Environment-Friendly Plant Production System: The Closed, Insulated Pallet[1]

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The Closed, Insulated Pallet System (CIPS) conserves resources. Plastic mulch, rigid plastic containers, poly for overwintering, fumigation covers and herbicides can be eliminated; fertilizer and water inputs can be reduced by 80% to 90% by conversion to CIPS. Benefits of CIPS include: environmental effects of production are reduced or eliminated, productivity is increased, differential costs of production are comparable or less than in conventional systems, marginal or non-productive land can be used, and labor conditions and labor efficiency are enhanced.

INTRODUCTION

Greenhouse and nursery growers require new production technology to meet current multiple challenges. Challenges include: (1) elimination of production-related pollution, such as waste water discharge and aerial drift; (2) reduction and conservation of energy, chemical, soil and water resources; (3) elimination of marked seasonal fluctuation in labor, and total annual labor requirement through palletization and mechanization, (4) effective integration of biological controls, beneficial microorganisms and provision of plant production environment to enhance plants' ability to withstand pathogens and insects; (5) prevention of temperature extremes and rapid temperature fluctuations in the plant-root environment; (6) more efficient plant shipping and handling. The new closed, insulated pallet system designed to meet these challenges is a buffered, plant-driven system with high-use efficiency of resource inputs and no waste discharge from the system. CIPS is being developed and evaluated by an interdisciplinary research team from Oregon State University; Oregon Graduate Institute; USDA Horticulture Crops Research Laboratory; the Ohio State University; the Boskoop Nursery Stock Research Station, BIOSYS, and Briggs Nursery, Inc.

A number of approaches have been evaluated to reduce the amount and composition of runoff water from nursery and greenhouse production areas including: (1) collecting and recycling irrigation/fertigation water, (2) increasing irrigation system efficiency, such as with drip systems, and (3) decreasing fertilizer application rates and improving the timing of applications. Although each of these methods has merit, none takes a comprehensive approach to addressing the many production and environmental challenges facing our industry.

METHODS AND MATERIALS

The pallet is comprised of a base unit (tray) and a top (lid). The top and base define a plant-root compartment Plant-root containers are inserted into the root compartment through holes in the pallet top. A collar sealing to the plant stem(s) and extending and sealing to the pallet top results in an essentially continuous, sealed top (lid) that is moisture impermeable, radiation opaque, radiation reflective and thermally-insulated to prevent moisture and heat exchange between the shoot aerial environment above the pallet lid and the enclosed root chamber. The plant-root environment enclosed within the pallet is isolated from the shoot environment.

The shell of the prototype pallet used in this research is fiberglass with a white gel coat. The pallet top is insulated with two inches of urethane foam within the lid combined with the one inch thick urethane foam board collar and amorphous urethane foam that seals plant stems to the pallet collar-lid. The collar and amorphous urethane foam are covered by reflective, opaque aluminum foil. The sidewalls of the pallet are covered by a perimeter insulating urethane foam board one-inch thick extending from the base of the pallet upward to the lid The bottom of the pallet base is not insulated and is placed in direct contact with the underlying earth to allow conductive heat transfer between the water reservoir in the pallet base and the earth.

In the USDA-SBIR Phase 1 research, each individual rigid, black polyethylene plastic one-gal container was placed in the root compartment in contact with a 6- × 6-inch square base by 9-in. high capillary pedestal of rockwool. However, the plant roots were not contained within the containers, and the rockwool was compressed and heavy when wet. Therefore, in subsequent experiments a pouch basket supporting a cross-shaped capillary mat of Troy Flo-Thru Moisturizing Mat and root pouches have been used. Root pouches, 3-liter volume, of 3-ply polypropylene spunbound-meltdown-spunbound 1.2-1.4 ounces/yard fabric from Kimberly-Clark Corporation had a coating of latex containing copper hydroxide (25-100 grams of copper hydroxide from Griffin Agricultural Chemicals per liter of latex carrier) for root containment and regulation of root growth

Plants and moist medium with uniformly incorporated dolomite or gypsum are placed into the root pouch sitting on the cross-shaped capillary mat within the pouch basket extending beneath the pallet lid. Initially, only irrigation water is applied to the top surface of the medium to establish capillarity; gravitational water is allowed to drain from the pouches leaving only absorptive and capillary water within the medium. Fertilizer is then placed on the top surface of the root medium and the moisture-impermeable collar sealed to the plant stem and to the surrounding lid to create a sealed surface

The pallet lid with sealed-in pouch baskets is transported and placed onto the pallet base. The flaps of the capillary mat drop into the water reservoir within the pallet base. Water moves upward from the pallet reservoir into the medium by adsorption and capillarity. After absorption and capillary equilibrium are achieved, further movement of water upward will be in response to plant uptake to support growth and transpiration. Within the top-sealed root pouch, gravitational and evaporative movement of water does not occur. Therefore, no leaching or convection of fertilizer in solution occurs. Fertilizer ion removal by direct root contact before or after diffusion of ions along chemical gradients is plant driven. Fertilizer ions diffuse along a chemical gradient from the fertilizer reservoir at the top of the medium to the root, movement of fertilizer ions is in response to uptake by the plant roots.

Research and evaluation of materials for CIPS is ongoing.

RESULTS AND DISCUSSION

Thermodynamics and Spectral Characteristics of CIPS[2]. The effects of the rates and extremes of daily and seasonal temperature changes of the two production systems on the survival and growth of 16 woody plant species were evaluated. Data to date indicate very little daily fluctuation of root temperatures within the CIP (closed, insulated pallet) and very slow rates of change of root temperatures within the CIP in response to rapid changes in air temperature.

The spectron SE590 loaned from NASA AMES was used to acquire spectral data The spectrometer has 250 discrete bands across 400 to 1100 namomethers (10^{-9}). The sensor measures the brightness of the plants and pallets. Reflection from plants in individual containers sitting on gravel was approximately 10% of the energy in the visible wave lengths. The covered pallets reflected about 40% of the energy.

Fertilizer and Irrigation Water Dynamics[3]. In CIPS compared with the traditional, overhead sprinkler system (TOSS), plant growth in bark medium was two- to three-fold greater. Fifteen-fold greater plant growth was obtained in CIPS with vermiculite-peat medium than in TOSS with bark medium. Root growth and distribution (horizontal and vertical distribution of roots within the medium) was significantly greater in CIPS than in TOSS Ninety percent less water was used in CIPS compared with the open container, and plant growth (grams fresh weight) was significantly greater in CIPS

Beneficial Microorganisms in CIPS.

A) Bacterial agents[4]. Plant growth was significantly increased in the CIPS by addition of biocontrol bacterial agents. Plant growth in TOSS was not significantly increased by addition of biocontrol bacterial agents. In CIPS, biocontrol bacterial agents significantly increased plant growth (gfw-shoots) in the absence of phytophthora inoculum (66.8 compared with 51.4 gfw).

B) Biocontrol nematode agents[5]. In the traditional, overhead sprinkler-irrigated system (TOSS), the biocontrol nematode was effective with all eight plant species. In the closed, insulated pallet system (CIPS), the biocontrol nematode, *Steinernema carpocapsae*, was effective in only four of the eight plant species, with these four species, the highest efficacy was obtained in *Ilex wilsonii* and *Potentilla.* In CIPS, in the plant root matrix of *Viburnum*, *Amelanchier*, miniature rose and *Chrysanthemum* (= *Dendranthema*, "Florists' chrysanthemums") there were factors that inhibited the survival or efficacy of the biocontrol nematode.

Differential Cost Analysis[6]. Annual costs were hypothesized to vary significantly by system. The following costs were compared: (1) land utilization, (2) surface preparation of production area, (3) mechanization, (4) plant containers, (5) specific labor, (6) fertilizer and pesticides, (7) irrigation water, and (8) annual plant shelter. Based on initial assumptions, the preliminary analysis indicates that the annual costs for the Closed, Insulated Pallet Production System with partial automation are as low as or lower than those for the other five production systems. We are continuing to detail and modify cost analysis of the plant-driven system

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