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MODERATOR RAUCH: Thank you, George. I am now going to call on Clyde Elmore, Agriculture Extension Specialist, University of California, Davis, to talk on pollution by weeds. Clyde:

WEED POLLUTION

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Plants are a necessary complement of our environment and lend much beauty and pleasure to man. Plants may also be detrimental in many ways to the health, wealth and well being of man and animals.

Much physical harm and discomfort arise from man and animals contacting thorny bushes and trees such as thistles, starthistle, gorse, or *Opuntia sp.*, cactus, as well as plants with lesser armament. Others of this type include members of the families *Cactaceae* and *Euphorbiaceae*, generally of the desert regions of America, Africa and Asia. Plants also are poisonous to man and animals. In the western United States sheep losses from feeding on halogeton are great. In one reported case in Idaho 1,620 sheep were lost in a single day.

The expenditure of funds and lack of crop return for the control of weeds cost the people of California over 374 million dollars for a year (over 1 million/day). In the U.S. a staggering 2.5 billion figure was suggested in 1968.

Although the total costs of weed control in ornamentals (Table 1) appear small in proportion to large acreage crops such as corn, the dollar per acre figure is one of the highest of any crop. As in other crops, costs increased considerably during a period from 1959 to 1968. With increased labor costs, costs have undoubtedly continued to rise.

Plants are not always weeds. They are considered to be weeds when they interfere with land or water resource utiliza-

tion, or adversely affect human welfare. A plant is a weed only in terms of human attitude; thus, a plant that is a weed to one man may be a wildflower to another. All plants may be weeds in given circumstances but no plant is always a weed, although it is difficult to imagine when poison oak or ivy would not be considered weeds.

Unwanted plants in nursery plantings (containers, field plantings, and ground covers) can be considered pollutants. They often are considered pollutants in the midwest and eastern United States when ragweed (a hay fever plant) is shedding pollen.

The principal weed pollutants in the California container nursery industry are *Oxalis corniculatis*, yellow woodsorrel; *Senecio vulgaris*, common groundsel; *Poa annua*, annual bluegrass; *Euphorbia maculata*, prostrate spotted spurge; *Sonchus oleracea*, common sowthistle; and *Cardamine oligosperma*, lesser-seeded bittercress. (Table 2) Susceptibility to some of the newer herbicides are given. In a study of weed control costs to growers in Massachusetts in 1967, O. Johnson[1] reported that few nurserymen knew how much weeds are costing them. In field plantings, however, costs ranged from $123/A to $600/A among seven nurseries. In transplant beds costs jumped to $2,916/A to $6,256/A.

In a presentation made in 1971 at the Western Region IPPS meeting in Santa Barbara, I reported the cost of hand weeding newly-planted ground covers was $2,941 per acre where no herbicide was used. On some herbicide-treated areas costs for hand weeding including herbicide ranged from $281 to $388 per acre. These costs were for weeding two months after, treatment; little additional hand weeding was needed during the remainder of the season. An additional trial was conducted at the South Coast Field Station, Tustin, California, during 1972 and combined hand weeding and herbicide costs were determined for the full year of establishment (Table 3). While these costs appear quite high, the plot area was perhaps no weedier than some roadside plantings.

Weeds can compete for light and nutrients with ornamental plants so severely that increases in growth of ornamentals of 50% or more can be realized where weed control measures are employed. Hand weeding is not a complete answer to eliminating or even greatly decreasing weed populations. In four California container ornamental tests in 1972-73, hand weeding decreased weeds over a three month period an average of 29%. (Table 4). By contrast, several herbicides reduced weeds on the average from 53 to 88 percent over the sample period. The most effective herbicide was oryzalin (SURFLAN®) a new material not yet on

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[1]Johnson, Oscar, "*Costs of Nursery Weed Control*", *The Rhode Island Nurserymen's Newsletter*, September, 1967, No. 31.

the market but one of particular interest to nurserymen. Oryzalin, a soil-active herbicide, should be available by fall of 1974. Oryzalin appears very safe to established ornamental plants (Table 5), and it is also controlling some of the more important weed species (Table 4). Weeds such as oxalis (Table 6), annual bluegrass as well as other annual grasses are controlled. Control has been less effective with spotted spurge and common sowthistle. Oryzalin, like trifluralin, nitralin, and DCPA are quite weak on common groundsel and lesser-seeded bittercress.

Another herbicide of particular interest is oxadiazon (RONSTAR®). This compound also appears to be safe on most woody ornamental plants and ground covers and should find a place in ornamental weed control (Table 5).

Although alachlor (LASSO®) and dibutalin (AMEX 820®) appear safe enough to use in ornamentals grown in containers, they do not afford control of those weeds that are tolerant of available herbicides. The residual control is shorter than nitralin or oryzalin.

Residual control of annual weeds in containers may be from 3 to 4 months following treatment. This short residual control of weeds is principally due to the high adsorption capacity of the organic potting mix and the excessive amount of water needed by plants grown in containers. In ground cover field plantings, residual control may last 6 months or longer. The residual characteristics of the newer herbicides are similar to simazine. Safety to ornamental plants (Table 4) is many fold greater with herbicides like trifluralin, nitralin, DCPA, oryzalin, dibutalin, than simazine. Mammalian toxicity, like simazine, is quite low.

Although new herbicides are being developed that appear safe to use in ornamental crops, usage may be slow to develop. Registrations for use in ornamental crops are more difficult and labeling by the chemical companies must be reviewed and implemented for use. Herbicides must also be used as a tool in addition to good management and cultural practices that decrease seeding of weeds and introduction of foreign seeds.

Table 1. Cost of Chemical Weed Control in the United States. 1968

Crops	Total (1,000 dollars)	Avg/Acre (dollars)
Ornamentals	1,810	20.26
Lawns	112,708	29.46
Corn	204,483	4.18

Table 2. Relative Control of 12 Weed Species Common to Container Ornamentals With 8 Herbicides

	Preemergence Control[1]																	
	trifluralin 2 lb/A	trifluralin 4 lb/A	nitralin 2 lb/A	nitralin 4 lb/A	oryzalin 2 lb/A	oryzalin 4 lb/A	dibutalin 4 lb/A	dibutalin 8 lb/A	DCPA 10 lb/A	DCPA 15 lb/A	oxadiazon 2 lb/A	oxadiazon 4 lb/A	alachlor 2 lb/A	alachlor 4 lb/A	simazine 1 lb/A	simazine 2 lb/A	Na-propamide 4 lb/A	Na-propamide 8 lb/A
Amaranthus retroflexus (pigweed)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Cardamine oligosperma (bittercress)	●	▲	●	▲	●	▲	●	▲	●	●	⊕	⊕	▲	▲	●	●	●	●
Chenopodium album (lambsquarters)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	▲	⊕	⊕	⊕	⊕	⊕
Conzya (marestail)	●	●	●	●	●	▲	●	●	●	●	▲	▲	-	-	⊕	⊕	●	▲
Digitaria sanguinalis (crabgrass)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	▲	⊕	-	-	●	●	⊕	⊕
Echinochloa crusgalli (barnyard grass)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	▲	⊕	●	▲	▲	⊕	●	▲	⊕	⊕
Euphorbia maculata (spotted spurge)	●	▲	●	▲	●	▲	●	▲	▲	⊕	-	-	-	-	●	●	▲	⊕
Poa annua (annual bluegrass)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	▲	⊕	▲	▲	▲	▲	⊕	⊕	⊕	⊕
Portulaca oleracea (purslane)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	▲	⊕	⊕	⊕	-	-	⊕	⊕	-	-
Oxalis corniculatus (weeping woodsorrel)	●	▲	●	▲	▲	⊕	●	▲	●	●	-	-	●	●	▲	▲	-	-
Senecio vulgaris (common groundsel)	●	●	●	●	●	▲	●	●	●	●	▲	▲	●	●	▲	⊕	●	●
Sonchus (sowthistle)	●	●	●	●	●	▲	●	●	●	●	▲	▲	●	●	▲	⊕	●	▲

⊕ - good to excellent control 70% or higher; ◀ - fair to good control 50-70%; ● - poor to fair 20-50%; - not sufficient data
*lb/A is pounds active ingredient per sprayed acre

Table 3. Field Grown Ground Covers Weed Control Costs (Dollars)

Herbicide	lb a.i./A	Herbicide* cost	Weeding cost/A	Total cost/A	Total cost per 1000 sq. ft.
diphenamid + trifluralin	10 & 2	82	551	632	15
nitrofen	4	38	1,892	1,930	44
alachlor	4	38	853	890	20
dibutalin	4	32[1]	954	988	23
oryzalin	2	36[1]	515	550	13
oxadiazon	2	40[1]	396	435	10
nitralin	2	36	1,275	1,311	30
nitrofen + nitralin	4 & 2	66	533	600	14
hand weeded control	-	-	5,063	5,063	116

*Herbicides applied 7/13/72; 3/9/73 ($7.50 application cost)

[1]estimated price (no market price established)

Table 4. Average Over-all Weed Control from 4 Trials - Percent

Herbicide	Rate* lb a.i./A	1	2	3	4	AVG
DCPA	10	42	58	65	49	53.5
DCPA	15	50	75	76	36	59.3
trifluralin	2	26	81	88	59	63.5
trifluralin	4	51	64	98	76	72.3
alachlor	2	53	68	64	46	57.8
alachlor	4	52	55	75	56	59.5
alachlor	8	42	75	92	68	69.2
oxadiazon	1	54	69	77	78	69.5
oxadiazon	2	64	73	88	78	75.8
oryzalin	2	50	55	99.3	82	71.6
oryzalin	4	75	80	99.6	82	84.2
oryzalin	8	90	72	99.7	92	88.4
hand weeded	-	20	64	4	29	29.3

*lb a.i./A = pounds active ingredient per sprayed acre

Table 5. Plant Species Tested by Herbicide[1]. Number - Maximum 1b a.i./A Applied without injury.

Plant Species	simazine	trifluralin	nitralin	oryzalin	alachlor	oxadiazon	DCPA	Na-propamide	pronamide	nitrofen	dibutalin
Ajuga reptans	S	-	2*†	-	-	-	8*	8*	2*†	4*	-
Berberis darwinii	-	4	4	4	8	4	-	-	-	-	4
Buxus microphylla var. *japonica*	2*	4	-	-	2*	-	15	16*	2*†	-	-
Callistemon citrinus	2	8	8	8	8	2	15	-	-	-	8
Carpobrotus edulis[2]	S	2	2	4	8	4	8	4	2	4	8
Ceanothus gloriosus	-	-	4	4	4	4	-	-	-	-	4
Cotoneaster lacteus (c. *parneyi*)	2	4	-	8	8	2	15	-	-	-	-
Delasperma alba	S	2*	2*	4*	8*	2*	8*	4*	2*†	4*	8*
Erica canaliculata 'Rosea'	0.5	-	2	-	8	-	-	16	2	-	-
Escallonia 'Fradesi'	-	4	1	8	8	2	15	-	-	-	-
Eucalyptus sideroxylon	-	4	-	8	8	2	15	-	-	-	-
Euonymus japonica 'Aureo-variegata'	2	4	-	8	8	2	15	-	-	-	-
Gazania splendens	S	2	2*	4*	-	-	8*	8*	2*†	8*	-
Grevillea 'Noelli'	0.5*	2	2*	-	8*	-	-	16*	2*	-	-
Hebe buxifolia	0.5*	2	2*	-	2*	-	-	8*	2*†	-	-
Hedera canariensis	0.5*	2*	2*	4*	8*	4*	8*	8*	2*†	8*	8*
Hedera helix	0.5*	2	2*	-	-	-	8*	8*	2*	8*	-
Hypericum calycinum	S	2	2*	-	-	-	8*	4*	2*†	4*	-
Ilex aquifolium 'San Gabrial'	3	4	-	8	8	2	15	-	-	-	8
Ilex cornuta 'Rotunda'	3	4	-	8	8	2	15	-	-	-	-
Juniperus chinensis 'Torulosa'	4	4	-	8	8	2	15	-	-	-	-
Juniperus chinensis 'Wiltonii'	2	4	-	8	8	2	15	-	-	-	-
Juniperus sabina 'Tamariscifolia'	4	4	-	8	8	2	15	8	2*†	-	8
Ligustrum japonicum	2	4	4	8	8	4	15	-	-	-	8
Hymenocyclus luteolus [*Malephora luteolum*]	S	2	2*	2*	8*	-	8*	4*	2*†	8*	-
Myrtus communis	-	4	2	8	4	1†	15	-	-	-	4
Nerium oleander	2	4	4	8	8	2	15	-	-	-	-
Osteospermum fruticosum	S	2*	2*	4*	8*	4*	8*	8*	8*	8*	8*
Photinia x fraseri	1	4	-	8	8	2	15	-	-	-	-
Pinus thunbergiana	8	4	-	8	8	2	15	-	-	-	-
Pittosporum tobira	1	4	-	8	8	2	15	-	-	-	8
Pyracantha coccinea	2	4	-	8	8	4	20	8	-	-	-
Rhaphiolepis indica	8	4	-	8	8	2	15	-	-	-	-
Sedum brevifolium	0.5*	2*	2*	4*	4*	2*†	8*	4*	8*	8*	8*
Ternstroemia gymnanthera	-	4	-	8	8	2	15	-	-	-	-
Trachelospermum jasminoides	-	4	-	8	8	2	15	-	-	-	-
Vinca major	0.5*	2*	2*	4*	8*	2*	16*	-	-	4*	8*
Vinca minor	0.5*	2*	2*	4*	8*	4*	4*	8*	2*†	8*	8*
Xylosma congestum	0.5	4	-	8	8	2	15	-	-	-	-

[1]Plants established from liners in gallon containers; a minimum of 3 weeks.
[2]Planted as unrooted cuttings.
*Newly planted rooted liners. S Sensitive.
†Injury occured at lowest rate applied. - Sufficient data not available.

Table 6. Control of *Oxalis corniculatus* With Four Herbicides in Container Grown Ornamentals

Herbicide	Rate lb a.i./A	Weed Control[a]	*Pyracantha* sp. Growth Indices[b]	Top Weight (gms)[c]
trifluralin	4.0	9.1	97.9	101.8 a
oryzalin	2.0	10.0	84.2	98.7 a
oryzalin	4.0	10.0	66.2	93.7 a
oryzalin	8.0	10.0	108.8	97.4 a
linuron	1.0	9.2	100.6	80.8 abc
simazine	2.0	4.2	84.6	98.4 a
simazine	4.0	9.1	77.5	100.8 a
simazine + charcoal	4.0	5.1	103.5	68.3 c
linuron + charcoal	1.0	8.0	118.7	82.3 abc
charcoal	-	9.7	104.1	72.4 bc
weeded	-	2.8	72.0	94.9 a
non-weeded	-	1.9	68.2	90.8 ab

[a] 0 = no effect; 10 = complete control

[b] $\frac{\text{Height in cm x diameter in cm}}{2}$

[c] Any mean followed by the same letter is not significantly different at the 0.05 level

Further research is being conducted on several aspects of the control of weeds, including application methods of sub-surface blading for control of *Convolvulus arvensis* (field bindweed), microwave irradiation of seeds as preplant treatments, as well as determining safety and use of new and established herbicides. The future is bright for methods to combat weeds in our environment.

MODERATOR RAUCH: Thank you, Clyde. I would now like to turn the program back to George Oki.

GEORGE OKI: For the second half of this morning's session Tok Furuta will act as moderator.

TOK FURUTA: We will now resume the program with a discussion by Howard Brown on his experiences in visiting some nurseries in England.