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ABSTRACT

Tomato (*Lycopersicum esculentum* 'Early Girl') seedling growth was evaluated in substrates containing varying proportions of ground rice hulls. Substrates were formulated containing 0, 30, 60, and 90% ground rice hulls with one-half of the treatments also treated with a surfactant. Seedling growth in two of the ground rice hull-containing substrates was generally similar to the two controls of 90% peat or 100% vermiculite. The germination percentages for all ground rice hull-containing substrates were similar to the two controls. Ground rice hulls are a viable alternative to peat and vermiculite seedling substrates.

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INTRODUCTION

Artificial substrates are most commonly used in greenhouse crop production (Nelson, 1998). These substrates are made of various components blended in varying proportions to produce a substrate with physical and chemical properties suitable for its intended use (Blunt, 1988). These components may be naturally occurring, man-made, or a municipal or agricultural by-product. One of the commonly used natural components is Sphagnum peat (peat). Sphagnum peat is generally used in artificial substrates for its water- and nutrient-holding capacity. However, significant interest has been expressed in finding alternatives to peat due to environmental concerns (Barkham, 1993; Buckland, 1993; Robertson, 1993) and costs associated with this component.

Some research has been completed in the use of municipal waste products such as waste paper products (Chong and Cline, 1993; Norrie and Gosselin, 1996), composted yard waste (Beeson, 1996), and municipal sewage sludge (Mori et al., 1981) as alternatives to peat. Additional research has been conducted on industrial and agricultural waste products. Some of these include coconut coir (Evans and Stamps, 1996), composted rice hulls (Laiche and Nash, 1990), processed poultry feathers (Evans, 2004), kenaf (Wang, 1994), and composted animal manures (Tyler et al., 1993).

Many of these alternative substrates were discarded due to their chemical or physical properties not meeting the needed properties for the substrate mix as used by the industry. Additionally, expense eliminated or greatly slowed others, such as ground bovine bone as a replacement for perlite (Evans, 2004).

Rice hulls are a by-product of the rice milling industry in Arkansas and across the United States. It has been estimated that 31 million metric tons of fresh rice hulls are produced annually in the United States (Kamath and Proctor, 1998).

Fresh rice hulls have not been used in potting substrates in the past because it was believed they caused nitrogen depletion. However, it was recently found that nitrogen depletion did not occur to any significant extent (Evans and Gachukia, 2004) when fresh rice hulls are used as a component in substrates. Furthermore, rice seeds have been a common contaminant of rice hulls and, therefore, created a weed problem (Evans and Gachukia, 2004). However, parboiled rice hulls were found to be free of viable weed seeds (Evans and Gachukia, 2004).

MEET THE STUDENT-AUTHOR

Matthew K. Nutt

I am from Monett, Mo., where I graduated from Monett High School in 2000. I plan to graduate with honors distinction in the spring of 2005 with my B.Sc. in horticultural science. The Robert L. & Marilyn Bogle Scholarship and the Missouri Federated Garden Clubs Scholarship allowed me to pursue my degree, which I may not have been able to otherwise. Some of my collegiate activities included National Society of Collegiate Scholars, Gamma Beta Phi, and the Fraternity of Alpha Zeta.

I contacted Dr. Evans about the possibility of completing a research project with him, and he suggested that I assist him on some of his alternative horticultural media research. This project has allowed me to gain valuable skills and knowledge that I will be able to apply in future situations in my career. I plan to work in the industry after pursuing my master's degree and eventually teach in an academic institution.

All previous research conducted with rice hulls has replaced perlite and used whole parboiled fresh rice hulls to provide for drainage and air-filled pore space. Substrate particle size directly affects pore size. Large particles create large pores that drain and become air-filled after irrigation. Small particles create small pores that retain water for use by the plant. By grinding rice hulls, the particle size is reduced. The smaller-sized rice hull particles should create small pores that hold water. Thus, ground rice hulls (GRH) might be used as an alternative to peat. Further, grinding destroys any viable rice seed eliminating the weed problem and allowing for the use of non-parboiled hulls.

Surfactants are used in the horticultural industry to increase the water-holding capacity of substrates. These surfactants are used on many alternative substrates to increase water-holding capacity. Their use might allow for the use of other alternative substrates which might not otherwise be useful due to low water-holding capacity. Ground rice hulls may not provide sufficient water-holding capacity and therefore may require that a surfactant be added to increase water-holding capacity.

The objective of this research was to determine if ground rice hull products could be used as an alternative to peat in the production of seedlings.

MATERIALS AND METHODS

Rice hulls were acquired from Riceland Foods (Stuttgart, Ark.) and ground in a Wiley Hammer Mill (Arthur H. Thomas Co., Philadelphia, Penn.). This process created a product in which 98% of the particles were less than or equal to 2.0 mm in size (Fig. 1). The ground rice hulls (GRH) either remained untreated or were treated with the surfactant Soax (Scotts, Marysville, Ohio) at the recommended label rate.

Substrates were formulated by blending the GRH, peat, and perlite (4 to 6 mm). All substrates contained 10% perlite and 30, 60, or 90% GRH with the remainder being peat. Calcitic limestone was added to the peat to adjust its pH to approximately 5.5. Two control treatments were evaluated. One control consisted of 90% peat and 10% perlite with no surfactant. An additional control substrate of 100% vermiculite was also included.

Substrates were placed into five-cell-by-five-cell mini-plug trays, made from round #273 (5 ml volume per plug cell) plug trays. One tomato seed ('Early Girl') was planted per cell. Plug trays were then transferred to a bi-wall polycarbonate-glazed greenhouse. The low-temperature set point was 18°C. Light levels averaged 250 μmol . sec^{-1} . m^{-2} at 12 h. The trays of substrates were misted once or twice daily to ensure a constantly moist substrate required for germination. All trays were misted at the same time, thus applying the same amount of water to all substrates. The mini-plug trays were fertilized with a 25 mg . L^{-1} nitrogen solution using N-P-K 15-5-15 Excel (Scotts, Marysville, Ohio) with every misting from the start of the third week until the experiment was terminated at the end of the fifth week. There were eight treatments with three replications, with a tray being a replication. The replications were placed on the greenhouse bench in a random pattern.

An analysis of variance was run to establish if there were significant differences in seedling germination and growth among the different substrates. A least significant difference mean separation test (α = 0.05) was used to ascertain which means were significantly different.

RESULTS AND DISCUSSION

Seedlings grown in vermiculite had higher per-tray fresh shoot weights than seedlings grown in all other substrates (Table 1). Seedlings grown in the 90% GRH without surfactant and 60% GRH with surfactant had similar fresh shoot weights as the 90% peat substrate. All other GRH-containing substrates had lower fresh shoot weights than the 90% peat control.

Vermiculite, 90% GRH without surfactant, and 90% peat all had similar per-tray fresh root weights (Table 1). The 30% GRH with surfactant, 60% GRH without surfactant, and 90% GRH with surfactant had lower fresh root weights per tray than the 90% peat control.

Seedlings grown in 90% GRH without surfactant, 60% GRH with surfactant, 90% peat, and 100% vermiculite all had similar dry shoot weights. The 90% GRH with surfactant, 60% GRH without surfactant, and 30% GRH with surfactant had similar dry shoot weights per tray but were significantly lower than the controls. All seedlings had similar per-tray dry root weights regardless of the substrate. The germination percentage was similar for all substrates except the 30% GRH with surfactant, which was significantly lower than the 90% peat or 100% vermiculite controls.

Fresh shoot weights per plant for vermiculite and 90% GRH without surfactant were similar (Table 2). The fresh shoot weights per plant were similar for seedlings grown in 90% peat, 90% GRH without surfactant, and 60% GRH with surfactant. However, the 90% peat and 60% GRH with surfactant were significantly lower than vermiculite. Seedlings grown in 30% GRH-without-surfactant, 60% GRH-without-surfactant, 30% GRH-with-surfactant, and 90% GRH-with-surfactant substrates had lower per-plant fresh shoot weights than those grown in the 90% peat and vermiculite controls (Table 2).

The average fresh root-weights per plant for seedlings grown in the two controls of 90% peat or 100% vermiculite were similar to the 90% GRH without surfactant. All other seedlings grown in GRH-containing substrates had similar average fresh root-weights per plant and were significantly lower than the 90% peat control and 100% vermiculite control.

Seedlings grown in 30% GRH with surfactant and 90% GRH with surfactant had significantly lower average dry shoot-weights per plant compared to the two control substrates of 90% peat or 100% vermiculite. Seedlings grown in 90% GRH without surfactant and 60% GRH with surfactant had similar average dry shoot-weights per plant compared to the two control substrates of 90% peat and vermiculite. All seedlings had similar per-plant average dry root-weights regardless of the substrates.

This study shows the use of GRH in seedling production substrates is a viable replacement for peat. Seedlings grown in substrates containing 90% GRH without surfactant and 60% GRH with surfactant showed on a per-tray and per-plant basis results similar to the two controls of 100% vermiculite and 90% peat. The germination percentages in all GRH-containing substrates were similar to the seedlings grown in 90% peat except for those in 30% GRH with surfactant, which were significantly lower.

Surfactants possibly increased the water-holding capacity of the substrate, therefore exceeding the seedlings' moisture requirement. Also the surfactant used could have caused a slight phytotoxic reaction in the seedlings. This requires further investigation.

ACKNOWLEDGMENTS

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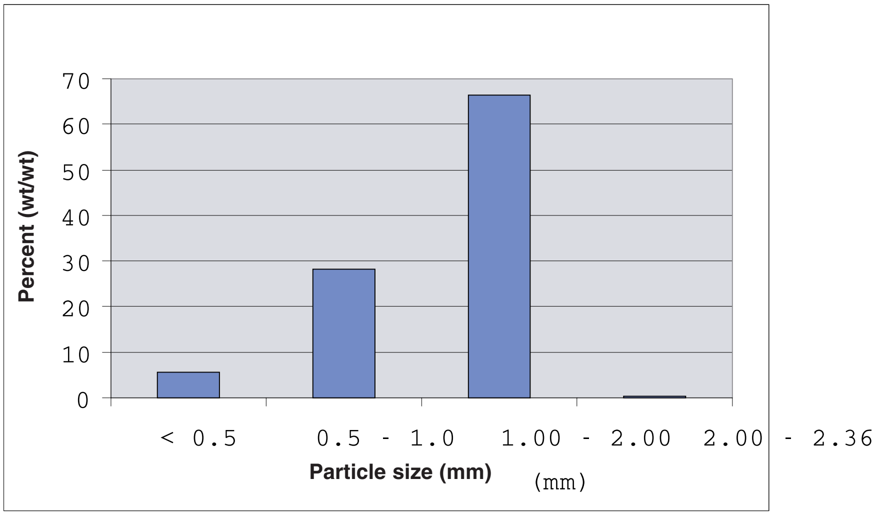

Fig. 1. Particle size distribution of ground rice hulls.

Table 1. Growth per tray of tomato seedlings in Sphagnum-peat-based substrates amended with ground rice hulls (GRH).

Substrate component (% vol/vol)									
Sphagnum peat	GRH[z]	GRH[z] w/ wetting agent	Perlite	Vermiculite	Fresh[y] shoot weight (g)	Fresh[y] root weight (g)	Dry[y] shoot weight (g)	Dry[y] root weight (g)	Germination %
90	0	0	10	0	1.30	1.05	0.21	0.10	89
60	30	0	10	0	0.95	0.73	0.16	0.07	92
30	60	0	10	0	0.88	0.62	0.15	0.07	92
0	90	0	10	0	1.41	1.16	0.21	0.11	79
60	0	30	10	0	0.60	0.51	0.11	0.07	69
30	0	60	10	0	1.26	0.81	0.19	0.09	87
0	0	90	10	0	0.77	0.57	0.09	0.10	81
0	0	0	0	100	1.75	1.29	0.22	0.11	92
Significance									
Substrate					***	**	***	NS	***
Block					NS	NS	NS	NS	NS
LSD (α=0.05)					0.29	0.39	0.05	0.04	10

NS, **, *** Nonsignificant or significant at the 0.01 or 0.001 level, respectively

[z] Ground rice hulls

[y] Weights for combined 5 x 5 plug tray

Table 2. Average per-plant growth weights of tomato in Sphagnum-peat-based substrates amended with ground rice hulls (GRH).

Substrate component (% vol/vol)								
Sphagnum peat	GRH [z]	GRH [z] w/ wetting agent	Perlite	Vermiculite	Avg[y] fresh shoot weight (g)	Avg[y] fresh root weight (g)	Avg[y] dry shoot weight (g)	Avg[y] dry root weight (g)
90	0	0	10	0	0.06	0.05	0.009	0.004
60	30	0	10	0	0.04	0.03	0.007	0.003
30	60	0	10	0	0.04	0.03	0.007	0.003
0	90	0	10	0	0.07	0.06	0.011	0.005
60	0	30	10	0	0.03	0.03	0.006	0.004
30	0	60	10	0	0.06	0.04	0.009	0.004
0	0	90	10	0	0.04	0.03	0.005	0.005
0	0	0	0	100	0.08	0.06	0.009	0.005
Significance								
Substrate					***	**	***	NS
Block					NS	NS	NS	NS
LSD (α=0.05)					0.01	0.02	0.002	0.002

NS, **, *** Nonsignificant or significant at the 0.01 or 0.001 level, respectively

[z] Ground rice hulls

[y] Weights are per-plant averages.