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# RESPONSES AND INTERACTIONS IN DESERT PLANTS AS INFLUENCED BY IRRIGATION AND NITROGEN APPLICATIONS

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## ABSTRACT

Effects of trickle irrigation and 25 or 100 kg N/ha applied as $NH_4NO_3$ were studied in Mercury Valley, adjacent to Rock Valley. During 1975, shrub growth continued at a more rapid pace in irrigated plots than in nonirrigated plots, but vegetative production shifted more from new stem growth toward proportionally greater production of deciduous structures. Fewer new shrub seedlings germinated and survived in 1975 than in 1974. Both irrigation and nitrogen treatments increased the numbers and biomass of winter annuals (primarily the grasses *Bromus rubens* and *Festuca octoflora*). Biomass on irrigated and fertilized plots was 342 kg/ha vs. 141 kg/ha on the controls. Summer annuals were nearly absent from each of the plots in 1975. Seed production was studied in the major shrub species. Irrigation increased fruit production per plant in all species; nitrogen increased it in some and decreased it in others. *Ambrosia dumosa* fruit production was reduced almost 50% by 100 kg N/ha, and *Larrea tridentata* fruit production was little affected by either irrigation or nitrogen.

## INTRODUCTION

A study is in progress to determine the effects of irrigation and nitrogen fertilization on a Mohave Desert shrub community. Earlier investigations (Romney et al. 1974), and our results from treatments applied in 1974 (Hunter et al. 1975), indicated that the marked response to supplemental irrigation generally masked any beneficial effects of nitrogen fertilizer on shrub growth. We did, however, observe an increase in the nitrogen content of some shrub and annual plant species in plots where nitrogen treatments were applied. We have not yet seen widespread evidence of nitrogen deficiency where shrubs have shown marked growth response to supplemental moisture applied over a period of three years. There have been, however, some cases where some individual shrubs and a number of annual species showed marked growth response to nitrogen applied to irrigated plots. We believe these observations are related to the reserve status of the available nitrogen pool underneath shrub clumps, and that insufficient treatment response time has elapsed to allow nitrogen deficiency to develop as the result of higher productivity during several successive years of optimal soil moisture. The basic premise of our continued work is to determine the extent to which the demand for nitrogen will limit plant growth, as available water is increased, and hence make N fertilization more effective in increasing primary productivity. This is the third in our series of progress reports.

## OBJECTIVES

The general objectives of this study are to determine the effects of supplemental moisture and nitrogen on plant growth and species population interactions within Mohave Desert shrub communities. Specific objectives partially covered by data in this report are to: 1) determine population biomass changes of shrubs and annuals in response to irrigation and nitrogen fertilization; 2) measure nitrogen changes in the soil in response to irrigation and nitrogen fertilization; 3) measure effects of fertilization and irrigation on the mineral content of shrub tissue; and 4) provide estimates of nitrogen utilization by plants when moisture is supplemented.

## METHODS

The design of trickle-irrigated plots and the measurement of precipitation, irrigation and soil water potentials were described in our previous report (Hunter et al. 1975). The dimensional analysis used to determine shrub biomass is basically that described in Wallace and Romney (1972). Tissue nitrogen and mineral analyses were performed as previously reported (Hunter et al. 1975). Soil nitrate analysis has not been changed, but soil ammonia was analyzed on a 2 *N* KCl extract (Bremner 1965), using an Orion ammonia electrode. This technique displaces and extracts essentially all the exchangeable ammonia. Data are stored under DSCODES A3URM01-12.

Seed production was estimated by counting actual seeds when there was a small number. For prolific plants, a count of stalks or branches was made, and an estimate of seeds per stalk recorded. Fruit samples were air-dried and weighed in groups of 10 to the nearest milligram. Analyses for nitrogen and mineral content are in progress. Ten fruit each of *Larrea tridentata* and *Ephedra funerea* and five of *Sphaeralcea ambigua* from each plot were dissected to determine numbers of filled seeds.

## RESULTS

### SUPPLEMENTAL MOISTURE

Precipitation at the Mercury Valley plots is recorded in Table 1; Table 2 reports dates and amounts of irrigation water applied, and some examples of the soil water potentials on selected plots are given in Table 3. Water was added to summer-irrigated plots when water potentials at 30 cm had dropped to near —30 bars in June and again near —40 bars in August. On plots with winter water, irrigation occurred in late October when water potentials were lower than —75 bars.

Table 3 contains data (plot 12) indicating the slow movement of water from natural rainfall past the 60-cm depth which was observed for the unwatered control plots. This condition continued during the early spring months, until mid-May, at which time the soil water potentials were high enough from rainfall in April to allow capillary flow of water (Lyon et al. 1952). We found some indication that one unwatered plot had received some moisture at the

60-cm depth from an irrigated plot located at about 4-m distance. There was, however, no near-surface indication of this crossover which might have occurred by lateral flow of moisture across the restrictive hardpan underlying these plots. We now recognize futher needs to investigate the distance of lateral movement of water among our study plots. Some additional placements of moisture tension psychrometers have been made to serve this need.

## POPULATION AND BIOMASS CHANGES

A preliminary summary of data on plant biomass changes obtained by dimensional analysis has been completed for the Mercury trickle-irrigation plots. Additional synthesis of the data is necessary, but this will await results from another dimensional analysis measurement scheduled to be made in August 1976. The preliminary results from the plot treatments clearly indicate that the incremental change in biomass on the irrigated plots increased much more in 1974 (84 to 133%) than in 1975 (20 to 70%). Total primary production was greater in 1975, however, as the result of continued growth on shrubs which have increased in size due to treatments. It was also apparent that the number of individual plants was greater on summer-watered plots than on winter-watered plots. We attribute this effect primarily to greater seedling survival on summer-watered plots.

Examples of data from our preliminary summary of treatment results have been arranged in Tables 4 through 7 to illustrate findings from overall plot response and individual species response to nitrogen and irrigation treatments. Earlier results from nitrogen fertilization and moisture interactions generally have shown that supplemental moisture has masked any beneficial growth response from added nitrogen. There has, however, been some trend for an increase in biomass resulting from the 100 kg/ha nitrogen treatment on the irrigated plots (Table 4).

**Table 1.** Precipitation on the Mercury trickle-irrigated plots during calendar 1975

| Date | | Amount | Date | | Amount | Date | | Amount |
|---|---|---|---|---|---|---|---|---|
| Mo | Day | mm | Mo | Day | mm | Mo | Day | mm |
| 1 | 28 | 0.3 | 4 | 1 | 1.5 | 9 | 10 | 2.8 |
| 2 | 03 | 1.0 | 4 | 7 | 1.0 | 9 | 11 | 5.4 |
| 2 | 14 | 0.5 | 4 | 11 | 3.1 | 10 | 07 | 3.1 |
| 2 | 15 | 17.5 | 4 | 12 | 11.1 | 10 | 12 | 0.3 |
| 3 | 06 | 9.4 | 4 | 18 | 0.3 | 10 | 22 | 0.5 |
| 3 | 10 | 3.9 | 4 | 26 | 0.3 | 10 | 31 | 1.0 |
| 3 | 11 | 0.3 | 5 | 21 | 9.5 | 11 | 28 | 2.6 |
| 3 | 12 | 0.8 | 7 | 27 | 0.3 | 12 | 10 | 0.5 |
| 3 | 14 | 2.0 | 7 | 28 | 0.3 | | | |
| 3 | 31 | 4.6 | 8 | 21 | 0.6 | | | |
| TOTALS | | | | | | | | 84.5 mm |

**Table 2.** Dates of irrigation on the Mercury trickle-irrigated plots during calendar 1975

| Treatment | Plot Block | Dates Applied | Amount Applied |
|---|---|---|---|
| Summer water | All | Jun 10-15 | 10 cm |
| | 1, 2, 3 | Aug 12-18 | 10 cm |
| | 9, 10, 11 | Aug 12-19 | 10 cm |
| | 16, 17, 24 | Aug 12-24 | 10 cm |
| | 20, 21, 22 | Aug 12-28 | 10 cm |
| Winter water | 5, 6, 8 | Oct 20-23 | 10 cm |
| | 15, 18, 19 | Oct 20-22 | 10 cm |
| | 23, 25, 26 | Oct 20-24 | 10 cm |
| | 27, 28, 29 | Oct 20-23 | 10 cm |

**Table 3.** Examples of soil water potentials (—bars) during 1975 on the Mercury trickle-irrigated plots

| Sampling Date | Summer irrigation | | | Winter irrigation | | Natural rainfall | | |
|---|---|---|---|---|---|---|---|---|
| | Plot 22 | | | Plot 6 | | Plot 12 | | |
| | 15 cm | 30 cm | 60 cm | 15 cm | 30 cm | 15 cm | 30 cm | 60 cm |
| 1/03 | 0 | -0.4 | 0 | -6.5 | 0 | 0 | -7.0 | <-85.3 |
| 1/17 | 0 | 0 | 0 | -2.1 | 0 | -2.2 | -5.9 | <-95.5 |
| 1/31 | 0 | -0.5 | 0 | -4.6 | -0.3 | -1.6 | -14.4 | <-96.8 |
| 2/18 | 0 | 0 | 0 | -0.9 | 0 | 0 | -2.2 | <-99.1 |
| 3/03 | 0 | -0.2 | 0 | 0 | 0 | -2.1 | -2.9 | <-99.0 |
| 3/18 | 0 | 0 | 0 | 0 | 0 | -5.7 | -2.2 | <-108.4 |
| 3/31 | 0 | -0.2 | 0 | 0 | -1.2 | -0.6 | -2.7 | -88.3 |
| 4/15 | 0 | 0 | 0 | -1.5 | -2.8 | 0 | -4.8 | -72.8 |
| 4/29 | -2.0 | -0.3 | 0 | -1.1 | -2.6 | -19.8 | -16.8 | -44.6 |
| 5/12 | -9.8 | -12.0 | 0 | -11.8 | -12.6 | -47.6 | -47.5 | -39.8 |
| 5/27 | -9.5 | -26.6 | -15.2 | -4.8 | -28.0 | <-56.5 | -42.8 | -20.0 |
| 6/9 | -51.6 | -32.8 | -40.6 | -59.0 | -35.0 | -55.7 | -45.7 | -35.8 |
| *6/26 | 0 | -2.9 | 0 | <-69.5 | -34.2 | <-76.2 | -52.3 | -50.0 |
| 7/7 | -11.4 | -22.1 | -23.8 | <-58.2 | -46.3 | <-65.3 | <-55.5 | -53.6 |
| 7/21 | <-65.5 | -39.2 | -39.7 | <-59.3 | <-68.3 | <-66.5 | <-67.8 | -55.8 |
| 8/04 | <-59.6 | -46.4 | -49.7 | <-58.0 | <-71.4 | <-64.2 | <-62.0 | <-63.4 |
| *8/19 | 0 | -0.3 | -1.6 | <-61.5 | <-74.0 | <-69.4 | <-71.5 | -66.1 |
| 9/2 | 0 | -0.7 | 0 | <-60.8 | <-75.3 | <-70.7 | <-75.0 | <-72.7 |
| 9/16 | -6.7 | -5.6 | -1.5 | <-60.8 | <-66.4 | -49.3 | <-75.6 | <-76.7 |
| 10/06 | -56.2 | -23.7 | - | <-53.3 | <-63.3 | <-74.9 | <-73.2 | <-76.6 |
| 10/20 | -43.3 | -32.3 | -41.2 | <-67.2 | <-74.5 | <-78.3 | <-80.8 | <-84.0 |
| 11/03 | <-75.7 | -35.4 | -45.5 | * 0 | -1.2 | <-82.6 | <-84.5 | <-87.8 |
| 11/19 | <-98.2 | -40.4 | -46.5 | -2.9 | 0 | <-98.3 | <-95.1 | <-97.0 |
| 12/02 | <-88.9 | -40.5 | -46.7 | 0 | 0 | <-96.2 | <-99.2 | <-99.1 |

* Irrigation applied in 1975; plots 22 and 6 had received supplemental irrigation during the late fall months of 1974.

Table 4. Examples of change in shrub biomass on irrigated and nitrogen-treated plots estimated by dimensional analysis methods (nitrogen treatment level as kg/ha equivalent)

| Sampling Date | Natural Rainfall 0N | Natural Rainfall 100N* | Supplemental Irrigation 0N | Supplemental Irrigation 100N |
|---|---|---|---|---|
| | kg/ha | kg/ha | kg/ha | kg/ha |
| February '74 | 3133 | 2484 | 2171 | 2253 |
| October '74 | 2864 | 2466 | 4266 | 5253 |
| October '75 | 3599 | 2860 | 5203 | 6475 |
| Ratio $\left(\frac{\text{Oct 75}}{\text{Feb 74}}\right)$ | 1.15 | 1.15 | 2.40 | 2.87 |

Table 5. Examples of shrub species response to nitrogen fertilization on trickle-irrigated plots

| Plant species | Sampling Date | 0 Nitrogen Biomass kg/ha | 0 Nitrogen Percent increase | 100 Nitrogen Biomass kg/ha | 100 Nitrogen Percent increase |
|---|---|---|---|---|---|
| Acamptopappus shockleyi | Feb. 1974 | 59 | | 84 | |
| | Oct. 1974 | 155 | 163 | 197 | 136 |
| | Oct. 1975 | 200 | 29 | 234 | 19 |
| Ambrosia dumosa | Feb. 1974 | 150 | | 80 | |
| | Oct. 1974 | 939 | 525 | 867 | 978 |
| | Oct. 1975 | 1108 | 18 | 1128 | 30 |
| Atriplex confertifolia | Feb. 1974 | 1126 | | 1018 | |
| | Oct. 1974 | 1572 | 40 | 1563 | 54 |
| | Oct. 1974 | 1871 | 19 | 2568 | 64 |
| Ephedra funerea | Feb. 1974 | 142 | | 242 | |
| | Oct. 1974 | 222 | 57 | 400 | 65 |
| | Oct. 1975 | 262 | 18 | 480 | 20 |
| Larrea tridentata | Feb. 1974 | 588 | | 713 | |
| | Oct. 1974 | 802 | 36 | 989 | 39 |
| | Oct. 1975 | 890 | 11 | 1098 | 11 |
| Lepidium fremontii | Feb. 1974 | 0 | | 13 | |
| | Oct. 1974 | 21 | - | 58 | 338 |
| | Oct. 1975 | 97 | 360 | 281 | 385 |
| Menodora spinescens | Feb. 1974 | 89 | | 82 | |
| | Oct. 1974 | 286 | 222 | 323 | 293 |
| | Oct. 1975 | 472 | 65 | 665 | 106 |

Table 6. Plant species response to supplemental irrigation ranked according to increase in numbers and biomass

| Plant species | Percent increase in numbers | Plant species | Percent increase in biomass |
|---|---|---|---|
| Lepidium fremontii | 7,982 | Sphaeralcea ambigua | 3,473 |
| Sphaeralcea ambigua | 1,008 | Ambrosia dumosa | 1,798 |
| Ambrosia dumosa | 364 | Lepidium fremontii | 1,777 |
| Acamptopappus shockleyi | 290 | Acamptopappus shockleyi | 942 |
| Atriplex confertifolia | 205 | Atriplex confertifolia | 402 |
| Ephedra funerea | 107 | Menodora spinescens | 229 |
| Larrea tridentata | 58 | Ephedra funerea | 84 |
| Menodora spinescens | 23 | Larrea tridentata | 11 |

Table 7. Effects of summer and winter irrigation during the period of October 1974 to October 1975 on changes in shrub biomass

| Plant species | Percent increase in shrub biomass * Summer irrigation | Percent increase in shrub biomass * Winter irrigation |
|---|---|---|
| Acamptopappus shockleyi | 2030 | 431 |
| Ambrosia dumosa | 1884 | 227 |
| Atriplex confertifolia | 410 | 708 |
| Ephedra funerea | 206 | 70 |
| Larrea tridentata | 4 | -8 |
| Menodora spinescens | 143 | 151 |
| Sphaeralcea ambigua | 3785 | 393 |
| Lepidium fremontii | 1736 | 1347 |

* Data include loss from death of new seedlings.

Shrub species showed varied growth response to supplemental moisture. Table 5 contains data for several prominent species grown on irrigated plots with and without nitrogen fertilization. The increment of increased biomass was highest in 1974 for most shrubs, and especially for *Ambrosia dumosa*. During 1975 (the second year of treatment), the vegetative production shifted more from new stem growth toward proportionally greater production of deciduous structures. There were some indications of species response to added nitrogen, but any beneficial effects from this fertilization treatment were generally inconclusive for the first and second sampling periods according to our preliminary summary data. Again, we point out that these results are based upon estimates from nondestructive dimensional measurements (regressions of biomass on volume derived from destructive measurements elsewhere) which may not detect subtle changes.

In Table 6, the plant species have been ranked according to their percent increase in numbers and change in biomass as the result of receiving supplemental moisture. The standing of a plant species in these rankings is an indication of its ability to spread quickly into new areas and to grow rapidly in response to an increased moisture supply. These results support the observations we have made during the past decade of studies at the Nevada Test Site wherein *Ambrosia dumosa*, *Lepidium fremontii* and *Sphaeralcea ambigua* have been among those plant species which respond especially during seasons following above-normal rainfall.

Some effects on different plant species of supplemental moisture applied during winter versus summer months are shown in Table 7. For most species there were greater increases in biomass from the added summer irrigations (Table 2) on established shrubs. This effect can generally be attributed to greater numbers and survival of new seedlings and additional production of foliage during a prolonged growing season on the summer-irrigated plots. These Mohave Desert species characteristically drop their new leaves and go dormant in late spring when the soil moisture tension becomes greater than —30 bars. From one month to six weeks of prolonged growth activity can be achieved by supplemental moisture applied before this dormancy occurs in many deciduous species. *Ambrosia dumosa*, which usually is an excellent indicator of soil moisture stress through induced dormancy, will remain in viable condition during the summer months as long as the plots are irrigated. *Sphaeralcea ambigua* continues its growth on summer-watered plots, but this plant is rapidly decimated by grazing jackrabbits attracted to its lush foliage. Although it is a slow-growing shrub, the continued succulence of the foliage of *Larrea tridentata* makes it one of the most visibly responsive shrubs to summer irrigation.

## GROWTH OF WINTER ANNUALS

Winter annuals were harvested in May 1975 from 16 0.1-$m^2$ areas on each of 15 plots, 7 dry and 8 irrigated. Table 8 summarizes the data obtained from these samplings. Nitrogen increased the sizes of winter annuals, and decreased their numbers (statistics have not been done on raw data; the decrease in numbers was also evident in shrub seedlings). By far the most important of the annuals in terms of biomass are the grasses *Bromus rubens* and *Festuca octoflora* (Table 9). On the watered plots there is a trend developing toward population increase in the grass *Schismus arabicus*, which is not as inhibited by the hot summer temperatures as are *Bromus* and *Festuca*. Several other species show an increase in response to water (Table 10).

Summer annuals were harvested in September 1975. They were much smaller than in 1974 (Table 11), developing little past the seedling stage.

## FRUIT PRODUCTION

It became obvious as the experiment progressed that true productivity could not be determined by dimensional analysis alone, since a shift was occurring toward greater proportional production of deciduous structures. A major effect of water appeared to be an increase in fruit production. In 1975 we undertook a study of fruit production in the major species on the trickle-irrigated plots. Data are summarized in Table 12. Irrigation increased fruit production in all species. Nitrogen treatments decreased fruit production in some species and increased it in others. For example, the *Ambrosia dumosa* fruit production was reduced to about one half by the highest nitrogen treatment level (100 kg/ha). *Lepidium fremontii* fruit production was nearly tripled as the result of nitrogen applications, while fruiting in *Larrea tridentata* was little affected by either irrigation or nitrogen treatments.

## SOIL NITROGEN ANALYSIS

The results of nitrate and ammonia analyses are listed in Tables 13 and 14 for samples of soil taken June 6, 1975, from underneath shrub clumps and from the bare soil areas between shrub clumps. Effects of the fertilizer amendment (which were expressed as changing concentrations in the soil profile during 1974) were not apparent to the 22-cm depth of samples taken in 1975, even though the treatments affected growth and reproduction of annual plants and some shrubs. There was some indication of elevated nitrate levels remaining in the 22-cm depth of the bare area soil profile, but the results generally show that the nitrogen amendment had moved down below that depth. The high degree of variation in data from analyses would indicate that a clean frontal displacement of the amendment down into the soil profile had not yet occurred.

**Table 8.** Winter annuals occuring on trickle-irrigated and nitrogen-fertilized plots in Mercury Valley

| Plant species | Number and weights of annual plants | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Dry | | Dry + N | | Irrigated | | Irrigated + N | |
| | #/10$m^2$ | g/10$m^2$ | #/10$m^2$ | g/10$m^2$ | #/10$m^2$ | g/10$m^2$ | #/10$m^2$ | g/10$m^2$ |
| *Bromus rubens* | 897 | 77.1 | 814 | 102.7 | 1932 | 192.7 | 2142 | 336.5 |
| *B. tectorum* | 0 | 0.0 | 0 | 0.0 | 3 | 1.6 | 0 | 0.0 |
| *Camissonia boothii* | 0 | 0.0 | 3 | 1.0 | 0 | 0.0 | 0 | 0.0 |
| *C. munzii* | 4 | 3.4 | 3 | 0.3 | 17 | 0.3 | 6 | 0.6 |
| *Caulanthus cooperi* | 19 | 1.6 | 12 | 1.8 | 2 | 0.0 | 8 | 3.3 |
| *C. lasiophyllis* | 0 | 0.0 | 0 | 0.0 | 40 | 4.6 | 67 | 1.2 |
| *Chaenactis carphoclinia* | 24 | 0.4 | 22 | 0.8 | 26 | 0.5 | 14 | 0.6 |
| *C. macrantha* | 38 | 3.8 | 30 | 6.8 | 20 | 1.2 | 16 | 1.4 |
| *Chorizanthe rigida* | 14 | 0.5 | 11 | 0.8 | 24 | 0.7 | 14 | 0.3 |
| *Cryptantha circumscissa* | 50 | 0.9 | 37 | 1.0 | 17 | 0.1 | 25 | 0.3 |
| *C. nevadensis* | 73 | 2.3 | 47 | 3.0 | 33 | 0.7 | 38 | 0.8 |
| *C. recurvata* | 23 | 0.5 | 17 | 0.5 | 9 | 1.2 | 4 | 0.2 |
| *Descurainia pinnata* | 2 | 0.0 | 4 | 0.1 | 226 | 17.2 | 54 | 7.5 |
| *Eriogonum trichopes* | 3 | 0.1 | 2 | 0.0 | 0 | 0.0 | 8 | 0.3 |
| *Erodium cicutarium* | 0 | 0.0 | 5 | 1.2 | 0 | 0.0 | 3 | 0.2 |
| *Festuca octoflora* | 2373 | 45.1 | 1684 | 40.1 | 2522 | 34.5 | 1451 | 29.5 |
| *Gilia cana* | 8 | 0.1 | 19 | 0.9 | 131 | 3.0 | 56 | 1.1 |
| *Ipomopsis polycladon* | 37 | 0.7 | 23 | 0.5 | 61 | 2.4 | 48 | 2.0 |
| *Langloisia setosissima* | 9 | 0.1 | 8 | 0.1 | 52 | 1.0 | 30 | 1.5 |
| *Lepidium lasiocarpum* | 2 | 0.0 | 26 | 0.4 | 0 | 0.0 | 2 | 0.2 |
| *Linanthus demissus* | 10 | 0.0 | 5 | 0.0 | 20 | 0.1 | 61 | 0.6 |
| *Lygodesmia exigua* | 0 | 0.0 | 0 | 0.0 | 3 | 0.1 | 2 | 0.0 |
| *Pectocarya* sp. | 11 | 0.7 | 6 | 0.4 | 14 | 0.9 | 42 | 2.3 |
| *Phacelia fremontii* | 19 | 3.9 | 13 | 2.5 | 53 | 1.0 | 67 | 4.8 |
| *Salsola* spp. | 0 | 0.0 | 13 | 0.2 | 0 | 0.0 | 0 | 0.0 |
| *Schismus arabicus* | 0 | 0.0 | 2 | 0.7 | 73 | 8.1 | 139 | 11.1 |
| *Sisymbrium altissimum* | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 10 | 5.4 |
| Totals | 3613 | 141.3 | 1735 | 201.3 | 5276 | 272.2 | 4305 | 411.9 |

**Table 9.** Dominant winter annuals on irrigated and dry plots, May 1975

| Species | % of total winter annuals (wt/wt) | |
|---|---|---|
| | Irrigated | Dry |
| *Bromus rubens* | 77.2 | 61.9 |
| *Festuca octoflora* | 9.4 | 24.2 |
| *Descurainia pinnata* | 3.6 | 0.0 |
| *Cryptantha nevadensis* | 0.2 | 1.8 |
| *Schismus arabicus* | 2.8 | 0.4 |

Table 10. Winter annuals five times as common on irrigated as on dry plots, May 1975

| Species | Number $X10^{-3}$/ha |  |  | Weight/plant (mg) |  |  |
|---|---|---|---|---|---|---|
|  | Irrigated | Dry | Ratio | Irrigated | Dry | Ratio |
| *Caulanthus lasiophyllus* | 53.8 | 0.0 | 00.0 | 53.7 | 0.0 | 00.0 |
| *Schismus arabicus* | 106.1 | 1.7 | 62.4 | 90.9 | 400.0 | 0.2 |
| *Descurainia pinnata* | 140.3 | 3.6 | 39.0 | 87.9 | 30.6 | 2.9 |
| *Linanthus demissus* | 40.5 | 5.4 | 7.5 | 9.4 | 1.9 | 5.1 |
| *Langloisia setosissima* | 40.6 | 7.9 | 5.1 | 31.5 | 15.2 | 2.1 |
| *Gilia cana* | 93.7 | 18.6 | 5.0 | 22.0 | 45.7 | 0.5 |
| *Bromus rubens* | 2037.0 | 814.0 | 2.5 | 129.0 | 126.2 | 1.0 |

Table 11. Summer annual plants on Mercury plots harvested September 1974 and September 1975

| Treatment | Date | Number of plots | *Salsola* spp. |  | *Eriogonum* spp. |  |
|---|---|---|---|---|---|---|
|  |  |  | #/ha | kg/ha | #/ha | kg/ha |
| Summer & winter water | 1974 | 24 | - | 425.9 | - | 248.0 |
|  | 1975 | 12 | 6083 | 1.8 | 2958 | 1.3 |
| Winter water only | 1975 | 12 | 42 | 0.0 | 2208 | 0.9 |
| Control Plots | 1974 | 6 | - | 0.1 | - | 0.6 |
|  | 1975 | 8 | 188 | 0.0 | 562 | 0.1 |

Table 12. Fruit production on major shrubs as affected by trickle irrigation and nitrogen fertilization

| Plant species | Nitrogen treatment | No. plants sampled[a] | Fruit per plant | Weight per fruit, mg[b] | Seeds per fruit |
|---|---|---|---|---|---|
| *Acamptopappus shockleyi* | Wet ON | 13 | 47 ± 13 | 147 ± 16 | 47 ± 2 |
|  | Wet 25N | 14 | 50 ± 11 | 135 ± 12 | 54 ± 4 |
|  | Wet 100N | 13 | 67 ± 15 | 130 ± 14 | 47 ± 3 |
|  | Dry ON | 2 | 10 ± 1 | 137 | 51 ± |
|  | Dry 25N | 4 | 31 ± 10 | 147 ± 2 | 44 ± 3 |
|  | Dry 100N | 4 | 5 ± 2 | 120 ± 24 | 43 ±14 |
| *Ambrosia dumosa* | Wet ON | 17 | 4341 ± 629 | 5.0 ±0.2 | 0.4 |
|  | Wet 25N | 17 | 3140 ± 623 | 4.8 ±0.2 | 0.3 |
|  | Wet 100N | 17 | 2317 ± 570 | 5.0 ±0.2 | 0.7 |
|  | Dry ON | 2 | 485 ± 350 | 3.0 | 0.4 |
|  | Dry 25N | 4 | 71 ± 32 | 2.5 ±1.5 | 0.4 |
|  | Dry 100N | 3 | 53 ± 24 | 3.5 ±1.5 | 0.4 |
| *Atriplex confertifolia* | Wet ON | 16 | 7365 ±2061 | 9.3 ±1.1 |  |
|  | Wet 25N | 18 | 4968 ±1451 | 9.6 ±0.7 |  |
|  | Wet 100N | 17 | 6018 ±1435 | 11.1 ±1.6 |  |
|  | Dry ON | 7 | 956 ± 20 | 7.1 ±1.4 |  |
|  | Dry 25N | 4 | 256 ± 123 | 3.4 ±0.6 |  |
|  | Dry 100N | 4 | 1738 ± 669 | 4.8 ±0.2 |  |
| *Larrea tridentata* | Wet ON | 12 | 423 ± 150 | 22.3 ±1.9 | 1.5 ±0.4 |
|  | Wet 25N | 14 | 132 ± 48 | 25.8 ±1.8 | 1.8 ±0.5 |
|  | Wet 100N | 12 | 225 ± 82 | 19.4 ±0.8 | 0.3 ±0.1 |
|  | Dry ON | 6 | 278 ± 218 | 20.2 ±2.5 | 1.6 ±0.6 |
|  | Dry 25N | 2 | 28 ± 8 | 16 | 0.1 |
|  | Dry 100N | 4 | 175 ± 59 | 24 | 2.0 |
| *Lepidium fremontii* | Wet ON | 13 | 564 ± 338 | 2.0 ±1.0 |  |
|  | Wet 25N | 21 | 1379 ± 658 | 1.8 ±0.2 |  |
|  | Wet 100N | 24 | 1985 ± 662 | 1.6 ±0.2 |  |
|  | Dry ON | 5 | 392 ± 160 | 3.0 |  |
|  | Dry 25N | 1 | 500 | 1.0 |  |
|  | Dry 100N | 3 | 500 ± 252 | 1.0 |  |
| *Sphaeralcea ambigua* | Wet ON | 18 | 145 ± 64 | 40 ± 3 | 11.8 ±1.3 |
|  | Wet 25N | 10 | 107 ± 62 | 39 ± 2 | 9.5 ±1.7 |
|  | Wet 100N | 11 | 60 ± 23 | 38 ± 4 | 7.5 ±0.6 |
|  | Dry ON | 3 | 13 ± 5 | 24 ± 8 | 2.0 ±2.0 |
|  | Dry 25N | 0 | -- | -- | -- |
|  | Dry 100N | 3 | 43 ± 24 | 32 ± 8 | 7.5 ±2.5 |

[a] Plants sampled mid-June, except for *Larrea* (July 11), *Atriplex* (Dec. 8).
[b] Fruit weight calculated from pooled samples.

Table 13. Nitrate concentrations in soil samples taken June 6, 1975, from underneath shrub clumps and from bare soil between shrubs on the Mercury plots

| Nitrogen applied* | Depth in profile | Natural rainfall |  | Irrigation |  |
|---|---|---|---|---|---|
|  |  | shrub | bare | shrub | bare |
| kg/ha | cm | micrograms N per gram dry soil |  |  |  |
| 0 | 0 - 7.5 | 3.4 ± 2.5 | 1.0 ± 0.5 | 3.5 ± 2.2 | 10.0 ± 6.9 |
|  | 7.5 - 15 | 1.7 ± 1.3 | 0.6 ± 0.6 | 1.7 ± 0.9 | 6.0 ± 3.8 |
|  | 15 - 22 | 1.6 ± 1.2 | 0.6 ± 0.2 | 1.1 ± 0.4 | 3.7 ± 2.2 |
| 25 | 0 - 7.5 | 1.2 ± 1.0 | 3.8 ± 3.0 | 3.0 ± 1.1 | 2.6 ± 1.7 |
|  | 7.5 - 15 | 0.4 ± 0.2 | 1.2 ± 0.6 | 1.7 ± 0.5 | 3.3 ± 1.6 |
|  | 15 - 22 | 0.6 ± 0.1 | 1.4 ± 0.7 | 1.5 ± 0.5 | 3.4 ± 1.9 |
| 100 | 0 - 7.5 | 3.8 ± 2.8 | 3.4 ± 1.6 | 3.5 ± 1.7 | 16.7 ±14.2 |
|  | 7.5 - 15 | 2.2 ± 0.8 | 3.0 ± 2.2 | 3.4 ± 2.4 | 10.3 ± 7.7 |
|  | 15 - 22 | 1.6 ± 1.1 | 2.4 ± 0.8 | 4.4 ± 3.2 | 6.7 ± 4.1 |

* $NH_4NO_3$ applied to soil surface March 1974.

Table 14. Ammonia concentrations in soil samples taken June 6, 1975, from underneath shrub clumps and from bare soil between clumps on Mercury plots

| Nitrogen applied* | Depth in profile | Natural rainfall |  | Irrigation |  |
|---|---|---|---|---|---|
|  |  | shrub | bare | shrub | bare |
| kg/ha | cm | micrograms N per gram dry soil |  |  |  |
| 0 | 0 - 7.5 | 9.8 ± 3.2 | 10.7 ± 4.3 | 12.5 ± 3.3 | 11.7 ± 2.9 |
|  | 7.5 - 15 | 12.5 ± 3.1 | 10.2 ± 3.9 | 11.7 ± 2.8 | 11.4 ± 3.6 |
|  | 15 - 22 | 13.8 ± 3.2 | 13.6 ± 2.1 | 14.3 ± 2.6 | 17.4 ± 4.4 |
| 25 | 0 - 7.5 | 13.3 ± 6.7 | 15.1 ± 7.9 | 17.4 ± 5.0 | 10.4 ± 2.2 |
|  | 7.5 - 15 | 11.4 ± 4.6 | 10.5 ± 2.8 | 13.3 ± 4.0 | 12.5 ± 2.1 |
|  | 15 - 22 | 15.1 ± 6.5 | 8.9 ± 2.9 | 21.7 ± 7.6 | 15.5 ± 5.5 |
| 100 | 0 - 7.5 | 6.0 ± 0.2 | 21.2 ±12.4 | 11.2 ± 3.4 | 9.3 ± 2.2 |
|  | 7.5 - 15 | 6.6 ± 0.9 | 13.6 ± 6.4 | 9.7 ± 1.6 | 9.1 ± 2.3 |
|  | 15 - 22 | 23.0 ± 9.0 | 21.2 ± 1.8 | 11.9 ± 2.3 | 10.9 ± 2.5 |

* $NH_4NO_3$ applied to soil surface March 1974.

## DISCUSSION

Subjective observations made after irrigation in August and October 1975, showed leafing out of many species, resumption of growth and germination of new seedlings. Some plants which appear to be cool weather growers under natural conditions resumed activity in August. These include the *Ephedra* species, *Acamptopappus shockleyi, Menodora spinescens* and the small grass *Tridens pulchellus. Bouteloua barbata* and *Schismus arabicus* appear to be increasing their abundance on the summer-irrigated plots. In addition, shrub seedlings showed a much lower death rate in the summer-irrigated plots.

During winter, salt deposits appeared on the soil surface in some of the watered plots. We feel this is due to enhancement of capillary flow to the surface, not just an increase in salts due to irrigation.

The October irrigation germinated many more *Bromus rubens* and *Festuca octoflora* seeds than did the August irrigation. These are cool season grasses.

*Larrea tridentata* leaf water potentials were taken on a few plants in late August using a Wescor C-51 sample chamber. Equilibration time required was 4 to 6 hr, so that only one sample was taken daily. Leaf water potentials on watered plots ranged narrowly, from —45 to —57.5 bars. Control plot values ranged from —47 to —99 bars. The limited data suggest *Larrea* is absorbing water applied at least 8 m from its crown. The same problem of large root spread caused us to abandon one control plot in 1974 and initiate three others farther from the irrigated plots.

Insects appeared to be strongly affected by the presence of water. No systematic observations were taken, but there appeared to be an increase in harvester ant colonies, termite damage, aphids on *Ambrosia dumosa* foliage and mites on *Krameria parvifolia.*

There is considerable grazing by rabbits attracted to the more succulent vegetation on the summer-irrigated plots. Damage to shrubs and loss of biomass from predatory sources are not being measured. Hopefully, this will not cause too great an error in our estimations of changes in biomass as measured by the nondestructive dimensional analysis methods.

The second year of irrigation has shown a marked slowing in the increase of shrub size, presumably compensated by increased production of deciduous plant parts. Summer annuals also became a much less important part of the community. It appears that many of the shrubs originally present have increased their size to a point where the added moisture is completely utilized.

There are differences in species' response to time of irrigation and nitrogen fertilization which are becoming more apparent. *Ambrosia dumosa* is particularly favored by summmer irrigation. In contrast, some of the short-lived but fast-growing species which invaded the plots in 1974 did not compete well against the established shrubs in 1975. *Cryptantha virginensis, Encelia virginensis, Baileya multiradiata* and *Stephanomeria pauciflora* fall in this category. *Lepidium fremontii,* however, seemed to survive and grow relatively well in comparison.

Nitrogen effects appear to be more significant in 1975 than in 1974, particularly in increasing annual biomass and affecting fruit production by shrubs.

## EXPECTATIONS

Irrigation is continuing through the summer of 1976 along with the monitoring of soil moisture, temperature and rainfall. A final census and dimensional analysis will be performed. Phenological stages are being monitored in five species on six of the 33 plots. Our prime objectives in 1976 are to analyze data and synthesize results for the final report.

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