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# An Evaluation of the Salt Tolerance of Particular Varieties, Strains, and Selections of Three Grasses and Two Legumes

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# AN EVALUATION OF THE SALT TOLERANCE OF PARTICULAR VARIETIES, STRAINS, AND SELECTIONS OF THREE GRASSES AND TWO LEGUMES

by

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Farrel John Olsen, Jr.

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# INTRODUCTION

In arid and semiarid areas in the Western United States, soluble salts tend to accumulate in the soil in amounts harmful to crop production. A considerable portion of this land cannot be reclaimed due to the poor quality of permeability of the soil. Therefore, the wise selection of crops that will produce satisfactory yields on these soils in necessary.

The salt tolerance of many crop plants has been investigated; however, more information is needed on the relative salt tolerance of varieties, strains, and selections. Such information will permit the selection and development of varieties and strains of crop plants which may do well under such adverse conditions.

The objective of this research is to determine the effect of increasing levels of salinity on the growth, survival, and chemical composition of selected forage plants.

## REVIEW OF LITERATURE

### Saline and alkali soils

Saline soils contain amounts of soluble salts that are harmful to plant growth. These soils are very prevalent throughout the arid and semiarid regions of the world. Israelson (1950) reported that most saline and alkali soils in cultivated areas occur because of poor irrigation practices.

The United States Salinity Laboratory (1954) has placed salted soils into the following groups:

> Saline soils. Saline is used in connection with soils for which the conductivity of the saturation extract is more than 4 mhos/cm. at 25°C. and the exchangeable-sodium-percentage is less than 15. Ordinarily the pH is less than 8.5. These soils correspond to Hilgard's 'white alkali' soils and to the 'Solonchaks' of the Russian soil scientists. When adequate drainage is established, the excessive soluble salts may be removed by leaching and they again become normal soils.
>
> Saline-alkali soils. Saline-alkali is applied to soils for which the conductivity of the saturation extract is greater than 4 mhos/cm. at 25°C. and the exchangeable-sodium-percentage is greater than 15. These soils form as a result of the combined processes of salinization and alkalization. Under conditions of excess salts, the pH readings are seldom higher than 8.5 and the particles remain flocculated. If the excess soluble salts are leached downward, the properties of these soils may change markedly and become similar to those of non-saline-alkali soils.
>
> Nonsaline -alkali soils. Non-saline-alkali is applied to soils for which the exchangeable-

sodium-percentage is greater than 15 and the conductivity of the saturation extract is less than 4 mhos/cm. at 25°C. The pH readings usually range between 8.5 and 10.0 These soils correspond to Hilgard's 'black alkali' soils and in some cases to 'Solonetz,' as the latter term is used by the Russians.

<u>The effect of salts on plant growth</u>

Kearney and Scofield (1936) stated:

> The effects of the dissolved constituents of the soil solution are manifested in two ways. One is directly on the plants, and the other is on the physical condition of the soil, with subsequent or indirect effects on the plants. Of these two the nature of the direct effects on plants is not so well understood as is the effect on the soil. It is well known that when certain of these constituents occur in the soil solution at or above certain concentrations, the normal processes of plant growth are impaired or inhibited. It is not so well known how these growth processes are deranged, whether by retarding water absorption and its translocation within the plant or by some other disturbance of the vital processes. It seems probable that one constituent affects the plant in one way and another in a different way. It is known that some constituents are, in lower concentrations, not only harmless to plants but actually beneficial or even essential, while in higher concentrations these same constituents are injurious or poisonous.

Hayward (1954) concluded that one of the main effects of soil salinity is to limit water supply to the plant by increasing the osmotic pressure of the soil solution. This effect is intensified by an increase in the soil moisture tension, and the combined effect, total soil moisture stress, determines the growth of plants.

Ayers and Hayward (1948) suggested that soil salinity may affect the germination of seeds in two ways: (1) it may decrease the ease with which seeds may take up water and thereby decrease the rate of water entry; and (2) it may facilitate the intake of ions in sufficient amounts to be toxic.

Bower and Fireman (1957) reported that when selecting crops for saline soils, particular attention should be given to the salt tolerance of the crop during germination due to the fact that poor yields frequently result from the failure to obtain satisfactory stands.

Studies by Ayers and Hayward (1948) showed that although corn germinated at a higher level of sodium chloride than sugar beets or alfalfa, it is less tolerant of salinity during the later stages of growth. Their studies also indicated that there is no general relationship between the salt tolerance of a plant during the later phases of growth and that during germination. They concluded that certain salt tolerant crops are especially sensitive during germination whereas others are not.

Ayers (1953) studied the effects of various levels of sodium chloride on the germination and emergence of barley varieties. He found that salinity tended to increase the time required for emergence and decreased the percentage of seeds emerging.

Uhvits (1946) studied the effect of sodium chloride on the germination of alfalfa seeds in Petri dishes by placing seeds between filter papers moistened with solutions having different osmotic pressures. The use of solutions of increased osmotic pressures resulted in a decrease in the rate and percent of seeds germinating. The same effect was noted when mannitol was substituted for sodium chloride, except that the reduction in germination percentage was not as severe at equal osmotic concentrations. The decrease in rate and percentage of germination due to the moistening of the seeds with either sodium chloride or mannitol was attributed to the osmotic effect of the solution upon the entry of water into the seeds. The more severe reduction in the germination percentage due to the use of sodium chloride was attributed to injury caused by the accumulation of toxic amounts of chloride within the seed.

Harter (1908) observed that salts tended to stimulate plant growth when present in small amounts. The United States Salinity Laboratory (1954) reported that sodium and chloride present in relatively small concentrations may stimulate the productivity of certain crops. Broyer et. al. (1954) concluded from their studies that chlorine is an essential nutrient element. This may account for the increased production of some crops grown on soils where small amounts of sodium chloride have been added.

Magistad and Christianson (1944) noted that plants show few characteristic symptoms of salt injury unless the concentration is exceptionally high. Plants grown in saline soils and in sand cultures receiving saline solutions are smaller than the ones grown under normal conditions. However, if control plants are not available for comparison, the dwarf effect is not very apparent.

Fireman and Hayward (1955) stated:

> Saline soils are often recognized by the presence of white salt crusts; by damp, oily-looking surfaces devoid of vegetation; by stunted growth of crop plants, with considerable variability in size and with a deep blue-green foliage; and sometimes by tipburn and firing of the margins of leaves.

Hayward and Long (1941) grew tomato plants in three series of culture solutions consisting of a base nutrient series, a sodium chloride series, and a sodium sulfate series. They found that the leaflets of plants grown at the high salt concentrations were significantly thicker in the sodium chloride and sodium sulfate series. They observed that the leaves of the plants grown in high sodium chloride solutions were more succulent than those of the base nutrient and sodium sulfate series. Anthesis was delayed and flower bud formation was retarded on plants grown in high sodium chloride solutions. As the concentration in the culture solution was increased, the osmotic concentration of the sap increased.

Hayward and Brown (1956) studied the effect of increasing levels of salinity on the growth of several alfalfa varieties. They noticed that plants grown in the salinized basins were smaller and had a dark blue-green color which became more evident with increasing salt concentration. However, in all other respects the plants appeared normal. Plants in the salinized plots bloomed a few days earlier than those of the control plot, and most alfalfa varieties produced one cutting more per year on the salt plots.

Kearney and Scofield (1936) reported that the burning quality of tobacco, the length and fineness of cotton fiber, and the purity of sugarcane and sugar beets may diminish because of salts in the soil interfering with the growth of the plants. They also reported that when salts are present in large quantities some plants may take up excess quantities from the soil which render the forage unpalatable or even injurious to livestock.

Specific ion effects

There are several salts found in the soil solution. The most common ones consist of various proportions of the cations: sodium, calcium, and magnesium, and the anions: chloride, sulfate, and bicarbonate.

Hassen and Overstreet (1952) have shown that the adverse effects of certain salts on the elongation of radish seedlings is not due solely to increased osmotic pressure of the media, but the nature of the salt may be important also. They concluded that certain ions may exert specific effects on the nature of growth processes of radish seedlings.

Hayward and Magistad (1946) reported that the growth of some crops, such as peaches and beans, was reduced more by chloride than by sulfate salts. Flax, guayule, and some grasses were affected more by sulfate salts.

Wadleigh and Ayers (1945) studied the growth and biochemical composition of bean plants as conditioned by soil moisture tension and sodium chloride concentration. They found that an increase in the salt concentration tended to cause an increase in the percentage of nitrate nitrogen in the plants. Long (1943) observed that when large quantities of sodium chloride were present in the substrate, adsorption of nitrate nitrogen was reduced considerably.

Gauch and Wadleigh (1945) studied the effect of high concentrations of sodium, calcium, chloride, and sulfate on ionic absorption by bean plants. Their results indicated that the addition of salt to the base nutrient solution, regardless of the types of salt or the concentrations, had little effect on the phosphate concentrations in the plant parts.

Potassium absorption by plants as affected by cationic relationships was studied by Pierre and Bower (1943). It was observed that potassium absorption by plants is usually decreased by the presence of high concentrations of other cations.

Larson (1938) found that strawberry clover grown on saline soil contains more ash and lower percentages of nitrogen and calcium and higher percentages of magnesium, sodium, potassium, and phosphorus than the normal vigorous plants from non-saline soil.

Wadleigh et al. (1951) concluded that high levels of the calcium ion in the soil solution may be lethal to orchard grass when the associated anion is either chloride or nitrate.

Bower and Fireman (1957) reported that boron when present in the soil solution at concentrations of only a few parts per million, is highly toxic to many crop plants.

Gausman and Cowley (1954) conducted a test to ascertain the effects of artificial salinization on the perform ance of five grasses grown extensively in the Lower Rio Grande Valley. Their results indicated that the use of sodium chloride and calcium chloride treatments increased the sodium content of Coastal Bermuda grass and decreased the sodium content of Angleton grass and Rhodes grass. Differences were not statistically significant in regard to the percentages of nitrogen in the top growth of the grasses subjected to salinized water. However, the phosphoric acid content of some of the grasses did increase significantly due to the salt treatments.

Elgabaly (1955) used resin-sand systems to study the effects of sodium, magnesium, and calcium on the growth and cationic accumulation of barley plants. The dry weight, length of shoots, and length of roots were used to measure these effects. It was observed that when sodium was increased in the medium there was an increased absorption of sodium by the plants, an increased depletion in potassium, and a slight depletion in calcium and magnesium. The study indicated that compared at equal concentrations, magnesium and sodium were more deleterious on the growth of barley than calcium.

Physiological basis of salt tolerance

The halophytes are natural examples of plants that are salt tolerant. Considerable literature was reviewed by

Uphof (1941) on the physiology of halophytic plants with particular reference to osmotic pressure, transpiration, suction pressure, amount of salt taken up, and germination. Iljin (Hayward, 1954) affirmed that only those plants resistant to high accumulations of sodium in the cell sap should be considered as halophytes. Physiological characteristics which he considers important in the halophytes are: (1) the ability to develop high osmotic pressures of the tissue fluids in order to counteract the increased osmotic pressure of saline substrates; (2) the ability to accumulate large quantities of salts in the tissue fluids and to regulate such an accumulation; (3) a protoplasm that is resistant to the effects of sodium accumulation in the cell sap.

Collander (1941) observed that plant species which normally have relatively high concentrations of sodium throughout the plant seem to be the ones that are least sensitive to an increase in sodium concentration in the substrate. He also noted that many salt-sensitive species of plants take up relatively small amounts of salt.

Breazeale (1926) maintained that salt tolerance in plants is primarily a matter of adaptation and development of physiological differences, such as the development of mechanisms for lowering the rate of transpiration, or loss of water through leaves. Daubenmire (1947) asserts that salt tolerance appears to be a matter of physiologic adaptation acquired through time.

Repp and McAllister (1956) reported that the salt resistance of the protoplasm is a very important physiological factor in salt tolerance of plants. Hayward (1954) pointed out that the lack of salt tolerance in crop plants may be related to the inability to regulate adequately the intake of salt, and the sensitivity of the protoplasm to salt accumulations within their tissues.

Funk (1956) hypothesized that the favorable growth response of many plants on salted soils may be due to an ability to persist under adverse conditions of high salt and then make growth by obtaining water from a less concentrated soil solution either after a rain or irrigation or from a less concentrated part of the root zone.

## Techniques used for salt tolerance investigations

It is difficult to make accurate evaluation of crop growth on saline soils because of the diversity of salt conditions found within one area of a field. The United States Salinity Laboratory (1954) has developed several techniques for evaluating the salt tolerance of crop plants.

Artificially salinized field plots. This method utilizes 14-ft. square basins. These are leveled carefully to insure even distribution of the salinized irrigation water. They are surrounded by borders to restrict the salinized water to the basin. Salinization is accomplished by irrigation with waters artificially salinized with prescribed amounts of salts. If the soil is permeable and sufficient irrigations are applied, the salt concentrations in the basins tend to reach a steady value after the first few irrigations. Equal parts of sodium chloride and calcium chloride are added in prescribed amounts to the irrigation water to prevent the development of alkali conditions in the soil.

The salinization treatments are begun after the seedlings or transplants are established, since most crops are more sensitive to salinity during germination or following transplanting. Generally, the salinity is increased stepwise during the first 3 or 4 salinizing irrigations.

Drum culture. Salt is added to the drums in the initial irrigation or by mixing it with the dry soil in amounts calculated to give the desired level of salinity. After the initial salt has been added to the soil, non-saline irrigation water must be used to prevent further increases in salt concentration. Alternate surface and subirrigation are practiced in order to avoid the leaching of the salt downward in the drum. This also insures a more even distribution of the salt in the soil. Subirrigation is accomplished by introducing the irrigation water into a layer of fine gravel in the bottom of the drum. Drum cultures require a minimum of space and effort and are very useful in salinity studies where many treatments are desired.

Sand and water cultures. Sand and water cultures allow for precise control of the substrate. Therefore, problems difficult to solve by soil-culture methods can be studied more satisfactorily by sand or water cultures. These methods involve the addition of various salts to a base nutrient solution. Provision for adequate nutrition is made by using a base nutrient solution. Proper control of the pH of the nutrient solution must be maintained and adequate aeration must be provided.

Protoplasmic salt resistance test. Repp and McAllister (1956) developed a brief physiological test for predicting the salt tolerance of crop plants. This technique consists of cutting tangential stem sections containing the epidermis and some cortex tissues from the plants to be studied. These tangential stem sections are immersed in sodium chloride solutions of various concentrations for 24 hours. After removal, they are immersed in a hypertonic glucose solution for an hour and then examined under the microscope for plasmolysis. Plasmolized cells are considered uninjured while cells which fail to plasmolize are considered injured or dead.

Plant ratings for relative salt tolerance. Hayward and Wadleigh (1949) report that three criteria may be used to evaluate salt tolerance. They are: (1) the ability of a crop to survive on saline soils, (2) the ability of a crop to produce a satisfactory yield, and (3) the production of a crop on a saline soil compared to the production of the same crop on a non-saline soil.

Many species and some varieties of crop plants have been investigated by the United States Salinity Laboratory (1954) for their relative salt tolerance. In most instances, the artificial salinized field-plot technique was used to obtain the data reproduced in Tables 1 and 2.

Table 1. Relative salt tolerance ratings for forage crops

| $EC_e \times 10^3 = 18$ | $EC_e \times 10^3 = 12$ | $EC_e \times 10^3 = 4$ |
|---|---|---|
| Alkali sacaton | White sweetclover | White Dutch clover |
| Salt grass | Yellow sweetclover | Meadow foxtail |
| Nuttal alkaligrass | Perennial ryegrass | Alsike clover |
| Bermuda grass | Mountain brome | Red clover |
| Rhodes grass | Strawberry clover | Ladino clover |
| Rescue grass | Dallis grass | Burnet |
| Canada wildrye | Sudan grass | |
| Western wheatgrass | Hubam clover | |
| Barley (hay) | Alfalfa (California common) | |
| Birdsfoot trefoil | Tall fescue | |
| | Rye (hay) | |
| | Wheat (hay) | |
| | Oats (hay) | |
| | Orchardgrass | |
| | Blue grama | |
| | Meadow fescue | |
| | Reed canary | |
| | Big trefoil | |
| | Smooth brome | |
| | Tall meadow oatgrass | |
| | Cicer milkvetch | |
| | Sourclover | |
| | Sickle milkvetch | |
| $EC_e \times 10^3 = 12$ | $EC_e \times 10^3 = 4$ | $EC_e \times 10^3 = 2$ |

Table 2. Relative salt tolerance ratings for field crops

| $EC_e \times 10^3 = 16$ | $EC_e \times 10^3 = 10$ | $EC_e \times 10^3 = 4$ |
|---|---|---|
| Barley (grain) | Rye (grain) | Field beans |
| Sugar beets | Wheat (grain) | |
| Rape | Oats (grain) | |
| Cotton | Rice | |
| | Sorghum (grain) | |
| | Corn (field) | |
| | Flax | |
| | Sunflower | |
| | Casterbeans | |
| $EC_e \times 10^3 = 10$ | $EC_e \times 10^3 = 6$ | |

The numbers following $EC_e \times 10^3$ are the electrical conductivity values of the saturation extract in milimhos per centimeter at 25°C. associated with 50 percent decrease in yield.

## PLANT MATERIALS

The 5 species of crop plants included in this study were tall wheatgrass (Agropyron elongatum), Canada wild-rye grass (Elymus canadensis), reed canarygrass (Phalaris arundinacea), alfalfa (Medicago sativa), and strawberry clover (Trifolium fragiferum).

A commercial tall wheatgrass strain was planted a few years ago on a saline soil near Springville, Utah. The seed collected from these plants was replanted in non-saline soil and the seed obtained from these parent plants and their progeny was used as the source of tall wheatgrass seed for this study. Canada wild-rye grass seed was obtained from selections made over the state of Utah and also from North Dakota. Reed canarygrass seed was received from the stocks of U.S.D.A. collaborators and experiment stations. The seed for strawberry clover was obtained from the Field Crops Division of the A.R.S. Alfalfa seed was received from the various sources reported in Table 3.

### Grasses

Tall wheatgrass. Tall wheatgrass (Agropyron elongatum)is a native to Southern Europe and Asia Minor, where it lives primarily on saline meadows and seashores. It was introduced into the United States in 1909 from Turkey. It is a coarse, non-lodging, very late-maturing bunchgrass 2½ to 6 ft. tall. The grass makes excellent fall and spring recovery and remains green 3 to 6 weeks longer than most other grasses. It is very salt-tolerant and gives high yields on subirrigated alkaline soils. The full development of the plant requires 4 or 5 seasons (Weintraub, 1953).

Hafenrichter et al. (1949) described tall wheatgrass as a coarse, tall, vigorous, stemmy bunchgrass. They pointed out that it seems to be much more platable than its appearance indicates and its yield ranks among the highest of any grasses tested. Under irrigated conditions, it is not uncommon to obtain a production of more than 7 tons of hay per acre.

Beetle (1955) reported that tall wheatgrass has two outstanding qualities of other wheatgrasses. These are hardiness and drought resistance and the ability to produce excellent forage on soils too alkaline to grow any other useful crop.

Canada wild-rye grass. Canada wild-rye grass (*Elymus canadensis*) is a large, coarse, short-lived perennial bunchgrass. The plant height is from 3 to 5 feet, and the stems are coarse and woody. Although it is a cool-weather grass, it begins growth later in the spring and lasts longer into the summer. The palatability of Canada wild-rye grass is only fair (Hawk, 1951).

Canada wild-rye grass occurs in pure stands on wet alkaline sites. The seedling growth is slow in the cool weather of early spring and spring recovery of established stands is also slow. In Oregon under subirrigated conditions, it has averaged 4.56 tons of hay per acre (Hafenrichter et al. (1949).

Table 3. Sources of seed for alfalfa varieties used in the salt tolerance studies

| Variety | Source of Seed |
|---|---|
| A-224 Syn. 1 | Dr. Marion W. Pedersen |
| A-225 Northern Syn. | A.R.S. |
| A-250 (Utah Syn. Y) | Dr. Marion W. Petersen |
| A-251 (Utah Syn. Z) | Dr. Marion W. Pedersen |
| A-252 (Utah Syn. A) | Dr. Marion W. Pedersen |
| A-253 (Utah Syn. B) | Dr. Marion W. Pedersen |
| African A 4-34 (Ariz. Com.) | Arizona |
| Arizona Chilean | A.R.S. |
| Atlantic | Utah |
| "Bam" | Iran |
| Brigham Young | A.A. Borgeson of Santaquin, Ut. |
| Buffalo | Northrup King |
| Caliverde | A.R.S. |
| Cossack | A.R.S. |
| Delta Common | Camerson Adams of Delta, Ut. |
| DuPuits | A.R.S. |
| Hairy Peruvian | Arizona |
| Kansas Common | A.R.S. |
| Ladak | Oregon |
| Lahontan | Nevada |
| Narragansett | A.R.S. |
| Nemastan | Dr. Marion W. Pedersen |
| Nev. Syn. E. 1956 (O.F.S.) | Nevada |
| Nev. Syn. K. (O.F.S.) | Nevada |
| Nomad N B 21 | Oregon |
| Rambler | Canada |
| Ranger | Utah |
| Rhizoma | Canada |
| Sevelra | Idaho |
| So. African (W3275) | Northrup King |
| Stafford | Colorado |
| Swift Currant 3484 | Canada |
| Swift Currant M A 501 | Canada |
| Talent | A.R.S. |
| Terra Verde N. K. | Northrup King |
| Uruguay clone 10 | A.R.S. |
| Vernal | Utah |
| Williamsburg | A.R.S. |

Reed canarygrass. Reed canarygrass (*Phalaris arundinacea*) is a tall, coarse, sod-forming, cool-season perennial that reproduces by seed or vigorous rhizomes. It is believed to be a native of the temperate regions of Europe, Asia, and North America. The plant is well adapted to low, wet areas but also makes good growth on upland, well-drained soils supplied with ample moisture for spring and early summer growth. Often, it can be found growing along stream banks and around lake shores in areas where it is adapted (Ahlgren, 1956).

Weintraub (1953) describes reed canarygrass as a tall, coarse grass that spreads by rhizomes and tends to become sod-bound. The grass is adapted to cool regions but is not sensitive to heat or cold. It is especially adapted to swampy or overflowed lands. This grass is used for pasturage on wet lands, silage, hay, and erosion control along waterways.

Ioreed is a synthetic variety developed by the Iowa Agricultural Experiment Station. It is a recombination of the best selections from a large number of sources compared through a period of years and the best from Iowa selections (Heath and Hughes, 1951).

The variety Superior was developed in Oregon for use on upland sites. The seed is reported to show less tendency to shatter. It is also reported to make a somewhat shorter growth than the commercial unimproved reed canarygrass (Heath and Hughes, 1951).

Legumes

Alfalfa. Alfalfa (Medicago sativa) is the outstanding forage plant in the United States. Of all the commonly grown hay crops, it has the highest feed value. It is a vigorous, deep-rooted, highly productive perennial that is best adapted to a deep loam soil with open porous subsoils. The tolerance of alfalfa to alkali and salt concentrations is better than for most other farm crops (Wheeler, 1950).

A-224 Syn. 1 is a synthetic variety developed by Dr. H. M. Tysdal at Nebraska. It consists of 4 clones: C-53 Nebr., C-63 Iowa, C-87 Pa., and C-130 Nebr. These clones all have somewhat spreading or rhizomatous crowns. It is a pasture type plant.

A-225 Northern Syn. was developed at Nebraska by Dr. H. M. Tysdal for the northern United States. It is a synthetic consisting of 7 clones: C-2 Nebr., C-10 Nebr., C-27 Colo., C-32 Nebr., C-36 Nebr., C-46 Nebr., and C-57 Colo. These clones were selected for their cold resistance as well as other desirable characteristics.

A-250 (Utah Syn. Y) is made up of 3 selections out of 262-10 and 1 from a Grimm x Nemastan cross. The 4 plants were interpollinated to produce Utah Syn. Y. Dr. R. J. Evans did the work at the Utah Agricultural Experiment Station.

A-251 (Utah Syn. Z) is a synthetic made up of 4 Utah clones numbers: 60, 80, 123, and 151. The parentage of these clones involves the varieties Hardigan, Nemastan, Russian Grimm, and Turkistan 86696. Dr. R. J. Evans at the Utah Agricultural Experiment Station was credited with the work.

A-252 (Utah Syn. A) is a selection made from 4 Utah clones. Each plant was selected for high seed production. The plants selected each produced in excess of 200 grams of seed. Utah Syn. A was developed by Dr. Marion W. Pedersen of the U.S.D.A. - A.R.S. at the Utah Agricultural Experiment Station.

A-253 (Utah Syn. B) consists of 7 Utah clones including the clones in A-252. These clones were selected on the basis of high seed production. Each of the 7 clones produced in excess of 200 grams of seed. Dr. Marion W. Pedersen developed this synthetic at the Utah Agricultural Experiment Station (Pedersen, 1958).

Strawberry clover. Strawberry clover (*Trifolium frogiferum*) is a perennial, low-growing, pasture legume which spreads vegetatively by creeping stems that root at the nodes. It is adapted to a wide range of soil conditions. However, the plant is of particular value on wet saline or alkaline soils, although it will thrive in normal soils. One of its outstanding characteristics is its ability to survive flooding for 1 or 2 months. It will produce a pasture crop on land where the subsoil water table is so high that other crop plants are largely or wholly eliminated. Strawberry clover is principally a pasture plant, though it may be used as a green-manure crop (Wheeler, 1950).

## METHODS AND RESULTS

The 5 experiments conducted at 3 salinity levels in artificially salinized basins consisted of (1) comparing the performance of 39 selections of tall wheatgrass, (2) comparing the performance of 12 selections of Canada wild-rye grass, (3) comparing the performance of 27 varieties and/or strains of reed canarygrass, (4) comparing the performance of 38 varieties of alfalfa, and (5) comparing the performance of 10 varieties and/or strains of strawberry clover.

The above experiments were performed at the Greenville Experimental Farm at North Logan, Utah, on a salty clay loam soil. The basin layout is shown in Figures 1 and 2.

The artificially salinized field-plot technique was employed in these experiments. In previous years, 15 basins had been constructed, but due to the fact that they had been subjected to salinization treatments, it was necessary that soil samples be taken from each basin and analyzed. Samples were taken at 0-6, 6-12, 18-24, 30-36, and 42-48 inch depths in each basin. In addition, random samples were taken at the same depths in the areas where 10 more basins were later constructed. The analyses of the soil samples indicated that 4 (Table 4 basins I, II, III, and IV) of the basins were not suitable for salt tolerance studies and therefore were not used. Also, 1 other basin (Table 4, basin V) was not used because it was not needed. The analyses of soil samples from basins used are given in Tables 5, 6, 7, 8, and 9.

Twenty of these 14 x 14 ft. basins were prepared for planting early in the spring of 1957.

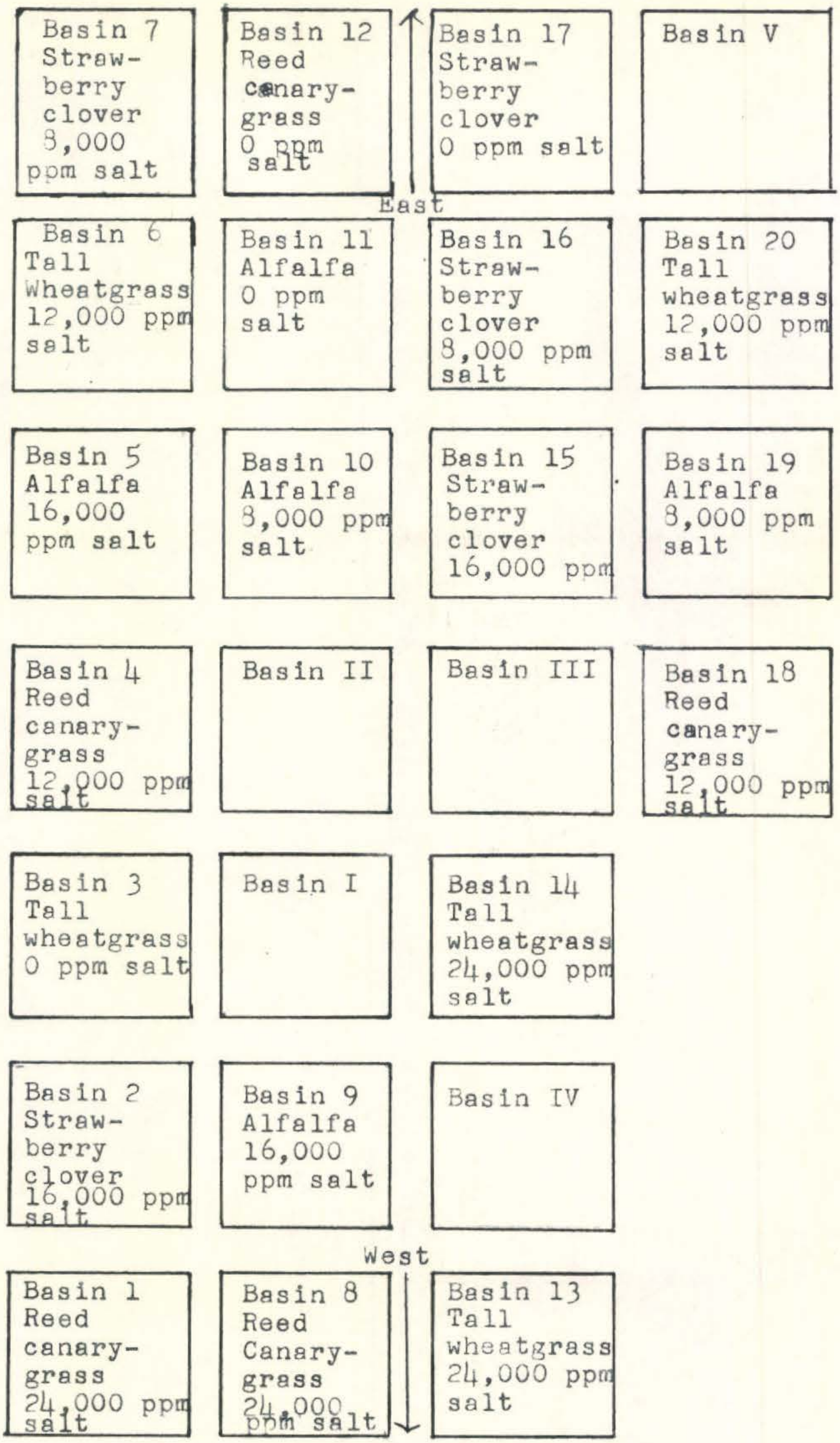


Figure 1. Salt basin arrangement on the Greenville Experimental Farm at North Logan, Utah, in 1957.

Figure 2., Salinized basins at the Greenville Experimental Farm at North Logan, Utah. The first 3 rows of basins in the foreground are part of Dr. D. R. Dewey's salt tolerance studies on crested wheatgrass.

Table 4. Analyses of soil samples taken from salt basins not used (April 11, 1957)

| Lab. No.[1] | Basin No. | Depth (inches) | pH Paste | pH 1:5 | Total Soluble Salts % | Sat. Ext. Cond. $KX10^3$ | Exch. Na. Me/100g | Base Exch. Cap. Me/100g | Exch. Na. % | Moist at Sat. % | Lime $CaCO_3$ % | Water Sol. Na. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U571256 | I | 0-6 | 8.5 | 9.8 | .09 | 3.2 | .4 | 14.2 | 3 | 28 | + | .79 |
| U571257 | I | 6-12 | 7.9 | 9.7 | .28 | 3.6 | .03 | 14.1 | 1 | 30 | + | .99 |
| U571258 | I | 18-24 | 7.3 | 8.2 | .79 | 28.7 | 1.71 | 11.9 | 14 | 35 | + | 5.53 |
| U571259 | I | 30-36 | 7.6 | 9.7 | .81 | 23.5 | 1.04 | 8.0 | 13 | 33 | ++ | 3.70 |
| U571260 | I | 42-48 | 7.6 | 8.3 | .62 | 22.2 | 1.2 | 6.2 | 19 | 28 | ++ | 2.60 |
| U571251 | II | 0-6 | 8.5 | 9.9 | .07 | 2.0 | .4 | 14.6 | 3 | 28 | + | .54 |
| U571252 | II | 6-12 | 8.1 | 9.5 | .25 | 8.4 | 4.5 | 14.3 | 31 | 34 | + | 2.55 |
| U571253 | II | 18-24 | 7.4 | 8.2 | 1.1 | 35.2 | 3.5 | 12.4 | 28 | 34 | + | 14.42 |
| U571254 | II | 30-36 | 7.5 | 8.3 | .79 | 20.1 | 1.3 | 7.6 | 19 | 32 | ++ | 3.23 |
| U571255 | II | 42-48 | 7.7 | 8.5 | .60 | 19.9 | 1.3 | 6.9 | 19 | 31 | ++ | 3.46 |
| U571286 | III | 0-6 | 8.9 | 9.8 | .06 | 1.5 | 4.2 | 14.6 | 29 | 26 | + | .37 |
| U571287 | III | 6-12 | 8.8 | 9.7 | .08 | 2.1 | 3.9 | 14.9 | 26 | 29 | + | .57 |
| U571288 | III | 18-24 | 7.6 | 8.2 | 1.3 | 31.2 | 2.1 | 11.9 | 17 | 36 | ++ | 5.09 |
| U571289 | III | 30-36 | 7.7 | 8.1 | 1.4 | 29.3 | 3.7 | 7.9 | 47 | 36 | ++ | 4.89 |
| U571290 | III | 42-48 | 7.9 | 8.2 | 1.1 | 29.3 | 1.0 | 5.5 | 19 | 30 | ++ | 3.70 |
| U571276 | IV | 0-6 | 8.7 | 10.0 | .08 | 2.0 | .5 | 15.0 | 3 | 30 | + | .68 |
| U571277 | IV | 6-12 | 8.7 | 9.8 | .06 | 1.6 | 4.6 | 14.6 | 31 | 27 | + | .50 |
| U571278 | IV | 18-24 | 7.9 | 8.9 | .33 | 8.2 | 2.2 | 13.1 | 17 | 37 | + | 2.59 |
| U571279 | IV | 30-36 | 7.5 | 8.3 | .82 | 24.7 | 1.7 | 9.8 | 17 | 34 | ++ | 3.16 |
| U571280 | IV | 42-48 | 7.7 | 8.4 | .52 | 16.4 | .8 | 7.1 | 12 | 32 | ++ | 1.44 |
| U571301 | V | 0-6 | 8.0 | 8.5 | .02 | 1.0 | .3 | 14.2 | 2 | 29 | + | .02 |
| U571302 | V | 6-12 | 8.0 | 8.4 | .02 | .6 | .2 | 13.2 | 2 | 34 | + | .03 |
| U571303 | V | 18-24 | 8.1 | 8.6 | .02 | .4 | .2 | 10.4 | 1 | 30 | + | .06 |
| U571304 | V | 30-36 | 8.2 | 8.6 | .02 | .6 | .1 | 6.9 | 2 | 29 | ++ | .06 |
| U571305 | V | 42-48 | 8.5 | 8.9 | .02 | .4 | .2 | 5.7 | 3 | 28 | ++ | .04 |

[1] Soil samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Cooperative Soils Laboratory, Logan, Utah

Table 5. Analyses of soil samples taken from salt basins prior to planting them to tall wheatgrass (April 11, 1957)

| Lab. No.[1] | Basin No. | Depth (inches) | pH Paste | pH 1:5 | Total Soluble Salts % | Sat. Ext. Cond. $KX10^3$ | Exch. Na Me/100g | Base Exch. Cap. Me/100g | Exch. Na % | Moist at Sat. % | Lime $CaCO_3$ % | Water Soluble Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U571221 | 3 | 0-6 | 7.9 | 8.8 | .02 | .6 | .6 | 14.1 | 4 | 33 | + | .14 |
| U571222 | 3 | 6-12 | 8.2 | 9.0 | .03 | .8 | .9 | 13.3 | 7 | 31 | ++ | .20 |
| U571223 | 3 | 18-24 | 8.3 | 9.3 | .04 | 1.0 | 1.3 | 13.0 | 10 | 30 | ++ | .26 |
| U571224 | 3 | 30-36 | 8.5 | 9.5 | .04 | .9 | 1.0 | 8.4 | 12 | 29 | ++ | .24 |
| U571225 | 3 | 42-48 | 7.8 | 8.5 | .44 | 11.8 | 6.1 | 6.3 | 2 | 33 | ++ | 2.08 |
| U571236 | 6 | 0-6 | 8.0 | 8.6 | .02 | .9 | .3 | 14.5 | 2 | 34 | + | .04 |
| U571237 | 6 | 6-12 | 8.0 | 8.7 | .02 | .5 | .2 | 14.3 | 1 | 36 | + | .02 |
| U571238 | 6 | 18-24 | 7.8 | 8.5 | .04 | .8 | .4 | 12.6 | 3 | 35 | ++ | .03 |
| U571239 | 6 | 30-36 | 7.8 | 8.6 | .04 | 1.2 | .2 | 8.5 | 2 | 30 | ++ | .05 |
| U571240 | 6 | 42-48 | 7.9 | 8.6 | .04 | 1.2 | .3 | 6.2 | 4 | 30 | ++ | .02 |
| U571301 | 20 | 0-6 | 8.0 | 8.5 | .02 | 1.0 | .3 | 14.2 | 2 | 29 | + | .02 |
| U571302 | 20 | 6-12 | 8.0 | 8.4 | .02 | .6 | .2 | 13.2 | 2 | 34 | + | .03 |
| U571303 | 20 | 18-24 | 8.1 | 8.6 | .02 | .4 | .2 | 10.4 | 1 | 30 | + | .06 |
| U571304 | 20 | 30-36 | 8.2 | 8.6 | .02 | .6 | .1 | 6.9 | 2 | 29 | ++ | .06 |
| U571305 | 20 | 42-48 | 8.5 | 8.9 | .02 | .4 | .2 | 5.7 | 3 | 28 | ++ | .04 |
| U571271 | 13 | 0-6 | 8.2 | 8.7 | .02 | .5 | .3 | 14.1 | 2 | 32 | + | .01 |
| U571272 | 13 | 6-12 | 8.1 | 8.6 | .02 | .7 | .3 | 13.3 | 2 | 35 | + | .03 |
| U571273 | 13 | 18-24 | 8.1 | 8.7 | .03 | .5 | .3 | 13.3 | 2 | 36 | ++ | .01 |
| U571274 | 13 | 30-36 | 8.1 | 8.8 | .02 | .4 | .3 | 10.8 | 3 | 32 | ++ | .01 |
| U571275 | 13 | 42-48 | 8.1 | 8.8 | .02 | .4 | .3 | 7.9 | 3 | 29 | ++ | .01 |
| U571281 | 14 | 0-6 | 8.2 | 8.8 | .03 | 1.6 | .7 | 14.4 | 5 | 35 | + | 1.47 |
| U571282 | 14 | 6-12 | 8.5 | 9.3 | .04 | 1.0 | 1.8 | 14.5 | 12 | 25 | + | .19 |
| U571283 | 14 | 18-24 | 8.5 | 9.4 | .03 | .8 | 1.8 | 13.2 | 14 | 32 | ++ | .21 |
| U571284 | 14 | 30-36 | 8.3 | 9.4 | .03 | .9 | 1.5 | 9.7 | 15 | 30 | ++ | .22 |
| U571285 | 14 | 42-48 | 8.6 | 9.3 | .03 | .8 | 1.0 | 7.6 | 14 | 31 | ++ | .21 |

[1]Soil samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Cooperative Soils Laboratory, Logan, Utah.

Table 6. Analyses of soil samples taken from salt basins prior to planting them to Canada wild-rye grass (April 11, 1957)

| Lab No.[1] | Basin No. | Depth (inches) | pH Paste | pH 1:5 | Total Soluble Salts % | Sat. Ext. Cond. KX10³ | Exch. Na Me/100g | Base Exch. Cap. Me/100g | Exch. Na % | Moist at Sat. % | Lime $CaCO_3$ % | Water Soluble Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U571241 | 12 | 0-6 | 8.2 | 8.5 | .03 | .6 | .2 | 14.2 | 1 | 33 | + | .02 |
| U571242 | 12 | 6-12 | 8.2 | 8.4 | .03 | .5 | .3 | 13.7 | 2 | 34 | + | .02 |
| U571243 | 12 | 18-24 | 8.3 | 8.6 | .04 | 1.2 | .2 | 11.7 | 2 | 36 | ++ | .03 |
| U571244 | 12 | 30-36 | 7.7 | 8.3 | .09 | 3.8 | .2 | 8.0 | 3 | 34 | ++ | .03 |
| U571245 | 12 | 42-48 | 7.6 | 8.5 | .16 | 5.2 | .6 | 6.5 | 8 | 32 | ++ | .03 |
| U571226 | 4 | 0-6 | 8.2 | 9.2 | .03 | 1.0 | 1.0 | 14.6 | 7 | 32 | + | .23 |
| U571227 | 4 | 6-12 | 8.5 | 9.4 | .04 | 1.3 | 1.7 | 14.6 | 11 | 32 | + | .36 |
| U571228 | 4 | 18-24 | 8.3 | 9.5 | .08 | 2.3 | 1.7 | 13.5 | 13 | 28 | ++ | .56 |
| U571229 | 4 | 30-36 | 7.4 | 8.2 | 1.2 | 29.7 | .6 | 9.4 | 6 | 35 | ++ | 5.11 |
| U571230 | 4 | 42-48 | 8.2 | 8.8 | 1.1 | 25.2 | .1 | 6.9 | 1 | 33 | ++ | 3.37 |
| U571306 | 18 | 0-6 | 7.9 | 8.6 | .02 | .5 | .2 | 14.0 | 2 | 33 | + | .22 |
| U571307 | 18 | 6-12 | 8.2 | 8.6 | .02 | .5 | .2 | 13.7 | 1 | 32 | + | .02 |
| U571308 | 18 | 18-24 | 8.2 | 8.6 | .04 | .8 | .2 | 10.2 | 2 | 32 | ++ | .02 |
| U571309 | 18 | 30-36 | 8.3 | 8.8 | .03 | .8 | .2 | 7.5 | 2 | 31 | ++ | .03 |
| U571310 | 18 | 42-48 | 8.0 | 8.0 | .04 | 1.2 | .2 | 5.5 | 3 | 29 | ++ | .07 |
| U571211 | 1 | 0-6 | 8.0 | 8.4 | .03 | 1.8 | .2 | 15.0 | 1 | 44 | ++ | .07 |
| U571212 | 1 | 6-12 | 7.8 | 8.5 | .02 | 1.2 | .2 | 14.6 | 1 | 35 | + | .10 |
| U571213 | 1 | 18-24 | 7.7 | 8.6 | .03 | 1.2 | .2 | 15.1 | 1 | 38 | + | .10 |
| U571214 | 1 | 30-36 | 8.0 | 8.6 | .03 | .6 | .2 | 11.5 | 2 | 36 | ++ | .02 |
| U571215 | 1 | 42-48 | 8.3 | 8.6 | .02 | .4 | .2 | 8.0 | 3 | 33 | ++ | .02 |
| U571266 | 8 | 0-6 | 8.0 | 8.6 | .03 | .6 | .3 | 14.4 | 2 | 32 | + | .02 |
| U571267 | 8 | 6-12 | 8.0 | 8.6 | .02 | .5 | .3 | 13.6 | 2 | 37 | + | .01 |
| U571268 | 8 | 18-24 | 8.1 | 8.7 | .02 | .4 | .3 | 12.6 | 2 | 32 | + | .01 |
| U571269 | 8 | 30-36 | 8.1 | 8.8 | .03 | .4 | .3 | 11.0 | 3 | 32 | ++ | .01 |
| U571270 | 8 | 42-48 | 8.2 | 8.9 | .02 | .4 | .3 | 7.4 | 4 | 32 | ++ | .01 |

[1]Soil samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Laboratory, Logan, Utah.

Table 7. Analyses of soil samples taken from salt basins prior to planting them to reed canarygrass (April 11, 1957)

| Lab. No.[1] | Basin No. | Depth (inches) | Paste | pH 1:5 | Total Soluble Salts % | Sat. Ext. Cond. KXIO$^3$ | Exch. Na Me/100g | Base Exch. Cap. Me/100g | Exch. Na % | Moist at Sat. % | Lime $CaCO_3$ % | Water Soluble Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U571241 | 12 | 0-6 | 8.2 | 8.5 | .03 | .6 | .2 | 14.2 | 1 | 33 | + | .02 |
| U571242 | 12 | 6-12 | 8.2 | 8.4 | .03 | .5 | .3 | 13.7 | 2 | 34 | + | .02 |
| U571243 | 12 | 18-24 | 8.3 | 8.6 | .04 | 1.2 | .2 | 11.7 | 2 | 36 | ++ | .03 |
| U571244 | 12 | 30-36 | 7.7 | 8.3 | .09 | 3.8 | .2 | 8.0 | 3 | 34 | ++ | .03 |
| U571245 | 12 | 42-48 | 7.6 | 8.5 | .16 | 5.2 | .6 | 6.5 | 8 | 32 | ++ | .03 |
| U571226 | 4 | 0-6 | 8.2 | 9.2 | .03 | 1.0 | 1.0 | 14.6 | 7 | 32 | + | .23 |
| U571227 | 4 | 6-12 | 8.5 | 9.4 | .04 | 1.3 | 1.7 | 14.6 | 11 | 32 | + | .36 |
| U571228 | 4 | 18-24 | 8.3 | 9.5 | .08 | 2.3 | 1.7 | 13.5 | 13 | 28 | ++ | .56 |
| U571229 | 4 | 30-36 | 7.4 | 8.2 | 1.2 | 29.7 | .6 | 9.4 | 6 | 35 | ++ | 5.11 |
| U571230 | 4 | 42-48 | 8.2 | 8.8 | 1.1 | 25.2 | .1 | 6.9 | 1 | 33 | ++ | 3.37 |
| U571306 | 18 | 0-6 | 7.9 | 8.6 | .02 | .5 | .2 | 14.0 | 2 | 33 | + | .22 |
| U571307 | 18 | 6-12 | 8.2 | 8.6 | .02 | .5 | .2 | 13.7 | 1 | 32 | + | .02 |
| U571308 | 18 | 18-24 | 8.2 | 8.6 | .04 | .8 | .2 | 10.2 | 2 | 32 | ++ | .02 |
| U571309 | 18 | 30-36 | 8.3 | 8.8 | .03 | .8 | .2 | 7.5 | 2 | 31 | ++ | .03 |
| U571310 | 18 | 42-48 | 8.0 | 8.0 | .04 | 1.2 | .2 | 5.5 | 3 | 29 | ++ | .07 |
| U571211 | 1 | 0-6 | 8.0 | 8.4 | .03 | 1.8 | .2 | 15.0 | 1 | 44 | ++ | .07 |
| U571212 | 1 | 6-12 | 7.8 | 8.5 | .02 | 1.2 | .2 | 14.6 | 1 | 35 | + | .10 |
| U571213 | 1 | 18-24 | 7.7 | 8.6 | .03 | 1.2 | .2 | 15.1 | 1 | 38 | + | .10 |
| U571214 | 1 | 30-36 | 8.0 | 8.6 | .03 | .6 | .2 | 11.5 | 2 | 36 | ++ | .02 |
| U571215 | 1 | 42-48 | 8.3 | 8.6 | .04 | .4 | .2 | 8.0 | 3 | 33 | ++ | .02 |
| U571266 | 8 | 0-6 | 8.0 | 8.6 | .03 | .6 | .3 | 14.4 | 2 | 32 | + | .02 |
| U571267 | 8 | 6-12 | 8.0 | 8.6 | .02 | .5 | .3 | 13.6 | 2 | 37 | + | .01 |
| U571268 | 8 | 18-24 | 8.1 | 8.7 | .03 | .4 | .3 | 12.6 | 2 | 32 | + | .01 |
| U571269 | 8 | 30-36 | 8.1 | 8.8 | .03 | .4 | .3 | 11.0 | 3 | 32 | ++ | .01 |
| U571270 | 8 | 42-48 | 8.2 | 8.9 | .02 | .4 | .3 | 7.4 | 4 | 32 | ++ | .01 |

[1]Soil samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. - Cooperative Soils Laboratory, Logan, Utah

Table 8. Analyses of soil samples taken from salt basins prior to planting them to alfalfa (April 11, 1957)

| Lab. No.[1] | Basin No. | Depth (inches) | pH Paste | pH 1:5 | Total Soluble Salts % | Sat. Ext. Cond. $KX10^3$ | Exch. Na Me/100g | Base Exch. Cap. Me/100g | Exch. Na % | Moist at Sat. % | Lime $CaCO_3$ % | Water Soluble Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U571241 | 11 | 0-6 | 8.2 | 8.5 | .03 | .6 | .2 | 14.2 | 1 | 33 | + | .02 |
| U571242 | 11 | 6-12 | 8.2 | 8.4 | .03 | .5 | .3 | 13.7 | 2 | 34 | + | .02 |
| U571243 | 11 | 18-24 | 8.3 | 8.6 | .04 | 1.2 | .2 | 11.7 | 2 | 36 | ++ | .03 |
| U571244 | 11 | 30-36 | 7.7 | 8.3 | .09 | 3.8 | .2 | 8.0 | 3 | 34 | ++ | .03 |
| U571245 | 11 | 42-48 | 7.6 | 8.5 | .16 | 5.2 | .6 | 6.5 | 8 | 32 | ++ | .03 |
| U571246 | 10 | 0-6 | 8.0 | 8.6 | .02 | .7 | .3 | 14.5 | 2 | 33 | ++ | .04 |
| U571247 | 10 | 6-12 | 8.1 | 8.8 | .02 | .6 | .7 | 14.3 | 5 | 32 | ++ | .11 |
| U571248 | 10 | 18-24 | 8.3 | 9.5 | .02 | .8 | .0 | 12.8 | 0 | 30 | ++ | .20 |
| U571249 | 10 | 30-36 | 8.9 | 9.6 | .03 | .8 | 1.4 | 7.9 | 18 | 28 | ++ | .19 |
| U571250 | 10 | 42-48 | 8.4 | 9.4 | .03 | 1.0 | 1.1 | 5.7 | 20 | 27 | ++ | .22 |
| U571306 | 19 | 0-6 | 7.9 | 8.6 | .02 | .5 | .2 | 14.0 | 2 | 33 | + | .22 |
| U571307 | 19 | 6-12 | 8.2 | 8.6 | .02 | .5 | .2 | 13.7 | 1 | 32 | + | .02 |
| U571308 | 19 | 18-24 | 8.2 | 8.6 | .04 | .8 | .2 | 10.2 | 2 | 32 | ++ | .02 |
| U571309 | 19 | 30-36 | 8.3 | 8.8 | .03 | ..8 | .2 | 7.5 | 2 | 31 | ++ | .03 |
| U571310 | 19 | 42-48 | 8.0 | 8.0 | .04 | 1.2 | .2 | 5.5 | 3 | 29 | ++ | .07 |
| U571231 | 5 | 0-6 | 7.6 | 8.2 | .04 | 1.2 | .7 | 14.6 | 5 | 31 | + | .22 |
| U571232 | 5 | 6-12 | 8.3 | 9.1 | .04 | 1.1 | 1.0 | 14.4 | 7 | 31 | + | .27 |
| U571233 | 5 | 18-24 | 8.3 | 9.3 | .04 | 1.0 | 1.5 | 13.4 | 11 | 32 | ++ | .26 |
| U571234 | 5 | 30-36 | 8.4 | 9.5 | .04 | .9 | 1.2 | 8.3 | 14 | 27 | ++ | .24 |
| U571235 | 5 | 42-48 | 7.9 | 9.0 | .19 | 5.5 | .7 | 6.1 | 12 | 29 | ++ | 1.18 |
| U571261 | 9 | 0-6 | 8.2 | 8.6 | .02 | 1.3 | 4.9 | 14.6 | 33 | 32 | + | .10 |
| U571262 | 9 | 6-12 | 8.2 | 9.0 | .03 | .6 | 1.2 | 14.6 | 8 | 28 | + | .17 |
| U571263 | 9. | 18-24 | 8.1 | 9.1 | .03 | 1.0 | 1.5 | 13.5 | 11 | 30 | ++ | .24 |
| U571264 | 9 | 30-36 | 8.4 | 9.1 | .03 | .9 | 1.1 | 9.9 | 12 | 28 | ++ | .19 |
| U571265 | 9 | 42-48 | 8.0 | 8.9 | .09 | 1.8 | .6 | 5.7 | 11 | 29 | ++ | .35 |

[1]Soil samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Cooperative Soils Laboratory, Logan, Utah

Table 9. Analyses of soil samples taken from salt basins prior to planting them to strawberry clover (April 11, 1957)

| Lab. No.[1] | Basin No. | Depth (inches) | pH Paste | pH 1:5 | Total Soluble Salts % | Sat. Ext. Cond. KXIO$^3$ | Exch. Na Me/100g | Base Exch. Cap. Me/100g | Exch. Na % | Moist at Sat. % | Lime $CaCO_3$ % | Water Soluble Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U571301 | 17 | 0-6 | 8.0 | 8.5 | .02 | 1.0 | .3 | 14.2 | 2 | 29 | + | .02 |
| U571302 | 17 | 6-12 | 8.0 | 8.4 | .02 | .6 | .2 | 13.2 | 2 | 34 | + | .03 |
| U571303 | 17 | 18-24 | 8.1 | 8.6 | .02 | .4 | .2 | 10.4 | 1 | 30 | + | .06 |
| U571304 | 17 | 30-36 | 8.2 | 8.6 | .02 | .6 | .1 | 6.9 | 2 | 29 | ++ | .06 |
| U571305 | 17 | 42-48 | 8.5 | 8.9 | .02 | .4 | .2 | 5.7 | 3 | 28 | ++ | .04 |
| U571236 | 7 | 0-6 | 8.0 | 8.6 | .02 | .9 | .3 | 14.5 | 2 | 34 | + | .04 |
| U571237 | 7 | 6-12 | 8.0 | 8.7 | .02 | .5 | .2 | 14.3 | 1 | 36 | + | .02 |
| U571238 | 7 | 18-24 | 7.8 | 8.5 | .04 | .8 | .4 | 12.6 | 3 | 35 | ++ | .03 |
| U571239 | 7 | 30-36 | 7.8 | 8.6 | .04 | 1.2 | .2 | 8.5 | 2 | 30 | ++ | .05 |
| U571240 | 7 | 42-48 | 7.9 | 8.6 | .04 | 1.2 | .3 | 6.2 | 4 | 30 | ++ | .02 |
| U571296 | 16 | 0-6 | 8.2 | 8.9 | .02 | 1.0 | .9 | 13.8 | 7 | 30 | + | .18 |
| U571297 | 16 | 6-12 | 8.5 | 9.4 | .03 | 1.0 | 1.7 | 13.0 | 13 | 28 | + | .24 |
| U571298 | 16 | 18-24 | 8.5 | 9.5 | .04 | .8 | 1.9 | 10.2 | 19 | 28 | ++ | .04 |
| U571299 | 16 | 30-36 | 8.6 | 9.3 | .03 | .8 | 1.3 | 7.1 | 18 | 32 | ++ | .02 |
| U571300 | 16 | 42-48 | 7.9 | 8.9 | .09 | .6 | 1.3 | 5.3 | 24 | 26 | ++ | .01 |
| U571216 | 2 | 0-6 | 8.2 | 8.5 | .02 | .4 | .3 | 15.3 | 2 | 39 | ++ | .04 |
| U571217 | 2 | 6-12 | 8.3 | 8.8 | .02 | .5 | .8 | 13.0 | 6 | 35 | ++ | .14 |
| U571218 | 2 | 18-24 | 8.1 | 9.0 | .03 | .6 | 1.3 | 14.6 | 9 | 30 | ++ | .14 |
| U571219 | 2 | 30-36 | 8.3 | 9.0 | .02 | .6 | 1.1 | 9.8 | 11 | 30 | ++ | .02 |
| U571220 | 2 | 42-48 | 8.2 | 9.1 | .02 | .9 | .5 | 7.2 | 7 | 28 | ++ | .19 |
| U571291 | 15 | 0-6 | 7.8 | 8.7 | .03 | 1.1 | 1.0 | 13.1 | 8 | 35 | + | .02 |
| U571292 | 15 | 6-12 | 8.2 | 9.1 | .04 | .8 | 1.3 | 13.1 | 10 | 34 | + | .24 |
| U571293 | 15 | 18-24 | 8.4 | 9.4 | .04 | 1.1 | 1.7 | 11.2 | 15 | 30 | ++ | .29 |
| U571294 | 15 | 30-36 | 8.4 | 9.4 | .04 | 1.1 | 1.3 | 8.2 | 16 | 28 | ++ | .24 |
| U571295 | 15 | 42-48 | 8.7 | 9.4 | .03 | .9 | 1.2 | 6.3 | 19 | 27 | ++ | .19 |

[1] Soil samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Cooperative Soils Laboratory, Logan, Utah

After the basins were tilled and leveled, ammonium nitrate and treble superphosphate were added at the rates of 100 pounds per acre of N and 130 pounds per acre of $P_2O_5$.

The basins were planted in a randomized block design with paired plants of each selection, strain, and/or variety of a species replicated 4 times in each basin. The rows were 12 inches apart and the plants spaced 6 inches apart within each row. In each of the 5 experiments, 1 basin was used for the control and 2 basins were used for each of the other 2 treatments.

The salinization treatments consisted of equal parts of sodium chloride and calcium chloride added in prescribed amounts to the irrigation water. The grasses were artificially salinized with irrigation water containing 0, 12,000, and 24,000 ppm respectively of added salt and the legumes were artificially salinized with irrigation water containing 0, 8,000, and 16,000 ppm of added salt.

Soil samples were taken at the 0-6 inch depth randomly within each basin twice during the growing season to determine the approximate ppm of total salts in the soil. These samples were analyzed using a conductivity bridge.

Most of the species were harvested when fully mature; however, some of them did not mature and were, therefore, harvested at the end of the growing season. Yield data were taken on the air dry forage.

Samples of dried plant material were saved from tall wheatgrass, reed canarygrass, and alfalfa. Two selections, strains, and/or varieties from each species were analyzed. Sodium, calcium, and potassium were determined by the methods employed by the United States Salinity Laboratory (1954) after wet digestion of the dried plant material with nitric and perchloric acids.

Duncan's (1955) Multiple Range test was used to test the significant differences between selections, strains, and/or varieties. This test is based on the fact that the difference for significance between means varies with the number of means in the comparison. As means further apart in rank are compared, the difference required for significance increases. Any 2 means which are found in the same range have no significant difference between them. However, a significant difference does exist between those means which are not found within the least significant range.

Experiment 1. Salt tolerance of tall wheatgrass selections

Procedure and results. Salt tolerance studies were conducted using the following 39 selections of tall wheatgrass:

| | | |
|---|---|---|
| 1. | Utah | 2 |
| 2. | Utah | 2-6 |
| 3. | Utah | 2-13 |
| 4. | Utah | 4 |
| 5. | Utah | 4-6 |
| 6. | Utah | 4-12 |
| 7. | Utah | 6-6 |
| 8. | Utah | 6-12 |
| 9. | Utah | 8 |
| 10. | Utah | 8-6 |
| 11. | Utah | 8-13 |
| 12. | Utah | 10 |
| 13. | Utah | 10-6 |
| 14. | Utah | 10-12 |
| 15. | Utah | 12-6 |
| 16. | Utah | 12-12 |
| 17. | Utah | 14 |
| 18. | Utah | 14-7 |
| 19. | Utah | 14-13 |
| 20. | Utah | 16 |
| 21. | Utah | 16-6 |
| 22. | Utah | 16-13 |
| 23. | Utah | 18 |
| 24. | Utah | 18-7 |
| 25. | Utah | 18-13 |
| 26. | Utah | 20 |
| 27. | Utah | 20-6 |
| 28. | Utah | 20-13 |
| 29. | Utah | 22 |
| 30. | Utah | 22-6 |
| 31. | Utah | 22-12 |
| 32. | Utah | 24 |
| 33. | Utah | 24-5 |
| 34. | Utah | 24-10 |
| 35. | Utah | 26 |
| 36. | Utah | 26-12 |
| 37. | Utah | 28 |
| 38. | Utah | 28-5 |
| 39. | Utah | 28-10 |

The above selections were started in the greenhouse on March 9, 1957. On May 16th, uniform seedlings were transplanted into one 14 x 14 ft. field basin. However, due to 2 weeks of rainy weather, the planting of the other 4 basins was delayed until the 29th of May.

On July 4th the plants appeared to be well established and growing vigorously. They were clipped on this date in order to have uniform plants when salinization treatments were initiated the following day. The mixing tanks are shown in Figure 3. The amounts and concentrations of the salinized irrigation water applied during the growing season are given in Table 10A. The effect of this added salt is shown in Figures 4,5, and 6.

Total salts (ppm) in the soil were determined for each of the tall wheatgrass basins from soil samples taken on July 29th and September 3rd. The results are given in Table 10B.

On September 25th all the plants were harvested. About half of them had headed by this time. Yield results are given in the Table 10C. The Multiple Range test of the ranked means of the yields of the selections on the control basin is given in Table 10D. A comparative test of ranked means of the yield of selections on the basins salinized with 12,000 and 24,000 ppm added salt is presented in Tables 10E and 10F.

Observations on survival were made on October 11, 1957. The percent of the plants surviving is given in Table 10G.

The cation content of the plant material from the 2 selections Utah 6-6 and Utah 8-6 is given in Table 10H.

Observations. The plants on the salinized basins were smaller and the leaves tough, brittle, and non-pliable.

Most of the plants died at the highest salinity level. Those surviving showed signs of necrosis on the tips of the leaves.

The plants on the salinized basins headed a few days earlier than those on the non-salinized.

Utah 28-10 selection produced the highest mean yield on the non-salinized basin but did not show significance from 24 other selections. Selection Utah 10 had the smallest mean yield.

The 2 basins salinized with irrigation water containing 12,000 ppm added salt were analyzed separately because of the different planting dates. Ranked means from the basin planted 2 weeks early indicated that Utah 2 selection produced the highest mean yield. Utah 12-12 selection had the lowest mean yield.

Ranked means of the yield of tall wheatgrass selections receiving salinization treatments of irrigation water containing 24,000 ppm salt showed that Utah 6-12 yielded significantly more when compared to the other 19 selections which survived the treatment. Utah 12-12 selection had the lowest mean yield of the survivors.

Sodium and calcium content of the leaves of Utah 6-6 and Utah 8-6 increased as sodium and calcium in the irrigation water were increased. However, the potassium content in Utah 6-6 decreased as sodium and calcium in the irrigation water were increased.

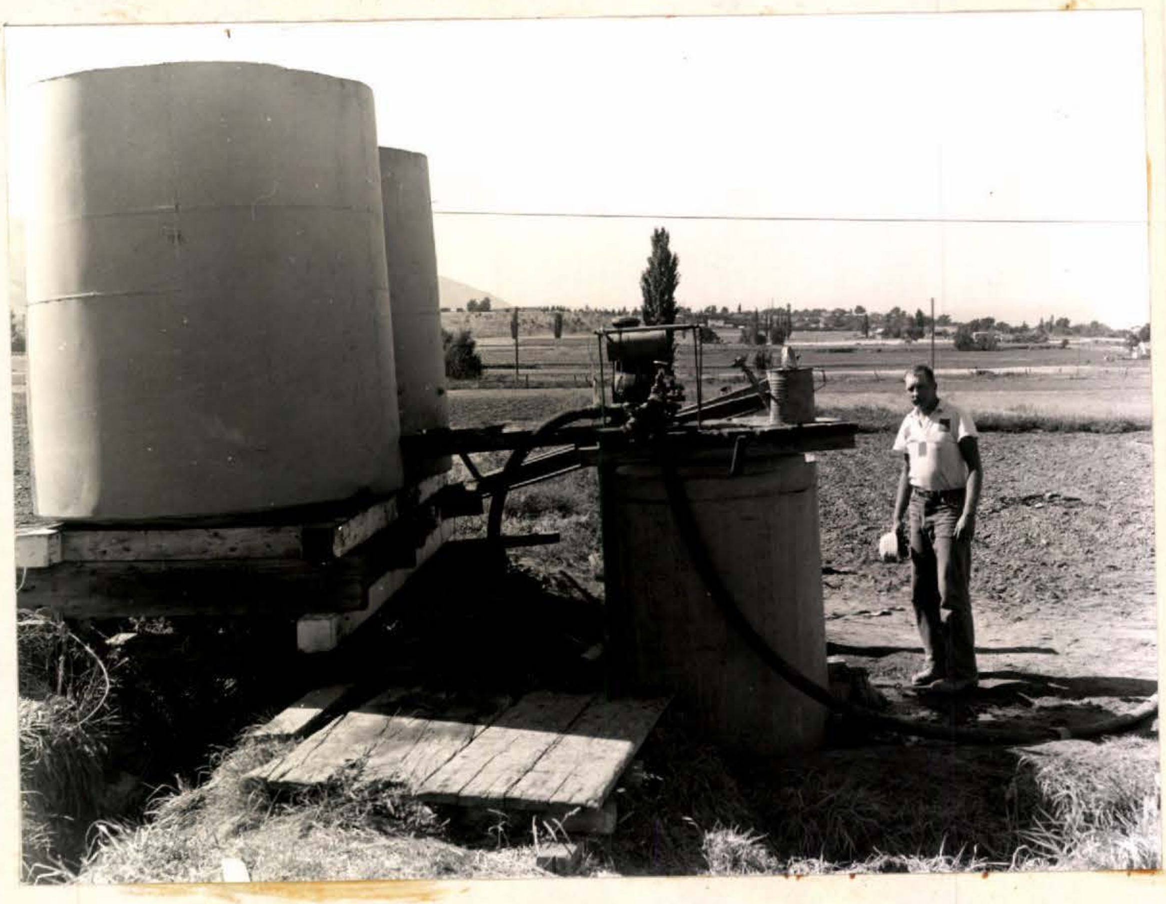

Figure 3. Salt mixing tanks. The 2 large metal tanks on the left were used for water storage. Water was pumped into them from the ditch. Water flowed by gravity to the smaller tanks where prescribed amounts of salt were added and mixed manually. The salinized irrigation water flowed by gravity or was pumped to the basins.

Table 10A. Salinizing treatments on basins containing tall wheatgrass

| Date | Amount of Water (inches) | Concentration of salt added (ppm) to the irrigation water (one-half $N_aCl$ - one-half $CaCl_2$) Basin 1 | Basin 2 | Basin 3 | Basin 4 | Basin 5 |
|---|---|---|---|---|---|---|
| July 5 | 4.0 | 0 | 2,500 | 2,500 | 2,500 | 2,500 |
| July 12 | 4.0 | 0 | 6,000 | 6,000 | 12,000 | 12,000 |
| July 18 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| July 26 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 2-3 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 12 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 21 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 29 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Sept. 9 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Sept. 18 | 6.0 | 0 | 0 | 0 | 0 | 0 |

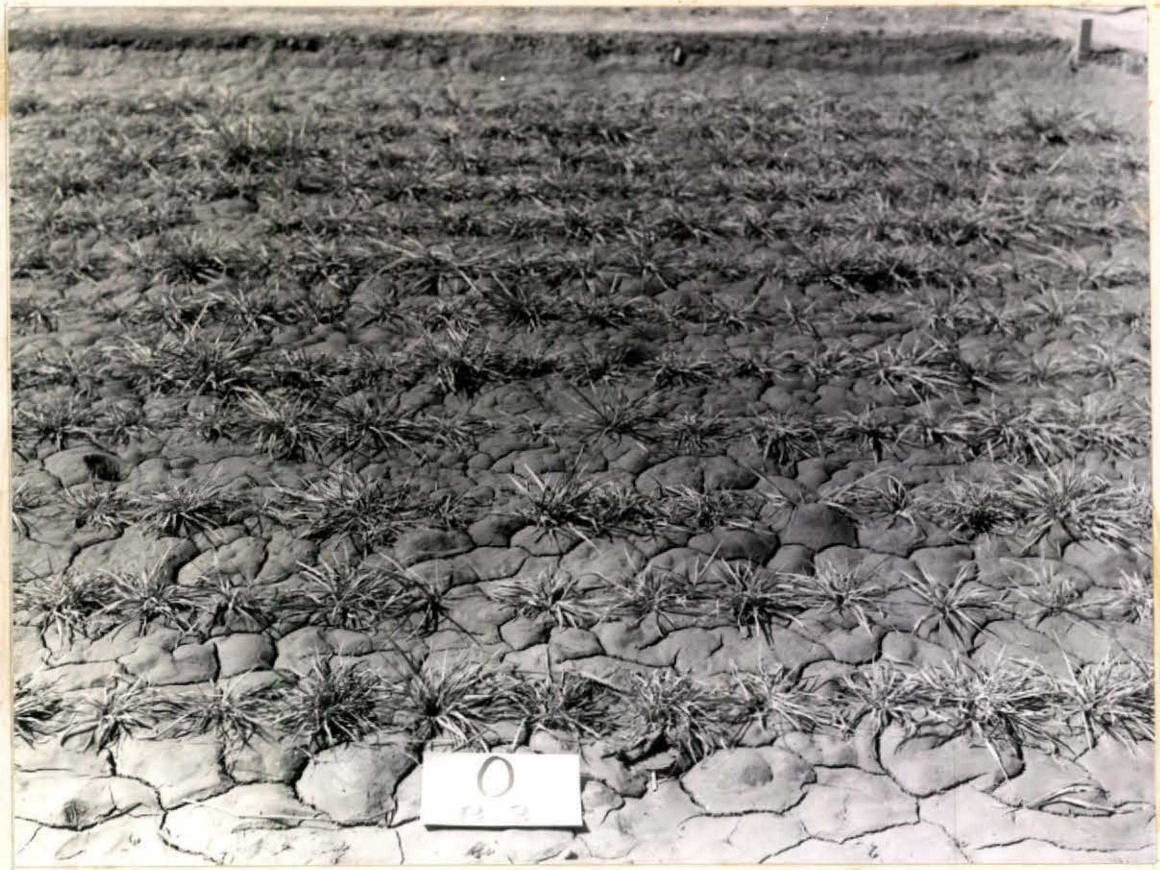

Figure 4. Tall wheatgrass on the non-salinized basin.
(August 1, 1957)


Figure 5. Tall wheatgrass on a basin salinized with irrigation water containing 12,000 ppm added salt. (August 1, 1957)


Figure 6. Tall wheatgrass on a basin salinized with irrigation water containing 24,000 ppm added salt. (August 1, 1957)

Table 10B. Total salts in the soil determined by a conductivity bridge on salinized basins of tall wheatgrass

| Salt added (ppm) to irrigation water ($NaCl$ and $CaCl_2$) | Approximate ppm total salts | | Average |
|---|---|---|---|
| | July 29 | September 3 | |
| 0 | 258 | 264 | 261 |
| 12,000 | 4,480 | 6,397 | 5,439 |
| 12,000 | 6,566 | 6,014 | 6,285 |
| 24,000 | 16,177 | 17,980 | 17,079 |
| 24,000 | 17,864 | 17,048 | 17,456 |

Table 10C. Comparative total yields of air dry forage of tall wheatgrass on salinized plots (Yields are recorded in grams per basin)

| Selection | | Control[1] | 12,000 ppm[2] | | 24,000 ppm[3] |
|---|---|---|---|---|---|
| Utah | 2 | 144 | 133 | 10 | 4 |
| Utah | 2-6 | 134 | 63 | 7 | 0 |
| Utah | 2-13 | 144 | 60 | 11 | 0 |
| Utah | 4 | 184 | 42 | 10 | 3 |
| Utah | 4-6 | 135 | 53 | 11 | 2 |
| Utah | 4-12 | 150 | 64 | 13 | 0 |
| Utah | 6-6 | 176 | 79 | 16 | 0 |
| Utah | 6-12 | 166 | 77 | 21 | 15 |
| Utah | 8 | 179 | 116 | 16 | 0 |
| Utah | 8-6 | 144 | 52 | 12 | 4 |
| Utah | 8-13 | 117 | 82 | 13 | 3 |
| Utah | 10 | 76 | 92 | 13 | 0 |
| Utah | 10-6 | 108 | 76 | 18 | 4 |
| Utah | 10-12 | 101 | 75 | 13 | 2 |
| Utah | 12-6 | 82 | 59 | 13 | 0 |
| Utah | 12-12 | 84 | 30 | 4 | 1 |
| Utah | 14 | 155 | 88 | 28 | 2 |
| Utah | 14-7 | 135 | 107 | 23 | 4 |
| Utah | 14-13 | 110 | 78 | 8 | 0 |
| Utah | 16 | 116 | 52 | 13 | 0 |
| Utah | 16-6 | 98 | 56 | 16 | 0 |
| Utah | 16-13 | 127 | 64 | 4 | 0 |
| Utah | 18 | 101 | 34 | 11 | 0 |
| Utah | 18-7 | 92 | 51 | 5 | 0 |
| Utah | 18-13 | 131 | 54 | 20 | 2 |
| Utah | 20 | 161 | 48 | 7 | 1 |
| Utah | 20-6 | 90 | 52 | 12 | 0 |
| Utah | 20-13 | 96 | 48 | 7 | 2 |
| Utah | 22 | 129 | 101 | 11 | 1 |
| Utah | 22-6 | 105 | 58 | 7 | 0 |
| Utah | 22-12 | 126 | 74 | 12 | 2 |
| Utah | 24 | 101 | 51 | 6 | 0 |
| Utah | 24-5 | 121 | 68 | 7 | 0 |
| Utah | 24-10 | 117 | 56 | 12 | 0 |
| Utah | 26 | 80 | 43 | 14 | 6 |
| Utah | 26-12 | 117 | 30 | 4 | 1 |
| Utah | 28 | 139 | 94 | 6 | 0 |
| Utah | 28-5 | 149 | 85 | 16 | 6 |
| Utah | 28-10 | 199 | 65 | 10 | 2 |

[1] Figures represent yield from one basin only.

[2] First column figures represent the yield from the basin planted 2 weeks early. Second column figures represent the yeild from the basin planted at the same time as the other basins.

[3] Figures represent yield from two basins.

Table 10C. (Continued)

| | Control | 12,000 ppm | | 24,000 ppm |
|---|---|---|---|---|
| Mean | 126.13 | 66.92 | 11.79 | 1.72 |
| F value for selection | 1.59* | 2.54** | 1.42 | 2.55** |
| $S\bar{X}$ | 6.09 | 3.61 | .11 | .22 |
| C. V. percent | 9.65 | 10.83 | 19.08 | 35.83 |

*Significant at .05 level

**Significant at .01 level

Table 10D. Ranked means of the yield of tall wheatgrass from the control basin

| Selection | Means | *Least significant ranges at the 5 percent level (Duncan's Multiple Range test) | | | | | |
|---|---|---|---|---|---|---|---|
| Utah 28-10 | 49.75 | x | | | | | |
| Utah 4 | 46.00 | x | x | | | | |
| Utah 8 | 44.76 | x | x | x | | | |
| Utah 6-6 | 44.00 | x | x | x | x | | |
| Utah 6-12 | 41.50 | x | x | x | x | x | |
| Utah 20 | 40.26 | x | x | x | x | x | x |
| Utah 14 | 38.76 | x | x | x | x | x | x |
| Utah 4-12 | 37.50 | x | x | x | x | x | x |
| Utah 28-5 | 37.26 | x | x | x | x | x | x |
| Utah 2 | 36.00 | x | x | x | x | x | x |
| Utah 2-12 | 36.00 | x | x | x | x | x | x |
| Utah 8-6 | 36.00 | x | x | x | x | x | x |
| Utah 28 | 34.74 | x | x | x | x | x | x |
| Utah 4-6 | 33.74 | x | x | x | x | x | x |
| Utah 14-7 | 33.74 | x | x | x | x | x | x |
| Utah 2-6 | 33.36 | x | x | x | x | x | x |
| Utah 18-13 | 32.76 | x | x | x | x | x | x |
| Utah 22 | 32.26 | x | x | x | x | x | x |
| Utah 16-13 | 31.76 | x | x | x | x | x | x |
| Utah 22-12 | 31.50 | x | x | x | x | x | x |
| Utah 24-5 | 30.26 | x | x | x | x | x | x |
| Utah 8-13 | 29.26 | x | x | x | x | x | x |
| Utah 24.10 | 29.26 | x | x | x | x | x | x |
| Utah 26-12 | 29.26 | x | x | x | x | x | x |
| Utah 16 | 29.00 | x | x | x | x | x | x |
| Utah 14-13 | 27.50 | | x | x | x | x | x |
| Utah 10-6 | 27.00 | | x | x | x | x | x |
| Utah 22-6 | 26.26 | | x | x | x | x | x |
| Utah 10-12 | 25.26 | | x | x | x | x | x |
| Utah 18 | 25.26 | | x | x | x | x | x |
| Utah 24 | 25.26 | | | x | x | x | x |
| Utah 16-6 | 24.50 | | | x | x | x | x |
| Utah 20-13 | 24.00 | | | x | x | x | x |
| Utah 18-13 | 23.00 | | | x | x | x | x |
| Utah 20-6 | 22.50 | | | | x | x | x |
| Utah 12-12 | 21.00 | | | | x | x | x |
| Utah 12-6 | 20.50 | | | | x | x | x |
| Utah 26 | 20.00 | | | | | x | x |
| Utah 10 | 10.00 | | | | | | x |

* A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Table 10E. Ranked means of the yield of tall wheatgrass receiving 12,000 ppm salt

| Selection | | Means[1] | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | | |
|---|---|---|---|---|---|---|
| Utah | 2 | 33.25 | │ | | | |
| Utah | 8 | 29.00 | │ | │ | | |
| Utah | 14-7 | 26.75 | │ | │ | │ | |
| Utah | 22 | 25.25 | │ | │ | │ | |
| Utah | 28 | 23.50 | │ | │ | │ | │ |
| Utah | 10 | 23.00 | │ | │ | │ | │ |
| Utah | 14 | 22.00 | │ | │ | │ | │ |
| Utah | 28-5 | 21.25 | │ | │ | │ | │ |
| Utah | 8-12 | 20.50 | │ | │ | │ | │ |
| Utah | 6-6 | 19.75 | │ | │ | │ | │ |
| Utah | 14-13 | 19.50 | │ | │ | │ | │ |
| Utah | 6-12 | 19.25 | │ | │ | │ | │ |
| Utah | 10-6 | 19.00 | │ | │ | │ | │ |
| Utah | 10-12 | 18.75 | │ | │ | │ | │ |
| Utah | 22-12 | 18.50 | │ | │ | │ | │ |
| Utah | 14-7 | 17.00 | │ | │ | │ | │ |
| Utah | 28-10 | 16.25 | | │ | │ | │ |
| Utah | 6-6 | 16.00 | | │ | │ | │ |
| Utah | 16-13 | 16.00 | | │ | │ | │ |
| Utah | 2-6 | 15.75 | | │ | │ | │ |
| Utah | 2-13 | 15.00 | | │ | │ | │ |
| Utah | 12-6 | 14.75 | | │ | │ | │ |
| Utah | 22-6 | 14.50 | | │ | │ | │ |
| Utah | 16-6 | 14.00 | | │ | │ | │ |
| Utah | 24-10 | 14.00 | | │ | │ | │ |
| Utah | 18-13 | 13.50 | | │ | │ | │ |
| Utah | 4-6 | 13.25 | | │ | │ | │ |
| Utah | 8-6 | 13.00 | | │ | │ | │ |
| Utah | 16 | 13.00 | | │ | │ | │ |
| Utah | 20-6 | 13.00 | | │ | │ | │ |
| Utah | 18-7 | 12.75 | | │ | │ | │ |
| Utah | 24 | 12.75 | | │ | │ | │ |
| Utah | 20 | 12.00 | | | │ | │ |
| Utah | 20-13 | 12.00 | | | │ | │ |
| Utah | 26 | 10.75 | | | │ | │ |
| Utah | 4 | 10.50 | | | │ | │ |
| Utah | 18 | 8.50 | | | | │ |
| Utah | 26-12 | 7.50 | | | | │ |
| Utah | 12-12 | 7.50 | | | | │ |

* A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

[1] Ranked means from the basin planted 2 weeks early.

Table 10F. Ranked means of the yield of tall wheatgrass receiving 24,000 ppm salt

| Selection | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) |
|---|---|---|
| Utah 6-12 | 1.88 | |
| Utah 26 | .75 | |
| Utah 28-5 | .75 | |
| Utah 2 | .50 | |
| Utah 8-6 | .50 | |
| Utah 10-6 | .50 | |
| Utah 14-7 | .50 | |
| Utah 4 | .38 | |
| Utah 8-13 | .38 | |
| Utah 4-6 | .25 | |
| Utah 10-12 | .25 | |
| Utah 14 | .25 | |
| Utah 18-13 | .25 | |
| Utah 20-13 | .25 | |
| Utah 22-12 | .25 | |
| Utah 28-10 | .25 | |
| Utah 20 | .13 | |
| Utah 22 | .13 | |
| Utah 26-12 | .13 | |
| Utah 12-12 | .13 | |

* A significant difference exists between any 2 means which are not found within the same range. There is no significant difference between any 2 means within the same range

Table 10G. Percent survival of plants within tall wheatgrass selections (October 11, 1957)

| Selection | | Control | 12,000 ppm[1] | | 24,000 ppm |
|---|---|---|---|---|---|
| Utah | 2 | 100 | 100 | 87 | 18 |
| Utah | 2-6 | 100 | 100 | 87 | 6 |
| Utah | 2-13 | 100 | 100 | 75 | 0 |
| Utah | 4 | 100 | 87 | 75 | 18 |
| Utah | 4-6 | 100 | 100 | 100 | 18 |
| Utah | 4-12 | 100 | 100 | 87 | 12 |
| Utah | 6-6 | 100 | 100 | 100 | 18 |
| Utah | 6-12 | 100 | 100 | 75 | 43 |
| Utah | 8 | 100 | 100 | 100 | 0 |
| Utah | 8-6 | 100 | 100 | 62 | 6 |
| Utah | 8-13 | 100 | 100 | 75 | 18 |
| Utah | 10 | 100 | 100 | 75 | 0 |
| Utah | 10-6 | 100 | 100 | 87 | 31 |
| Utah | 10-12 | 100 | 100 | 87 | 0 |
| Utah | 12-6 | 100 | 100 | 75 | 0 |
| Utah | 12-12 | 100 | 75 | 37 | 12 |
| Utah | 14 | 100 | 100 | 87 | 12 |
| Utah | 14-7 | 100 | 100 | 75 | 18 |
| Utah | 14-13 | 100 | 100 | 87 | 18 |
| Utah | 16 | 100 | 100 | 62 | 6 |
| Utah | 16-6 | 100 | 100 | 87 | 6 |
| Utah | 16-13 | 100 | 100 | 75 | 0 |
| Utah | 18 | 100 | 100 | 100 | 0 |
| Utah | 18-7 | 100 | 100 | 50 | 0 |
| Utah | 18-13 | 100 | 100 | 100 | 0 |
| Utah | 20 | 100 | 100 | 62 | 0 |
| Utah | 20-6 | 100 | 100 | 100 | 18 |
| Utah | 20-13 | 100 | 100 | 87 | 6 |
| Utah | 22 | 100 | 87 | 100 | 0 |
| Utah | 22-6 | 100 | 100 | 12 | 0 |
| Utah | 22-12 | 100 | 100 | 62 | 12 |
| Utah | 24 | 100 | 100 | 87 | 0 |
| Utah | 24-5 | 100 | 100 | 50 | 0 |
| Utah | 24-10 | 100 | 100 | 62 | 0 |
| Utah | 26 | 87 | 100 | 87 | 25 |
| Utah | 26-12 | 100 | 100 | 75 | 12 |
| Utah | 28 | 100 | 100 | 50 | 6 |
| Utah | 28-5 | 100 | 100 | 87 | 31 |
| Utah | 28-10 | 100 | 100 | 87 | 6 |

[1]First column figures represent the basin planted 2 weeks early. Second column figures represent the basin planted at the same time as the other basins.

Table 10H. Cation content of plant material from 2 selections of tall wheatgrass

| Salt added to irrigation water (ppm) | Lab. No.[1] | Selection | Me/100 gm. dry matter | | |
|---|---|---|---|---|---|
| | | | Na | Ca | K |
| 0 | U573853 | Utah 6-6 | 16.0 | 12.9 | 72 |
| 12,000 | U573855 | | 18.2 | 35.0 | 65 |
| 12,000 | U573857 | | 24.5 | 39.6 | 64 |
| 24,000 | U573859 | | 33.2 | 39.6 | 63 |
| 0 | U573854 | Utah 8-6 | 15.0 | 21.1 | 65 |
| 12,000 | U573856 | | 15.6 | 32.2 | 79 |
| 12,000 | U573858 | | 18.7 | 36.8 | 63 |

[1]Plant samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Cooperative Soils Laboratory, Logan, Utah.

Utah 6-12 selection demonstrated remarkably good ability to survive at the highest salinization treatment.

Experiment 2. Salt tolerance of Canada wild-rye grass selections

Procedure and results. Salt tolerance studies were conducted using the following selections of Canada wild-rye grass:

1. Utah 1
2. Utah 2
3. Utah 10
4. Utah 11
5. Utah 12
6. Utah 13
7. Utah 14
8. Utah 15
9. Utah 16
10. Utah 17
11. Utah 18
12. Utah 19

The above named selections were started in the greenhouse and uniform seedlings were transplanted to 5 basins which also were used for the salt tolerance studies of reed canarygrass. The transplanting was completed on May 30, 1957.

On July 4th the plants were clipped in order that they would be as near uniform as possible. The salinization treatments began the next day with the amounts and concentrations of the irrigation water given in Table 11A. The effect of this added salt is shown in Figures 7, 8, and 9.

The total salts (ppm) in each basin were determined on July 29th and September 3rd. The results are presented in Table 11B.

The selections of Canada wild-rye grass were harvested on August 28th. At this time, the grass had matured and was well headed. This grass was the earliest maturing of the 3 grasses tested. Yields of the air dry forage are presented in Table 11C. The Multiple Range test of the ranked means of the yield of the selections on the control basin is given in Table 11D. A comparative test of ranked means of the yields of selections in the basins salinized with 12,000 ppm added salt is presented in Table 11E.

Table 11A. Salinization treatments on basins containing Canada wild-rye grass

| Date | Amount of Water (inches) | Concentration of salt added (ppm) to the irrigation water (one-half NaCl - one-half $CaCl_2$) | | | | |
|---|---|---|---|---|---|---|
| | | Basin 1 | Basin 2 | Basin 3 | Basin 4 | Basin 5 |
| July 5 | 4.0 | 0 | 2,500 | 2,500 | 2,500 | 2,500 |
| July 12 | 4.0 | 0 | 6,000 | 6,000 | 12,000 | 12,000 |
| July 18 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| July 26 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 2 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 12 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 21 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. 29 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Sept. 9 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Sept. 18 | 6.0 | 0 | 0 | 0 | 0 | 0 |


Figure 7. Canada wild-rye grass and reed canarygrass on the non-salinized basin. (August 1, 1957)

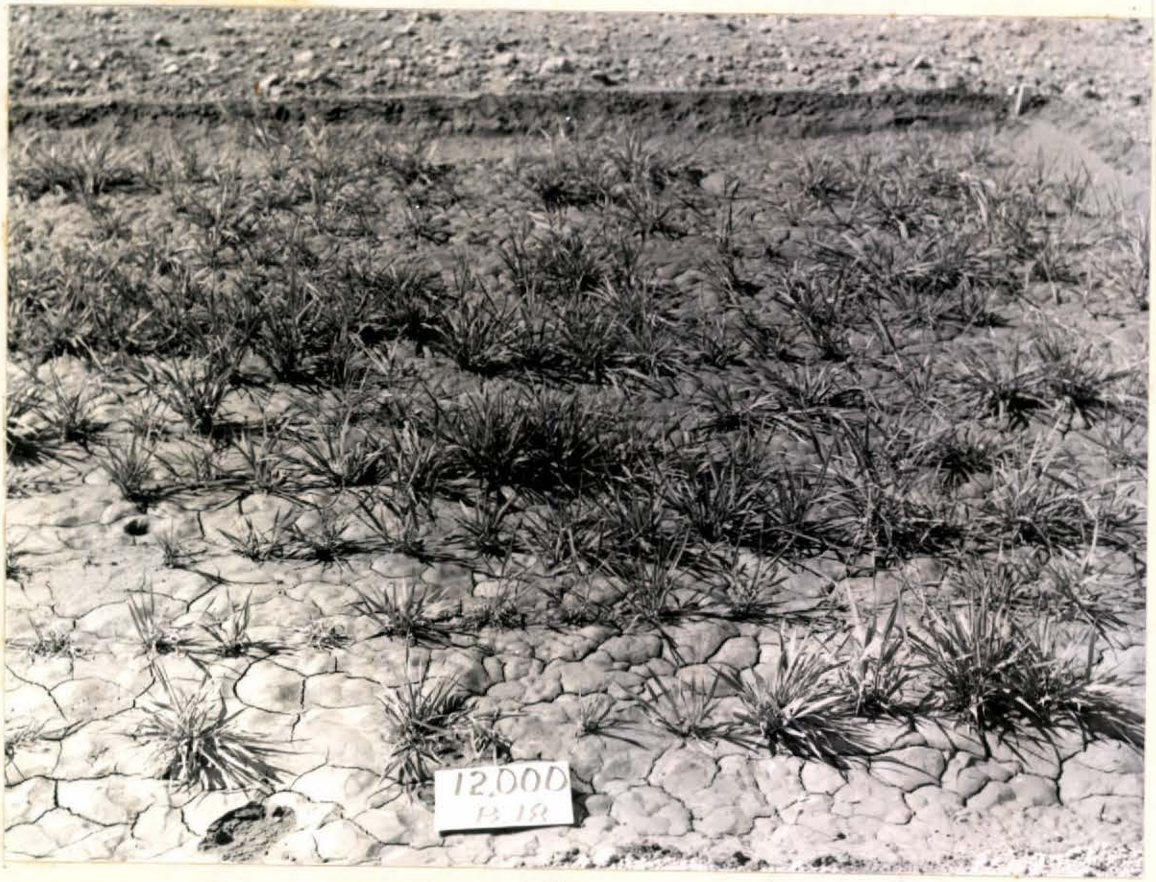


Figure 8. Canada wild-rye grass and reed canarygrass on a basin salinized with irrigation water containing 12,000 ppm added salt. (August 1, 1957)


Figure 9. Canada wild-rye grass and reed canarygrass on a basin salinized with irrigation water containing 24,000 ppm added salt. (August 1, 1957)

Table 11B. Total salts in the soil as determined by a conductivity bridge on salinized basins of Canada wild-rye grass

| Salt added (ppm) to irrigation water ($NaCl$ and $CaCl_2$) | Approximate ppm total salts | | Average |
|---|---|---|---|
| | July 29 | September 3 | |
| 0 | 360 | 264 | 302 |
| 12,000 | 5,219 | 6,914 | 6,066 |
| 12,000 | 4,761 | 5,716 | 5,239 |
| 24,000 | 18,459 | 14,760 | 16,609 |
| 24,000 | 20,641 | 17,048 | 18,844 |

Table 11C. Comparative total yields of air dry forage of Canada wild-rye grass on salinized basins (Yields are recorded in grams per basin)

| Selection | Control[1] | 12,000 ppm[2] | 24,000ppm[2] |
|---|---|---|---|
| Utah 1 | 17 | 13 | 0 |
| Utah 2 | 72 | 25 | 2 |
| Utah 10 | 140 | 85 | 6 |
| Utah 11 | 107 | 40 | 4 |
| Utah 12 | 99 | 100 | 6 |
| Utah 13 | 103 | 59 | 4 |
| Utah 14 | 119 | 58 | 5 |
| Utah 15 | 51 | 32 | 6 |
| Utah 16 | 75 | 30 | 6 |
| Utah 17 | 84 | 31 | 4 |
| Utah 18 | 101 | 40 | 0 |
| Utah 19 | 74 | 32 | |
| | --- | --- | --- |
| Mean | 86.83 | 45.42 | 3.58 |
| F value for selection | 3.16** | 3.98** | .97 |
| $S\bar{X}$ | 4.49 | 1.60 | .98 |
| C.V. percent | 10.3 | 9.99 | 24.67 |

**Significant at .01 level

[1]Figures represent yield from one basin only.

[2]Figures represent yield from two basins.

Table 11D. Ranked means of yield of Canada wild-rye grass from the control basin

| Selection | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | |
|---|---|---|---|---|
| Utah 10 | 35.00 | │ | | |
| Utah 14 | 29.75 | │ | │ | |
| Utah 11 | 26.75 | │ | │ | |
| Utah 13 | 25.75 | │ | │ | |
| Utah 18 | 25.25 | │ | │ | |
| Utah 17 | 21.00 | │ | │ | │ |
| Utah 16 | 18.75 | │ | │ | │ |
| Utah 19 | 18.50 | │ | │ | │ |
| Utah 2 | 18.00 | │ | │ | │ |
| Utah 12 | 14.75 | │ | │ | │ |
| Utah 15 | 12.75 | | │ | │ |
| Utah 1 | 4.25 | | | │ |

*A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Table 11E. Ranked means of the yield of Canada wild-rye grass from basins receiving 12,000 ppm salt

| Selection | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | |
|---|---|---|---|---|
| Utah 12 | 12.50 | │ | | |
| Utah 10 | 10.63 | │ | │ | |
| Utah 13 | 7.38 | │ | │ | │ |
| Utah 14 | 7.25 | │ | │ | │ |
| Utah 11 | 5.00 | | │ | │ |
| Utah 18 | 5.00 | | │ | │ |
| Utah 15 | 4.00 | | │ | │ |
| Utah 19 | 4.00 | | │ | │ |
| Utah 17 | 3.88 | | │ | │ |
| Utah 16 | 3.75 | | │ | │ |
| Utah 2 | 3.13 | | | │ |
| Utah 1 | 1.63 | | | │ |

*A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Observations. The selections of Canada wild-rye grass headed earlier in the control basin than in the basins receiving salinization treatments. The plants subjected to the salinization treatments were smaller and showed some symptoms of leaf burning or necrosis. However, in all other respects, they appeared normal.

F tests indicated that selection differences were highly significant within the control basin and the basins salinized with irrigation water containing 12,000 ppm of added salt.

Utah 10 selection had the highest mean yield in the control but did not show significance from 9 other selections. Utah 1 had the lowest mean yield and was not significantly different from 6 other selections used in the non-salinized basin.

Ranked means of the yield of Canada wild-rye grass from basins receiving irrigation water containing 12,000 ppm of added salt show that Utah 12 selection has the highest mean average yield but is not significantly different from Utah 10, Utah 13, and Utah 14. Utah 1 was the poorest yielding selection.

The plant growth was reduced considerably at the highest salt concentration (24,000 ppm) and there were no significant differences between the selections.

Experiment 3. Salt tolerance of varieties and strains of reed canarygrass

Procedure and results. The following varieties and strains of reed canarygrass were used in this salt tolerance study:

1. Ioreed
2. Superior
3. Utah 15
4. Utah 16
5. Utah 17
6. Utah 18
7. Utah 19
8. Utah 20
9. Utah 21
10. Utah 22
11. Utah 36
12. Utah 37
13. Utah 43
14. Utah 48
15. Utah 49
16. Utah 50
17. Utah 51
18. Utah 52
19. Utah 53
20. Utah 54
21. Utah 55
22. Utah 56
23. Utah 57
24. Utah 58
25. Utah 59
26. Utah 60
27. Utah 61

The reed canarygrass varieties and strains were started in a germinator. After germinating, the seedlings were planted in wooden flats in the greenhouse. On May 30, 1957, the young seedling plants were transplanted to the field basins.

The plants appeared well established and growing satisfactorily on July 4th at which time they were clipped to insure uniform plants. Salt treatments were initiated the following day. Table 12A lists the amounts and concentrations of salinized irrigation water applied throughout the growing season.

Table 12A. Salinizing treatments on basins containing reed canarygrass

| Date | | Amount of Water (inches) | Concentration of salt added (ppm) to the irrigation water (one-half NaCl - one-half $CaCl_2$) Basin 1 | Basin 2 | Basin 3 | Basin 4 | Basin 5 |
|---|---|---|---|---|---|---|---|
| July | 5 | 4.0 | 0 | 2,500 | 2,500 | 2,500 | 2,500 |
| July | 12 | 4.0 | 0 | 6,000 | 6,000 | 12,000 | 12,000 |
| July | 18 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| July | 26 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. | 2 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. | 12 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. | 21 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Aug. | 29 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Sept. | 9 | 4.0 | 0 | 12,000 | 12,000 | 24,000 | 24,000 |
| Sept. | 18 | 6.0 | 0 | 0 | 0 | 0 | 0 |

Soil samples were taken from each basin on July 29th and September 3rd. These were analyzed for total salts (ppm) and the results are presented in Table 12B.

On September 17th the reed canarygrass was harvested; however, none of the plants had fully headed. The comparative yields of air dry forage are given in Table 12C. The Multiple Range test of the yields of the varieties and strains on the control basin is given in Table 12D. A comparative test of ranked means in the basins salinized with 12,000 ppm added salt is presented in Table 12E.

On October 11, 1957, a survival count was taken and the percent survival is presented in Table 12F.

The cation content of the plant material from Ioreed and Utah 60 is given in Table 12G.

Table 12B. Total salts in the soil as determined by a conductivity bridge on salinized basins of reed canarygrass

| Salt added (ppm) to irrigation water ($NaCl$ and $CaCl_2$) | Approximate ppm total salts | | Average |
|---|---|---|---|
| | July 29 | September 3 | |
| 0 | 360 | 264 | 302 |
| 12,000 | 5,219 | 6,914 | 6,066 |
| 12,000 | 4,761 | 5,716 | 5,239 |
| 24,000 | 18,459 | 14,760 | 16,609 |
| 24,000 | 20,641 | 17,048 | 18,844 |

Table 12C. Comparative total yields of air dry forage of reed canarygrass on salinized basins (Yields are recorded in grams per basin)

| Strain or Variety | Control[1] | 12,000 ppm[2] | 24,000 ppm[2] |
|---|---|---|---|
| Ioreed | 288 | 60 | 3 |
| Utah 15 | 186 | 68 | 0 |
| Utah 16 | 288 | 118 | 3 |
| Utah 17 | 154 | 97 | 0 |
| Utah 18 | 108 | 105 | 0 |
| Utah 19 | 165 | 117 | 0 |
| Utah 20 | 168 | 105 | 0 |
| Utah 21 | 49 | 27 | 0 |
| Utah 22 | 123 | 65 | 0 |
| Superior | 84 | 29 | 3 |
| Utah 36 | 124 | 71 | 0 |
| Utah 37 | 123 | 128 | 0 |
| Utah 43 | 158 | 45 | 0 |
| Utah 48 | 94 | 40 | 0 |
| Utah 49 | 185 | 65 | 0 |
| Utah 50 | 223 | 91 | 2 |
| Utah 51 | 182 | 97 | 0 |
| Utah 52 | 145 | 114 | 0 |
| Utah 53 | 177 | 91 | 0 |
| Utah 54 | 206 | 78 | 0 |
| Utah 55 | 160 | 66 | 0 |
| Utah 56 | 185 | 83 | 0 |
| Utah 57 | 64 | 26 | 0 |
| Utah 58 | 157 | 109 | 0 |
| Utah 59 | 173 | 62 | 0 |
| Utah 60 | 237 | 149 | 0 |
| Utah 61 | 153 | 164 | 0 |
| Mean | 161.44 | 84.07 | .41 |
| F value for strain | 1.71* | 3.58** | .87 |
| $s\bar{X}$ | 11.04 | 2.36 | .05 |
| C. V. percent | 13.67 | 7.95 | 95.46 |

*Significant at .05 level

**Significant at .01 level

[1] Figures represent yield from one basin only.

[2] Figures represent yields from two basins.

Table 12D. Ranked means of yield of reed canarygrass from the control basin

| Strain or Variety | Means | *Least significant ranges at the 5 percent level (Duncan's Multiple Range test) | | | |
|---|---|---|---|---|---|
| Ioreed | 72.00 | │ | | | |
| Utah 16 | 72.00 | │ | | | |
| Utah 60 | 59.25 | │ | │ | | |
| Utah 50 | 55.75 | │ | │ | │ | |
| Utah 54 | 51.50 | │ | │ | │ | |
| Utah 15 | 46.50 | │ | │ | │ | │ |
| Utah 49 | 46.25 | │ | │ | │ | │ |
| Utah 56 | 46.25 | │ | │ | │ | │ |
| Utah 51 | 45.50 | │ | │ | │ | │ |
| Utah 53 | 44.25 | │ | │ | │ | │ |
| Utah 59 | 43.25 | │ | │ | │ | │ |
| Utah 20 | 42.00 | │ | │ | │ | │ |
| Utah 19 | 41.25 | │ | │ | │ | │ |
| Utah 55 | 40.00 | │ | │ | │ | │ |
| Utah 43 | 39.50 | │ | │ | │ | │ |
| Utah 58 | 39.25 | │ | │ | │ | │ |
| Utah 17 | 38.50 | │ | │ | │ | │ |
| Utah 61 | 38.25 | │ | │ | │ | │ |
| Utah 52 | 36.25 | │ | │ | │ | │ |
| Utah 36 | 31.00 | | │ | │ | │ |
| Utah 22 | 30.75 | | │ | │ | │ |
| Utah 37 | 30.75 | | │ | │ | │ |
| Utah 18 | 27.00 | | │ | │ | │ |
| Utah 48 | 23.50 | | │ | │ | │ |
| Superior | 21.00 | | │ | │ | │ |
| Utah 57 | 16.00 | | | │ | │ |
| Utah 21 | 12.25 | | | | │ |

*A significant difference exists between any 2 means which are not found within the same range. There is no significant difference between any 2 means within the same range.

Table 12E. Ranked means of the yield of reed canarygrass from basins receiving 12,000 ppm salt

| Strain or Variety | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| Utah 61 | 20.50 | │ | | | | |
| Utah 60 | 18.63 | │ | │ | | | |
| Utah 37 | 16.00 | │ | │ | │ | | |
| Utah 16 | 14.75 | │ | │ | │ | │ | |
| Utah 19 | 14.62 | │ | │ | │ | │ | |
| Utah 52 | 14.25 | │ | │ | │ | │ | │ |
| Utah 58 | 13.63 | │ | │ | │ | │ | │ |
| Utah 18 | 13.13 | │ | │ | │ | │ | │ |
| Utah 20 | 13.13 | │ | │ | │ | │ | │ |
| Utah 17 | 12.13 | │ | │ | │ | │ | │ |
| Utah 51 | 12.13 | │ | │ | │ | │ | │ |
| Utah 50 | 11.38 | │ | │ | │ | │ | │ |
| Utah 53 | 11.38 | │ | │ | │ | │ | │ |
| Utah 56 | 10.38 | | │ | │ | │ | │ |
| Utah 54 | 9.75 | | │ | │ | │ | │ |
| Utah 36 | 8.88 | | │ | │ | │ | │ |
| Utah 15 | 8.50 | | │ | │ | │ | │ |
| Utah 55 | 8.25 | | │ | │ | │ | │ |
| Utah 22 | 8.13 | | │ | │ | │ | │ |
| Utah 49 | 8.13 | | | │ | │ | │ |
| Utah 59 | 7.75 | | | │ | │ | │ |
| Ioreed | 7.50 | | | │ | │ | │ |
| Utah 43 | 5.63 | | | | │ | │ |
| Utah 48 | 5.00 | | | | | │ |
| Superior | 3.63 | | | | | │ |
| Utah 21 | 3.68 | | | | | │ |
| Utah 57 | 3.25 | | | | | │ |

*A significant difference exists between any 2 means which are <u>not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Table 12F. Percent survival of plants within reed canarygrass varieties and/or strains (October 8, 1957)

| Strain or Variety | Control | 12,000 ppm | 24,000 ppm |
|---|---|---|---|
| Ioreed | 100 | 87 | 6 |
| Utah 15 | 100 | 87 | 6 |
| Utah 16 | 100 | 87 | 18 |
| Utah 17 | 100 | 100 | 0 |
| Utah 18 | 100 | 100 | 0 |
| Utah 19 | 100 | 100 | 18 |
| Utah 20 | 100 | 87 | 0 |
| Utah 21 | 100 | 68 | 6 |
| Utah 22 | 100 | 75 | 0 |
| Superior | 100 | 87 | 6 |
| Utah 36 | 87 | 93 | 0 |
| Utah 37 | 100 | 87 | 12 |
| Utah 43 | 100 | 81 | 0 |
| Utah 48 | 100 | 56 | 6 |
| Utah 49 | 100 | 87 | 6 |
| Utah 50 | 100 | 93 | 18 |
| Utah 51 | 100 | 68 | 18 |
| Utah 52 | 100 | 87 | 0 |
| Utah 53 | 100 | 81 | 0 |
| Utah 54 | 100 | 43 | 0 |
| Utah 55 | 100 | 62 | 0 |
| Utah 56 | 100 | 87 | 0 |
| Utah 57 | 87 | 43 | 12 |
| Utah 58 | 100 | 87 | 6 |
| Utah 59 | 100 | 87 | 0 |
| Utah 60 | 100 | 100 | 6 |
| Utah 61 | 100 | 87 | 6 |

Table 12G, Cation content of plant material from a reed canarygrass variety and strain

| Salt added to irrigation water (ppm | Lab. No.[1] | Variety or Strain | Me/100 gm. dry matter | | |
|---|---|---|---|---|---|
| | | | Na | Ca | K |
| 0 | U573847 | Ioreed | .8 | 23.5 | 40 |
| 12,000 | U573849 | | 19.4 | 60.3 | 47 |
| 12,000 | U573851 | | 29.9 | 58.9 | 46 |
| 0 | U573848 | Utah 60 | 1.1 | 22.5 | 53 |
| 12,000 | U573850 | | 18.8 | 59.8 | 42 |
| 12,000 | U573852 | | 24.0 | 65.3 | 50 |

[1]Plant samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. - Cooperative Soils Laboratory, Logan, Utah.

Observations. Reed canarygrass grows in the salt-free basin had smooth, bright green leaves free from necrosis. The plant growth was rank. However, the plants subjected to salinization treatments were small with dark green to bluish-green leaves. Their leaf tips were frequently necrotic.

The variety Ioreed and the strain Utah 16 had the highest mean yield of all the varieties and strains grown on the control; however, they did not show significance from 17 other strains of reed canarygrass. The strain Utah 21 had the smallest mean yield.

Ranked means of the yield of reed canarygrass from basins receiving 12,000 ppm salt in the irrigation water show that the strain Utah 61 produced the highest mean yield. The strain Utah 57 was the poorest yielding but was not significantly different from Utah 21 strain and the variety Superior.

At the highest salt level there were no significant differences between the strains and varieties.

Ioreed and Utah 60 accumulated sodium and calcium in their leaves with increasing salinity. Increasing salinity decreased the amount of potassium in the leaves of Utah 60 but increased the amount found in Ioreed.

Experiment 4. Salt tolerance of alfalfa varieties

Procedure and results. Salt tolerance studies were carried on using the following 38 varieties of alfalfa.

1. A-224 Sny. 1
2. A-225 Northern Syn.
3. A-250 (Utah Syn. Y)
4. A-251 (Utah Syn. Z)
5. A-252 (Utah Syn. A)
6. A-253 (Utah Syn. B)
7. African A 4-35 (Arizona Common)
8. Arizona Chilean
9. Atlantic
10. "Bam"
11. Brigham Young
12. Buffalo
13. Caliverde
14. Cossack
15. Delta Common
16. DuPuits
17. Hairy Peruvian
18. Kansas Common
19. Ladak
20. Lahontan
21. Narragansett
22. Nemastan
23. Nev. Syn. E. 1956 (O.F.S.)
24. Nev. Syn. K. (O.F.S.)
25. Nomad N B 21
26. Rambler
27. Ranger
28. Rhizoma
29. Sevelra
30. So. African (W3275)
31. Stafford
32. Swift Currant 3484
33. Swift Currant M A 501
34. Talent
35. Terra Verde N. K.
36. Uruguay clone 10
37. Vernal
38. Williamsburg

The above named varieties were started in the greenhouse and transplanted into the salt basins on May 31, 1957.

On July 2nd the plants were clipped in order to have uniform plants at the beginning of the salinization treatments which started the next day.

The date, amount, and concentration of the salinized irrigation water applied throughout the growing season are given in Table 13A. The effect of this added salt is shown in Figures 10, 11, and 12.

Soil samples were taken from each basin on July 27th and September 3rd and analyzed for total salts (ppm). The results are presented in Table 13B.

The alfalfa was harvested at about 1/10 bloom on August 3rd and again on September 17th. The combined yield of both harvests is given in Table 13C. The Multiple Range test of the ranked means of the yields of the varieties on the control basin is given in Table 13D. Tables 13E and 13F present the comparative test of ranked means of the yields of varieties on the basins salinized with 8,000 and 16,000 ppm of added salt.

Survival counts were taken on October 11, 1957. The percent of the plants surviving is given in Table 13G.

Buffalo and A-253 (Utah Syn. B) were analyzed for cation content. The results of the analyses are presented in Table 13H.

Table 13A. Salinizing treatments on basins containing alfalfa

| Date | Amount of Water (inches) | Concentration of salt added (ppm) to the irrigation water (one-half NaCl - one-half $CaCl_2$) | | | | |
|---|---|---|---|---|---|---|
| | | Basin 1 | Basin 2 | Basin 3 | Basin 4 | Basin 5 |
| July 3 | 4.0 | 0 | 2,500 | 2,500 | 2,500 | 2,500 |
| July 10 | 4.0 | 0 | 5,000 | 5,000 | 8,000 | 8,000 |
| July 17 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| July 25 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 2 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 12 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 21 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 29 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Sept. 9 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Sept. 18 | 6.0 | 0 | 0 | 0 | 0 | 0 |

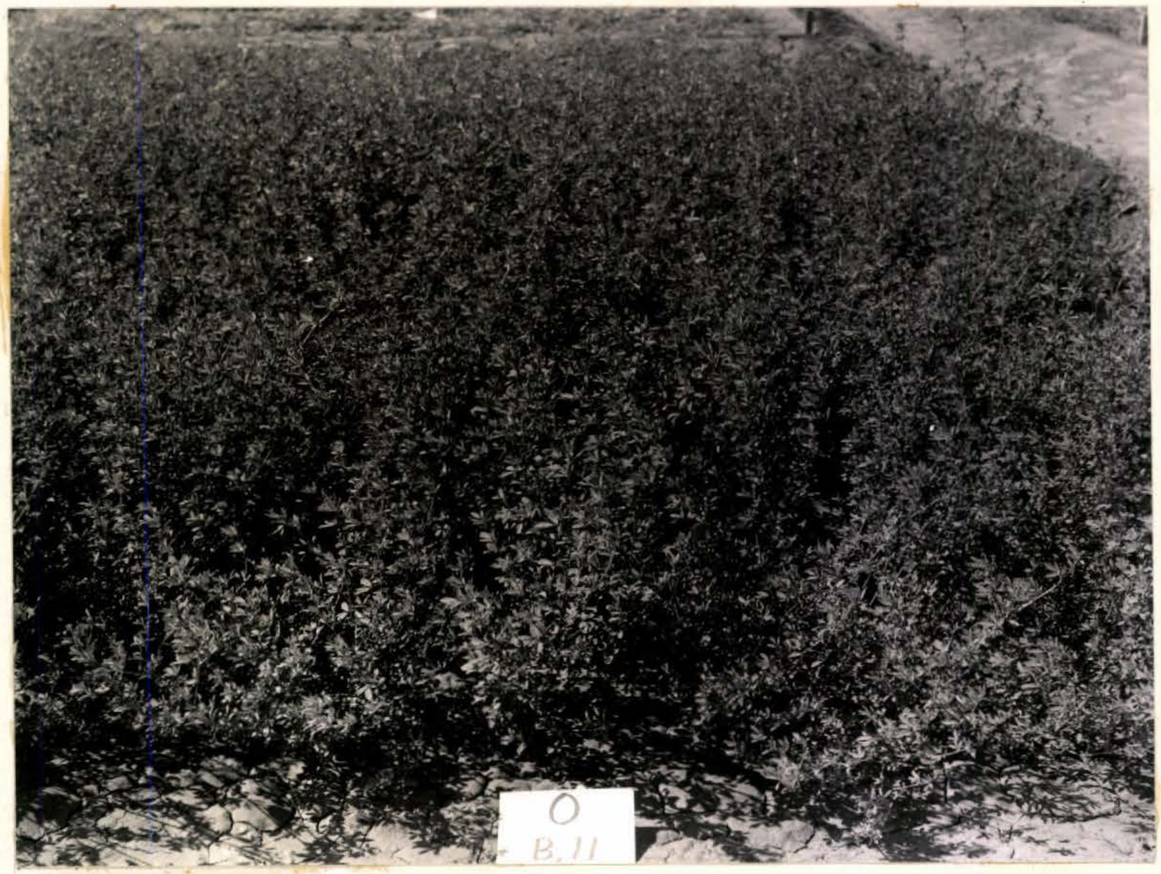


Figure 10. Alfalfa on the non-salinized basin. (August 1, 1957)

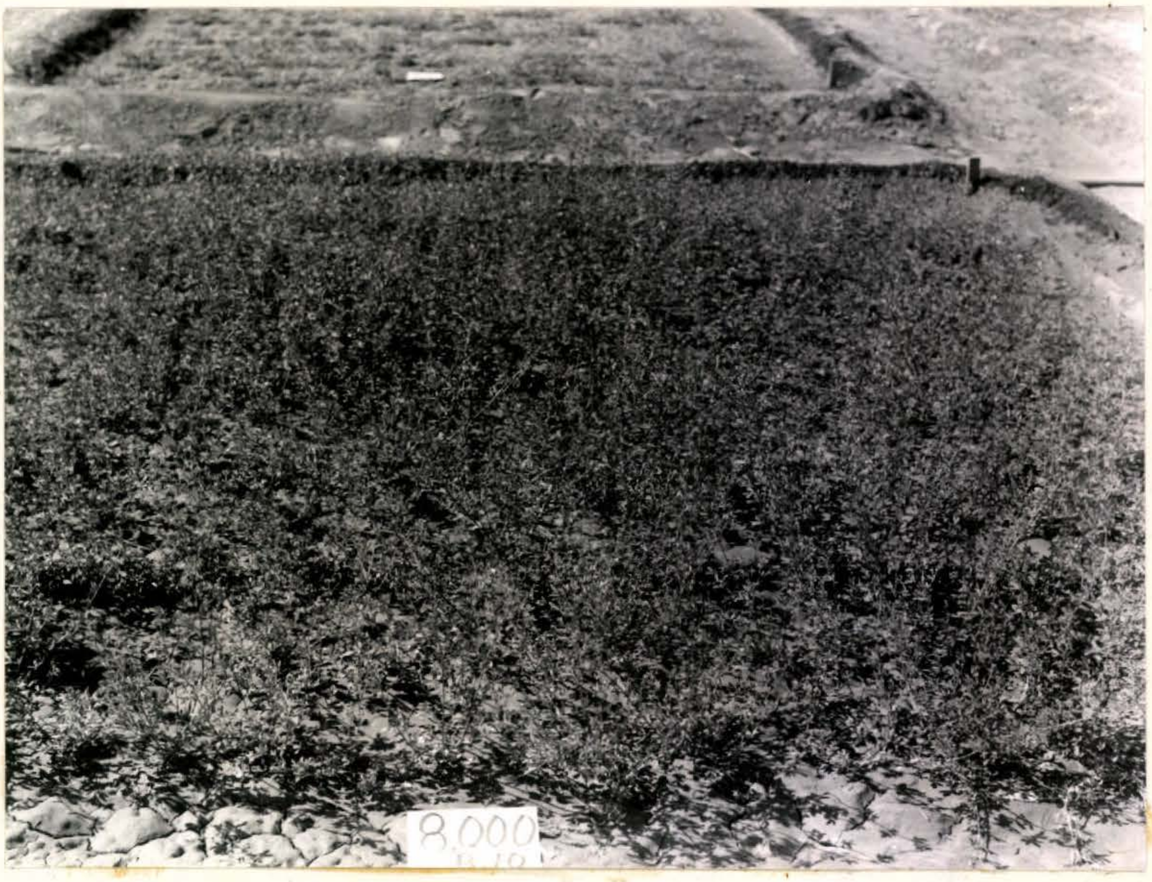


Figure 11. Alfalfa on a basin salinized with irrigation water containing 8,000 ppm added salt. (August 1, 1957)

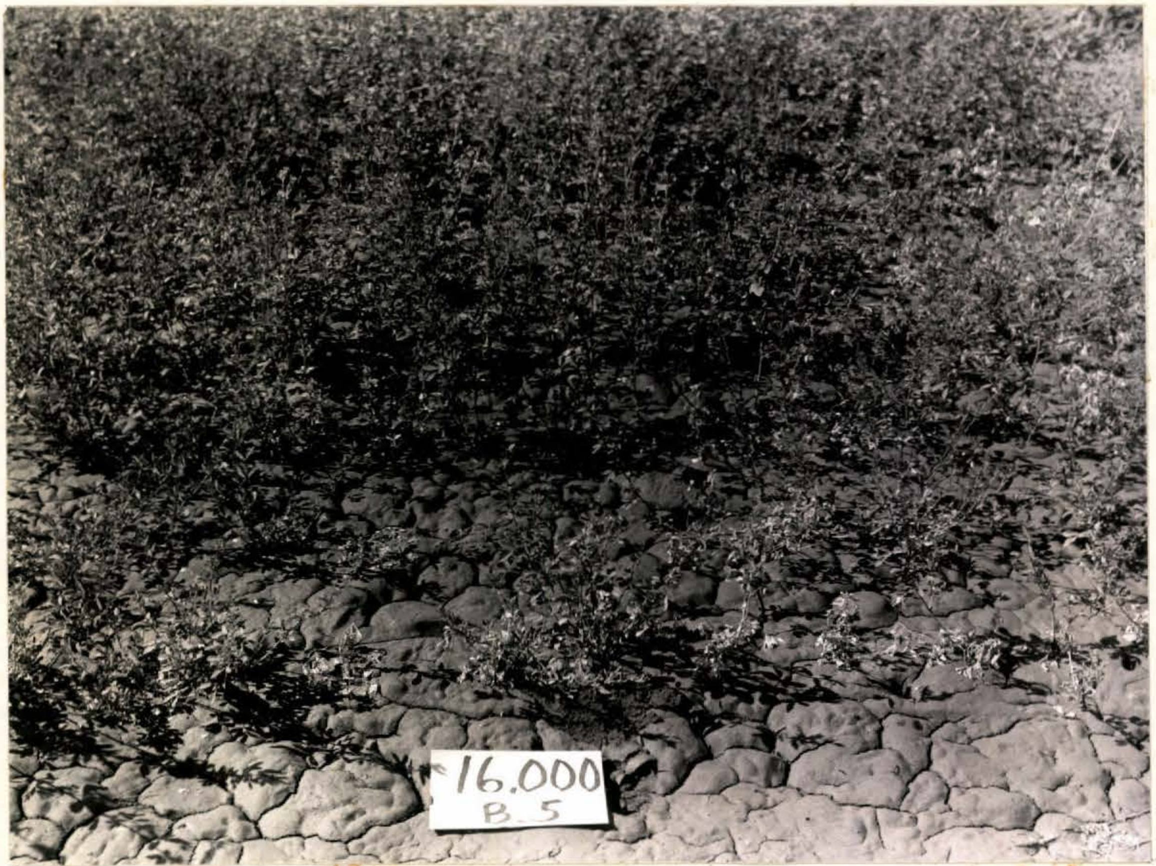


Figure 12. Alfalfa on a basin salinized with irrigation water containing 16,000 ppm added salt. (August 1, 1957)

Table 13B. Total salts in the soil as determined by a conductivity bridge on salinized basins of alfalfa

| Salt added (ppm) to irrigation water ($NaCl$ and $CaCl_2$) | Approximate ppm total salts | | Average |
|---|---|---|---|
| | July 29 | September 3 | |
| 0 | 268 | 264 | 266 |
| 8,000 | 5,547 | 4,400 | 4,973 |
| 8,000 | 4,272 | 4,608 | 4,440 |
| 16,000 | 9,255 | 6,716 | 7,986 |
| 16,000 | 10,478 | 6,215 | 8,348 |

Table 13C. Comparative total yields of air dry forage of alfalfa on salinized basins
(Yields are recorded in grams per basin)

| Variety | Control[1] | 8,000 ppm[2] | 16,000 ppm[2] |
|---|---|---|---|
| A-224 Syn. 1 | 298 | 277 | 110 |
| A-225 Northern Syn. | 215 | 212 | 117 |
| African A 4-35 (Arizona Common) | 316 | 237 | 139 |
| Arizona Chilean | 218 | 295 | 72 |
| Atlantic | 365 | 263 | 119 |
| "Bam" | 198 | 60 | 67 |
| Brigham Young | 274 | 254 | 90 |
| Buffalo | 308 | 243 | 153 |
| Caliverde | 269 | 282 | 137 |
| Cossack | 294 | 260 | 115 |
| Delta Common | 243 | 224 | 103 |
| DuPuits | 285 | 238 | 106 |
| Hairy Peruvian | 285 | 308 | 90 |
| Kansas Common | 243 | 219 | 97 |
| Ladak | 259 | 227 | 95 |
| Lahontan | 159 | 248 | 112 |
| Narragansett | 191 | 243 | 82 |
| Nemastan | 222 | 214 | 95 |
| Nev. Syn. E 1956 (O.F.S.) | 262 | 299 | 133 |
| Nev. Syn. K (O.F.S.) | 272 | 222 | 140 |
| Nomad N B 21 | 177 | 97 | 47 |
| Rambler | 210 | 95 | 50 |
| Ranger | 308 | 189 | 107 |
| Rhizoma | 240 | 199 | 88 |
| Sevelra | 255 | 180 | 87 |
| So. Arican (W3275) N. K. | 202 | 163 | 88 |
| Stafford | 288 | 169 | 95 |
| Swift Currant 3484 | 172 | 171 | 65 |
| Swift Currant M A 501 | 106 | 104 | 38 |
| Talent | 197 | 262 | 116 |
| Terra Verde N. K. | 380 | 326 | 150 |
| Uruguay clone 10 | 235 | 217 | 103 |
| Utah Syn. Y | 255 | 219 | 94 |
| Utah Syn. Z | 325 | 229 | 107 |
| Utah Syn. A | 263 | 306 | 137 |
| Utah Syn. B | 270 | 135 | 64 |
| Vernal | 231 | 185 | 67 |
| Williamsburg | 189 | 189 | 116 |
| Mean | 249.45 | 217.37 | 99.76 |
| F value for variety | 2.27** | 4.41** | 2.18** |
| $S\overline{X}$ | 9.42 | 3.71 | 2.4 |
| C. V. percent | 7.50 | 4.84 | 6.80 |

**Significant at .01 level

[1]Figures represent yield from one basin only.

[2]Figures represent yield from two basins.

Table 13D. Ranked means of yield of alfalfa from the control basin

| Variety | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | | |
|---|---|---|---|---|---|
| Terra Verde N. K. | 95.00 | \| | | | |
| Atlantic | 91.25 | \| | \| | | |
| Utah Syn. Z | 81.25 | \| | \| | \| | |
| African A 4-35 (Arizona Common) | 79.00 | \| | \| | \| | |
| Buffalo | 77.00 | \| | \| | \| | |
| Ranger | 77.00 | \| | \| | \| | |
| A-224 Syn. 1 | 74.50 | \| | \| | \| | |
| Cossack | 73.50 | \| | \| | \| | |
| Stafford | 72.00 | \| | \| | \| | |
| DuPuits | 71.25 | \| | \| | \| | |
| Hairy Peruvian | 71.25 | \| | \| | \| | |
| Brigham Young | 68.50 | \| | \| | \| | |
| Nev. Syn. K (O.F.S.) | 68.00 | \| | \| | \| | |
| Utah Syn. A | 67.50 | \| | \| | \| | |
| Caliverde | 67.25 | \| | \| | \| | \| |
| Utah Syn. B | 65.75 | \| | \| | \| | \| |
| Nev. Syn. E 1956 (O.F.S.) | 65.50 | \| | \| | \| | \| |
| Ladak | 64.75 | \| | \| | \| | \| |
| Sevelra | 63.75 | \| | \| | \| | \| |
| Utah Syn. Y | 63.75 | \| | \| | \| | \| |
| Kansas Common | 60.75 | \| | \| | \| | \| |
| Delta Common | 60.75 | \| | \| | \| | \| |
| Rhizoma | 60.00 | \| | \| | \| | \| |
| Uruguay clone 10 | 58.75 | \| | \| | \| | \| |
| Vernal | 57.75 | \| | \| | \| | \| |
| Nemastan | 55.50 | \| | \| | \| | \| |
| Arizona Chilean | 54.50 | \| | \| | \| | \| |
| A-225 Northern Syn. | 53.75 | \| | \| | \| | \| |
| Rambler | 52.50 | \| | \| | \| | \| |
| So. African (W3275) N. K. | 50.50 | | \| | \| | \| |
| "Bam" | 49.50 | | \| | \| | \| |
| Talent | 49.25 | | \| | \| | \| |
| Narragansett | 47.75 | | | \| | \| |
| Williamsburg | 47.25 | | | \| | \| |
| Nomad N B 21 | 44.25 | | | \| | \| |
| Swift Currant 3484 | 43.00 | | | \| | \| |
| Lahontan | 39.75 | | | \| | \| |
| Swift Currant M A 501 | 26.50 | | | | \| |

*A significant difference exists between any 2 means which are not found within the same range. There is no significant difference between any 2 means within the same range.

Table 13E. Ranked means of the yield of alfalfa from basins receiving 8,000 ppm salt

| Variety | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) |
|---|---|---|
| Terra Verde N. K. | 40.75 | |
| Hairy Peruvian | 38.50 | |
| Utah Syn. A | 38.25 | |
| Nev. Syn E 1956 (O.F.S.) | 37.38 | |
| Arizona Chilean | 36.88 | |
| Caliverde | 35.25 | |
| A-224 Syn. 1 | 34.63 | |
| Atlantic | 32.88 | |
| Talent | 32.75 | |
| Cossack | 32.50 | |
| Brigham Young | 31.75 | |
| Lahonton | 31.00 | |
| Buffalo | 30.38 | |
| Narragansett | 30.38 | |
| DuPuits | 29.75 | |
| African A 4-35 (Arizona Common) | 29.63 | |
| Utah Syn. Z | 28.63 | |
| Ladak | 28.38 | |
| Delta Common | 28.00 | |
| Nev. Syn. K (O.F.S.) | 27.75 | |
| Kansas Common | 27.38 | |
| Utah Syn. Y | 27.38 | |
| Uruguay clone 10 | 27.13 | |
| Nemastan | 26.75 | |
| A-225 Northern Syn. | 26.50 | |
| Rhizoma | 24.88 | |
| Ranger | 23.63 | |
| Williamsburg | 23.63 | |
| Vernal | 23.13 | |
| Sevelra | 22.50 | |
| Swift Currant 3484 | 21.38 | |
| Stafford | 21.13 | |
| So. African (W3275) N. K. | 20.38 | |
| Utah Syn. B | 16.88 | |
| Swift Currant M A 501 | 13.00 | |
| Nomad N B 21 | 12.13 | |
| Rambler | 11.87 | |
| "Bam" | 7.50 | |

*A significant difference exists between any 2 means which are not found within the same range. There is no significant difference between any 2 means within the same range.

Table 13F. Ranked means of yield of alfalfa from basins receiving 16,000 ppm salt

| Variety | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | | |
|---|---|---|---|---|---|
| Buffalo | 19.13 | │ | | | |
| Terra Verde N. K. | 18.75 | │ | │ | | |
| Nev. Syn. K (O.F.S.) | 17.50 | │ | │ | | |
| African A 4-35 (Arizona Common) | 17.38 | │ | │ | | |
| Caliverde | 17.13 | │ | │ | | |
| Utah Syn. A | 17.13 | │ | │ | │ | |
| Nev. Syn E 1956 (O.F.S.) | 16.63 | │ | │ | │ | │ |
| Atlantic | 14.88 | │ | │ | │ | │ |
| A-225 Northern Syn. | 14.63 | │ | │ | │ | │ |
| Talent | 14.50 | │ | │ | │ | │ |
| Williamsburg | 14.50 | │ | │ | │ | │ |
| Cossack | 14.38 | │ | │ | │ | │ |
| Lahontan | 14.00 | │ | │ | │ | │ |
| A-224 Syn. 1 | 13.75 | │ | │ | │ | │ |
| Ranger | 13.38 | │ | │ | │ | │ |
| Utah Syn. Z | 13.38 | │ | │ | │ | │ |
| DuPuits | 13.25 | │ | │ | │ | │ |
| Uruguay clone 10 | 12.88 | │ | │ | │ | │ |
| Delta Common | 12.88 | │ | │ | │ | │ |
| Kansas Common | 12.13 | │ | │ | │ | │ |
| Ladak | 11.88 | │ | │ | │ | │ |
| Nemastan | 11.88 | │ | │ | │ | │ |
| Stafford | 11.88 | │ | │ | │ | │ |
| Utah Syn. Y | 11.75 | │ | │ | │ | │ |
| Brigham Young | 11.25 | │ | │ | │ | │ |
| Hairy Peruvian | 11.25 | │ | │ | │ | │ |
| Rhizoma | 11.00 | │ | │ | │ | │ |
| So. African (W3275) N. K. | 11.00 | │ | │ | │ | │ |
| Sevelra | 10.38 | │ | │ | │ | │ |
| Narragansett | 10.25 | │ | │ | │ | │ |
| Arizona Chilean | 9.00 | │ | │ | │ | │ |
| Vernal | 8.38 | │ | │ | │ | │ |
| "Bam" | 8.38 | │ | │ | │ | │ |
| Swift Current 3484 | 8.13 | | │ | │ | │ |
| Utah Syn. B | 8.00 | | │ | │ | │ |
| Rambler | 6.25 | | │ | │ | │ |
| Nomad N B 21 | 5.88 | | | │ | │ |
| Swift Current M A 501 | 4.75 | | | | │ |

*A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Table 13G. Percent survival of plants within alfalfa varieties (October 11, 1957)

| Variety | Control | 8,000 ppm | 16,000 ppm |
|---|---|---|---|
| A-224 Syn. 1 | 100 | 93 | 75 |
| A-225 Northern Syn. | 87 | 62 | 87 |
| African A 4-35 (Arizona Common) | 100 | 87 | 81 |
| Arizona Chilean | 100 | 93 | 56 |
| Atlantic | 75 | 87 | 75 |
| "Bam" | 100 | 81 | 68 |
| Brigham Young | 100 | 87 | 75 |
| Buffalo | 100 | 100 | 81 |
| Caliverde | 100 | 87 | 93 |
| Cossack | 100 | 100 | 68 |
| Delta Common | 100 | 100 | 75 |
| DuPuits | 100 | 87 | 87 |
| Hairy Peruvian | 100 | 100 | 68 |
| Kansas Common | 75 | 87 | 81 |
| Ladak | 100 | 68 | 37 |
| Lahontan | 87 | 87 | 87 |
| Narragansett | 100 | 81 | 56 |
| Nemastan | 100 | 93 | 87 |
| Nev. Syn. E. 1956 (O.F.S.) | 100 | 93 | 93 |
| Nev. Syn. K. (O.F.S.) | 100 | 93 | 100 |
| Nomad N B 21 | 100 | 87 | 68 |
| Rambler | 75 | 43 | 31 |
| Ranger | 100 | 87 | 87 |
| Rhizoma | 100 | 87 | 68 |
| Sevelra | 100 | 93 | 62 |
| So. African (W3275) N. K. | 100 | 81 | 81 |
| Stafford | 100 | 93 | 62 |
| Swift Currant 3484 | 87 | 93 | 62 |
| Swift Currant M A 501 | 100 | 56 | 25 |
| Talent | 100 | 100 | 81 |
| Terra Verde N. K. | 100 | 100 | 93 |
| Uruguay clone 10 | 100 | 93 | 87 |
| Utah Syn. Y | 100 | 93 | 75 |
| Utah Syn. Z | 100 | 100 | 68 |
| Utah Syn. A | 100 | 100 | 87 |
| Utah Syn. B | 100 | 100 | 62 |
| Vernal | 100 | 81 | 31 |
| Williamsburg | 100 | 93 | 87 |

Table 13H. Cation content of plant material from 2 varieties of alfalfa

| Salt added to irrigation water (ppm) | Lab. No.[1] | Variety | Na | Ca | K |
|---|---|---|---|---|---|
| 0 | U573837 | Buffalo | 3.4 | 119.1 | 42 |
| 8,000 | U573839 | | 11.2 | 159.2 | 40 |
| 8,000 | U573841 | | 13.5 | 197.3 | 35 |
| 16,000 | U573843 | | 31.0 | 173.9 | 30 |
| 16,000 | U573845 | | 34.6 | 183.1 | 28 |
| 0 | U573838 | A-253 | 4.6 | 126.5 | 46 |
| 8,000 | U573840 | | 12.8 | 146.3 | 41 |
| 8,000 | U573842 | | 15.5 | 174.3 | 41 |
| 16,000 | U573844 | | 65.1 | 227.2 | 32 |
| 16,000 | U573846 | | 59.0 | 223.6 | 31 |

[1]Plant samples analyzed by the U.S.D.A. - S.C.S. - U.S.U. Cooperative Soils Laboratory, Logan, Utah

Observations. The alfalfa varieties grown on the non-salinized basins were bright green in color and had a luxuriant growth. The alfalfa grown on the salinized basins had a dark, bluish-green color and a dwarfed appearance. Leaves of the alfalfa plants receiving salinization treatments were considerably thickened and had a waxy feel due to heavy cuticle development and a waxy covering. These plants showed extensive necrosis and shedding of the older leaves. They bloomed 6-8 days earlier than the non-salinized plants.

F tests indicated that the varietal differences were highly significant for each of the treatments.

The ranked means of the yields of alfalfa varieties from the non-salinized basin show that the variety Terra Verde N. K. produced the highest mean yield but did not show significance from 28 other varieties. Swift Currant M A 501 was the poorest yielding variety.

Ranked means of the yields of alfalfa varieties in basins salinized with irrigation water containing 8,000 ppm of added salt show that Terra Verde N. K. had the highest mean average yield. "Bam" was the poorest yielding selection but did not show significance from 9 other varieties.

The Multiple Range test of ranked means at the highest salinity level (16,000 ppm) indicates that the variety Buffalo produced the highest mean yield. Swift Currant M A 501 was the poorest yielding variety.

The alfalfa varieties which had the highest ranked means at the high salinity level were generally the ones that had high survival percentages.

Increasing levels of salinity resulted in an increase of sodium and calcium in the leaves of the varieties Buffalo and A-253 (Utah Syn. B). The potassium content decreased as sodium and calcium were added in increasing amounts to the irrigation water.

Experiment 5. Salt tolerance of strawberry clover varieties and strains

Procedure and results. The varieties and strains of strawberry clover used in this salt tolerance study are listed below.

1. Palestine
2. Salina
3. F.C. 22797
4. F.C. 22798
5. F.C. 22800
6. F.C. 22801
7. F.C. 22874
8. F.C. 24311
9. F.C. 24315
10. F.C. 24868

The strawberry clover varieties and strains were started in the greenhouse. Uniform seedlings were transplanted to the field basins on May 31, 1957.

On July 2nd the plants were clipped to insure uniformity of size when the salinization treatments commenced on July 3rd. Table 14A lists the amounts and concentrations of salinized irrigation water applied throughout the growing season. The effect of this added salt is shown in Figures 13, 14, and 15.

Soil samples were taken from each basin on the 29th of July and the 3rd of September. These were analyzed for total salts (ppm) with the results presented in Table 14B.

On August 8th the strawberry clover was harvested. Slow recovery prevented a second harvest. The comparative yields of air dry forages are given in Table 14C. A comparative test of ranked means in the basins salinized with 8,000 and 16,000 ppm added salt is presented in Tables 14D and 14E.

Table 14A. Salinizing treatments on basins containing strawberry clover

| Date | Amount of Water | Concentration of salt added (ppm) to the irrigation water (one-half NaCl - one-half $CaCl_2$) | | | | |
|---|---|---|---|---|---|---|
| | (inches) | Basin 1 | Basin 2 | Basin 3 | Basin 4 | Basin 5 |
| July 3 | 4.0 | 0 | 2,500 | 2,500 | 2,500 | 2,500 |
| July 10 | 4.0 | 0 | 5,000 | 5,000 | 8,000 | 8,000 |
| July 17 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| July 25 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 2 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 12 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 21 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Aug. 29 | 4.0 | 0 | 8,000 | 8,000 | 16,000 | 16,000 |
| Sept. 9 | 4.0 | 0 | 0 | 0 | 0 | 0 |


Figure 13. Strawberry clover and birdsfoot trefoil on the non-salinized basin August 1, 1957. These 2 legumes were planted on the same basins, but because there were not sufficient replications of each variety of birdsfoot trefoil no report was made on this species.


Figure 14. Strawberry clover and birdsfoot trefoil on a basin salinized with irrigation water containing 8,000 ppm added salt. (August 1, 1957)


Figure 15. Strawberry clover and birdsfoot trefoil on a basin salinized with irrigation water containing 16,000 ppm added salt. (August 1, 1957)

Table 14B. Total salts in the soil as determined by a conductivity bridge on salinized basins of strawberry clover

| Salt added (ppm) to irrigation water ($NaCl$ and $CaCl_2$) | Approximate ppm total salts July 29 | September 3 | Average |
|---|---|---|---|
| 0 | 243 | 264 | 253 |
| 8,000 | 4,370 | 4,804 | 4,587 |
| 8,000 | 5,205 | 3,642 | 4,424 |
| 16,000 | 9,445 | 9,208 | 9,327 |
| 16,000 | 9,601 | 10,813 | 10,207 |

Table 14C. Comparative total yields of air dry forage of strawberry clover on salinized basins (Yields are recorded in grams per basin)

| Variety or strain | Control[1] | 8,000 ppm[2] | 16,000 ppm[2] |
|---|---|---|---|
| Palestine | 43 | 54 | 23 |
| Salina | 81 | 63 | 38 |
| F.C. 22797 | 99 | 127 | 70 |
| F.C. 22798 | 78 | 84 | 66 |
| F.C. 22800 | 103 | 101 | 68 |
| F.C. 22801 | 98 | 71 | 39 |
| F.C. 22874 | 66 | 82 | 49 |
| F.C. 24311 | 89 | 128 | 64 |
| F.C. 24315 | 82 | 133 | 57 |
| F.C. 24868 | 50 | 56 | 34 |
| Mean | 78.9 | 89.9 | 50.8 |
| F value for variety or strain | 2.12 | 7.41** | 4.77** |
| $S\bar{X}$ | 3.50 | 1.40 | ..98 |
| C.V. percent | 8.88 | 4.44 | 5.45 |

**Significant at .01 level

[1]Figures represent yield from one basin only.

[2]Figures represent yield from two basins.

Table 14D. Ranked means of yield of strawberry clover from basins receiving 8,000 ppm salt

| Variety or Strain | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | |
|---|---|---|---|---|
| F.C. 24315 | 16.63 | │ | | |
| F.C. 24311 | 16.00 | │ | │ | |
| F.C. 22797 | 15.88 | │ | │ | │ |
| F.C. 22800 | 12.63 | │ | │ | │ |
| F.C. 22798 | 10.50 | | │ | │ |
| F.C. 22874 | 10.25 | | │ | │ |
| F.C. 22801 | 8.88 | | | │ |
| Salina | 7.88 | | | │ |
| F.C. 24868 | 7.00 | | | │ |
| Palestine | 6.75 | | | │ |

*A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Table 14E. Ranked means of yield of strawberry clover from basins receiving 16,000 ppm salt

| Variety or Strain | Means | *Least significant ranges at the 1 percent level (Duncan's Multiple Range test) | | |
|---|---|---|---|---|
| F.C. 22797 | 8.75 | │ | | |
| F.C. 22800 | 8.50 | │ | | |
| F.C. 22798 | 8.25 | │ | │ | |
| F.C. 24311 | 8.00 | │ | │ | |
| F.C. 24315 | 7.13 | │ | │ | |
| F.C. 22874 | 6.13 | │ | │ | │ |
| F.C. 22801 | 4.88 | │ | │ | │ |
| Salina | 4.75 | │ | │ | │ |
| F.C. 24868 | 4.25 | | │ | │ |
| Palestine | 2.88 | | | │ |

*A significant difference exists between any 2 means which <u>are not</u> found within the same range. There is no significant difference between any 2 means within the same range.

Observations. Strawberry clover varieties and strains subjected to salinization treatments were a dark green color. Their leaves were considerably thickened and had a waxy feel due to a heavy cuticle development and waxy covering. The salinization treatments hastened the rate of maturity of strawberry clover.

F tests indicated highly significant yield differences among varieties and strains on the salinized basins. However, there were no significant differences on the non-salinized basin.

Ranked means of the yields of strawberry clover from basins receiving 8,000 ppm salt show that the strain F.C. 24315 produced the highest mean yield but did not show significance from the strains F.C. 24311, F.C. 22797, and F.C. 22800. Palestine had the lowest mean yield.

Ranked means of the yields of strawberry clover from basins receiving 16,000 ppm salt indicate that strain F.C. 22797 had the highest mean yield. The variety Palestine had the lowest mean yield but did not show significance from 3 other strains and the variety Salina.

When strawberry clover was clipped on the salinized basins recovery was slow.

## DISCUSSION

This study has shown that significant differences in salt tolerance exist between selections, strains, and/or varieties within species.

The plants grown on salinized basins were smaller and had fewer leaves. They were a dark, blue-green color whereas the plants receiving no salinization treatment were a light green color. Leaves of legumes were thickened and had a waxy feel due to heavy cuticle development and a waxy covering. Necrosis was evident on the leaf tips of many of the plants at the higher salinity levels. The maturity of the plants was accelerated by the use of the salt treatments with the exception of Canada wild-rye grass.

The stage of growth at which plants are subjected to a salinity stress appears to be an important factor in determining the final response of the plants to the stress. In this study the basin of tall wheatgrass planted 2 weeks early yielded considerably more than the basin planted later but subjected to the same treatment.

Although tall wheatgrass is slow to reach its maximum growth and development, it appears to be the most salt tolerant of the 3 grass species studied. It was the only grass species at the end of the growing season which had a considerable number of plants surviving at the highest salinity level. The tall wheatgrass selection Utah 6-12 exhibited outstanding salt tolerance. It would appear that the more salt tolerant plants of this selection could be selected by growing relatively large populations of its plants on salinized basins using a sufficiently high level of salinization to eliminate a large percentage of the population. Generally on the salinized basins, tall wheatgrass selections having the highest survival percentages gave the highest yield.

After Canada wild-rye grass was harvested, it failed to recover appreciably on the salinized basins. It did not produce an abundance of leaves and appeared to be rather coarse and stemmy. However, the United States Salinity Laboratory (1954) reports that it is quite salt tolerant.

Of the 3 grasses tested, reed canarygrass produced the largest yields on the control. It appears to have a considerable range in salt tolerance among its strains and varieties.

Alfalfa showed more salt tolerance than strawberry clover. It was interesting to note that the variety Terra Verde N. K. did consistently well in all of the treatments. There is a considerable range of salt tolerance among alfalfa varieties with the variety Buffalo being the most productive at the 16,000 ppm salt level. It may be possible to select a more salt tolerant strain from this variety. The alfalfa varieties on the salinized basins recovered well after clipping.

Strawberry clover varieties and strains did not show exceptionally good salt tolerance. Its importance as a pasture plant is due mainly to its ability to survive flooding for prolonged periods of time. Wet saline and alkaline soils contain salts that are highly diluted, and, therefore, strawberry clover is able to withstand the harmful effects of the salts and seems adapted to such soils. However, on saline and alkaline soils which are not wet, the salts are concentrated and cause an adverse effect on the growth of strawberry clover plants.

The sodium and calcium content of the leaves of tall wheatgrass, reed canarygrass, and alfalfa generally increased as sodium and calcium in the irrigation water were increased. Conversely, the potassium content decreased in 4 of the 6 instances. It is believed that the decrease in the potassium content of the leaves was a result of greater competition between cations due to the high concentrations of sodium and calcium in the irrigation water. It was noted that the alfalfa variety A-253 (Utah Syn. B) at the high salt level accumulated considerably more sodium and calcium than the variety Buffalo. Due to the fact that A-253 (Utah Syn. B) was one of the lowest yielding varieties found at the high salt level, it is possible that the excess of these two cations or of one of these cations may have had a toxic effect on the protoplasm within the cells which resulted in smaller, less vigorous plants.

The salt tolerance of crop plants is believed to be heritable. It is thought that the inheritance is somewhat similar to that of yield. Coarseness and harshness of a plant appear to be genetic factors that are linked to salt tolerance. Generally, plants which are coarse and harsh demonstrate better tolerance to salt.

Salt resistance of plants may be attributed to: (1) the ability of the plant to withstand periods of drouth, (2) the faculty of the plant to increase the osmotic pressure of its tissue fluids as the salinity of the soil increases, (3) the capacity of the plant to regulate the ionic concentration of the ions needed and exclude those not needed, and (4) the resistance of the protoplasm to the toxic effects of ions in excess.

## SUMMARY AND CONCLUSIONS

1. The effect of increasing levels of salinity on the growth, yield, survival, and chemical composition of particular varieties, strains, and selections of 3 grasses and 2 legumes was tested. The artificially salinized field-plot technique was employed. Selected plant samples were analyzed for sodium, calcium, and potassium content.

2. Significant differences in salt tolerance were found to exist between selections, strains, and/or varieties within a species.

3. Tall wheatgrass was the most salt tolerant of the 3 grasses tested. Of the tall wheatgrass selections, Utah 6-12 was the most salt tolerant.

4. The poorest salt tolerance of the grasses was exhibited by Canada wild-rye grass. Utah 12 was the most productive Canada wild-rye grass selection on the salinized basins.

5. Utah 61 was the most salt tolerant strain of reed canarygrass.

6. Alfalfa showed considerably more salt tolerance than strawberry clover. Buffalo was the most productive alfalfa variety at the highest salinity level,however, Terra Verde N. K. did well in all of the treatments.

7. Salt appeared to adversely effect the recovery ability of strawberry clover. Of the varieties and strains

tested, the strain F. C. 22797 showed the most salt tolerance.

8. Salinization treatments consisting of sodium chloride and calcium chloride generally increased the sodium and calcium content in the leaves of tall wheatgrass, reed canarygrass, and alfalfa but usually decreased the potassium content.

9. This study indicated that excellent opportunities exist in the selection and development of varieties and strains of forage crops for use on salty soils.

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