 hours after application to ensure solution absorption into the media. A volume of 27.5 ml of uniconazole was added to 2 liters of reverse-osmosis purified water and poured on the root medium of each pot. One liter would have been sufficient, as much of the solution was not absorbed (the Mitchell lab protocol was developed for a smaller grained calcined clay granule with more water holding capacity). A third set of Turface pots received a similar application of reverse osmosis water without the growth regulator. The application caused tillers shoots to form on the plants. These were removed and counted as the experiment progressed.

Tassel Storage and Pollination Technique

On 22 June, most tassels were shedding pollen and silks had emerged from many ear tips. Ear tips were cut 2-3 cm to create silk "brush" as their silks emerged. Day temperature setpoint was lowered to 21°C (70°F). Open pollination was commenced on 23 June for all plants by manually shaking stems for about 10 seconds to dislodge pollen between 9:30AM and 10:30AM each morning. This was continued through 27 June, when the technique yielded no visible pollen.

For the two sets of plants to be used for tassel storage technique, half of their exposed tassels were cut off and stored in a dark cooler at 42°F on 23 June. One leaf was left on each tassel. They were kept in a solution of tap water and fresh flower preservative. Five grams of the preservative were dissolved in 0.5 liters. The stems of the tassels were cut underwater every two days and floral preservative solution replaced, as for cut flower maintenance. Tassels from the two plant sets were kept separate. There were 10 tassels from the designated “Stored Tassel” set but only 4 tassels from the “Growth Regulator with Stored Tassel” set. This was because the latter set of plants exhibited tight leaf rolling around the tassel that kept it from emerging fully. This phenomenon was observed in both growth regulator plant sets so appears to be a side effect of the chemical. The tassels were stored in the cooler until 2 July, with pollen collection and application to ear silks in greenhouse every day beginning 26 June. This effectively increased the pollination period for these sets of plants for 5 days beyond the open pollination period. Note that the stored tassel sets received pollen from both open pollination and the stored tassels.

Collection of pollen from stored tassels began on 26 June. Tassels were removed from cooler at 8:45 AM and placed in a work room of normal indoor temperature and lighting. At 11:15 AM, pollen was shaken off tassels on a large piece of paper, transferred to a smaller piece of office paper and then applied to ear silks of all 20 plants of the respective plant set. Application was made by tapping paper over the silks. Greenhouse fans were turned off during the application. Pollinations were complete by 11:30 AM. Pollen was applied to primary and secondary ears, and if present, tertiary ears. Priority was given to primary ear unless its ear silks were shriveled indicating they were no longer viable. Beginning on 29 June, an attempt was made to quantify the pollen yield from the stored tassels by weighing. The 4 tassels from the “Growth Regulator with Stored Tassel” set yielded 0.2-0.3 grams pollen each day measured. The “Stored Tassel” set with ten total tassels yielded 0.5g to 1.0g each day. It should be noted that this set yielded 0.5g of pollen nine days after being cut from the plant. It was assumed by the investigator that the pollen was viable by the turgid, round appearance of the pollen under microscope versus the shrunken, irregular shape of pollen left at room temperatures for just 30 minutes.

Light measurements inside the canopy near the ears were attempted on 7 July. It varied from 610-776 $\mu\text{mol}/\text{m}^2/\text{s}$ inside the canopy, as compared to 1350 $\mu\text{mol}/\text{m}^2/\text{s}$ in the open greenhouse.

Experiment 14

Effect of Root Medium, Watering Method and Fertilizer Strength on Growth and Seed Yield of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

A follow up to Experiment 13 was conducted to see if growth and yield could be improved with stronger fertilizer or by keeping a tray to hold irrigation water under the plants.

On 26 June 2009, seed of corn hybrid Pioneer 34M95 were sown in 44- 20.3 cm (8-inch) diameter round “standard” plastic pots. Two seeds were sown per pot, later thinned to one seedling following germination on week later. Sixteen pots were filled with Profile Greens-Grade and another 16 pots with Turface MVP. Twelve pots were filled with a 1:1 mix of the field soil and a medium grade potting mix (Metro-Mix 510) as described in Experiment 13. For

all pots in this study using calcined clay granules, the same method was used to keep the granules from leaking out the drainage holes as described in Experiment 13.

The pots were divided into groups of 4 single-pot replicates with these treatments:

- 1:1 mix, 200 ppm N applied at every irrigation by drip irrigation program
- 1:1 mix, 200 ppm N applied at each irrigation by hand watering
- 1:1 mix, 600 ppm N applied at each irrigation by hand watering

The above set was to test the effect of triple-strength fertilizer and to compare hand watering on an “as needed” basis against a drip irrigation on a timer.

The two sets described below examined fertilizer strength and what the effect would be of constant sub-irrigation via the 2-cm deep white tray or the 3-cm deep clear saucer. The drip irrigation system filled the trays and saucers. There has been no evidence to date that these root media could be over-watered or over-fertilized, resulting in poor plant health.

- Profile, 200 ppm N applied at every irrigation by drip, no tray beneath
- Profile, 200 ppm N applied at every irrigation by drip, white display tray beneath
- Profile, 200 ppm N applied at every irrigation by drip, clear saucer beneath
- Profile, 600 ppm N applied at every irrigation by drip, white tray beneath

- Surface, 200 ppm N applied at every irrigation by drip, no tray beneath
- Surface, 200 ppm N applied at every irrigation by drip, white display tray beneath
- Surface, 200 ppm N applied at every irrigation by drip, clear saucer beneath
- Surface, 600 ppm N applied at every irrigation by drip, white tray beneath

The pots were placed in a greenhouse with polyethylene film room and polycarbonate sidewalls with 25.5°C day / 21°C night (78°F / 70°F) temperature setpoints. Pots were randomized on 30-cm centers (12-inch) within rows and 76-cm between rows (30-inches). Irrigation programming was the same as described in Experiment 13. For the 600 ppm N groups, trays were filled by hand using a triple strength formulation of 21-5-20 fertilizer.

Due to teaching demands of the greenhouse, on 18 August, the entire experiment and set up was moved to a glass greenhouse with the same temperature. The plants were placed on tables rather than on floor.

Plant heights and seed counts of ear commenced on week of 29 July. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Experiment 15

Effect of Root Medium on Growth and Seed Yield of Greenhouse-Grown Corn in Low Light Season

Tyler Mason, Justin Kottkamp, Arek Varjabedian, Rob Eddy and Dan Hahn

A winter study was initiated to further compare the three top-performing root media used in the studies carried out in Experiment 13 and 14. Fertilizer strength would be refined, and coarse-grade vermiculite as a root medium would also be compared.

On 25 November 2009, seed of corn hybrid Pioneer 34M95 were sown in thirty-six 20.3 cm (8-inch) diameter round "standard" plastic pots. Six sets of 6 pots were each filled with differing root media for comparison. Profile Greens-Grade and Turface MVP are both calcined clay granule products. The third root media is a typical mix used at university and corporate research greenhouses for corn, consisting of a 1:1 mix of field soil and a medium grade potting mix (Metro-Mix 510). The field soil had been dried and ground prior to mixing, and has been used successfully in container studies of agronomic crops by the Life Science Greenhouse complex on Purdue campus. A fourth media was coarse-grade vermiculite; a fifth was the same vermiculite treated with a top-dressing of 10 grams of slow-release 14-14-16 fertilizer with minor elements. The sixth media was a 2:1 Turface: medium vermiculite mixture.

Two seeds were sown per pot, later thinned to one seedling following germination one week later.

For the pots using Profile calcined clay granules, a method was devised to keep the granules from leaking out the drainage holes of the pots. Two pots were nested, the lower one filled with a wetted mixture of approximately 300 cc of extra coarse and 100 cc of coarse. This mixture covered the drainage holes of the upper pot without sealing. There are other methods to accomplish this, but we wanted to use materials readily available at most greenhouses and methods easily adapted and scaled to larger production.

The pots were placed in a greenhouse with polyethylene film room and polycarbonate sidewalls with 24°C day / 19.5°C night (75°F / 67°F) temperature setpoints. Plants were approximately eight inches apart. Supplemental lighting of approximately 60 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using high pressure sodium fixtures for 16 hours per day. On 14 January 2010, the plants were moved to a glass-glazed greenhouse with temperatures more suitable for corn of 25.5°C day / 21°C night (78°F / 70°F). Supplemental light was doubled to 125 $\mu\text{mol}/\text{m}^2/\text{s}$ in this new location, using a combination of high pressure sodium and metal halide fixtures. Plant spacing increased to twelve-inch centers, while watering and fertilization were unchanged.

Pots were irrigated with clear water using a hose at sow date. No further irrigation was required until 2 Dec 2009, when automated irrigation programming was initiated on the Turface, Profile and Turf/Verm pots. The irrigation programming was achieved with Priva microprocessor climate control initiating a drip irrigation system with one dripper per pot. The program initiated irrigation every two hours for two minutes. The two minute run time was divided into one-minute periods with a five minute pause between to allow for lateral movement of water in the pot. The program ran from 6:00 AM to 8:00PM daily. The irrigation programming had been shown to be detrimental to early vegetative growth in the other soil types by earlier observation, so the vermiculite, top-dressed vermiculite and the 1:1 mix were watered as needed by placing the drippers on the pots for two full cycles of irrigation, then removed. On 22 January (leaf stage V8), the drippers were placed permanently in these three groups.

Fertilizer solution was used for every irrigation event beginning 2 December. Irrigation solution consisted of 15-3-16 at a concentration of 400 ppm N. Note that this was twice the strength as earlier studies. The solution pH was adjusted to approximately 5.6 using 93% sulfuric acid.

On 22 January, plants were reorganized into two blocks because the plant height of the 1:1 media and the vermiculite media were so much shorter they were at risk of being shaded. Those treatment groups were randomized together on the south side of the block, while the other three groups were randomized on the north side. Spacing was unchanged.

On 5 January, plant height measurements were recorded, as measured from the pot rim to the tip of the longest leaf extended vertically by hand. Leaf stage was also recorded. Chlorophyll measurements were taken with a chlorophyll meter by averaging three measurements taken at the midpoint of the most recently expanded leaf.

Electrical conductivity and pH of root media were made on 24 February. Pollination commenced on 9 February by shaking plants for 6-10 seconds each morning. Final plant height, stalk diameter and seed counts were made on 3-5 March. Means comparison by analysis of variance was performed using SPSS 16.0 for Windows.

Experiment 16

Effect of Fertilizer Formulation and Strength on Early Vegetative Growth of Greenhouse-Grown Corn

Justin Kottkamp, Rob Eddy and Dan Hahn

Three differing fertilizers, each at two different strengths, were compared on vegetative growth. The hypothesis was that 20-20-20 would produce better plants due to high urea content.

On 24 November 2009, seed of corn hybrid Pioneer 34M95 were sown in thirty 15 cm (6-inch) diameter round "standard" plastic pots. Six sets of 5 pots were each filled with Profile Greens calcined clay granules. Two seeds were sown per pot, later thinned to one seedling following germination one week later.

The pots were placed in a greenhouse with polyethylene film room and polycarbonate sidewalls with 24°C day / 19.5°C night (75°F / 67°F) temperature setpoints. Plants were approximately six inches apart. Supplemental lighting of approximately 60 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using high pressure sodium fixtures for 16 hours per day.

Fertilizer treatments were applied by sub-irrigation by filling a tray under the pots. Plants were not randomized because of this sub-irrigation arrangement, but some effort was put into shuffling the trays so none would be shaded by the others for the entire experiment. Plants were watered as needed with one of three fertilizer formulations, each at a 200 ppm N and 400 ppm N strength. The formulations were 15-3-16, 21-5-20 and 20-20-20. All three formulations are acidic. Testing of solutions 5 January 2010 indicated these pH and N levels (N based on conversion of electrical conductivity readings on manufacturers' labels):

15-3-16, 200 ppm N: pH 5.9, N=233

15-3-16, 400 ppm N: pH 5.6, N=457

20-20-20, 200 ppm N: pH 5.8, N=226

20-20-20, 400 ppm N: pH 5.6, N=407

21-5-20, 200 ppm N: pH 6.0, N=225

21-5-20, 400 ppm N: pH 5.8 N=388

On 13 January, plant height measurements were recorded, as measured from the pot rim to the tip of the longest leaf extended vertically by hand. Leaf stage was also recorded.

Experiment 17

Effect of Fertilizer Application Method on Early Vegetative Growth of Greenhouse-Grown Corn in Vermiculite Root Medium

Justin Kottkamp, Rob Eddy and Dan Hahn

Corn plants were grown to compare the effect of four different fertilizer treatments on vegetative growth in coarse vermiculite, a root medium that typically induces chlorosis.

On 24 November 2009, seed of corn hybrid Pioneer 34M95 were sown in twenty 15 cm (6-inch) diameter round “standard” plastic pots. Four sets of 5 pots were each filled with coarse-grade vermiculite. Two seeds were sown per pot, later thinned to one seedling following germination one week later.

The pots were placed in a greenhouse with polyethylene film room and polycarbonate sidewalls with 24°C day / 19.5°C night (75°F / 67°F) temperature setpoints. Plants were approximately six inches apart. Supplemental lighting of approximately 60 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using high pressure sodium fixtures for 16 hours per day.

Fertilizer solution treatments were applied continuously for the first ten days and then only as needed to avoid water stress by filling trays under the pots. Some stress was observed following the constant sub-irrigation for all plants in the study. Plants were not randomized because of this sub-irrigation arrangement, but some effort was put into shuffling the trays so none would be shaded by the others for the entire experiment. Plants were watered as needed with one of four fertilizer treatments, each using 15-3-16 fertilizer. The slow release fertilizer used in two groups was 10 grams per pot of slow-release 14-14-16 fertilizer with minor elements.

200 ppm N

200 ppm N supplemented with a surface top-dressing of slow release fertilizer

400 ppm N

400 ppm N supplemented with a surface top-dressing of slow release fertilizer

On 13 January, plant height measurements were recorded, as measured from the pot rim to the tip of the longest leaf extended vertically by hand. Leaf stage was also recorded.

Experiment 18

Feasibility of a High-Volume Greenhouse Cultivation Method for Corn

Rob Eddy and Dan Hahn

Corn plants were grown in very small containers under tight spacing to determine if ears could be successfully pollinated.

A study was initiated on 25 November 2009 using seed of corn hybrid Pioneer 34M95 sown in two small container sizes. Eighteen 10-cm (4-inch) square pots and thirty-six 5-cm (2-inch) cells of 606 tray-inserts were filled with Turface MVP calcined clay granule products. One seed was sown per container. Only twelve of the cells were filled per 606 tray-insert, leaving rows of cells empty. Each of these three tray-inserts were placed in a white display tray

without holes that would be kept full of irrigation solution. Likewise, three of these trays each held 6 of the 10-cm square pots each. Plants were approximately 5 inches apart for the square 10-cm pots. For the 5-cm cell inserts, plants were approximately 4 cm apart within rows with 15 cm separating the rows. Fifteen centimeters separated the trays on the growing table.

Later in the study, two additional 606 tray-inserts were placed under each the existing ones to provide more support. It is advised to do this at initiation of the study.

The pots were placed in a greenhouse with polyethylene film room and polycarbonate sidewalls with 24°C day / 19.5°C night (75°F / 67°F) temperature setpoints. Supplemental lighting of approximately 60 $\mu\text{mol}/\text{m}^2/\text{s}$ was provided using high pressure sodium fixtures for 16 hours per day. On 19 January 2010, the plants were moved to a glass-glazed greenhouse with temperatures more suitable for corn of 25.5°C day / 21°C night (78°F / 70°F). Supplemental light was doubled to 125 $\mu\text{mol}/\text{m}^2/\text{s}$ in this new location, using a combination of high pressure sodium and metal halide fixtures.

Plants were irrigated with automatically with fertilizer solution from date of sowing. The irrigation programming was achieved with Priva microprocessor climate control initiating a drip irrigation system with two drippers per holding tray. The solution was then absorbed by the root medium by capillary action. The program initiated irrigation every two hours for two minutes. The two minute run time was divided into one-minute periods with a five minute pause between to allow for lateral movement of water in the pot. The program ran from 6:00 AM to 8:00PM daily.

Fertilizer solution was 15-3-16 at a concentration of 400 ppm N. The solution pH was adjusted to approximately 5.6 using 93% sulfuric acid.

Final plant height, stalk diameter and seed counts were recorded on 8 March.

Experiment 19

Calcium Solutions Applied into Corn Whorl for Control of Ca Deficiency of Greenhouse-Grown Corn

Jeannie Ross, Rob Eddy and Dan Hahn

Calcium solutions were applied to whorls to determine if calcium deficiency could be prevented in a susceptible line.

Seed of a corn inbred line known for exhibiting calcium deficiency during seedling stage were acquired from Purdue University Agronomy department. On 12 August 2008, they were sown in 5-cm (2-inch) cells of "606" tray-inserts filled with Pro-Mix BX soilless mix, one seed per cell. They were placed in a glass greenhouse with 25.5°C day / 21°C night (78°F / 70°F) temperature and fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N.

Whorl applications were done with a syringe, placing as much of the treatment solution in the whorl as it would hold. Treatment groups consisted of 6 plants each were as follows:

No treatment

Reverse osmosis control

1 g CaCl₂ per liter water (259 ppm Ca) applied once weekly

1 g CaCl₂ per liter water (259 ppm Ca) applied twice weekly

2 g CaCl₂ per liter water (518 ppm Ca) applied once weekly

2 g CaCl₂ per liter water (518 ppm Ca) applied twice weekly

Visual observations were made weekly until termination of experiment after 30 days.

Experiment 20

Light Intensity and Temperature Effect on Onset of Calcium Deficiency in Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Corn plants were grown in plant growth chambers under differing environments to determine if calcium deficiency could be prevented in a susceptible line.

Seed of a corn inbred line known for exhibiting calcium deficiency during seedling stage were acquired from Purdue University Agronomy department. On 30 January 2009, they were sown in 25-cm x 51-cm trays (10x20-inch, trade name "1020 trays") filled with Pro-Mix BX soilless mix. Eight total trays were seeded with eighteen seeds each. Two trays were placed in four locations, a glass greenhouse and three Percival plant growth chambers. The chambers were illuminated 16 hours per day using fluorescent lamps. Two shelves were available, allowing two different light intensities in each chamber. The greenhouse light was supplemented with high pressure sodium fixtures providing 60 $\mu\text{mol}/\text{m}^2/\text{s}$ at plant canopy.

The treatments consisting of temperatures and light intensities were as follows:

Greenhouse, 27°C day / 21°C night (80°F / 70°F) temp, supplemented light

Greenhouse, 27°C day / 21°C night (80°F / 70°F) temp, supplemented light with 50% shade cloth

Chamber, 27°C day / 21°C night (80°F / 70°F) temp, 435 $\mu\text{mol}/\text{m}^2/\text{s}$

Chamber, 27°C day / 21°C night (80°F / 70°F) temp, 145 $\mu\text{mol}/\text{m}^2/\text{s}$

Chamber, 24°C day / 24°C night (75°F / 75°F) temp, 435 $\mu\text{mol}/\text{m}^2/\text{s}$

Chamber, 24°C day / 24°C night (75°F / 75°F) temp, 145 $\mu\text{mol}/\text{m}^2/\text{s}$

Chamber, 21°C day / 15.5°C night (70°F / 60°F) temp, 435 $\mu\text{mol}/\text{m}^2/\text{s}$

Chamber, 21°C day / 15.5°C night (70°F / 60°F) temp, 145 $\mu\text{mol}/\text{m}^2/\text{s}$

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Observations of calcium deficiency symptoms as well as leaf stage were recorded on 13 March.

Experiment 21

Effect of Calcium Application to Seeds on Calcium Deficiency of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Corn seeds were soaked in CaCl₂ solutions or covered in hydrated lime prior to sowing to determine if calcium deficiency could be prevented in a susceptible line.

Seed of a corn inbred line known for exhibiting calcium deficiency during seedling stage were acquired from Purdue University Agronomy department. On 14 March 2009, they were sown in 25-cm x 51-cm trays (10x20-inch) filled with a 1:1 mix of Pro-Mix BX soilless mix and Turface MVP calcined clay granules. Five total trays were seeded with ten seeds each. The trays were placed in a Percival plant growth chamber with temperature of 27°C day / 21°C night (80°F / 70°F) night. The chambers were illuminated 16 hours per day using fluorescent lamps, providing an intensity of 180 $\mu\text{mol}/\text{m}^2/\text{s}$.

Prior to sowing, the seeds were treated with one of the following:

No treatment

Reverse osmosis water soak of 2 hours

1% CaCl_2 (10,000 ppm Ca) solution soak of 2 hours

5% CaCl_2 (50,000 ppm Ca) solution soak of 2 hours

0.25% CaSO_4 (2,500 ppm Ca) solution soak of 2 hours

Rolled in hydrated lime

Plants were fertilized at each irrigation with 15-5-15 fertilizer at a concentration of 200 ppm N. Observations of calcium deficiency symptoms were recorded weekly for four weeks.

Experiment 22

Effect of Temperature and Photoperiod on Calcium Deficiency of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Corn plants were grown in plant growth chambers under differing environments to determine if calcium deficiency could be prevented in a susceptible line. A previous study had indicated less deficiency occurred at lower temperatures, and it was hypothesized that continuous light would increase Ca uptake via transpiration.

Seed of a corn inbred line known for exhibiting calcium deficiency during seedling stage were acquired from Purdue University Agronomy department. On 8 January 2010, they were sown in 10-cm (4-inch) square pots filled with a 1:1 mix of Pro-Mix BX soilless mix and Turface MVP calcined clay granules. One seed was sown per pot. Twelve pots were placed in each of three Conviron plant growth chambers. The chambers were illuminated using fluorescent lamps providing an intensity of approximately 300 $\mu\text{mol}/\text{m}^2/\text{s}$ at plant canopy.

The treatments consisted of the following chamber environments:

27°C day / 21°C night (80°F / 70°F) temp, 16-hour photoperiod

27°C day / 21°C night (80°F / 70°F) temp, 24-hour photoperiod

21°C day / 15.5°C night (70°F / 60°F) temp, 16-hour photoperiod

Plants were fertilized at each irrigation with 15-3-16 at a concentration of 200 ppm N. Observations were made weekly until plants were terminated 21 days later.

Experiment 23

Effect of Sonicating Seeds and Calcium Solution Seed Soaks on Calcium Deficiency of Greenhouse-Grown Corn

Rob Eddy and Dan Hahn

Prior to sowing, corn seeds were exposed to ultrasound in a standard lab ultrasonic cleaner, then soaked in a calcium solution to determine if seedling calcium deficiency could be prevented in a susceptible line.

Seed of a corn inbred line known for exhibiting calcium deficiency during seedling stage were acquired from Purdue University Agronomy department. On 17 January 2010, thirty-two seeds were placed in an ultrasonic cleaning bath containing 300 ml of reverse osmosis water. The ultrasonic cleaner was activated for 15 minutes. The seeds were removed and allowed to air dry for two days. Seeds were then divided into groups of eight and soaked in one of the following treatment solutions for six hours:

Reverse osmosis water

CaNO₃/MgSO₄ solution, (2000 ppm Ca, 1000 ppm Mg)

Ca-EDTA solution, 4.8 g/l

CaCl₂ solution, (1000 ppm Ca)

Eight seeds that had not been sonicated or soaked were used as a control group. Seeds were sown on 19 January in 6-cm x 4-cm (2.5-inch x 1.5-inch) plastic 1204 tray-inserts filled with a 1:1 mix of Pro-Mix BX soilless mix and Turface MVP calcined clay granules. One seed was sown per cell. All plants were placed in a Conviron plant growth chamber with a temperature setpoint of 21°C day / 15.5°C night (70°F / 60°F), shown in an earlier study to induce more Ca deficiency symptoms. The chamber was illuminated using fluorescent lamps providing an intensity of approximately 300 μmol/m²/s at plant canopy.

Plants were fertilized at each irrigation with 15-3-16 at a concentration of 200 ppm N. Observations were made weekly until plants were terminated 21 days later.

The experiment was repeated on 3 February using 16 seeds for each of the following treatments groups:

Untreated control

Reverse osmosis water

CaCl₂ solution, 1000 ppm Ca

CaCl₂ solution, 3000 ppm Ca

Methodology was identical except that 80 ml of reverse osmosis water was used during sonication rather than 300 ml. It should be noted that the water in the ultrasonic cleaner heated up undesirably with this lesser amount.

Experiment 24

Effect of Calcium Solution Soil Drenches on Calcium Deficiency of Greenhouse-Grown Corn

Jeannie Ross, Rob Eddy and Dan Hahn

Various calcium solutions and a zinc chelate were applied as irrigation solution to determine if calcium deficiency could be prevented in seedling corn of a susceptible line.

Seed of a corn inbred line known for exhibiting calcium deficiency during seedling stage were acquired from Purdue University Agronomy department. On 20 January 2010, they were sown in 15-cm (6-inch) diameter pots filled with a 1:1 mix of Pro-Mix BX soilless mix and Turface MVP calcined clay granules. One seed was sown per pot.

Plants were grown in a glass greenhouse with temperatures setpoints of 25.5°C day / 21°C night (78°F / 70°F). Supplemental light was 125 $\mu\text{mol}/\text{m}^2/\text{s}$ in this new location, using a combination of high pressure sodium and metal halide fixtures activated for 16 hours per day.

Thirty six total pots were planted, six replicates of the following treatments:

Control group

CaNO₃/MgSO₄ solution, (2000 ppm Ca, 1000 ppm Mg)

Zn-EDTA solution, .3 g/l

Ca-EDTA solution, 4.8 g/l

CaCl₂ solution, (1000 ppm Ca)

The CaNO₃/MgSO₄ solution was prepared by modifying a protocol published by Iowa State University Department of Agronomy's Plant Transformation Facility to treat Ca-deficiency symptoms (see references). Separate stock solutions of the two salts are made, at a rate of 720 g of CaNO₃ (4H₂O) per liter of water, and 370 g of MgSO₄ (7H₂O) per liter. Ten ml of each stock solution are then mixed in 3.79 liters of water that is applied to plants as irrigation solution. The two commercial fertilizer chelates are mixed at the rates listed above. Zinc is hypothesized to improve calcium uptake into the plants. The calcium chloride solution is made by diluting a 13% CaCl₂ solution sold commercially for greenhouse corrective applications. The dilution rate was 15.3 ml per liter of water.

The solutions were applied at time of sowing and each week thereafter for three weeks, for a total of three applications. Application involved watering as normal with the solutions until solution dripped freely from the drainage holes of the pots. The control group was watered with clear water. All plants were fertilized once with a solution of 15-3-16 at a concentration of 200 ppm N on day 12 and 20. It should be noted that levels of individual nutrients, including nitrogen, varied between treatments. Observations were made weekly until plants were terminated on day 30.

