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Optimizing Greenhouse Rice Production: Materials, Methods, and References

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Purdue Methods:
Optimizing Greenhouse Production of Rice, Materials and Methodology

1. Root Substrate, Irrigation and Fertilization Study (2007)

A study was initiated 7 July 2007 to compare growth of rice in differing root media, watering methods and fertilization schedule. Seeds of Oryza sativa japonica 'Nipponbare' were sown into 10 different root media and placed in a Purdue greenhouse in West Lafayette, IN. One seed was planted per pot with extra pots sown per treatment to ensure 5 replicates were available for comparison. The pots used are described in the commercial industry as "5-inch azalea" (ITML Horticultural Products, Inc. Brantford, ON, Canada), having a 12.5-cm diameter and a 9-cm height. They were filled to the inner lip for an approximate volume of 982 cc. All pots were irrigated until germination by letting the pots stand in tap water at a depth of 1-3 cm using 10-cm x 50-cm trays without drainage holes ("white display trays", T.O. Plastics, Minneapolis, MN).

The root media compared were a locally dug sandy loam mineral soil of pH 6.2; Pro-Mix 'BX' commercial soilless mix (Premier Horticulture Inc, Quakertown, PA); 'Profile Greens' and 'Turface MVP' calcined clay granules (Profile Products LLC, Buffalo Grove, IL); and 1:1 by volume combinations of soil/Profile, soil/Turface, soil/Pro-Mix, Profile/Pro-Mix and Turface/Pro-Mix. For the pots containing only soil or only Profile, the bottom of the pots were lined with filter paper to keep these fine-grained materials from leaking out the drainage holes. Fertilizer was applied to all seedlings on 17 July, using a solution of (in mg per liter) 200 N, 29 P, 167 K, 67 Ca, 30 Mg, and micronutrients supplied from a commercial fertilizer formulation (Miracle Gro® Excel® 15-5-15 Cal-Mag; The Scotts Co., Marysville, OH). Adjustment of pH to range 5.7 - 6.0 and alkalinity reduction was achieved via 93% sulfuric acid (Ulrich Chemical, Indianapolis) at 0.08 ml per liter.

Watering and fertilization treatments commenced on 24 July. Half the plants were kept under constant sub-irrigation with tap water as during germination, while half were irrigated with the same water using drip irrigation (Netafim USA, Fresno, CA) initiated by a timer two times per day for two minutes. Within both of these watering methods groups, sets of each root media type were split so that half were fertilized with the solution described above one time per week; the other half, two times per week. Fertilizer solution was applied by filling up the reservoir in the pot from the inner lip to the rim twice, for a total approximate volume of solution of 245 cc.

Plants were grown under natural lighting at a temperature of 24C day and 18.3C during the night. Germination success was counted on 17 July. Tiller count and plant height were recorded on 15 August as well as a visual rating of chlorosis. A number was assigned to each plant according to this ranking: 4-no chlorosis; 3-slight chlorosis; 2-moderate chlorosis without scorch of tips or margins; and 1-moderate to severe chlorosis with tip or margin scorch.

2. Pot Size and Fertilization Study (2008)

Building from knowledge gained from a 2007 study, a new study was initiated on 23 January 2008 to compare growth and flowering of rice in differing pot size and fertilization schedule. Seeds of Oryza sativa japonica 'Nipponbare' were sown into 3 different container sizes filled with Profile Greens calcined clay granules (Profile Products LLC, Buffalo Grove, IL). The bottom of the pots were lined with filter paper to keep these fine-grained materials from leaking out the drainage holes. The container sizes were all from the same manufacturer (ITML Horticultural Products, Inc. Brantford, ON, Canada) and referred to by US trade names consisting of diameter and shape: 3-inch square, 4-inch square and 5-inch azalea-style round. The 3-inch square pots were 7.0 cm in diameter and 6.5 cm deep, and filled to the inner lip for an approximate volume of 300 cc. The 4-inch square pots were 9.0 cm in diameter and 7.5 cm deep, and filled to the inner lip for an approximate volume of 567 cc. The 5-inch round pots had a diameter of 12.5 cm diameter and a 9.0 cm height, and filled to the inner lip for an approximate volume of 982 cc. Two seeds were sown per pot and later thinned to one plant per pot. All pots were irrigated until germination by letting the pots stand in tap water at a depth of 1-3 cm using 10-cm x 50-cm trays without drainage holes ("white display trays", T.O. Plastics, Minneapolis, MN) underneath the pots.

On 15 February, fertilizer treatments were initiated. Half the plants were kept under constant sub-irrigation with tap water as during germination, and fertilized twice per week. Fertilizer solution was applied by filling up the reservoir in the pot from the inner lip to the rim twice, for a total approximate volume of solution of 245 cc. The other half of the plants were sub-irrigated continuously with the same fertilizer solution. These plants also received the twice weekly application in order to keep the fertilizer salts from accumulating near the surface of the pots.

Both treatment groups received the same fertilizer solution of (in mg per liter) 200 N, 29 P, 167 K, 67 Ca, 30 Mg, and micronutrients supplied from a commercial fertilizer formulation (Miracle Gro® Excel® 15-5-15 Cal-Mag; The Scotts Co., Marysville, OH). Adjustment of pH to range 5.7 - 6.0 and alkalinity reduction was achieved via 93% sulfuric acid (Ulrich Chemical, Indianapolis) at 0.08 ml per liter.

Plants were grown under natural lighting at a temperature of 26.1C day and 22.2C during the night. Supplemental lighting was provided by 1000W high pressure sodium lighting at 100 $\mu mol/m^2/s$ for 16 hours. Germination success was counted on 15 February. Panicle count and plant height were recorded on 12 May through 15 May. Seeds from each treatment group were collected, dried and weighed to determine yield.

3. Slow Release Fertilizer Study (2014)

Background: We've developed a rice protocol using calcined clay granules as a root substrate, auto-irrigation filling trays that simulate "paddy culture." We tried automating fertilization but have had difficulty with excess salts from fertilizer accumulating and causing growth problems. Currently, we are hand-watering twice a week with fertilizer.

Goal: Compare slow release fertilizer against liquid feed fertilization on rice

Species: Rice, japonica "Nipponbare"

Pots: 5-inch diameter "azalea" style pot. 12.5 cm diameter x 9 cm tall.

Substrate: Profile 'Greens Grade' porous ceramic granules

Irrigation: Automated filling of sub-irrigation trays 4x/day with clear water

Temperature: 27.8 day / 22.2 night (82F day, 72F night)

Treatments:

Control solution, fertilized by apply fertilizer solution into top of pots (not trays)
Slow release granules, 1/2X, top dressed
Slow release granules, 1/2X, banded layered in middle of pot at filling
Slow release granules, 1X, top dressed
Slow release granules, 1X, banded layered in middle of pot at filling
Slow release granules, 2X, top dressed
Slow release granules, 2X, banded layered in middle of pot at filling

Fertilizer formulation:
Control Solution **-** 3:1 mixture of Peter's Excel 15N–5P–15K and Peter's Excel 21N–5P–20K, respectively; to provide the following (in mg/L): 200 N, 26 P, 163 K, 50 Ca, 20 Mg, 1.0 Fe, 0.5 Mn and Zn, 0.24 Cu and B, and 0.1 Mo. Nitrate form was 76% of nitrogen provided. Irrigation water was supplemented with 93% sulfuric acid at 0.08 mL/L to reduce alkalinity to 100 mg/L and pH to a range of 5.8 to 6.2.

Slow Release – Osmocote Plus 15-9-12, 5-6 month duration.

Replicates: 10 pots each, one plant per pot (two seeds sown and later thinned to one)

Number of pots: 7 treatments x 10 reps = 70

Note: Barrier plants were used on north and south ends of experimental plants. They were not used in the study, but to provide similar light conditions to all plants.

Trays/Layout: 5 pots per tray = 14 trays. 10-cm x 50-cm "display" trays without drainage holes. Treatments were not randomized within trays to avoid contamination due to leaching fertilizer. Individual trays randomized. Two irrigation drippers per tray.

Data:
Weekly pH and soluble salts (EC) of three pots/treatment
Monthly leaf "Greenness" using Minolta SPAD meter of three pots/treatment
Number of panicles at harvest
Seed weight at harvest

Sources:
Profile Greens Grade - Profile Products LLC, Buffalo Grove, IL, USA
Fafard Superfine Mix - SunGro Horticulture, Agawam, MA, USA
"Display" trays - T.O. Plastics, Minneapolis, MN
Peters water soluble fertilizers - Everris, Marysville, OH, USA

4. Substrate, Slow Release Fertilizer and Photoperiod Study (2015)

Background: We've developed a rice protocol using calcined clay granules as a root substrate, auto-irrigation filling trays that simulate "paddy culture." We tried automating fertilization but have had difficulty with excess salts from fertilizer accumulating and causing growth problems. Currently, we are hand-watering twice a week with fertilizer. Pot size increased from past production to lessen water stress during irrigation system failures.

Goal: Compare slow release fertilizer against liquid feed fertilization on rice

Species: Rice, japonica "Nipponbare"

Pots: 6-inch "standard round" style pot. 15 cm diameter x 14.5 cm tall.

Substrate: Unless indicated, 80% Turface 'MVP' porous ceramic granules / 20% Fafard Superfine Germination Mix

Irrigation: Automated filling of sub-irrigation trays 4x/day with clear water

Fertilizer:
Osmocote Plus 15-9-12 slow release fertilizer (5-6 month) incorporated at 14g/pot, second application top-dressed when soil monitoring indicated EC below 2.5 dS/cm

Trays: Unless indicated, 10-cm x 50-cm "display" trays without drainage holes

Temperature: 27.8 day / 22.2 night (82F day, 72F night)

Treatments:
1. 80% Turface /20 % Fafard Superfine Mix
2. 100% Profile 'Greens Grade' porous ceramic
3. 50% Turface /50 % Fafard Superfine Mix
4. Deep sub-irrigation tray, 80% Turface /20 % Fafard Superfine Mix
5. Short-day (SD) applied for 1 week, beginning after 1 month
6. Short-day (SD) applied for 2 weeks, beginning after 1 month
7. Short-day (SD) applied for 3 weeks, beginning after 1 month
8. Short-day (SD) applied for 1 week, beginning after 2 months
9. Short-day (SD) applied for 2 week, beginning after 2 months
10. Short-day (SD) applied for 3 week, beginning after 2 months

Replicates: 10 pots each, one plant per pot (two seeds sown and later thinned to one)

Number of pots: 7 treatments x 10 reps = 70

Note: Barrier plants were used on north and south ends of experimental plants. They were not used in the study, but to provide similar light conditions to all plants.

Trays/Layout: 5 pots per tray = 18 "display" trays. 10-cm x 50-cm trays without drainage holes. Treatments were not randomized within trays to avoid contamination due to leaching fertilizer. Individual trays randomized. Two irrigation drippers per tray.

Data:
Weekly pH and soluble salts (EC) of three pots from these treatments: 1,2,3,4
Monthly leaf "Greenness" using Minolta SPAD meter of three pots/treatment
Number of panicles at harvest
Seed weight at harvest

Sources:
Turface MVP - Profile Products LLC, Buffalo Grove, IL, USA
Profile Greens Grade - Profile Products LLC, Buffalo Grove, IL, USA
Fafard Superfine Mix - SunGro Horticulture, Agawam, MA, USA
Deep sub-irrigation tray - L 1020 trays without holes, Landmark Plastic, Akron OH, USA
"Display" trays - T.O. Plastics, Minneapolis, MN, USA

5. 2015 Root Substrate Study (2015)

Background: We determined that slow release fertilizer was not suitable and that growth was improved and irrigation failure reduced with a deep tray for the sub-irrigation. This study will verify previous results that a root substrate composed of greater than 50% calcined clay granules will be optimum.

Goal: Determine optimum root substrate of greenhouse grown rice

Species: Rice, japonica "Nipponbare"

Pots: 6-inch "standard round" style pot. 15 cm diameter x 14.5 cm tall. (two, nested, with 2 ply cheesecloth between).

Tray: No-hole 1020, 2.5" deep

Irrigation: Automated filling of sub-irrigation trays 4x/day with fertilizer solution, Mon-Friday and tap water, Sat-Sun

Temperature: 28.3 day / 22.8 night (83F day, 73F night)

Treatments:
1. Fafard 2
2. 75% Fafard 2 : 25% Turface 'MVP' porous ceramic granules
3. 50% Fafard 2 : 50% Turface
4. 25% Fafard 2 : 75% Turface
5. Turface

Replicates: 5 pots each, two seeds sown and later thinned to one

Number of pots: 9 treatments x 5 reps = 45 Note: 20 plants as "barrier plants" on ends of rows to control light competition.

Trays/Layout: 5 pots per tray = 9 trays. Except for barrier plants that aren't experimental, complete randomization of plants. Two drippers per tray.

Data:
Weekly pH and soluble salts (EC) of three pots from these treatments: 1,2,3,4
Monthly leaf "Greenness" using Minolta SPAD meter of three pots/treatment
Number of panicles at harvest
Seed weight at harvest

Sources:
Turface MVP - Profile Products LLC, Buffalo Grove, IL, USA
Fafard 2 and Fafard 52 mix - SunGro Horticulture, Agawam, MA, USA
Deep sub-irrigation tray - L 1020 trays without holes, Landmark Plastic, Akron OH, USA

6. Photoperiod Study (2015)

Background: The study will determine what sequence of photoperiod induction will shorten the length of the production cycle. Long-day grown plants were taking 6-9 months to flower.

Goal: Determine optimum photoperiod sequence of greenhouse grown japonica rice

Pots: 6-inch "standard round" style pot. 15 cm diameter x 14.5 cm tall. (two, nested, with 2 ply cheesecloth between). 3" square pots. 7 cm wide x 6.8 cm tall.

Tray: No-hole 1020, 2.5" deep for 6" standard pots. White display tray, 1" deep for 3" square pots.

Substrate: 75% Turface / 25% Fafard 2

Irrigation: Automated sub-irrigation trays 4x/day with fertilizer solution, Mon-Friday and tap water, Sat-Sun in greenhouse. Hand-watering to fill trays in growth chamber, same fertilization schedule.

Temperature:
Long-Day Greenhouse: 28.3 day / 22.8 night (83F day, 73F night) in greenhouse, natural day in summer and then supplemental light to maintain 16 hour day in fall.
Short-Day Growth chamber: 28.3 constant in chamber with 8 hour photoperiod, 0800-1600.

Treatments:
1. 6" pot, 4 weeks in long-day greenhouse (LD), 1 week in short-day chamber (SD), back to LD greenhouse
2. 6" pot, 4 weeks in LD, 2 weeks in SD, back to LD
3. 6" pot, 4 weeks in LD, 3 weeks in SD, back to LD
4. 6" pot, 7 weeks in LD, 1 week in SD, back to LD
5. 6" pot, 7 weeks in LD, 2 weeks in SD, back to LD
6. 6" pot, 7 weeks in LD, 3 weeks in SD, back to LD
7. 3" pot, 4 weeks in SD, then to LD
8. 3" pot, 4 weeks in SD, then to LD and transplanted into 6" pot
9. 3" pot, 7 weeks in SD, then to LD and left in 3" pot
10. 3" pot, 7 weeks in SD, then to LD, transplanted to 6" pot

Replicates: 5 each for treatments 1-6. 12 each for treatments 7-10.

Data:
Days to flowering
Number of panicles at harvest

Seed weight at harvest

Sources:
Turface MVP - Profile Products LLC, Buffalo Grove, IL, USA
Fafard 2 Mix - SunGro Horticulture, Agawam, MA, USA
Deep sub-irrigation tray - L 1020 trays without holes, Landmark Plastic, Akron OH, USA
"Display" trays - T.O. Plastics, Minneapolis, MN, USA

Related References

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