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Factors Contributing to Production and Distribution of Chihuahuan Desert Annuals

P. D. Whitson

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P. D. Whitson
University of Northern Iowa

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ABSTRACT

The temporal germination-emergence, phenological development, density and survivorship responses of 47 annual and 20 perennial plants were monitored twice monthly throughout 1973 and 1974 at three sites adjacent to the Jornada Validation Site, both for control and for 18 water amendment treatments under the prevailing climate. The sites are representative of *Larrea tridentata*, *Bouteloua eriopoda-Yucca elata* and *Ephedra trifurca-Prosopis glandulosa-Yucca elata* vegetation types in the Chihuahuan Desert. Summer annuals and perennials in treatment plots were stimulated to respond prior to control plots. Emergence during both 1973 and 1974 occurred during the period when the weekly average minimum air temperature first attained 16-17 C. A succession of species was monitored during the treatment periods suggesting multiple factor response control. Two winter annual emergence periods were monitored; each during considerably different climatic conditions (September, January). Volumetric soil samples collected monthly at each site were monitored for in situ seed germination responses at ten constant and altered temperatures. Following these conditions the soils were monitored for responses to fall and summer day temperature-light regimes. The accumulative monthly responses varied considerably with high-responding reserves recorded in July-August (1320-5800/m^2, 0-1 cm) and low responses in March-April (280-2880/m^2, 0-1 cm). Over 60% of the responses were recorded during exposure to the fall regime. The majority of summer annual species responded to constant and nonconstant soil temperatures above 13 C with the greatest frequency between 22-27 C. The winter annuals responded to a soil temperature range of 2-32 C with the greatest frequency being in the 15-27 C range.

INTRODUCTION

The range of factor parameters which contribute to years of good annual productivity is well established for the Nevada (Beatley 1974) and California (Went 1948, 1949; Went and Westergaard 1949; Juhren et al. 1956) Mohave Desert regions. Tevis (1958a, 1958b) and Patten and Smith (1973, 1974) have contributed to a definition of these aspects for the Sonoran Desert. These parameters are not well documented for the Chihuahuan Desert and their definition is a major objective of this project.

To reduce the time required to monitor a succession of several good and poor annual productivity years, a series of moisture-amendment treatments to induce good years under the prevailing climate was proposed for study. This approach attempts to maintain soil moisture near field capacity so that insight into temperature and photoperiod influences can be ascertained. Annual floral composition, density, phenological development and survivorship in prevailing climate controls can be related to the amendment treatments. In conjunction with the field efforts, laboratory studies on monthly volumetric soil samples with in situ seeds maintained near field capacity can be monitored for responses under controlled temperature and light. Soil seed reserve estimates and temporal-climatic maturation requirements can also be investigated. Soil samples with in situ seeds supplemented with *Larrea tridentata* material or leachates can provide insight into species sensitivity to the leachates and related distribution patterns.

OBJECTIVES

The primary objectives of this study are to:

1. Determine the amended soil moisture combination under the prevailing climatic conditions which yields "good" annual plant crops.
2. Determine the temperature range which yields maximum annual plant germination under controlled soil moisture conditions.
3. Investigate the effect of *Larrea* material upon germination of annual plants.

METHODS

The methods of this project may be considered under the following four categories: 1) site selection; 2) water amendment and monitoring of annual plant germination-emergence; 3) germination responses of annuals to temperature; 4) germination responses of annuals to *Larrea tridentata* materials.

Site Selection

Three off-site areas were selected and established in 1973 at the Jornada Validation Site as representative of the major vegetation-terrain areas present. One study site was established on the western margin of the playa fringe vegetation dominated by *Ephedra trifurca*, *Prosopis glandulosa* and *Yucca elata*. A second site was established below (northeast) the bajada grid where *Larrea tridentata* predominates, and the third site was located in the *Bouteloua eriopoda-Yucca elata* vegetation above (west) the bajada grid at the eastern base of Mount Summerford.

At each site a grid system was established to monitor a series of independent amendment treatments and controls during the annual climatic cycle. Each grid system was comprised of a series of twenty-seven 1-m^2 plots in the center of which was positioned a 70- x 70-cm control or treatment-sampling plot. The system was randomly established with four control and 23 treatment plots. Because of soil and terrain variation, each control and treatment consisted of duplicate plots designated A and B. Each plot was permanently subdivided into forty-nine 10- x 10-cm sampling quadrats to facilitate repetitive quadrat comparisons. The entire grid system was enclosed by 6.5-mm mesh fencing to a height of 45 cm, and 2.5-cm mesh above to 16 dm. Diagrammatic details are presented in the 1973 annual report (Whitson 1974).

Water Amendment

At each of the three sites a series of eight independent treatments (two plots each) was conducted and monitored during 1973 and a series of 10 during 1974. The amendment schedule during 1973 provided initial moisture in late April and at the beginning of each month thereafter. During 1974 initial moisture amendment began in January and proceeded each month through September. Following initial amendment the soil moisture was maintained near field capacity for at least three months, a period presumed to be sufficient for most annuals to be identifiable and to complete their respective life cycles.

The water was applied at the center of each treatment grid by a specially constructed aluminum conduit subsurface irrigator probe (15 mm x 24.5 cm) which was driven into the soil. The probe was connected to an elevated (7 dm) water drum (21 dl) by 7-mm (ID) thick-walled tygon tubing. Two nalgene twistcock connectors, one at the drum and the other in the line by the probe, were used to regulate water flow. The procedure provided controlled moisture without surface soil disturbance, very little surface water flow or runoff, and a sufficient depth reserve to maintain moderate evaporative losses.

The individual treatment and control plots were monitored for soil moisture and temperature (DSCODE A3UWP01) on a weekly to biweekly basis prior to each amendment. A gypsum resistance block and associated thermistor (identical to those in use on the validation site) buried at 15 cm were employed. These were positioned a month or two in advance of their use. Each control and treatment plot had a designated A plot where the block and thermistor were positioned 15 cm upslope and a B plot where they were positioned 15 cm downslope from the probe.

All plots were monitored nearly bimonthly for their annual and perennial plant composition (A3UWP02). For each taxon the number of vegetative, flowering and fruiting individuals present in each 10- x 10-cm quadrat was recorded. The quadrat system, a specially constructed bronze frame (3-mm welding rods), was similarly positioned each sampling period to subdivide the plot, facilitate identification updating of unknown taxa and updating of phenological status.

Germination Response to Temperature

At the beginning of each month a duplicate set of soil samples was collected adjacent to each site and used for in situ seed germination laboratory studies to obtain annual plant responses to temperature. A soil set consisted of a 0-1 cm and a 1-2 cm depth sample from a 50- x 50-cm area. The two 2500-cc duplicate depth samples were combined, thoroughly mixed, and 2500 cc removed for study. From the sample, 10 plastic petri dishes (10 x 2 cm) with a 3- to 4-mm distilled water-washed silicon sand foundation were supplied with 25 cc of the site soil and placed on a temperature gradient bar (Barbour and Racine 1967). The effective temperature range at midsoil depth was 4-34 C with 3-4 C difference between adjacent dishes. Distilled water was supplied daily to maintain field capacity moisture conditions. The dishes were subjected to a series of temperature-light conditions and the responses monitored. First the dishes were subjected to and monitored for 240+ hr at their respective constant temperature (A3UWP03). Next, the dishes were moved on the bar to provide an alternate temperature for a similar number of hours (A3UWP04). The alternation sequence consisted of the 34-20 C dishes (#1-5) being respectively changed with the 19-4 C dishes (#6-10). This provided a temperature shift of 15-16 C. The two tests were conducted in the dark. Following the previous two tests the dishes were next subjected to a fall day regime (A3UWP05), 12 hr 20 C photoperiod/12 hr 10 C dark period, for 240+ hr in a Percival WE95 walk-in chamber maintained at a 30% humidity and 85 watts m^{-2} irradiance from incandescent and florescent lights (LI-COR 18S Radiometer with pyranometer sensor). Next, the dishes were subjected to a summer day regime (A3UWP05), 14 hr 30 C photoperiod/10 hr 20 C dark period, for 240+ hr in the chamber.

The seeds which germinated and emerged daily were transplanted to 7.5-cm clay pots supplied with desert soil and maintained in the chamber or greenhouse until they could be identified. Winter annuals frequently required in excess of three months to be identified, whereas summer annuals flowered and fruited in three to six weeks.

Germination Responses to *Larrea tridentata* Materials

Because of limited bar space and time constraints, this aspect of the project has just been initiated and will therefore not be reported in this paper.

RESULTS

Control and Amendment Plots

Qualitatively, a total of 47 annual and 21 perennial plants (A3UWP02) has been recorded during the two-year study. Table 1 presents the annuals as classified according to their germination prevalence under natural conditions. Several exceptions, however, have been recorded under natural conditions. During the precipitation period of mid-July 1973, both *Eriogonum abertianum* var. *abertianum* and *E. abertianum* var. *ruberrimum* emerged in bajada site control plots. Likewise, during the early July 1974 precipitation period, *Lepidium lasiocarpum* emerged in the same control plots and, unlike the former year, continued growth until fruition only four weeks later. During mid-August 1973, *Eriogonum trichopes* emerged in amendment plots, but had died by early September.

A summary of the annual vegetation response pattern for control plots at the bajada site during 1973-74 is presented in Figure 1. The density of winter annuals during the spring

Table 1. Summer and winter annuals recorded in Jornada sampling plots, 1973-74 (A3UWP02)

SUMMER ANNUALS

GRAMINAE
- Aristida adscensionis[1]
- Bouteloua aristidoides
- Bouteloua barbata

CHENOPODIACEAE
- Chenopodium incanum
- Salsola kali

AMARANTHACEAE
- Amaranthus blitoides
- Amaranthus fimbriatus
- Amaranthus palmeri
- Amaranthus pubescens
- Tidestromia lanuginosa

NYCTAGINACEAE
- Boerhaavia intermedia

AIZOACEAE
- Mollugo cerviana

PORTULACACEAE
- Portulaca oleracea
- Portulaca sp.

ZYGOPHYLLACEAE
- Tribulus terrestris

EUPHORBIACEAE
- Euphorbia glyptosperma
- Euphorbia micromera
- Euphorbia serpyllifolia
- Euphorbia serrula[2]
- Euphorbia setiloba

LOASACEAE
- Mentzelia albicaulis

COMPOSITAE
- Iva ambrosiaefolia
- Pectis angustifolia
- Pectis papposa
- Verbesina encelioides

WINTER ANNUALS

POLYGONACEAE
- Eriogonum abertianum var. abertianum
- Eriogonum abertianum var. ruberrimum
- Eriogonum rotundifolium
- Eriogonum trichopes

PAPAVERACEAE
- Eschscholzia mexicana

CRUCIFERAE
- Descurainia pinnata
- Lepidium lasiocarpum
- Lepidium medium
- Lesquerella gordonii
- Streptanthus validus

LEGUMINOSAE
- Lupinus concinnus

GERANIACEAE
- Erodium texanum

ONAGRACEAE
- Oenothera sp.

POLEMONIACEAE
- Eriastrum diffusum
- Gilia opthalmoides

HYDROPHYLLACEAE
- Nama hispidum

BORAGINACEAE
- Cryptantha crassisepala
- Cryptantha micrantha

PLANTAGINACEAE
- Plantago patagonica

COMPOSITAE
- Aphanostephus skirrhobasis
- Calycoseris wrightii
- Chaenactis stevioides
- Haplopappus gracilis
- Malacothrix fendleri

[1]Taxa will be referred to by the first three letters of the genus and specific epithet.
[2]= EUPSLA

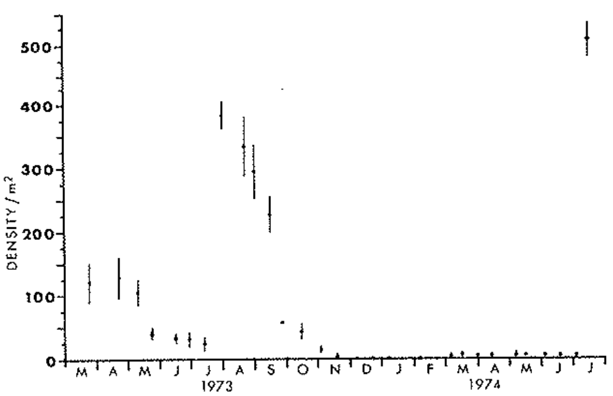

Figure 1. Mean and range of annual plant densities for the bajada site control plots during 1973 and 1974.

of 1974 is markedly less (Fig. 2) than for the same period of 1973 which followed a moist fall and winter. The 1974 summer annual emergence densities were greater and approximately two weeks earlier than in 1973.

A series of water amendment results for the bajada site is presented in Figure 3. Following initial water amendment in late April 1973 (Test 2) and maintenance of soil at near field capacity (-1 to -30 bars) thereafter, no emergence was observed until mid-June. Emergence was observed in Test 3 as well, although it was the first time emergence could have been expected since initial moisture amendment was in early June. Summer annual emergence was seemingly influenced by amendment until early or mid-October, although precipitation was coincident in early June and through mid-September with some seemingly influential effect (see Test 2, early June, late July; Test 3, early June; Test 4, late July; Test 5, early September) as well as no influence (see Test 3, late July; Tests 4 and 5, early September). Summer emergence thus spanned from mid-June to mid-October in amended plots while emergence was observed only from early August to early September in control plots. Only *Pectis angustifolia* emerged in early September control plots whereas several species emerged in the amendment plots. Table 2 presents a summary of the relative rank, density and emergence sequence in both amendment and control plots for the bajada site until peak densities were attained in 1973. The sequence of appearance in the flora indicates that factors other than water are influencing inclusion. A comparison of the control plot list with the amendment list indicates that some species are absent from the year's flora if the precipitation sequencing is not proper for their response. Four species which did not appear in the control plots but appeared in the amendment plots are: *Chenopodium incanum*, *Euphorbia glyptosperma*, *Tribulus terrestris* and *Verbesina encelioides*. *Chenopodium* appeared only in the earlier June amendments. The amendment plots indicate that only *Bouteloua aristidoides* is accentuated by water, whereas the remaining species are similar in abundance. Seemingly, all summer annuals attained an earlier reproductive status and maintained it for a longer duration in the amended plots. A point of added interest is the reproductive behavior of *Bouteloua barbata*, *B. aristidoides* and *Aristida adscencionis*. In amendment tests 6 and 7 the grasses reached maximum reproductive numbers in mid-September and many died following fruiting. A large number, however, in early November, produced new leaves from basal nodes and by mid- to late November had new reproductive structures from the same nodes. All control plot individuals were deceased by late November. A similar double-fruiting pattern has been observed for the three species in the greenhouse as well.

Figure 4 presents the soil moisture potentials for the control plots (A3UWP01) and a 7-day summary of mean, maximum and minimum air temperature values recorded at the bajada validation site weather station (A3UWJ02). Figure 2 indicates that control plots had no emergence following the early June 1973 precipitation, but emergence followed the late July precipitation. During both years the amended plots had emergence after the first 7-day mean minimum air temperature period above 15 C although the mean maximum, mean mean and the time of year were quite different. In 1973, summer annuals emerged until the weekly minimum mean dropped below the 15 C point even though the other means were lower than the initial emergence values.

The fall of 1973 provided an excellent opportunity to investigate the influence of water amendment upon winter annual emergence because of the dry conditions. Unlike the moist fall of 1974 (data not to be presented in this report), which supported "good" annual production, only influential amendment data are available for 1973 and early 1974 (Fig. 3). The first major record of emergence was the first of October (Tests 5, 6), although maximum densities were not attained until early to mid-November (Table 3). Because many of the emergent plants were in the unknown category, the sequence and rank of the different species are tenuous. Some of the unknowns could be late-emerging summer annuals; however, this is not assumed to be the general case. Between the early and mid-December samples, environmental conditions other than water stress caused the death of all emergent winter annuals prior to reaching reproductive status. Not until early February did a second emergence occur which reached a maximum density in early March. Only the two species of *Cryptantha* reached fruiting status prior to the termination of plot monitoring.

The relationship of winter annual emergence and presented climatic information (Fig. 1) is not definitive other than that a rapid rise or decline in temperature coincided with each emergence period. Additional analyses of these and other factors will be necessary to provide further elucidation.

The specific relationship between the time of germination and emergence in the field is not well established. On several occasions the author observed that during summer amendment programs emergences could be found in 48+ hr. Laboratory studies indicate that 72 hr are required for emergence of most species.

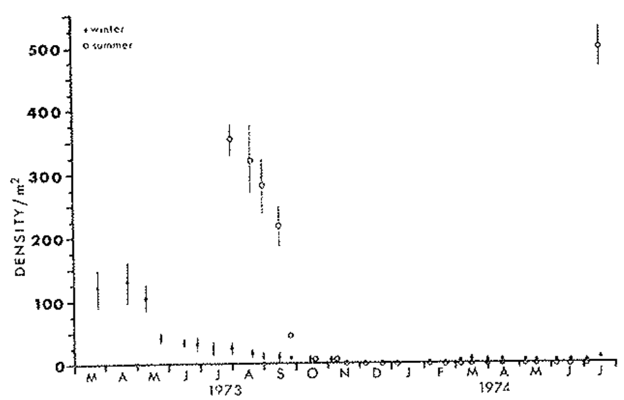

Figure 2. Mean and range of summer and winter annual plant densities for the bajada site control plots during 1973 and 1974.

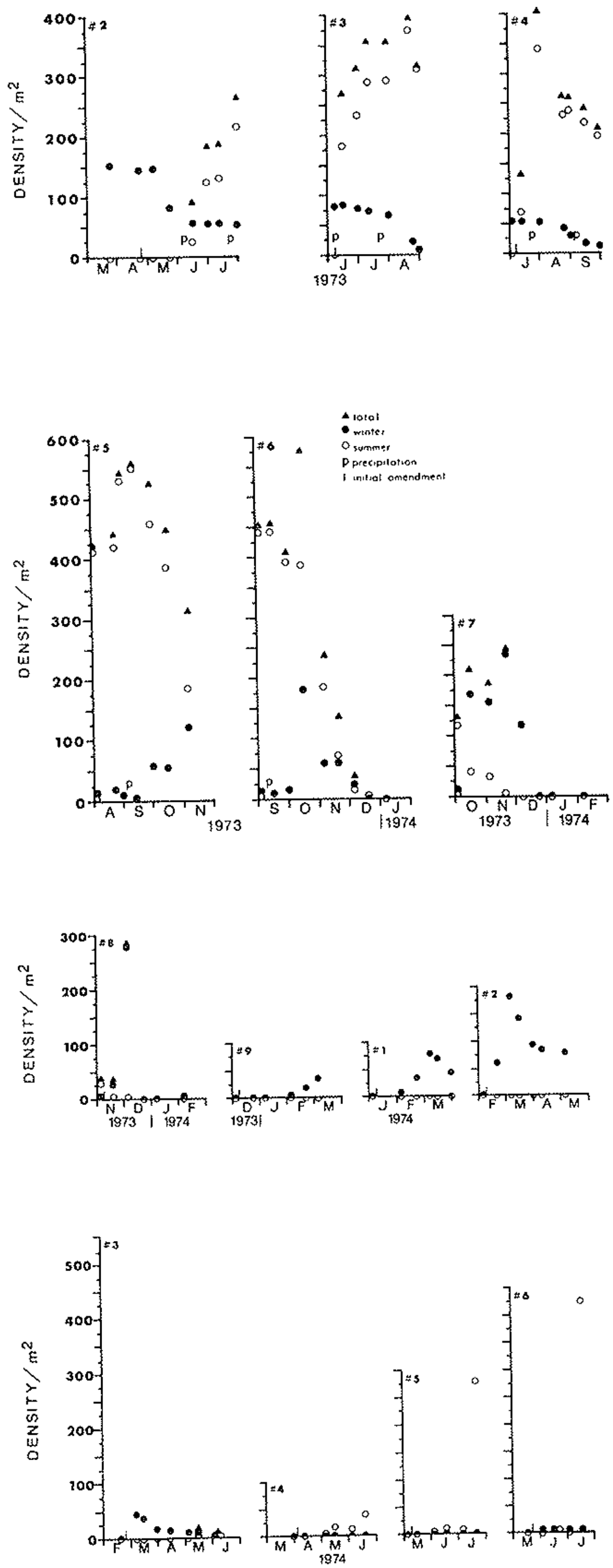

Figure 3. Densities of summer and winter annual plants in the bajada site amendment plots during 1973 and 1974.

Table 2. Relative rank, density (m^2) and emergence sequence of summer annuals in bajada site amendment and control plots during 1973

June 15	June 29	July 12	July 30	Aug. 21	Sep. 1	Sep. 14	July 30	Aug. 21	Sep. 1	Sep. 14
TESTS							CONTROLS			
*BOUARI 90	BOUARI 115	BOUARI 112	BOUARI 136	BOUARI 154	BOUARI 136	PECANG 128	*PECANG 98	PECANG 97	PECANG 92	PECANG 83
*BOUBAR 8	EUPMIC 46	EUPMIC 32	PECANG 68	PECANG 85	PECANG 96	BOUARI 121	*EUPMIC 76	BOUARI 87	BOUARI 92	BOUARI 75
*EUPMIC 2	*PECANG 8	BOUBAR 10	EUPMIC 64	EUPMIC 75	EUPMIC 60	EUPMIC 68	*BOUARI 73	EUPMIC 72	EUPMIC 63	EUPMIC 41
*ARIADS 1	BOUBAR 5	PECANG 3	BOUBAR 12	BOUBAR 27	BOUBAR 29	BOUBAR 35	*BOEINT 21	MOLCER 26	BOEINT 15	BOEINT 6
*CHEINC 1	*EUPSLA 2	EUPSLA 2	EUPSLA 12	MOLCER 21	EUPSLA 16	EUPSLA 18	*MOLCER 19	BOEINT 19	MOLCER 11	BOUBAR 5
*TIDLAN 1	ARIADS 1	TIDLAN 2	MOLCER 11	EUPSLA 16	MOLCER 13	MOLCER 14	*BOUBAR 6	BOUBAR 6	EUPSLA 6	EUPSLA 4
	*BOEINT 1	ARIADS 1	ARIADS 1	TIDLAN 11	BOEINT 8	BOEINT 6	*EUPSLA 5	EUPSLA 6	BOUBAR 5	POR 2
	CHEINC 1	BOEINT 1	BOEINT 5	BOEINT 3	TIDLAN 5	POROLE 6	*ARIADS 1	POR 4	POR 2	EUPSER 1
	*EUPSER 1	EUPSER 1	TIDLAN 5	POR 2	POROLE 4	TIDLAN 5	*POR 1	TIDLAN 1	*EUPSER 1	MOLCER 1
	TIDLAN 1	*MOLCER 1	ARIADS 1	ARIADS 1	POR 3	ARIADS 1	*POROLE 1		TIDLAN 1	TIDLAN 1
		*POR 1	POR 1	EUPSER 1	ARIADS 1	VERENC 1	*SALKAL 1		SALKAL 1	
		*SALKAL 1	*POROLE 1	POROLE 1	EUPSER 1	*EUPGLY 1	*TIDLAN 1			
			SALKAL 1	SALKAL 1	SALKAL 1	POR 1				
					*TRITER 1					
					*VERENC 1					

*First time to appear in control or amendment plots.

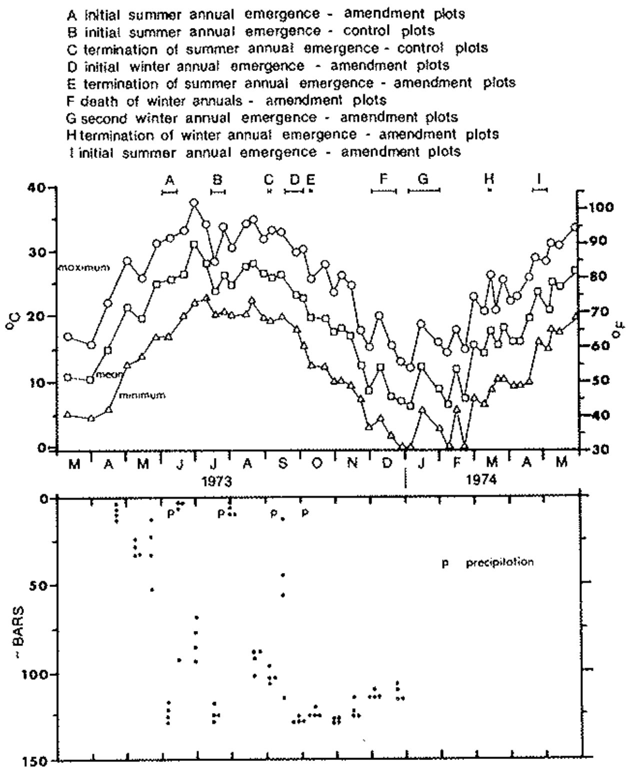

Figure 4. Bajada site summer and winter annual responses during 1973-74 in relation to seven-day mean maximum, mean mean, mean minimum air temperatures and control plot soil moisture potentials.

Table 3. Relative rank, density (m²) and emergence sequence of winter annuals in bajada site amendment plots during 1973-74

Sep. 28	Oct. 18	Nov. 4	Nov. 17	Dec. 5	Dec. 18	Jan. 5	Feb. 5	Feb. 17	Mar. 2	Mar. 15
*UNKVEG 30	UNKVEG 76	UNKVEG 95	UNKVEG 81	UNKVEG 126	None	None	ERITRI 2	ERITRI 27	ERITRI 46	ERITRI 26
	*CRYMIC 5	CRYMIC 10	CRYMIC 17	CRYMIC 8			CRYMIC 1	CRYMIC 6	CRYCRA 19	CRYMIC 18
	*ERIABE 1	*CRYCRA 3	CRYCRA 3	CRYCRA 1			UNKVEG 1	UNKVEG 4	CRYMIC 15	CRYCRA 9
	*DESPIN 1	ERIABE 1	ERITRI 2	ERITRI 1			*CHASTE 1	CRYCRA 3	CHASTE 7	CHASTE 9
	*ERIRUB 1	DESPIN 1	DESPIN 1	ERIABE 1			CRYCRA 1	CHASTE 2	ERIRUB 2	ERIRUB 4
		*ERITRI 1	LEP 1	LEP 1			ERIRUB 1		ERIABE 1	DESPIN 2
		*LEP 1	ERIABE 1	DESPIN 1					*ERIROT 1	ERIABE 1
			*HAPGRA 1						*NAMHIS 1	*EROTEX 1

*First identified time to appear.

Laboratory Germination Studies

A summary of all annual seed responses from the 1973 Jornada site soils to both constant and nonconstant temperatures is presented in Table 4. The summer annuals exhibited a significant inclination to germinate at temperatures above 18-20 C. Both *Tribulus terrestris* and *Iva ambrosiaefolia* exhibited notable exceptions. On the other hand, the winter annuals demonstrated no limited response range as either a group or species.

The total number of seeds which germinated from the top 1 cm of the 1973 site soils adjusted to a m^2 area is presented in Table 5. In each instance, except the March samples, the soils were sequentially exposed to the four temperature-light regimes. Considerable variation existed between paired monthly values although each site had peak densities in July-August. Both the bajada and grama sites exhibited similar magnitude peaks. A survey of all seed responses, both annual and perennial, indicated that 60% responded during the fall regime conditions. Individual species responses have not yet been tabulated.

DISCUSSION

The water amendment program of 1973-74 effectively provided a series of moisture treatments to plots of desert soil and stimulated both winter and summer annual emergence during unnatural emergence periods as monitored by control plots. Specific treatments indicate that temporal limits of specific phenophases can be established and related to climatic variables. The provision of overlapping treatments yielded the monitoring of responses in duplicate, thus providing an estimate of consistency for responses.

The initial summer annual emergence in amendment plots for both 1973 and 1974 relates significantly to the weekly mean minimum temperature value of 15 C. This suggests that minimum temperatures may be the second most major limiting or critical factor in summer annual emergence conditions. The emergence responses of several Jornada summer annual species, whose seeds were subjected to a variety of temperature-light regimes, support the field observations. Went (1949) reported similar laboratory evidence for the same and additional species responding from Hidden Valley, California, soils. Greater numbers emerged when the minimum temperature (night) was 13-17 C while the day temperatures were maintained at 27 C. Tevis (1958a) reported for the Lower Colorado Valley that *Euphorbia micromera* and *Bouteloua barbata* emerged only during July, August and September when the air minima ranged between 16 and 27 C. The succession of summer annuals into the amended plots may provide additional insight following a more complete analysis of the related factors. These will be reported upon at a later date. Our observations of initial summer annual emergence concur with Tevis (1958a) who found that most summer annual species can emerge 3-5 days after initial moisture amendment although peak densities may not be reached until later.

Winter annual emergence responses to amendment treatments and other climatic factors are significantly more complex upon initial inspection than summer annuals. Laboratory responses of seeds in Jornada soils subjected to a variety of temperature-light regimes also support this observation. The initial winter annual emergence period (amended plots) temperatures during 1973 were not greatly different from the inital summer annual emergence (amended plots) conditions of 1973-74. The second emergence period, not unlike the out-of-season winter rain conditions described by Beatley (1967, 1969, 1974), however, had significantly lower temperature conditions. The air temperature conditions were in close proximity to the minimum soil temperature of 10 C reported by Beatley (1974) to be permissible for germination. Other work in our laboratory on *Lepidium lasiocarpum*, *L. medium* and *Descurainia pinnata* indicates that all must germinate within the top 4-5 cm of the desert soil column in order to emerge (Larry Bell, pers. comm.). Thus the seeds are in a temperature regime not significantly different from the air temperature. Applying the depth optima, the Jornada soils were at or above the 10 C minima for only one week out of a nine-week period (Fig. 3). It was just following this warmer period that emergence was recorded. This suggests that fluctuating temperatures either above some minimum or below some maximum (inital September emergence) may provide the stimulatory "trigger" for winter annuals. Such a mechanism could account for the anomalous winter annual emergences following summer precipitation. Fluctuating temperatures of different magnitudes and ranges are stimulatory in some instances on the above-cited crucifers, although a clear-cut pattern has not yet emerged (Larry Bell, pers. comm.). Disturbance of the soil also stimulates germination-emergence.

Contrary to Beatley (1967), the Jornada winter annuals which emerged in the amended plots were susceptible to death during the late November-early December 1973 colder temperature period. Although the seedling roots were seemingly under no soil-moisture stress, the above-ground dry macroclimate was severe enough to exceed seedling tolerances. It is even quite possible that individual 2-hr minimum temperature values for the period of death were higher than the subsequent emergence in January (data not presently available). Both were periods of considerable temperature fluctuation and the seedlings of the first emergence may have been too rapidly subjected to fluctuating temperatures, whereas the seedlings of the second emergence are from seeds (embryos) which had experienced colder fluctuations of the annual cycle. Some winter annuals on the Jornada do not require the winter exposure to reach fruiting maturation ascribed by Beatley (1967) for some Mohave winter annuals. The known Jornada representatives are *Cryptantha micrantha*, *C. crassisepala* and *Lepidium lasiocarpum*. Controlled greenhouse- and growth chamber-grown winter annuals of other Jornada species do not support the theory that winter exposure contributes to their maturation.

Contrary to the 1973 report, the seeds in the soils which responded to constant and nonconstant temperatures did not constitute a large fraction of the responsive seed reserve. At all sites the responses (reserves) were more than doubled by the addition of responses to the fall and summer temperature-light regimes. The seed reserves by germination standards fluctuated greatly during the year with the 0-1 layer (m^2) yielding an annual average of of 880 $\pm$ 427 (SD) for the playa fringe, 1886 $\pm$ 2030 for the bajada and 2153 $\pm$ 1962 for the grama site. Goodall and Morgan (1974) reported values to compute 455 and 6852 seeds, respectively, from the 0-1 (m^2) playa fringe and bajada from July 1972 soils as analyzed by the carbonate flotation technique. Undoubtedly the values would be higher for 1973 soils analyzed by similar techniques as the July 1973 soils received a "good" winter annual yield of seeds.

Table 4. Germination responses of annual seeds in 1973 soils from the three Jornada sites to constant and nonconstant temperatures (C)

Species	Constant	Nonconstant
	WINTER ANNUALS	
Cryptantha crassisepala	20,20.5,26,32	24/9*,25/10,6/23
Cryptantha micrantha	19,23.5	26/10.5,28.5/12,28.5/13
Descurainia pinnata	5,15,18,19,20,21,23.5,24(2), 27,28.5,29	20/2,28.5/12,29/14.5,30/17.5,12.5/25
Eriastrum diffusum	8.5	
Eriogonum a. var. abertianum	6,8,12,22	34/16,4/18
a. var. ruberrimum	7	8/22
Eriogonum trichopes		4/20
Eriogonum spp.		12.5/24,12.5/25
Eschscholzia mexicana	23	
Happlopappus gracilis		15.5/27.5
Lepidium lasiocarpum	8,10,13,18,23,23.5,29	25/14,6/23
Lepidium medium	14,22.5,24,26(2),27,30.5	
Lepidium spp.	18,18.5(2),20.5,23.5,24,27	
Nama hispidum	15	
	SUMMER ANNUALS	
Amaranthus blitoides	27	15.5/27.5
Aristida adscensionis		34/19
Bouteloua aristidoides	18,24,25	
Chenopodium incanum		15.5/29
Euphorbia micromera		12.5/25
Euphorbia serrula	32	
Iva ambrosiaefolia	6,12,20.5	
Pectis angustifolia		4/20,6/22.5
Tidestromia lanuginosa	21,22	
Tribulus terrestris	30	25/13,8/22

*preceding temperature/germination temperature

Table 5. Number of germination responses by seeds present in 0-1 cm (m^2) depth Jornada soils (1973) to various temperature-light regimes

Month / Site	Constant	Nonconstant	Fall Regime	Summer Regime	Total
March					
Playa	40	---	280	40	360
Bajada	160	---	120	0	[illegible]
Grama	120	---	2480	280	2880
April					
Playa	200	120	400	120	840
Bajada	80	40	80	40	240
Grama	120	200	80	0	400
July					
Playa	360	160	800	120	1440
Bajada	680	320	4680	40	5720
Grama	160	280	560	480	1480
August					
Playa	200	160	1080	40	1320
Bajada	320	160	960	160	1600
Grama	1000	1120	3240	440	5800
November					
Playa	280	80	320	120	800
Bajada	600	600	960	80	2240
Grama	400	400	240	200	1240
December					
Playa	160	120	80	160	520
Bajada	240	40	880	80	1240
Grama	280	80	600	160	1120
% of Total	18	13	60	9	

EXPECTATIONS

During the coming year we will continue to analyze 1973-74 data, monitor control abiotic soil factors (A3UWP01) and plants (A3UWP02), monitor several amendment plots during early summer and early fall for both abiotic factors and plants, investigate the effect of temperature upon seeds in monthly soil samples (A3UWP03, 4, 5) and investigate the effect of *Larrea* material upon germination of seeds in monthly soil samples.

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