AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

EGG 11265-1062
UC-708

EG&G Energy Measurements
Environmental Sciences Department

EFFECTS OF SEEDBED PREPARATION, IRRIGATION, AND WATER HARVESTING ON SEEDLING EMERGENCE AT THE NEVADA TEST SITE

Paper for the Proceedings - 8th Wildland Shrub and Arid Land Restoration Symposium

February 1994

Conf-9310276--6

ABSTRACT

EFFECTS OF SEEDBED PREPARATION, IRRIGATION, AND WATER HARVESTING ON SEEDLING EMERGENCE AT THE NEVADA TEST SITE

V. K. Winkel, W. K. Ostler, W. D. Gabbert, and G. E. Lyon. EG&G Energy Measurements, Environmental Sciences Department, P.O. Box 1912, Las Vegas, NV 89125.

Approximately 800 hectares on the U.S. Department of Energy Nevada Test Site and vicinity are contaminated with plutonium. As part of a cleanup effort, both the indigenous vegetation and the top 5-10 cm of soil may be removed, and the soil may or may not be replaced. Technologies must be developed to stabilize and revegetate these lands. A study was developed to determine adaptable plant species, methods to prepare seedbeds for direct seeding and water harvesting, and proper irrigation rates. Plots were cleared of indigenous vegetation, and then prepared with various seedbed/water harvesting treatments including, pitting, land imprinting, and mulching. Other plots were treated with large water harvesting structures. Three irrigation treatments were superimposed over the seedbed/water harvesting treatments. Seedling emergence data was collected, and the treatment combinations compared. Supporting meteorological and soil data were collected with an automatic data-logger. Specific data included precipitation, and air temperature. In a year of above-average precipitation, irrigation did not generally aid germination and emergence of seeded species, and only slightly increased densities of species from the native seedbank. With the exception of increased shrub seedling densities in desert strips, there were no strong seedbed preparation/water harvesting treatment effects. In years of above-average rainfall, mulching and water harvesting treatments, and irrigation may not be necessary to insure adequate germination and emergence of adapted perennial grasses, forbs, and shrubs in the Mojave/Great Basin Transition Desert. Future collection of survival data will determine whether a maintenance irrigation program is necessary to ensure establishment of native plants.

EFFECTS OF SEEDBED PREPARATION, IRRIGATION, AND WATER HARVESTING ON SEEDLING EMERGENCE AT THE NEVADA TEST SITE

Introduction

During the 1950s and 1960s, a series of safety tests were conducted on and adjacent to the Nevada Test Site (NTS) to determine the consequences of accidental detonation or destruction of a nuclear device. This led to the contamination of approximately 800 hectares with plutonium. The U.S. Department of Energy Nevada Operations Office has developed a feasibility study to examine methods for cleaning up these contaminated lands. The objectives of the study are to evaluate technologies to: 1) selectively excavate the contaminated soil, 2) remove the plutonium from the soil, and 3) respread the clean soil on the site, and stabilize and revegetate the site.

Revegetating these disturbed areas will be difficult for the following reasons: 1) approximately 5-10 cm of topsoil will be removed and may not be replaced, 2) the structure and biological viability of the soil will be significantly altered, and 3) these areas are in harsh environments with high temperatures and limited, erratic precipitation.
Precipitation is the dominant factor controlling revegetation success in arid lands. While 250 mm of annual precipitation is generally considered the minimum necessary for revegetation by seeding (Plummer and others 1968, Vallentine 1989), much of the Mojave Desert and portions of the Great Basin Desert receive less than 150 mm of precipitation annually. For this reason, few attempts have been made to revegetate disturbed areas in these deserts by seeding. However, various revegetation efforts in arid and semiarid regions of the Southwest have shown that reseeding is practical and cost effective, provided proper techniques such as mulching, seedbed modification, and water harvesting are applied (Graves and others 1978, Kay 1979, Anderson 1987, and Clary 1983).

Several techniques that modify soil microtopography to concentrate precipitation have been developed and used successfully in the arid Southwest. The land imprinter has been shown to successfully harvest limited precipitation (Dixon and Simanton 1980), cover broadcast seeds (Winkel and others 1991), increase seedling emergence, firm seedbeds, reduce wind erosion, and increase seed-soil contact (Haferkamp 1987, Clary 1989, Winkel and Roundy 1991).

Pits have been used since the 1930s on the Great Plains and in the Southwest to prepare seedbeds, control competing plants, and concentrate limited precipitation (Vallentine 1989). Intensive water harvesting techniques such as catchment basins, desert stripping, and runoff farming have been used for centuries in the Middle East (National Academy of Sciences 1974, Boers and Ben-Asher 1982, Evernari and others 1982), and more recently in the southwestern United States (Morin and Matlock 1975, Fink and others 1980), and Mexico (Mendina and Garza 1987); and show promise to accelerate revegetation in the Mojave Desert. Various mulches have been shown to greatly reduce evaporation, stabilize soils and increase seedling establishment (Kay 1978, Fraser and Wolfe 1982, Brammer 1982). A variety of irrigation methods have been shown to aid emergence and establishment of native plants. The objective of this study was to determine effects of seedbed preparation, irrigation, and water harvesting on emergence of native grass, forb, and shrub species in the Mojave/Great Basin Transition Desert.

Methods

The study was conducted in Area 11 of the NTS in southern Nevada, approximately 113 km northwest of Las Vegas (Fig. 1). The study site is situated on an alluvial fan of the northern slope of French Peak mountain at an elevation of 1271 m. The soil is a gravelly sandy loam. The slope at the site is 3-5 percent and the aspect is northwest. The site is in a transition zone between the Mojave and Great Basin deserts with major plant species consisting of shadscale (*Atriplex confertifolia*), winterfat (*Ceratoides lanata*), wolfberry (*Lycium andersonii*), and Indian ricegrass (*Oryzopsis hymenoides*). The climate is characterized by hot summers and cool winters. Average annual precipitation for the past 30 years, obtained 5 km from the site, is 168 mm, which falls sporadically throughout the year.

The experimental design was a split split plot. Whole plots were irrigation treatments, split plots were seedbed/water harvesting treatments, and split split plots were species. A seed mix of eight seeded species was applied to six seedbed/water harvesting treatments within three irrigation treatments. The experiment included eighteen 7.5x20-m plots in each of three blocks. Irrigation treatments were randomized within blocks and seedbed/water harvesting treatments were randomized within irrigation treatments.

During September 1992, the plots were lightly brushed with a roadgrader to remove existing vegetation. Plots were harrowed in December 1992 to scarify the soil. Due to the loose structure of the soil, no further tilling was required. Following this initial seedbed preparation, each plot (with the exception of control plots), was seeded between December 11-14 at a rate of 20 kg/ha with a seed mixture of the following shrubs, forbs and grasses (percentage of mix in parenthesis): fourwing saltbush (*Atriplex canescens*)(10%), shadscale (*Atriplex confertifolia*)(11%), threadleaf rubber rabbitbrush (*Chrysothamnus nauseosus consimilis*)(40%), galleta grass (*Hilaria jamesii*)(10%), Indian ricegrass (*Oryzopsis hymenoides*)(9%), alkali sacaton (*Sporobolis airoides*)(5%), globemallow (*Sphaeralcea ambigua*)(4%), and spiney hopsage (*Grayia spinosa*)(11%). Seed was obtained commercially, and all species are native to the NTS. All seeds were drilled into moist soil to a depth of 1 cm. The moisture was a result of rain and snow that fell several days prior to, and intermittently during the period of seeding. Due to the loose structure of the soil, seed coverage was adequate. Following seeding, plots were treated with one of six seedbed preparation/water harvesting treatments including: 1) control, 2) drilled, 3) mulch/drill, 4) mulch/Imprint, 5) mulch/pit, and 6) desert strip.

"Control" plots were not drill-seeded, and received no treatment beyond brushing with a roadgrader. "Drilled" plots were drill-seeded with no further treatment. "Mulch/drill" plots were drill-seeded, mulched with 4500 kg/ha wheat straw, and then crimped with a disk-type crimper.

"Mulch/Imprint" plots were drill seeded, mulched with 4500 kg/ha wheat straw, and then imprinted with a Dixon-type land imprinter. The imprinter is composed of 10-cm geometric angle-iron forms welded on two separate 1x1-m cylinder capsules. The capsules are linked together with a common axle and filled with water. Total weight of the imprinter is approximately 5 metric tons. The imprinter produced imprints approximately 5-10 cm deep.

"Mulch/pit" plots were drill-seeded, mulched with 4500 kg/ha wheat straw, and then pitted with the Lee Pocket-Seeder. The Pocket-Seeder is a paddle-wheel type pitter that utilizes a hydraulic braking system to slow the speed of the paddle wheel to regulate the size of the pit it excavates.

The final treatment, referred to as a "desert strip" is a structure that includes a rainwater catchment or runoff-producing area and a plant-growing or runoff collection area. Catchments with 10% slopes were constructed with a road grader, and then sprayed with a watershedding treatment (3% sodium methylsilanolate in water solution) at a rate of 1.25 l/m^2. The bottom 1.5 m of the plot (bottom of the slope) was drill seeded, mulched with 4500 kg/ha wheat straw and crimped with a disk-type crimper. Due to frozen soils, mulching, imprinting, pitting, and crimping were delayed until January 19-20, 1993, one month following seeding. Desert strips were formed in September 1992, and the water-shedding treatment was applied on March 12, 1993.

All plots were treated with one of three irrigation treatments: 1) control, 2) germination irrigation, and 3) maintenance irrigation. "Control" plots received no supplemental irrigation. "Germination irrigation" plots received 80 mm of supplemental irrigation between March 26 and April 19, 1993. Plots receiving "maintenance irrigation", were watered at the same frequency and rate as plots receiving "germination irrigation", until May 12-14, 1993 when they received an additional 37 mm of water. Additionally, these plots received 26 mm on June 15, 1993, and then approximately 30 mm twice monthly until the first week of September 1993.

Seedling densities of all seeded species and the six major species present in the seedbank prior to seeding (seedbank species), were counted in 20 and five 1-m^2 quadrats per plot, respectively. Data collection of both seeded and seedbank species occurred between May 11 and May 20, 1993. Due to the abundance of seedbank species in the study plots, six major species were selected by collecting seedling density of all seedbank species from fourteen 1-m^2 quadrats and selecting the six with the highest density. These species included: *Amsinkia tessellata, Bromus rubens, Descurainia sophia, Mentzelia obscura, Phacelia fremontii*, and *Phlox stansburyi*.

Significant interactions and differences among treatment means were determined with analysis of variance and significant differences were identified with Duncans New Multiple Range Test.

Results and Discussion

Consistent precipitation began in mid December 1992 and continued through March 1993 (Fig. 2). Total precipitation from December 1, 1992 to April 5, 1993 was 270 mm, more than one and one half times the 30-year annual average. Soils were near field capacity at the surface from the first of January through February (although frozen for much of the time), and for several days during March. The top 1-3 cm of surface soils were observed to dry out for several days during mid-March. Emergence of seedbank species was first observed during the third week of January, but most did not emerge until air temperatures increased in early March (Fig. 2). Seedlings of seeded species, (notably Indian ricegrass), were first observed during mid-March.

Analyses of variance of seedling density data for both seeded and seedbank species showed highly significant ($p<0.0001$) 2 and 3-factor interactions, involving species, irrigation treatments, and seedbed/water harvesting treatments.

No Supplemental Irrigation

Seeded Species Emergence. Only Indian ricegrass and spiney hopsage had emergence greater than 1 seedling/m^2 when no supplemental irrigation was applied (Fig. 3). With the exception of the desert strip treatment, Indian ricegrass emergence was significantly greater ($p<0.05$) from treatments with mulch, then unmulched treatments. Indian ricegrass emergence was least from desert strips. In contrast, emergence of spiney hopsage was greatest from desert strips, moderate from the other mulch treatments, and least from unmulched treatments. Emergence of fourwing saltbush and rubber rabbitbrush from desert strips was double that from the other treatments, although this difference was not significant.

Seedbank Species Emergence. *B. rubens* and *A. tessellata* had the greatest seedling densities with no supplemental irrigation (Fig. 4). All other seedbank species produced less than 5 plants/m^2. There were significantly more ($p<0.05$) *B. rubens* plants in control plots than in all other treatments, with the exception of imprinted plots. Seedling densities of all other species (except *P. stansburyi*) were greatest in control plots, although these differences were not significant. Seedling densities of *B. rubens* and *A. tessellata* were significantly lower ($p<0.05$) in desert strip plots than in plots treated with all other seedbed treatments. Densities of *M. obscura*, *P. fremontii*, and *P. stansburyi* were also least in desert strip plots, although these differences were not significant. Densities of seedbank species were probably lowest from desert strip plots due to the lack of seed in the seedbank as a result of removing topsoil to form the desert strips. The fact that seedbank species emergence was least from desert strip plots, and therefore provided less competition for seeded species may explain why the density of spiney hopsage, fourwing saltbush and rubber rabbitbrush was highest from these plots.

Germination Irrigation

Seeded Species Emergence. Emergence of nearly all species in plots receiving 80 mm of supplemental irrigation during March and April was similar to those plots not receiving supplemental irrigation (Fig. 5). Again, only Indian ricegrass and spiney hopsage had densities greater than one seedling/m^2. Indian ricegrass densities were highest from mulch/imprint plots, followed by drilled and mulch/drill plots, control plots, mulch/pit plots, and then desert strips. Seedling densities of spiney hopsage were greatest from desert strips and pitted plots, moderate from drill, mulch/imprint, and mulch/drill plots, and least from control plots.

Seedbank Species Emergence. Although variable among species, densities of seedbank species was generally higher with 80 mm of supplemental irrigation than with no irrigation (Fig. 6). *B. rubens* had the highest plant densities, followed by *D. sophia*, and *A. tessellata*. Densities for all other species were lower than 5 plants/m^2. Densities of *B. rubens* among seedbed treatments with supplemental irrigation was similar to that among seedbed treatments without irrigation, with the exception that drill and mulch/drill plots had greater densities in irrigated plots. *A. tessellata* densities were highest ($p < 0.05$) from control and drill plots (both unmulched), and least and similar from mulched plots. *D. sophia* densities in irrigated plots were more than four times higher in control, drill, and mulch/drill plots than in the same unirrigated plots.

Maintenance Irrigation

Seeded Species Emergence. Due to the fact that irrigation rates and frequencies were the same for both irrigation treatments prior to seedling density data collection, densities of both seeded and seedbank species in plots receiving the two treatments should be similar. In general, this premise held true (Fig. 7). Again Indian ricegrass, and spiney hopsage emergence was greatest for most seedbed treatments with densities of greater than 2 seedlings/m^2. Densities of all other seeded species, with the exception of Galleta grass and alkali sacaton were below 1 seedling/m^2. Again, spiney hopsage densities in desert strip plots were significantly greater ($p < 0.05$) than in any other treatment. Densities of Galleta grass were greatest ($p < 0.05$) in mulch/imprint plots, moderate in drill plots, and least in all other plots.

Seedbank Species Emergence. Densities of seedbank species were generally slightly higher in the maintenance irrigation plots when compared to plots receiving the other irrigation treatments, although densities among seedbed treatments were variable (Fig. 8). *B. ruben* densities were greatest ($p < 0.05$) in mulch/imprint plots, followed by control plots, drill and mulch/pit plots, and then mulch/drill. *B. ruben* densities were lowest in desert strip plots. Densities of *D. sophia* where similar in maintenance irrigation and no irrigation plots, and both were much lower than densities in germination irrigation plots for most seedbed treatments. Densities of both *M. obscura* and *P. fremontii* were highest in control plots, least in desert strip plots, and moderate for all other seedbed treatments.

Conclusions

In a year of above average precipitation, supplemental irrigation did not generally increase germination and emergence of seeded species, and only slightly increased densities of species from the native seedbank. If soil water was sufficient for germination, then other factors must have caused the limited emergence of most seeded species. These factors may have included one or more of the following. Fragile imbibed seeds may have been damaged by the application of the mulching, imprinting, pitting and crimping treatments that were delayed because of frozen soil. The germinability of the seed may have been lower than expected. Some of the seed may have been harvested by the rodent population at the site. Conditions such as proper light regimes, alternating temperatures, etc. may not have been adequate for the release of seed dormancy.

Densities of some seeded shrubs were highest in desert strip plots probably a result of less competition in those plots due to decreased densities of seedbank species.

With the exception of increased shrub densities in desert strips, there were no strong seedbed preparation/water harvesting treatment effects. Mulch treatments did not generally increase seedling densities. Seedling densities in imprinted and pitted plots were not generally any greater then those in plots applied with the other treatments. Land imprinting, pitting, and other water harvesting treatments function by concentrating rainwater from runoff. In a year of above average rainfall, extra water from water harvesting probably was probably not necessary to promote germination and emergence.

This study has shown that in a year of above-average rainfall, mulching and water harvesting treatments, and irrigation may not be necessary to insure adequate germination and emergence of adapted perennial grasses, forbs, and shrubs. Future collection of survival data will determine whether a maintenance irrigation program is necessary to ensure establishment of native plants in the Mojave/Great Basin Transition Desert.

Literature Cited

Anderson, D. C. 1987. Evaluation Of Habitat Restoration On The Naval Petroleum Reserve #1, Kern County, California. U.S. Department of Energy Topical Report, EG&G/EM Santa Barbara Operations Report EGG 10282-2179.

Boers, T. M. and J. Ben-Asher. 1982. A review of rainwater harvesting. Agric. Water Manage. 5:145-158.

Brammer, R. L. 1982. Mulches, an old concept that remains important. In: E. F. Aldon, and W. R. Oaks (eds.). Reclamation Of Mined Lands In The Southwest, A Symposium, Soil Conservation Society Of America, New Mexico Chapter, Albuquerque, New Mexico.

Clary, R. F. Jr. 1983. Planting Techniques And Materials For Revegetation Of California Roadsides. Research Report No. FHWA/USDA LPMC-2, USDA Soil Conservation Service.

Clary, W. P. 1989. Revegetation by land imprinter and rangeland drill. Res. Pap. INT-397, USDA Forest Service, Intermountain Research Station.

Dixon, R. M. and J. R. Simanton. 1980. Land imprinting for better watershed management. In: Proceedings Of The Symposium On Watershed Management, American Society of Civil Engineers.

Evarnari, M., L. Shanan, and N. Tadmor. 1982. The Negev, The Challenge Of The Desert (2nd ed.), Harvard University Press, Cambridge Massachusetts.

Fink, D. H., G. W. Frasier, and K. R. Cooley. 1980. Water harvesting by wax-treated soil surfaces: progress, problems, and potential. Agric. Water Manage. 3:125-134.

Fraser, J. G. and H. G. Wolfe. 1982. Effects of mulch tackifiers on the establishment of native species in New Mexico. In: E. F. Aldon, and W. R. Oaks (eds.). Reclamation Of Mined Lands In The Southwest, A Symposium, Soil Conservation Society Of America, New Mexico Chapter, Albuquerque, New Mexico.

Graves, W. L., B. L. Kay, and W. A. Williams. 1978. Revegetation of disturbed sites in the Mojave Desert with native shrubs. Calif. Agric. 32:4-5.

Haferkamp, M. R., D. C. Ganskopp, R. F. Miller, and F. A. Sneva. 1987. Drilling versus imprinting for establishing crested wheatgrass in the sagebrush-bunchgrass steppe. J. Range Manage. 40:524-530.

Kay, B. L. 1978. Mulch and chemical stabilizers for land reclamation in dry regions. In: W. Schaller and P. Sutton (eds.). Reclamation Of Drastically Disturbed Lands, Amer. Soc. Agronomy, Madison, Wisconsin.

Kay, B. L. 1979. Summary Of Revegetation Attempts On The Second Los Angeles Aqueduct. Mojave Revegetation Notes No. 22, University Of California, Davis.

Medina, T. and C. Garza. 1987. Range seeding research in Northern Mexico. In: G. W. Fraiser and R. A. Evans (eds.). Proceedings of Symposium, Seed and Seedbed Ecology of Rangeland Plants. 21-23 April 1987, Tucson, Arizona. USDA, Agricultural Research Service.

Morin, C. A. and W. G. Matlock. 1975. Desert strip farming - computer simulation of an ancient water harvesting technique. In: G. W. Frasier (ed.). Proceedings of the water harvesting Symposium. 26-28, 1974, Phoenix, Arizona. U.S.D.A., Agricultural Research Service.

National Academy of Science. 1974. More Water for Arid Lands, Promising Technologies and Research Opportunities. National Academy of Science, Washington, D.C.

Plummer, A. P., D. R. Christensen, and S. B. Monsen. 1968. Restoring Big-Game Range In Utah. No 68-3, Utah Division of Fish and Game.

Vallentine, J. F. 1989. Range Development And Improvements (3rd ed.) Academic Press, Inc., San Diego.

Winkel, V. K. and B. A. Roundy. 1991. Effects of cattle trampling and mechanical seedbed modification on seedling emergence of grasses. J. Range Manage. 44:176-180.

Winkel, V. K., B. A. Roundy, and D. K. Blough. 1991. Effects of cattle trampling and mechanical seedbed preparation on burial of grass seeds. J. Range Manage. 44:171-175.

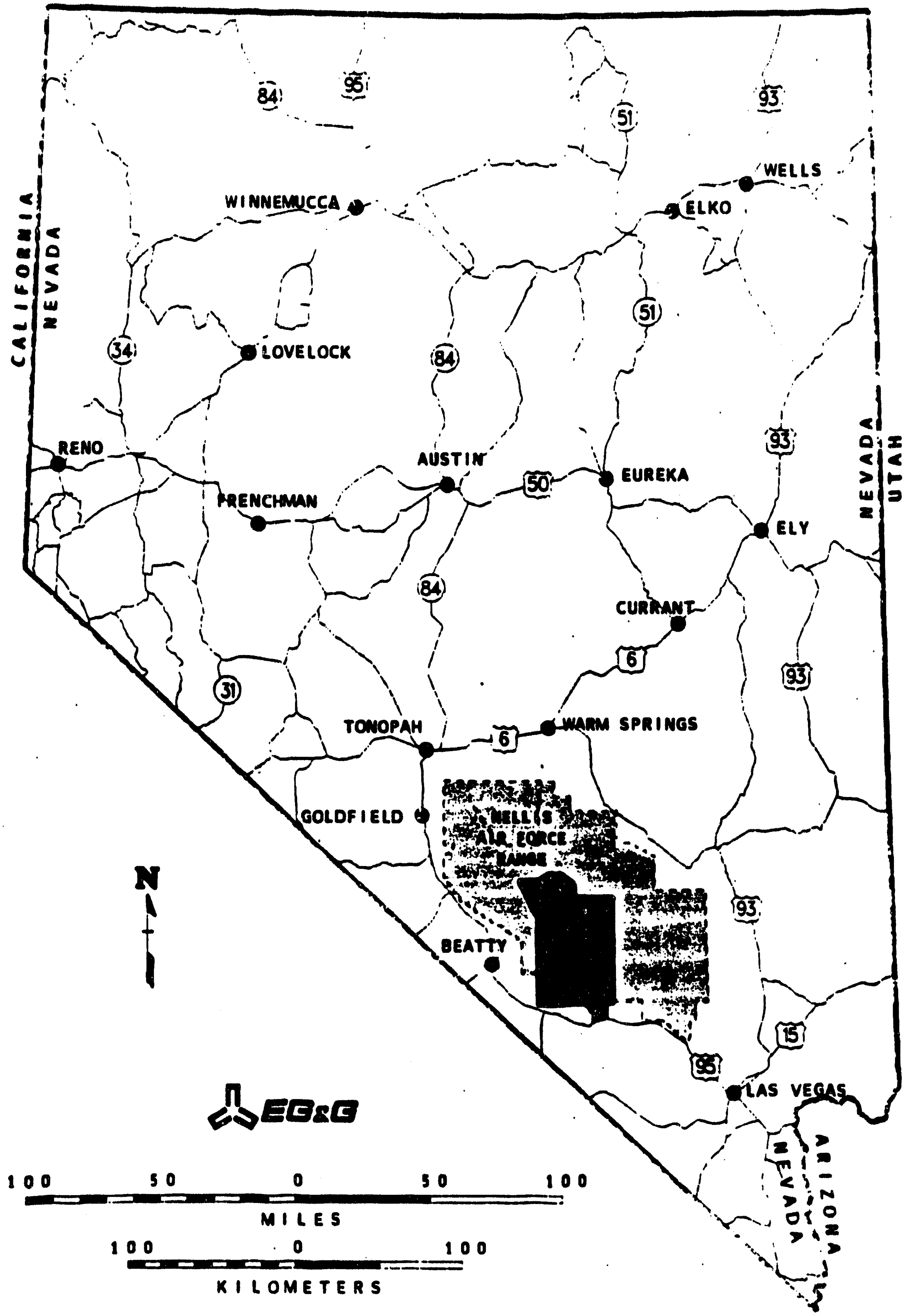

CALIFORNIA
NEVADA
WINNEMUCCA
WELLS
ELKO
LOVELOCK
RENO
AUSTIN
EUREKA
FRENCHMAN
ELY
NEVADA
UTAH
CURRANT
TONOPAH
WARM SPRINGS
GOLDFIELD
NELLIS AIR FORCE RANGE
BEATTY
LAS VEGAS
ARIZONA
NEVADA
N
EG&G
100 50 0 50 100
MILES
100 0 100
KILOMETERS

Fig. 1

Area 11, Nevada Test Site Weather Data
1992-1993

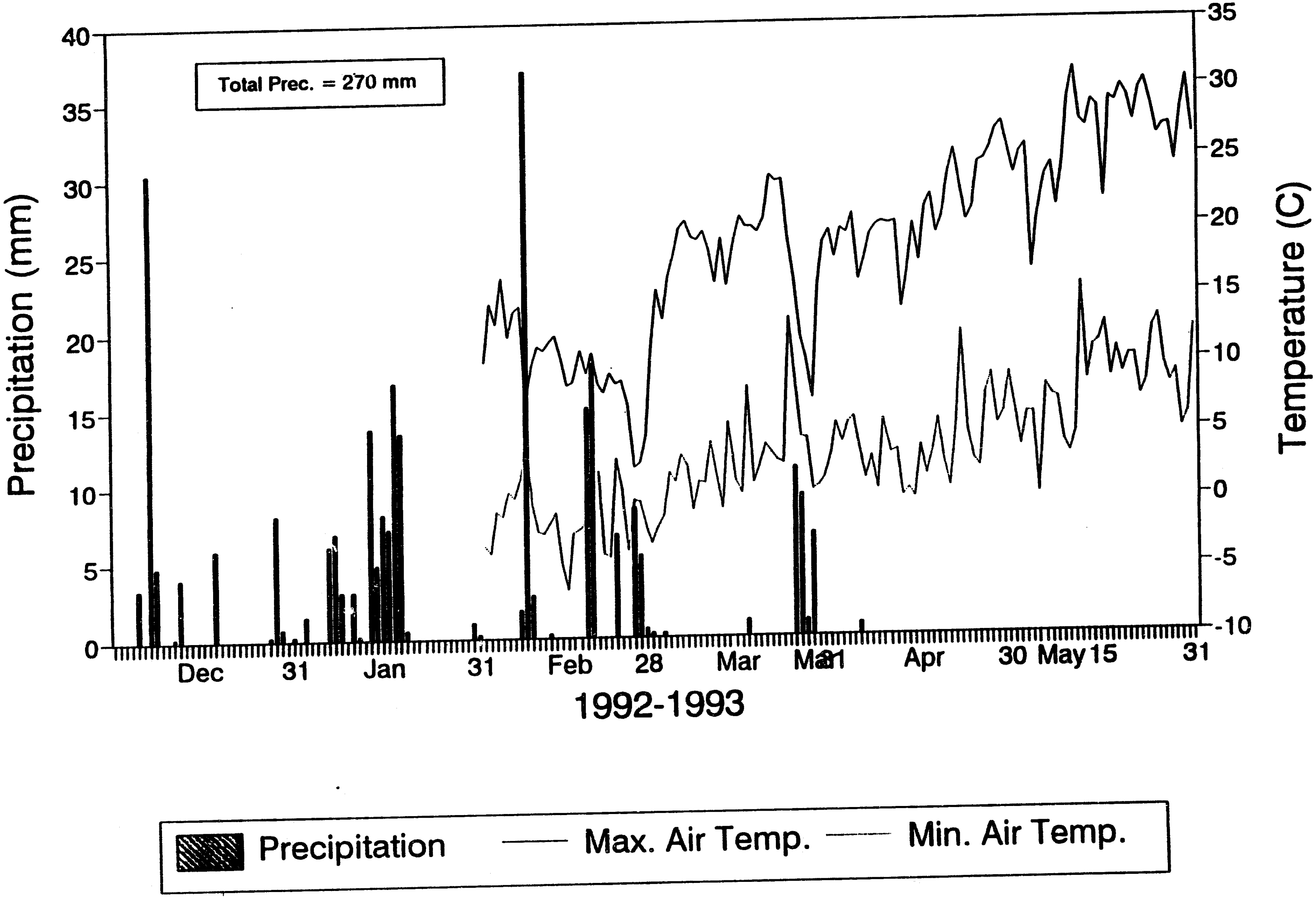


Fig. 2

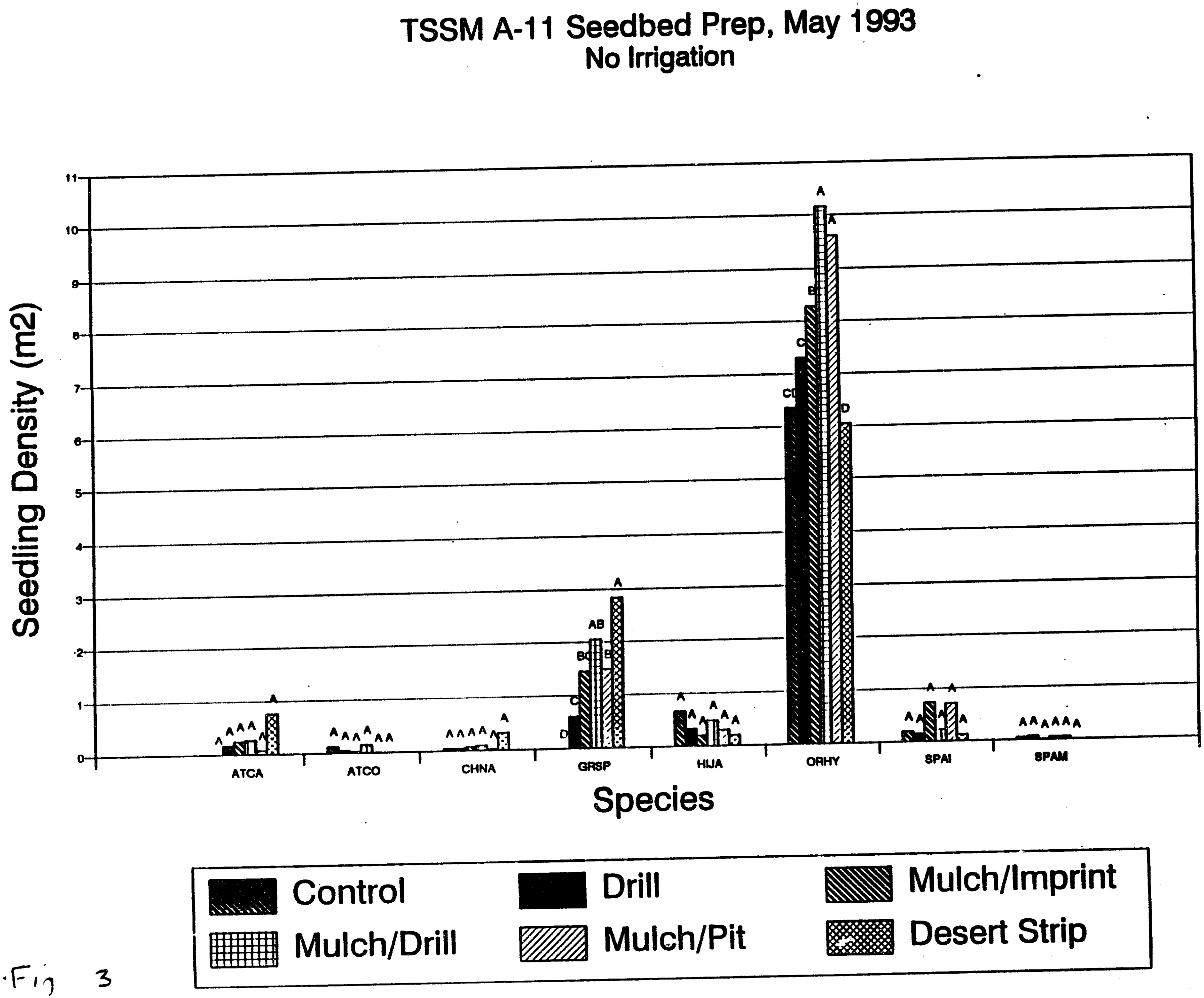

TSSM A-11 Seedbed Prep, May 1993
No Irrigation
Seedling Density (m2)
Species
ATCA
ATCO
CHNA
GRSP
HIJA
ORHY
SPAI
SPAM
Control
Drill
Mulch/Imprint
Mulch/Drill
Mulch/Pit
Desert Strip

Fig 3

TSSM A-11 Seedbed Prep. May 1993
No Irrigation

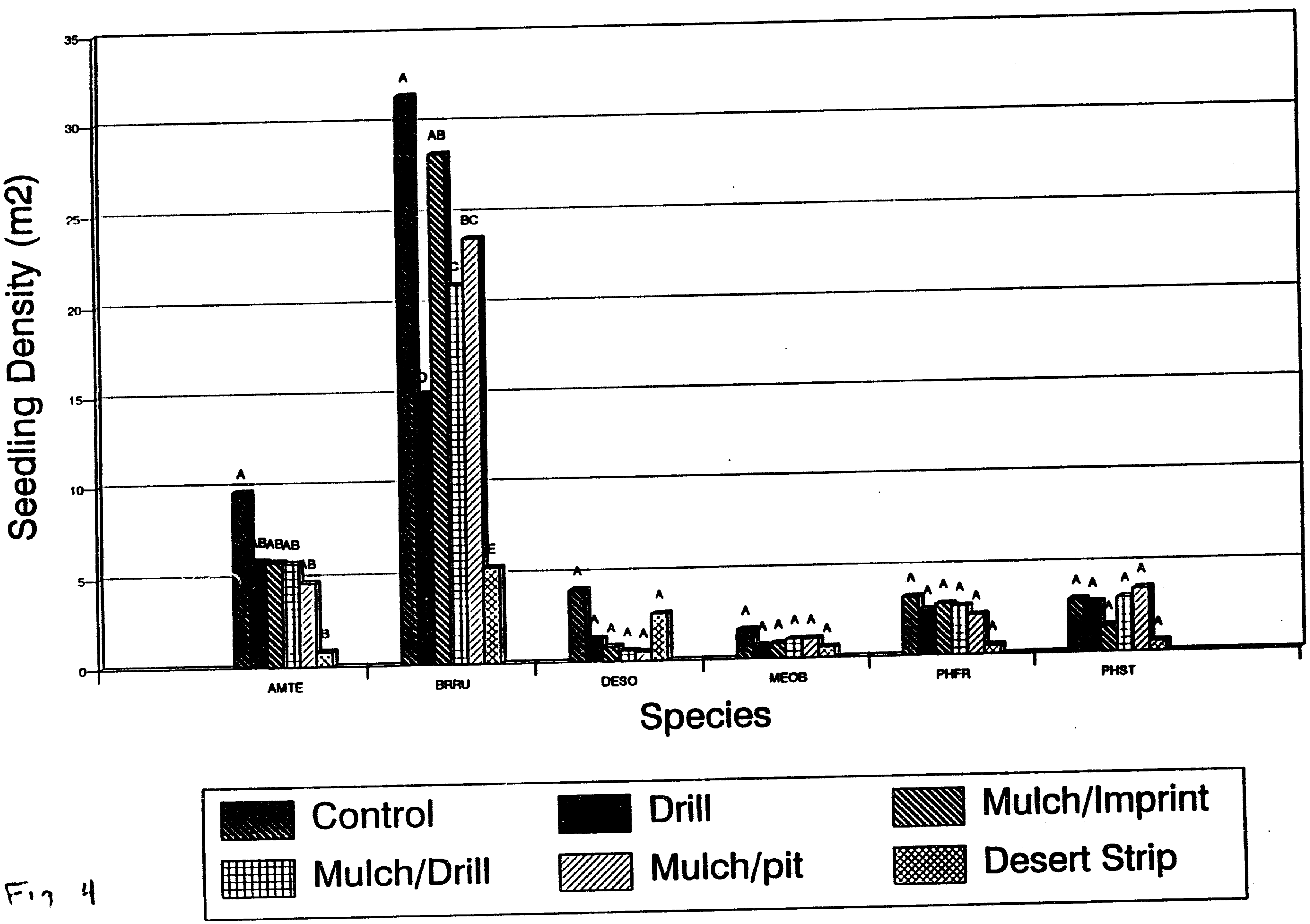


Fig 4

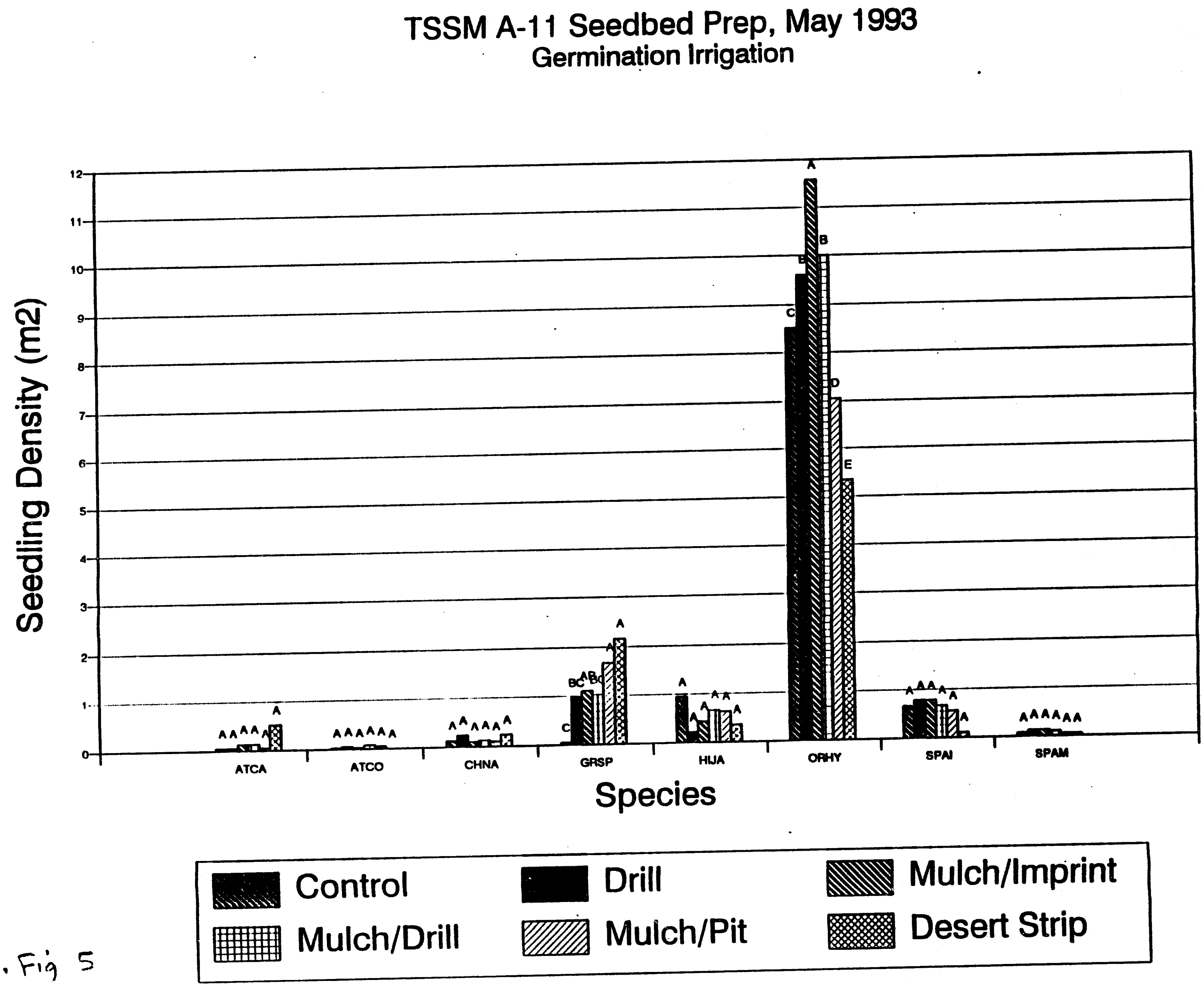

TSSM A-11 Seedbed Prep, May 1993
Germination Irrigation
Seedling Density (m2)
0
1
2
3
4
5
6
7
8
9
10
11
12
Species
ATCA
ATCO
CHNA
GRSP
HIJA
ORHY
SPAI
SPAM
Control
Drill
Mulch/Imprint
Mulch/Drill
Mulch/Pit
Desert Strip

Fig 5

TSSM A-11 Seedbed Prep. May 1993
Germination Irrigation

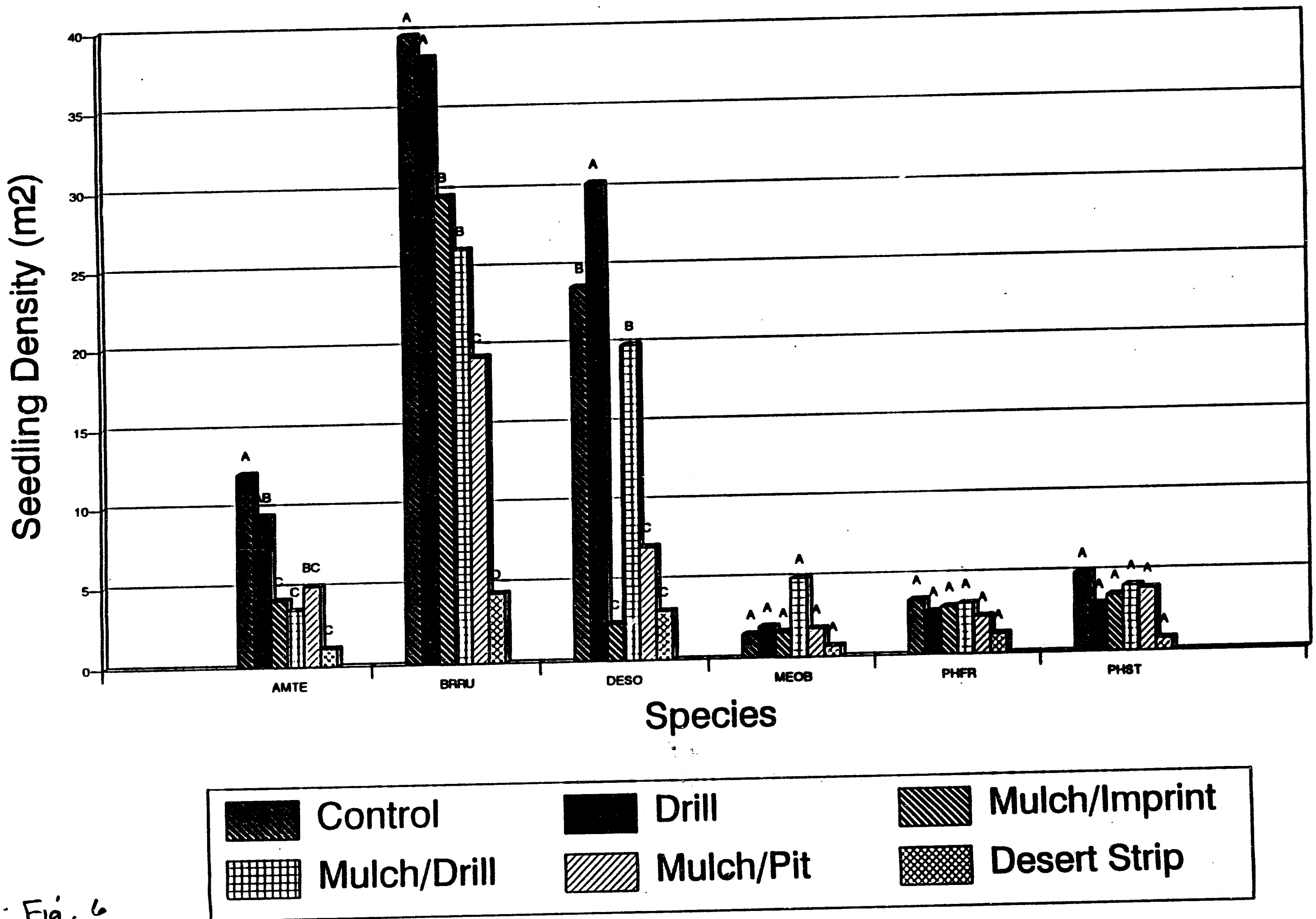
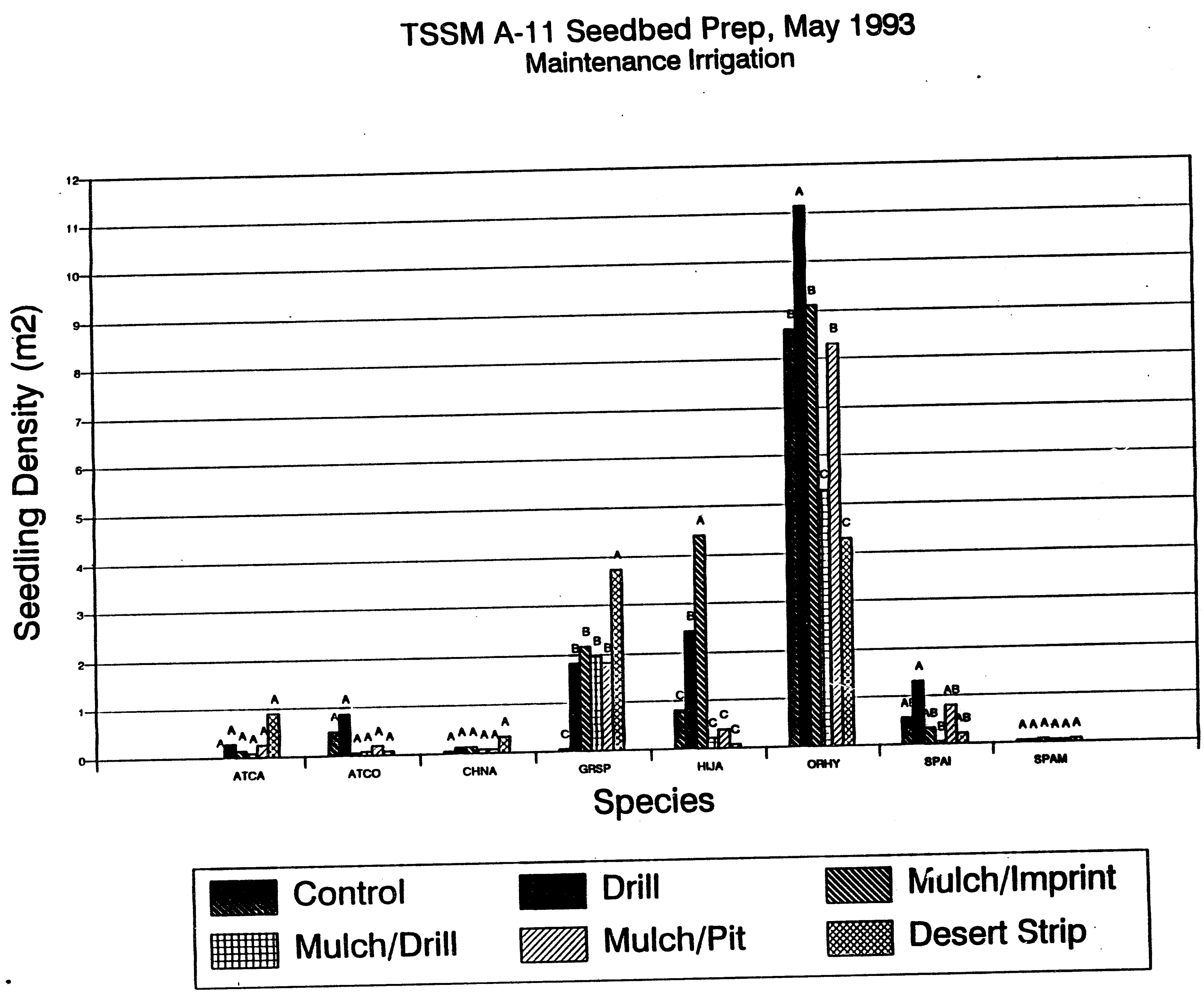


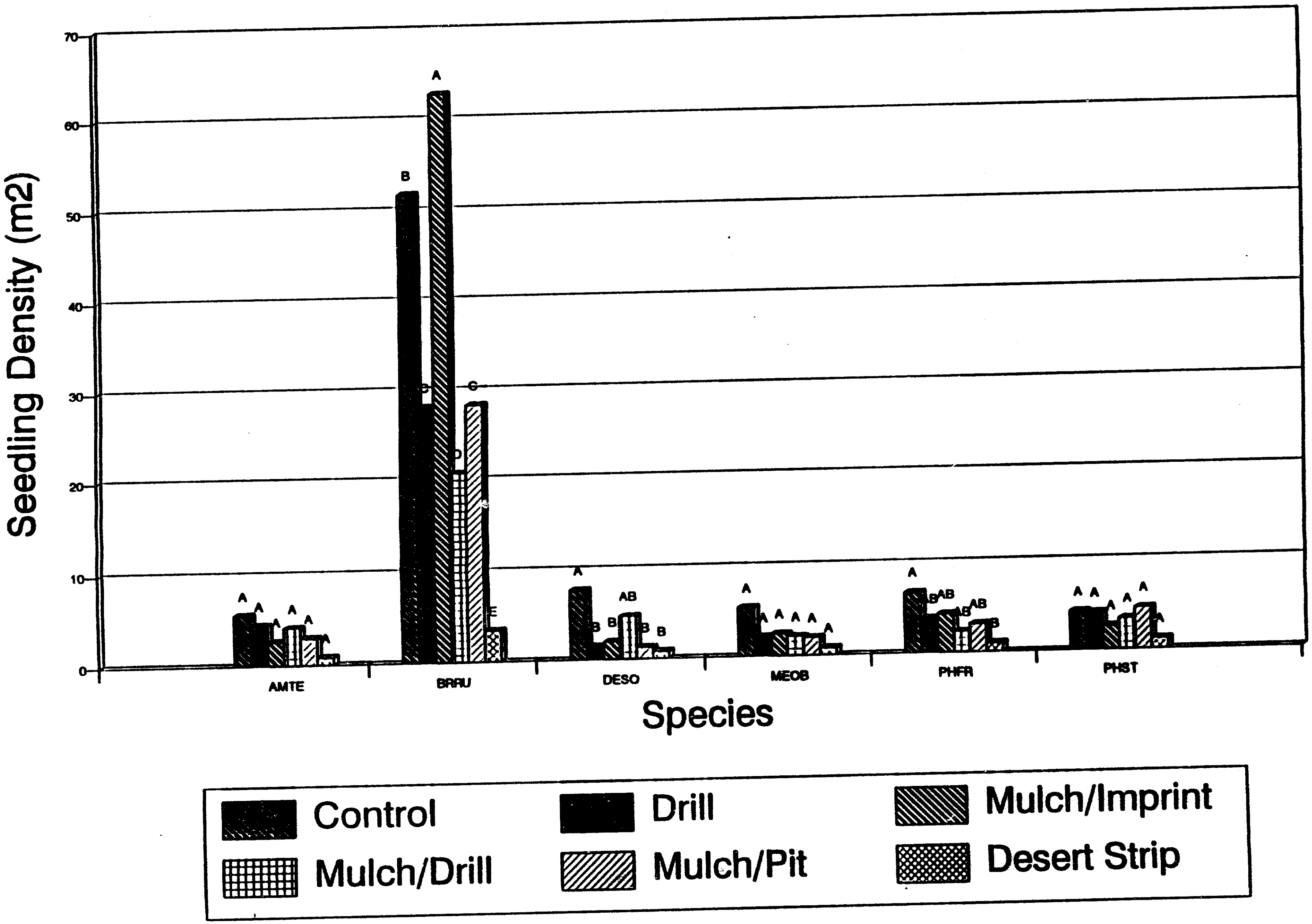
Fig. 6



TSSM A-11 Seedbed Prep, May 1993
Maintenance Irrigation
Seedling Density (m2)
0
1
2
3
4
5
6
7
8
9
10
11
12
ATCA
ATCO
CHNA
GRSP
HIJA
ORHY
SPAI
SPAM
Species
Control
Drill
Mulch/Imprint
Mulch/Drill
Mulch/Pit
Desert Strip

Fig. 7

TSSM A-11 Seedbed Prep. May 1993
Maintenance Irrigation



DATE
FILMED
7/11/94

END

4