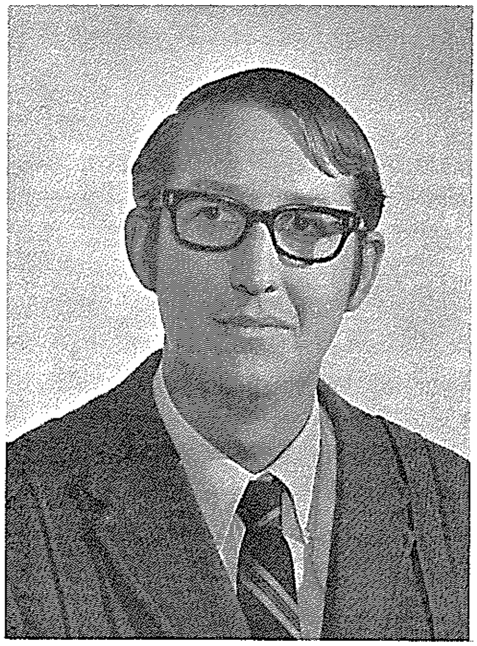
ANTITRANSPIRANTS: A POSSIBLE ALTERNATIVE TO THE ERADICATION OF SALTCEDAR THICKETS

Robert S. Cunningham[1]
David B. Thorud[2]

Biographical Sketch



In May, 1970, I graduated from the University of Arizona, with distinction, receiving a Bachelor of Science degree in Agriculture from the Department of Watershed Management under the Department's hydrology option. As an undergraduate assistant I was involved in data collection for two snow management studies as well as greenhouse and laboratory work with antitranspirants. My graduate studies are directed toward saltcedar antitranspirant investigations.

I am a member of Alpha Zeta national agricultural honorary, and a student member of the Society of American Foresters.

After completion of my graduate work at Arizona, I will be actively pursuing a career in land management.

Background

The demand for water in the arid West has resulted in various plans for increasing available supplies. One plan involves the eradication of phreatophyte vegetation adjacent to stream channels. Phreatophytes are often large water users because of their direct contact with shallow groundwater tables. Saltcedar (*Tamarix pentandra* Pall.) is a prime example, due to its vast areal extent and high water use which may exceed 180 cm per year (van Hylckama, 1970). Consequently, saltcedar is often the object of eradication management. This report presents a brief review of the motivations for and limitations of eradication, and proposes a possible management alternatives for situations where the retention of saltcedar communities may be desirable.

Tamarix is one of four genera of the *Tamaricaceae* family, native to Africa, Asia, and Europe. Although the taxonomy is somewhat uncertain, *T. pentandra* is believed to be the most common saltcedar throughout the West. *T. gallica* Linn. is another important species found mainly on saline soils near the Texas Gulf Coast. Saltcedar species have spread rapidly since their intro-

---

[1] Department of Watershed Management, University of Arizona
[2] Professor, Department of Watershed Management, University of Arizona

duction into the United States during the early 19th century, and now occupy an estimated 1.3 million acres of river bottom land in the West (Robinson, 1965). In the following discussion, the term saltcedar refers to T. pentandra.

Saltcedar is ecologically adaptive for several reasons. It sprouts prolifically and is capable of producing thousands of seeds throughout its growing season, although the majority are produced during May and June (Horton and others, 1960). Seeds germinate well in saline solutions which would be unfavorable for some competing vegetation (Hulett and Tomanek, 1961). Rapid growth is another competitive attribute. Van Hylckama (1970) reported growth rates as high as 5 cm per day for young shoots in ideal environments. All of the above factors combine to make saltcedar tenacious and difficult to control in moist riparian environments.

The reduction of flood hazards is another motivation for saltcedar eradication, in addition to water salvage. Dense saltcedar thickets can impede bankfull and larger flows and block normal overflow channels. This daming effect causes water to spread over adjacent lowlands. Such flooding has damaged agricultural lands. Channel clearing would reduce this hazard.

Wildlife utilization of saltcedar thickets has become an important consideration in eradication plans; some wildlife organizations have even stopped eradication programs by legal means. White-winged dove, an important game species, and other creatures including some "endangered species" have adapted readily to saltcedar thickets (Manes, 1970). Shaw (1961) outlined the evolution of the white-winged dove's association with saltcedar in the Gila Valley of Arizona. The clearing of mesquite bosques for agriculture prior to 1940 in combination with hunting during nesting periods almost decimated the dove population. Consequently, a closed summer hunting season was imposed (Arnold, 1943). These events took place at about the time saltcedar thickets were developing into suitable nesting sites. The combination of a closed season, readily available food and water, and new nesting sites enabled a large, concentrated white-winged dove population to become established. The closeness of these areas to an urban center contributed to their excellent hunting characteristics. Regardless of the circumstances resulting in the use of saltcedar thickets by dove, the thicket can be an important habitat for wildlife values. A "green strip" may also have aesthetic value in arid environments.

The application of a harmless foliar spray to reduce plant water use, combined with a limited channelization program, could provide an alternative to eradication which may be agreeable to both wildlife and water interests. Such sprays, antitranspirants, have been used to prevent the wilting of transplants and floral arrangements and to decrease winter desiccation damage (Gale and Hagan, 1966). Antitranspirants that close or narrow stomate apertures have generally been the most successful. Growth rates may be adversely affected if stomate apertures are reduced by treatment, but theoretically transpiration should decrease more than photosynthesis (Zelitch and Waggoner, 1962).

Alkenylsuccinic acids and their derivatives have closed stomata at low concentrations. The unsaturated hydrocarbons of these compounds may affect the lipid layers in plant cells and thereby cause an increase in the cell wall permeability to water (Kuiper, 1964). If the permeability increases, the turgor of guard cells should decrease and this should narrow stomatal apertures. Eight-hydroxyquinoline sulfate (8-HQS), a fungicide and chelating compound, has also reduced transpiration rates. Eight-HQS affects stomate apertures, but its mode of operation is not clear (Zelitch, 1969).

Brooks and Thorud (1971) demonstrated the effectiveness of antitranspirant foliar sprays on saltcedar (T. pentandra) in Arizona. The most successful compounds were: 8-HQS at 0.01M; a combination of the monoglyceryl ester of n-decenylsuccinic acid (GDSA) at 150 ppm and the monomethyl ester of n-decenylsuccinic acid (MDSA) at 150 ppm; and MDSA at 350 ppm. The three compounds reduced transpiration for 20 days by 36, 28 and 29% of control, respectively. However, a growth reduction for treated plants possibly caused some of the decrease in transpiration. Before these antitranspirants can be considered as workable alternatives to eradication, several additional aspects should be investigated, including the effects of retreatment and rainfall.

Methods and Materials

In this study, two greenhouse experiments were performed with saltcedar to evaluate the effects of rainfall and retreatments on the transpiration rates of plants treated with 8-HQS (0.01M) and MDSA (350 ppm). Antitranspirants were mixed in distilled water with 0.5% Triton X-100, a wetting agent. The 1st experiment was done in August 1970 and the 2nd from October through November 1970 in a greenhouse at Tucson. Plants were grown from stem cuttings taken on the Gila and San Pedro river flood plains. The plants were potted in sandy soil and were watered with nutrient supplement (Mace, 1968) once each week. Soil water levels were maintained near field capacity by adding sufficient water each evening. The effects of soil water stress on transpiration were probably minimized by this procedure. The soil was sealed with plastic sheeting during the day to prevent evaporation, but the sheeting was opened at night to facilitate gas exchange. Transpiration was measured gravimetrically with a solution balance of 1 g accuracy. Plant-pot weights were measured in the morning and evening to determine daily transpiration.

Rainfall was simulated for both experiments by spraying distilled water on foliage from an overhead sprinkler. The duration and intensity of each simulated rainfall event were 15 minutes and 15 cm per hour, respectively.

In experiment 1, 72 plants were assigned permanent bench positions, and pre-treatment transpiration rates were determined. These plants were 7-months-old and averaged 80 cm in height. The average pre-treatment transpiration rate was 293 g per day for 4 days. Of the 72 plants, 36 were selected for study and were grouped into 6 blocks of 6 plants each. Plants with similar transpiration rates were placed in the same block. Each block was then subdivided into 2 groups of 3 plants each. In each subgroup, 8-HQS was applied to 1 plant, MDSA to another and the 3rd was left untreated as a control. The antitranspirants were hand-sprayed on foliage outdoors at midmorning, under full sunlight and in still air. One subgroup in each block received the simulated rainfall 1 day after the antitranspirant treatments. Minimum and maximum daily air temperatures averaged 22° and 33° C during the post-treatment period. Minimum and maximum relative humidities averaged 39 and 73%.

The statistical design of the 2nd experiment was identical to that of the 1st; however, other factors differed. The plants for experiment 2 were obtained from the same locations, but were only 4-months-old and 50 cm in height. Thirty-six plants were selected from a total of 42. The average pre-treatment transpiration rate was 39 g per day. The greenhouse was artificially heated and sunlight was supplemented by 2 banks of florescent lights on 12-hour cycles. Antitranspirants were applied in the greenhouse at midmorning, under the florescent lights and in still air. A 2nd antitranspirant treatment was similarly applied 13 days after the initial treatment. Simulated rainfall was applied to 1 subgroup of each block 2 days after the initial treatment, and again 4 days after the 2nd treatment. Minimum and maximum daily air temperatures averaged 17° and 26° C during the post-treatment period. Minimum and maximum relative humidities averaged 29 and 56%. Transpiration measurements were terminated 31 days after the 2nd treatment when treated and untreated plants began to show signs of winter dormancy. Plants were cropped 17 days after transpiration measurements ended and oven-dry weights of foliage were determined.

The data for both experiments were analyzed for each sampling date by analysis of variance and the Duncan's new multiple range test at alpha levels of 0.05.

Results

Effects of Treatments Without Rainfall

The mean daily transpiration rates of plants receiving a single application of 8-HQS were 29 to 46% less than control for 5 to 7 days (Table 1). For 1 application of MDSA, the transpiration rates were 42 to 47% less than control for an additional 15 to 31 days (Table 1). Thus, the transpiration rates of plants receiving 2 treatments of 8-HQS and MDSA were 32 to 38% less than control for a total of 3 to 5 weeks (Figures 1 and 2).

Table 1. Summary of statistically significant responses for 8-HQS (0.01 M) and MDSA (350 ppm) treatments ($\alpha = 0.05$).

		Mean Reduction In Transpiration (%)		Treatment Duration (Days)	
Experiment Identification	Anti-trans-pirant	rain	no rain	rain	no rain
Experiment 1	8-HQS	28	29	4	5
	MDSA	39	47	10	13
Experiment 2 1st treatment	8-HQS	27	46	5	7
	MDSA	37	42	7	7
Experiment 2 2nd treatment	8-HQS	28	35	3	31
	MDSA	37	27	3	15
Experiment 2 overall effect of the 1st and 2nd treatments	8-HQS	27	38	8	38
	MDSA	37	32	10	22

Effects of Treatments With Rainfall

Rainfall effects were also evaluated by considering both the magnitude and duration of transpiration change following treatment with antitranspirants. These analyses were inconclusive for both 8-HQS and MDSA.

A total of 27 post-treatment days were analyzed in experiments 1 and 2. The rained-on plants transpired significantly less than plants receiving no rain on only two days for 8-HQS. No differences were significant for MDSA.

Analyses of treatment duration gave more variable results. In experiment 1, the transpiration rates of rained-on plants treated with 8-HQS were less than control for four days; while the duration for plants receiving no rain was five days (Table 1). For MDSA these values were 10 and 13 days, respectively. After the initial treatment with 8-HQS and MDSA in experiment 2, the durations for rained-on plants and those receiving no rain varied from five to seven days. None of these differences are considered important. However, the effect of rain seemed to be more pronounced following retreatments with 8-HQS and MDSA in experiment 2. Transpiration rates of rained-on plants were lower than control for only three days following retreatment (Table 1). In contrast, plants receiving no rain transpired less than control for 15 to 31 days following retreatment (Figures 1 and 2).

Effects of Treatment on Growth and Appearance

The dry weights of foliage from treated and control plants were not significantly different 48 days after retreatment in experiment 2. However, these growth determinations were based on limited measurements and are therefore only a crude index. The treated plants in both experiments showed no significant color or form differences in comparison to untreated plants during or after the experiments.

Discussion

Antitranspirants should be effective in reducing plant water use, harmless to the environment and economical, to be useful as a water salvage tool. The antitranspirants tested in this study were effective in reducing plant water use, but simulated rainfall may have shortened the duration of treatment effectiveness in one case. Rain appeared to have no influence on treatment effectiveness in other tests. Consequently, questions concerning rainfall remain unanswered. Even if rainfall is important under field conditions, there may be times when antitranspirants could be used effectively. For example, rainfall is usually light and water use by saltcedar is high during late spring runoff periods and early summer in Arizona. Applications of antitranspirants at this time may increase available water supplies.

An important requirement is that antitranspirants be harmless in the environment. No damaging effects of 8-HQS or MDSA on saltcedar were detected in our experiments. The plants appeared to remain healthy even after two successive applications. But this analysis involves only one phase of the environment. Other factors including human health, wildlife and water quality should be thoroughly investigated before antitranspirants are applied operationally.

The total expected cost of an operational treatment program has not been estimated. Eight-HQS and MDSA are used in small quantities and are relatively inexpensive, but many other costs must also be considered.

The experiments with antitranspirants on saltcedar have progressed to the point where field studies should be performed in natural thickets. The experimental conditions should permit measurement of treatment effects on groundwater depletion, plant condition, water quality, particularly if surface water is present, and possibly other environmental factors.

Summary

Considerable controversy concerning the eradication of saltcedar thickets for water salvage and flood control indicates that a management alternative may be desirable for some situations. The application of antitranspirants to saltcedar foliage may provide such an alternative.

In this study, the antitranspirants 8-HQS (0.01 M) and MDSA (350 ppm) were sprayed on the foliage of potted saltcedar plants in a greenhouse at Tucson. The transpiration rates of treated plants were 29 to 47% below control for 5 to 13 days after single applications of the compounds. Following a retreatment, the treated plants transpired 27 to 35% less than control for an additional 15 to 31 days. Consequently, plants receiving two treatments transpired less than control for a minimum of three weeks. These are considered important treatment effects.

Conceivably, rainfall could diminish treatment effectiveness. To test for rainfall effects, simulated rain was sprayed on plants in the greenhouse on the 1st, 2nd or 4th day after treatment with antitranspirants. These studies were inconclusive. Generally, rain did not change the magnitude of transpiration reduction following treatment with antitranspirants. Likewise, rain did not cause important changes in the duration of transpiration reduction in two tests. In another test, however, plants receiving rain transpired less than control for three days, while plants receiving no rain transpired less than control for 15 to 31 days. A rain-no rain difference of this magnitude could be important in an operational treatment program.

The growth, color and form of plants that were treated with one and two applications of 8-HQS and MDSA were not noticeably different from control plants during or after the experiments.

Acknowledgements

This paper was published as the University of Arizona Agricultural Experiment Station journal series 1758. The work was supported in part by funds provided by the U. S. Department of the Interior as authorized under the Water Resources Research Act of 1964, Public Law 88-379.

REFERENCES

1. Arnold, L. W. 1943. The western white-winged dove in Arizona. The Arizona Game and Fish Comm. Pittman-Robertson Project Arizona. 9-R, 103 pp.

2. Brooks, K. N. and D. B. Thorud. 1971. Antitranspirant effects on the transpiration and physiology of tamarisk. Water Resources Research (in press).

3. Friedman, J., Z. Shapira, and Y. Waisel. 1965. Tamarisk, a promising tree for fuel-break in Israel. Israel Journal Bot. 14: 208.

4. Gale, J. and R. M. Hagan. 1966. Plant antitranspirants. Ann. Rev. Plant Physiol. 17: 269-282.

5. Horton, J. S., F. C. Mounts, and J. M. Kraft. 1960. Seed germination and seedling establishment of phreatophyte species. U. S. Dept. Agr., Forest Service, Rocky Mtn. Forest and Range Exp. Sta., Sta. paper No. 48, 26 pp.

6. Hulett, G. K. and G. W. Tomanek. 1961. Effects of some environmental factors on germination of salt cedar (*Tamarix pentandra* Pall.) Trans., Kansas Acad. Science. 64 (2): 96-101.

7. Kuiper, P. J. C. 1964. Water transport across root cell membranes: effect of alkenylsuccinic acids. Science 143 (3607): 690-691

8. Mace, A. C., Jr. 1968. The influence of climatic, hydrologic, and soil factors on evapotranspiration rates of tamarisk (*Tamarix pentandra* Pall.). Ph.D. Dissertation, University of Arizona. 104 pp.

9. Manes, R. R. 1970. Threatened species doomed. In the Fatal Future, an Arizona Game and Fish Dept. publication. 25 pp.

10. Robinson, T. W. 1965. Introduction, spread and areal extent of salt cedar (*Tamarix*) in the Western States. U. S. Geol. Survey Prof. Paper 491-A. 12 pp.

11. Shaw, H. 1961. Influence of salt cedar on white-winged doves in the Gila Valley. Arizona Game and Fish Dept. Game Mgt. Div. Special Report. 9 pp.

12. van Hylckama, T. E. A. 1970. Water use by salt cedar. Water Resour. Res., 6 (3): 728-735.

13. Zelitch, I. 1969. Stomata control. Ann. Rev. Plant Physiol. 20: 329-350.

14. Zelitch, I. and P. E. Waggoner. 1962. Effect of chemical control of stomata on transpiration and photosynthesis. Proc. Natl. Acad. Sci. 48 (7): 1101-1108.

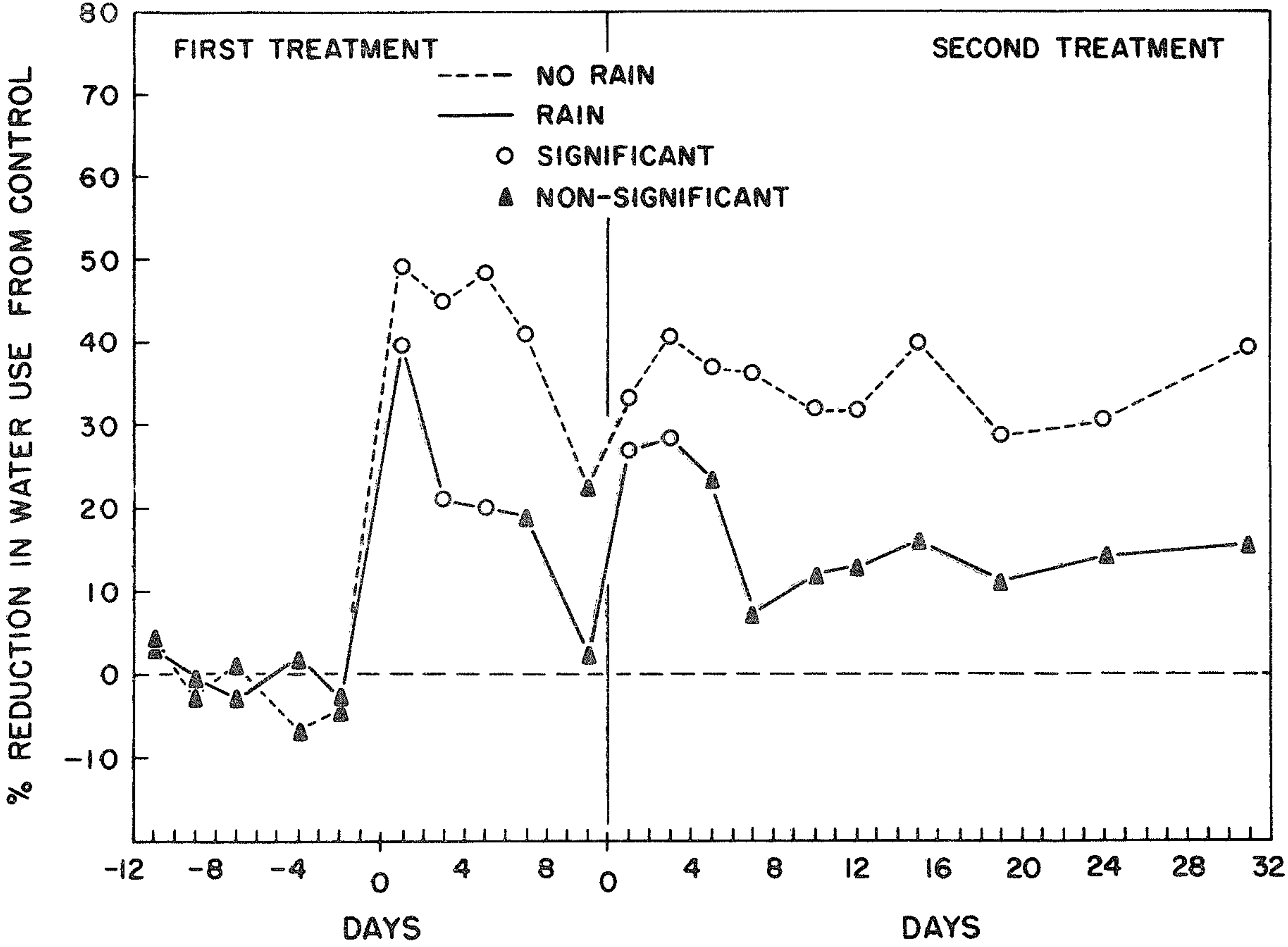


Figure I. Comparison of 8-HQS (.01 M) treatment and retreatment response. Treatments applied on days represented by zero.

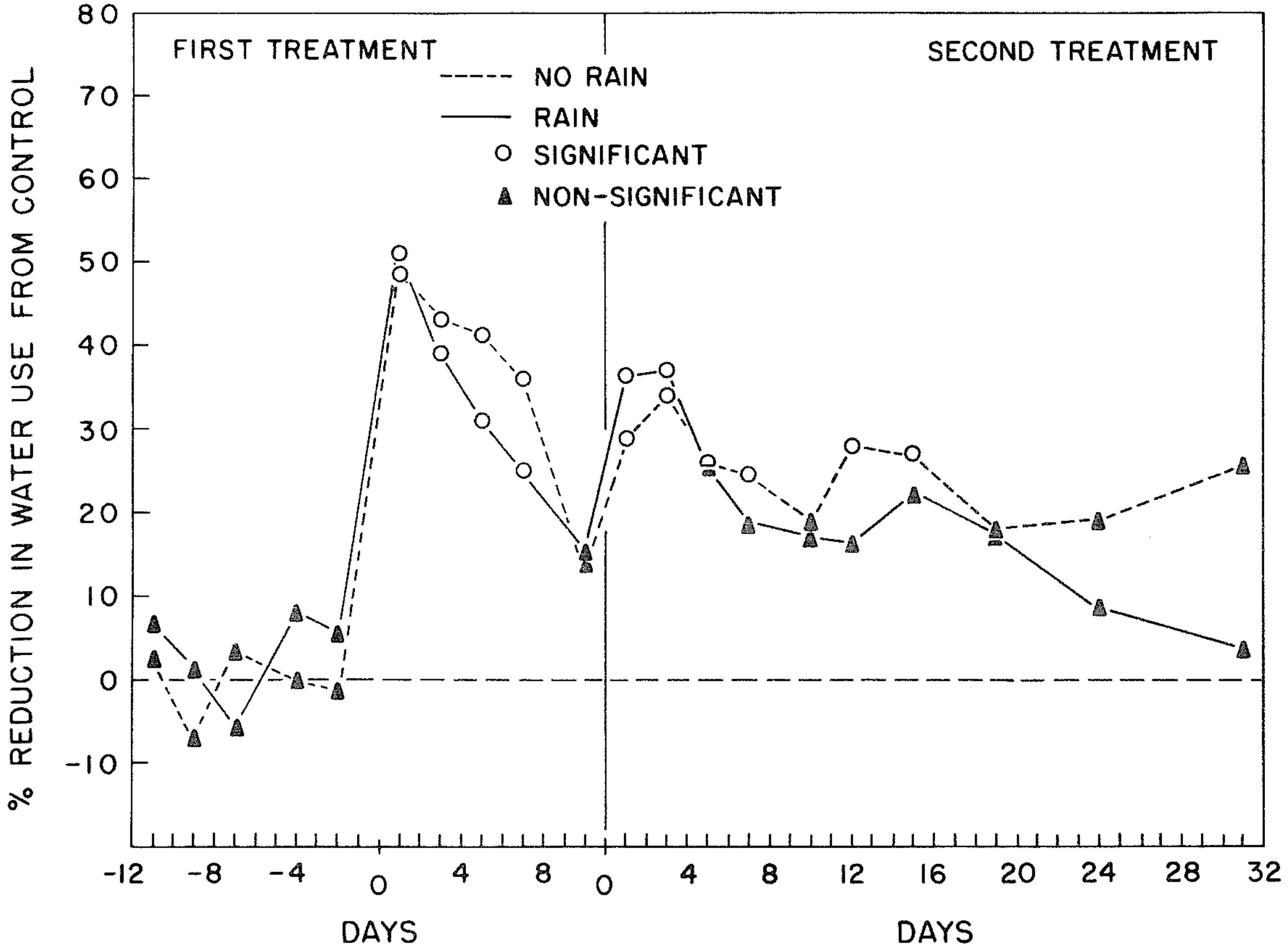


Figure 2. Comparison of MDSA (350 ppm) treatment and retreatment response. Treatments applied on days represented by zero.