AN INSULATED PALLET TO REDUCE LABOR COSTS AND TEMPERATURE STRESS IN CONTAINER PLANT PRODUCTION[1]

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Abstract. An insulated pallet system was devised and tested for handling and summer and winter temperature moderation Handling labor is required only twice instead of 6 to 9 times Since plants could not blow over, the weight of the growth medium could be reduced by 50% or more by eliminating sand as a component Plant growth and quality was increased by reduced root zone temperatures in summer Plants overwintered with the pallet system had no detectable root injury compared to moderate injury with a single layer poly-covered structure or with straw, and severe injury or death with no protection Ten advantages of the system are discussed.

INTRODUCTION

Labor is the greatest expense in producing container nursery stock (2,4,6). Individual containers are handled from 6 to 9 times during the production cycle (9). This does not include the additional labor involved in standing plants up after a windy day, or fastening plants to the soil with stakes or by wires attached to the top. A system that prevents plants in containers from blowing over substantially reduces labor costs, and could be very cost effective.

Stress from temperature extremes are major problems associated with container plant production (9). Roots of container-grown plants are not in their natural environment and are subject to temperature extremes. To prevent low temperature injury, the nursery industry is currently using many different techniques: a) bunching plants together or laying them down, b) bunching with paper wind barriers around the perimeter (5), c) improving nutritional practices to prepare plants for winter (7), d) mulching with straw (1), e) constructing single- or double-layer poly houses with or without a layer of poly or microfoam over the plants inside the houses (1,5), and e) laying plants down and covering with microfoam or microfoam and poly (3).

High temperature stress also restricts plant growth in containers. White containers reduce root injury and stimulate plant growth, but are generally not practical (8). Early planting of large liners reduce high temperature stress by developing a

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plant canopy over the container before summer's heat (9). Spacing plants so that the top of one plant shades the adjacent container from the intense afternoon sun aids growth (9).

After numerous studies in each of these areas (9), it appears that an insulated pallet system could solve several problems: 1) reduce labor, 2) prevent plants from blowing over, 3) reduce high temperature stress, 4) protect roots during overwintering, 5) reduce early spring growth, 6) reduce cost of bed preparation and maintenance, 7) provide a re-usable container shipping mechanism, 8) be adjusted to different production schemes, 9) potentially decrease soil-borne diseases, 10) eliminate weeds in drain holes, and 11) insure that containers are clean at shipping time. This is a summary of several related studies and a discussion of their potential.

PROCEDURES

During the summer of 1981, a study was conducted to measure the effects of three root environments on plant growth. Green #1 containers (approx. 3.5 liters) were compared, second — with the same container painted glossy white, and third — with the sidewall of the container shielded from any direct light by lightweight aluminum sheeting. All plants were grown in a mix of pine bark, peat, sand, 3-1-1 (v:v:v), with Osmocote 17-7-12, Micromax micronutrients, and dolomite @ 14, 1.5, and 8 lbs./yd.^{3} (8, 0.9, 4.75 kg/m^3), respectively. The 6 species (see Table 1) were grown in full sun and watered by overhead sprinklers as needed. Temperatures in containers were monitored every 2 hours during the period July 5 to 15, using thermocouples placed 3 in. below the surface and 1 in. in from the south side.

The highest temperatures recorded were at 5:00 p.m. The average high temperatures on 7 sunny days during August were 107°, 101°, and 96°F (42°, 39°, and 35°C) for green, white and aluminum covered containers, respectively, when the air temperatures averaged 97°F (36°C).

At the end of the growing season differences in top and root weights and, for some species, number of branches and visual grade, were greatest where the sides of the container were shaded by the aluminum (Table 1). Plant response was intermediate with the white container and poorest in the green containers. Azalea and elaeagnus benefited most from the aluminum shading; however, all responses measured for all species were greatest with the aluminum shading (Figure 1).

During the winter of 1981-82 and 1982-83, two studies were conducted to evaluate the insulating effect of a pallet on

Table 1. Effects of container, exposure, and color on plant response.

Plant and parameter measured	Aluminum covering	White container	Green container
Hetzi Japanese holly			
Ilex crenata 'Hetzii'			
Top wt. (g)	52 b[z]	37 a	43 a
Root wt. (g)	101 b	83 a	81 a
No. branches	25 b	16 a	17 a
Visual grade	8.5 b	5.8 a	6.2 a
wintercreeper			
Euonymus fortunei			
Top wt. (g)	46 b	27 a	32 a
Root wt. (g)	80 b	65 a	64 a
No. branches	8.2 b	6.0 a	6.2 a
Visual grade	8.9 b	4.6 a	4.8 a
Nellie Stevens holly			
Ilex × 'Nellie R. Stevens'			
Top wt. (g)	217 b	75 a	71 a
Root wt. (g)	131 b	113 a	109 a
No. branches	8.7 b	7.2 ab	
silverberry			
Elaeagnus macrophylla			
Top wt. (g)	93 c	55 b	38 a
Root wt. (g)	86 c	69 b	48 a
No. branches	9.3 c	6.0 a	5.2 a
Visual grade	8.9 c	5.4 b	2.2 a
Hinodegari azalea			
Rhododendron × 'Hinodegari'			
Top wt. (g)	45 b	31 a	24 a
Root wt. (g)	45 b	41 b	26 a
No. branches	24 b	16 a	14 a
Visual grade	8.9 c	4.8 b	3.3 a
red top or Fraser photinia			
Photinia × *fraseri*			
Top wt. (g)	84 b	64 a	57 a
Root wt. (g)	69 a	65 a	47 a

[z] Averages followed by the same letter are not significantly different using a protected LSD test at the 1% level.

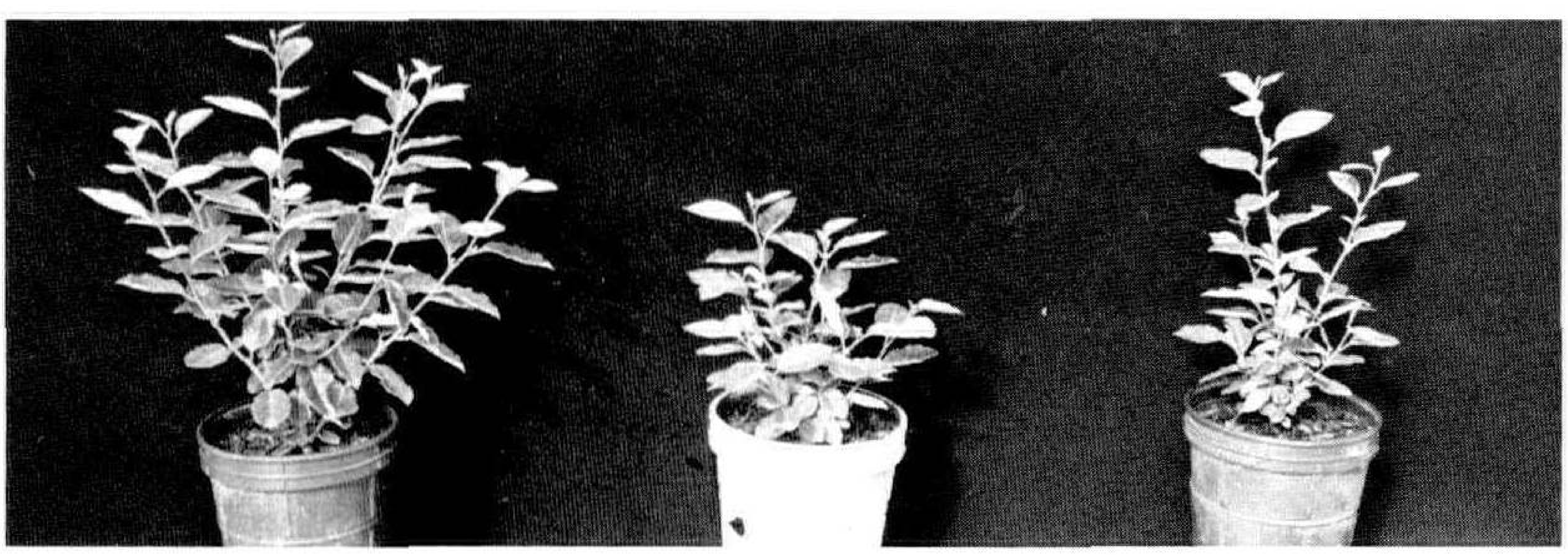

Figure 1. Growth of *Elaeagnus macrophylla* after one growing season in *(left)* container in aluminum pallet, *(center)* white container, and *(right)* green container, all exposed to direct sunlight.

root survival. For the winter of 1981-82 insulated pallets were constructed from solid 4-ft. × 8-ft. sheets of styrofoam, 2 in. and 4 in. thick (Figure 2). A special tool was made from sheet metal to taper holes for a snug fit of individual #1 containers. When the containers were in place, the sides of the pallets were covered with 2-in. styrofoam for additional root protection. Four species were used: *Euonymus fortunei*, evergreen wintercreeper; *Ilex crenata* 'Hetzii', Hetzi Japanese holly; *Ligustrum × vicaryi*, golden vicaryi privet, and *Juniperus procumbens*, Japanese garden juniper. A mix of 3 parts ground pine bark, one part sand, and one part peat was used as the growth medium. Four treatments were used: 1) 4-in. styrofoam pallet, 2) 2-in. styrofoam pallet, 3) heavy wheat straw mulch, and 4) no protection (plants bunched together). All treatments were replicated 4 times with 2 subsamples. The experiment began on November 17, 1981, with uniform plants of all species. All treatments were subjected to 3 natural levels of cold as follows: a) When temperatures reached 9°F (−11°C), two plants from each replication of each species were removed and placed in a heated greenhouse and evaluated for root injury. b) When the temperatures reached −4°F (−20°C), the second group of plants was removed and transferred to a heated greenhouse and evaluated. c) The third group remained outdoors throughout the winter; however, −4°F was the coldest temperature experienced.

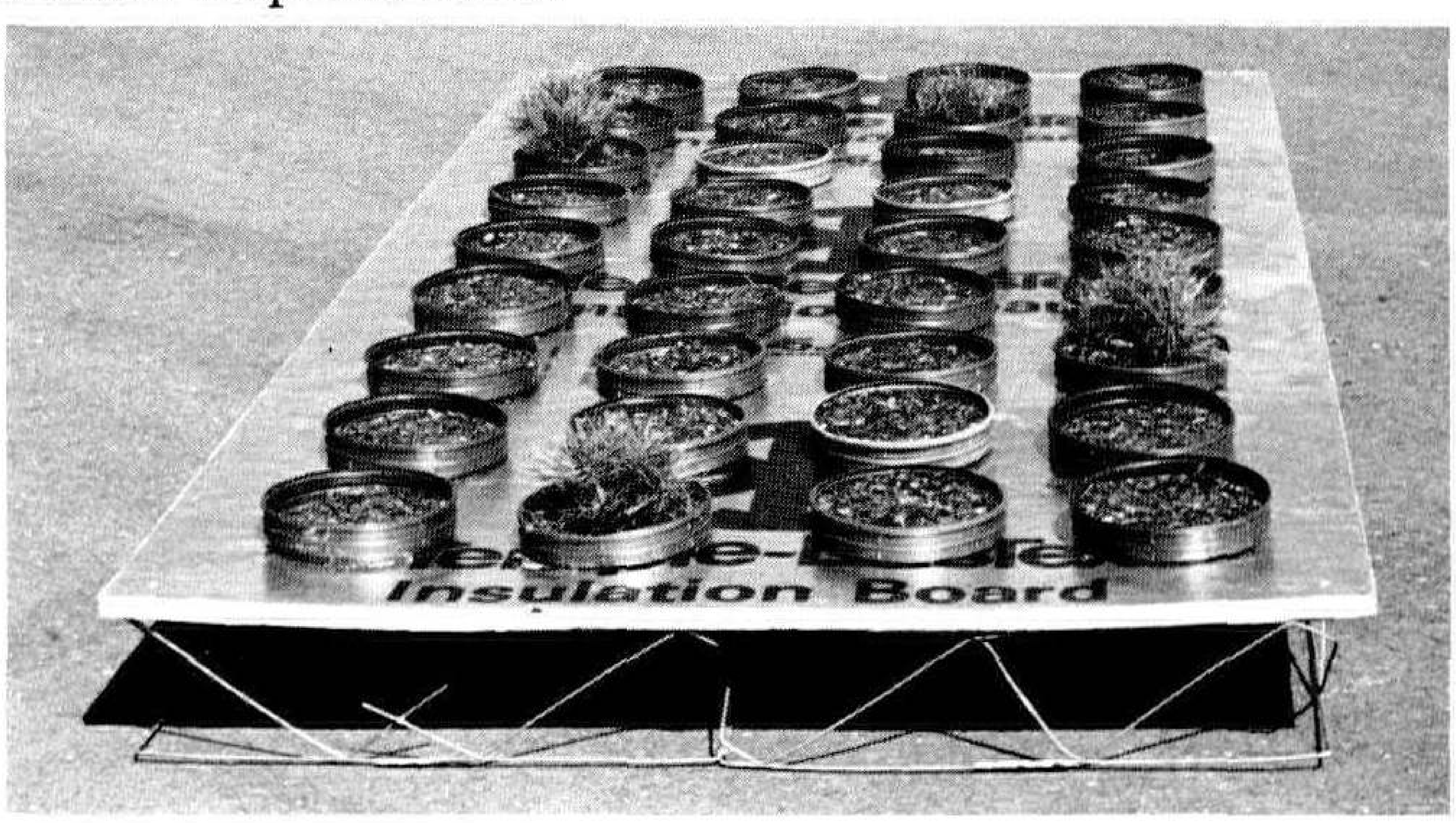

Figure 2. The insulated pallet system with 36 equally spaced containers. Plant roots in the containers are insulated from summer's heat and winter's cold when insulated on the sides, cannot blow over, and can be handled in units as opposed to individual containers.

Temperatures were checked in containers in the pallets throughout the winter and were found to be substantially warmer than pots that were jammed together, unprotected, or mulched with straw. The lowest temperature recorded for containers in either insulated pallet was 24°F (−5°C) during a period when outside temperatures reached −4°F (−20°C).

Marked differences were observed in root weight, top weight, and root counts, or visual root grades. In all cases results from the use of insulating pallets were superior to those from the straw mulch or those from exposed containers at the end of the winter (Table 2).

Table 2. Effects of root protection treatments on top and root weight and a visual root grade of golden vicary privet

		4 in styro-foam	2 in styro-foam	Straw mulch	Bunched but no protection
Date 1	top wt	157	143	163	167 NS
(9°F)	root wt	71	77	86	91 NS
	root grade	7	6	6	6 NS
Date 2	top wt	113 b	120 b[z]	103 b	22 a
(−4°F)	root wt	70 c	58 bc	44 b	17 a
	root grade	6 c	6 c	3 b	2 a
Date 3	top wt	54 b	72 b	52 b	dead a
(all	root wt	41 b	63 b	53 b	dead a
winter)	root grade	8 c	8 c	6 b	1 a
(−4°F)	root count	44 c	48 c	25 b	0 a

[z] Averages followed by the same letter are not significantly different at the 5% level using a protected LSD test. NS = not significantly different

Only the privet data are presented since all species responded similarly, except that tops of the unprotected holly plants were killed on date 2. There was little difference in the protective properties of the 2-in. and 4-in. styrofoam; the 4-in. material provided no additional protection, and during extreme temperatures was colder than the 2-in. pallet. This was probably due to the prevention of earth heating of the container. Some foliage discoloration occurred with the euonymus, but with the first flush of spring growth plants were full and attractive. Even with a hardy juniper, significant differences in root grade and in living root count were noted. These were readily visible when roots of plants that were overwintered in the insulated pallet were compared to those with straw mulch or with no protection (Figure 3).

During the 1982-83 winter, treatments consisted of a) plants in a single-poly covered structure, b) a pallet using ¾-in. urethane as an insulating top, c) straw mulch, and d) bunched plants, all using the same species. Growth medium was the same as the previous year. Winter conditions were somewhat milder overall, with a minimum temperature of 6°F (−15°C).

All plants survived the winter except the unprotected holly. However, spring top growth of the plants in the poly structure and in the insulated pallet were larger, reflecting less root injury than the straw mulch, or the unprotected plants.

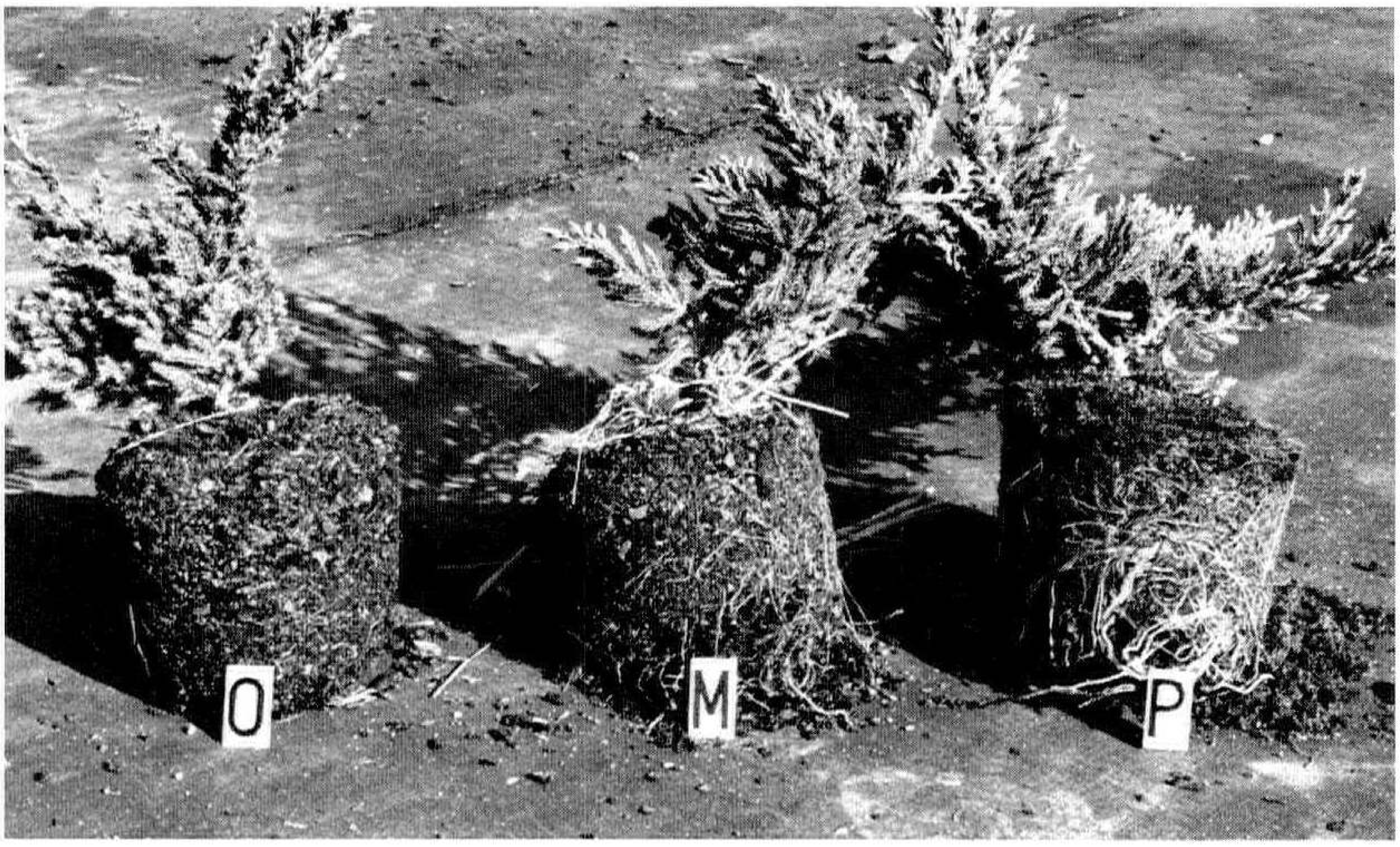

Figure 3. *Juniperus procumbens* plants after the winter *(left)* with no root protection, *(center)* heavily mulched with straw, and *(right)* with insulated pallet to protect the roots. The size of the spring flush of growth reflected the root injury.

DISCUSSION AND CONCLUSION

We envision this as part of a year-round production system for container nursery stock (Figure 2). In more northern areas, marginal plants may need additional protection of the top. Protection of the root system against cold injury could be adjusted to fit the geographic area by increasing or decreasing the insulating capacity of the top of the pallet. With a lightweight growth medium, this pallet system could quickly and easily handled by a lightweight fork lift. This system has the potential to reduce or eliminate many problems associated wit the production of container nursery stock and, at the same time, reduce labor costs.

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