This indicates that water cleanliness may not be a critical factor for satisfactory operation.

The drip pan proved suitable for irrigating a variety of ground surfaces ranging from smooth and level to rough, uneven, sloping and rocky; and from bare soil to high density grass, half shrub and forb cover. It was not tested on steep slopes or tall brush but appears to have a potential for use on these sites although steep slopes might induce difficulties because of rapid runoff.

We found drip pan irrigation usually required smaller, less elaborate border barriers than flood irrigation. On level, permeable ground and where lateral water movement from the plot is not critical border barriers might be entirely eliminated.

Weak air eddies were found to be desirable because they deflected drops falling from the drip pan to produce an essentially random impact pattern at the ground surface. We had no occasion to operate the drip pan in strong winds, but a plastic film wind shield around the pan frame should prevent adverse wind effects.

The drip pan was used as a high-intensity, low-velocity, low-impact sprinkler. As checked by five separate measurements with six individual catchment containers, it dripped 5.1 cm of water (+3%) per hour with uniform coverage. Any uneven dripping could be observed and corrected by adjusting the wick lengths. Drip pans were easy to level by blocking the corners of the frame base. We used a combination of four drip pans suspended over the treatment plot at a 9.1- dm (3-ft) height on a wooden frame (Fig. 2).

The drip pan can be adapted for many uses because water drop frequency, size, and impact force may all be varied to meet special requirements. Drop frequency can be varied by changing the size and spacing of the drip holes, the material, diameter and length of the wicks, and the height of the pressure head. Ellison and Pomerene (1944) with their wool wick rainfall applicator were able to apply water at rates ranging from 12.2 to 37.6 cm (+3%) per hour by changing the pressure head and drip-hole sizes. They also concluded that a still wider gradation was possible. We poured water directly into the drip pans with a calibrated bucket which caused the pressure head to vary. A constant pressure head could be achieved by using some type of constant head tank (Zwolinski, 1969; Meeuwig, 1971).

Waterdrop impact force can be varied by changing pan height and drop size because the kinetic energy of a falling body is equal to one-half the mass times the square of the velocity. The terminal velocity and impact force of different size drops falling from various heights can be determined from the curves developed by Laws (1940). Methods for measuring drop size are described by Pearson and Martin (1957).

Rainfall contains wide variety of drops ranging from approximately 0.25 to 7.00 mm in size (Laws and Parsons, 1943). A disadvantage of previous drip-type rainfall simulators is the limited range of drop sizes produced with the smaller sizes not represented (Mutchler and Hermsmeier, 1965). The drip pan because of its wicks and their location directly in the pan bottom has the potential for producing a wide range of drop sizes. Regulation of size will depend upon using the proper combination of drip-hole size, wick material, diameter, and length, and head pressure. The smallest part of the natural rainfall size spectrum may not be obtainable but this should not be important for most studies in which the drip pan would be used.

Winter Injury to Fourwing Saltbush

GORDON A. VAN EPPS

Highlight: Winter hardiness of fourwing saltbush (Atriplex canescens) varies with its point of origin. Data indicate that factors other than temperature and origin affect the hardiness of these plants, since variations in winter hardness occur between individual plants from the same source. The sex of a plant has no effect on hardness. Generally, seed for reseeding should be obtained from the immediate vicinity of, or from an area colder than, the anticipated planting site.

Fourwing saltbush (Atriplex canescens) occurs widely in the western states. In addition, it is one of the most rapid in vegetative growth and produces an abundance of forage savored by game and livestock. Cold tolerance is only one characteristic

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Literature Cited


Temperatures are not recorded at the
Wind chill is a definite factor at this
The two coldest months were
recorded. Snow accumulation in
varied from 10 to 18 inches.
yearly precipitation is 12.6 inches.
location.
long periods of cold temperatures
recorded. Snow accumulation in
January was a - 1°F. The g-month
period of September through May
brought precipitation of 12.1 inches as
compared to a preceding 13-year
average of 9.0 inches. Normal annual
precipitation is approximately 10.5
inches. Spring was late, followed by
hot, dry weather. Snow accumulation
varied from 10 to 18 inches.

Nephi Field Station is in a dry farm
area on the north slope of Levan Ridge
at an elevation of 5240 ft. Average
yearly precipitation is 12.6 inches.
Wind chill is a definite factor at this
location.

Precipitation for the 7-month
period of October, 1972, through
April, 1973, was 13.9 inches as
compared to a 70-year average of 7.9
inches for the same months.

Temperatures are not recorded at
the Station, but at a comparable location a
few miles away, the monthly averages
during these 7 months varied from a
-6 to 8.9°F departure from normal.
The two coldest months were
December and January with a -21°F
being the coldest temperature
recorded. Snow accumulation in
1972-73 was less than at the Snow
Field Station, which is unusual.

Plants of fourwing saltbush occur
naturally in the Ephraim area. By
contrast, none have been observed on
Levan Ridge even though introduced
plants do exceptionally well and
reseed naturally. It is assumed,
therefore, that naturally occurring
plants on Levan Ridge have been killed
out through cultivation or grazing.

**Plantings and Results**

One of the 1970-71 plantings on
the Snow Field Station consisted of
plants from 20 locations. These were
obtained either as transplants from a
nursery developed from seed planted
during July, 1970, or as year-old
wildings collected from other locations
during 1971. These were planted
randomly incorporating six
replications. Plants from all were
making good to vigorous growth and
all had flowered during the 1972
summer months. The pistillate plants
produced seed.

Variations in survival among plants
from different geographical sources or
ecotypes were dramatically evident in
1972-73 (Table 1). Plants originating
in areas having relatively mild climates
generally suffered the greatest injury.
Exceptions, for example, were plants
from the Snake Valley, west of Delta,
Utah, Hanksville, and from the Desert
Range Experiment Station. These
areas may be occasionally colder than
Ephraim, but plants from there did
not survive well—indicating the
probable influence of factors other
than temperature. Springfield reported
in 1970 that soils influenced the
adaptability of particular plant strains.
Plants indigenous to the Ephraim
area suffered fewer if any
complete kills. Although these plants
showed some dieback, it was less than
for plants from any other source.
Apparently, plants indigenous to an
area or from similar habitats sustain
less loss.

A small nursery of fourwing
saltbush was planted from seed June
19, 1972. The original seed sources
included 18 sites in Utah, 3 each in
Arizona and Idaho, and 1 in Montana.
More than ample seed was used to
obtain a good stand, as the utricles
from some sites were extremely low in
seed fill. The resultant plants were to
be used as transplant material. All
suffered winterkill losses. Seed from
near Kanab, Utah, and Lees Ferry,
Arizona, which are warm areas, were
completely killed. Young seedlings
from several central Utah sites varied
in injury from stem tip dieback to
dead. Plants from seeds collected near
Bridger, Montana, showed the least
winter injury.

In 1970, 1- to 2-year-old
transplants, whose original seed source
had been near Canjilon, New Mexico,
at an approximate 7000-ft elevation,
were established at the Nephi Field
Station. Plants were spaced with 12 to
80 ft² per plant, depending on plot
design, to allow comparison of seed
yields. In the fall of 1972, the
remaining 1840 live plants consisted of
1025 pistillate, 680 staminate, and
135 bisexual types. It had been
postulated that staminate plants might
be more winter hardy because of
possible greater food storage, while
pistillate plants might utilize food
reserve to a greater extent in
producing abundant fruits. Instead,
winter injury did not differ with sex,
since nearly 70% of the plants of each
sex were killed. All plants suffered
dieback, some much more than others.
This planting, as had those already
described, showed variations in winter
hardiness between individual plants
that had the same point of origin. Of
the plants suffering top kill, 12%
recovered from excellent basal
regrowth. Such regrowth normally
involves new buds that start a few
inches below the soil surface on the
basal stump.

Plants having a decumbent or
diffuse growth habit had greater
branch survival than the more erect
types. This is probably a superficial
hardiness brought about by protective
snow coverage.

Plants originating near Canjilon,
New Mexico, suffered greater winter

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**Table 1. Winter injury (%) to 20 sources of fourwing saltbush at Snow Field Station.**

<table>
<thead>
<tr>
<th>Plant source</th>
<th>Mean January minimum temperature (°F)</th>
<th>Complete winterkilled</th>
<th>Stem injury</th>
<th>Top killed base alive</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. Ephraim, Utah</td>
<td>17 (-15)</td>
<td>0</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>E. Salina, Utah</td>
<td>17 (-15)</td>
<td>0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>Bonanza, Utah</td>
<td>8 (-25)</td>
<td>8</td>
<td>68</td>
<td>28</td>
</tr>
<tr>
<td>S. Jericho, Utah</td>
<td>14 (-25)</td>
<td>21</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Hiawatha, Utah</td>
<td>14 (-18)</td>
<td>26</td>
<td>65</td>
<td>35</td>
</tr>
<tr>
<td>Canjilon, New Mexico</td>
<td>3 (-35)</td>
<td>33</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>Newcastle, Utah</td>
<td>14 (-32)</td>
<td>38</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Montrose, Colo.</td>
<td>13 (-27)</td>
<td>39</td>
<td>21</td>
<td>64</td>
</tr>
<tr>
<td>Keams Canyon, Ariz.</td>
<td>19 (-5)</td>
<td>43</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>Fry Canyon, Utah</td>
<td>14</td>
<td>48</td>
<td>27</td>
<td>64</td>
</tr>
<tr>
<td>Milford, Utah</td>
<td>13 (-34)</td>
<td>61</td>
<td>67</td>
<td>35</td>
</tr>
<tr>
<td>E. Flagstaff, Ariz.</td>
<td>15 (-16)</td>
<td>68</td>
<td>83</td>
<td>0</td>
</tr>
<tr>
<td>N. Holbrook, Ariz.</td>
<td>18 (-20)</td>
<td>71</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>Emery, Utah</td>
<td>9 (-20)</td>
<td>71</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Desert Range Exp. Sta., Utah</td>
<td>13 (-29)</td>
<td>73</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>E. Flagstaff, Ariz.</td>
<td>15 (-16)</td>
<td>86</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>House Rock Valley, Ariz.</td>
<td>20</td>
<td>94</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>W. Delta, Utah</td>
<td>14 (-25)</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1 Only 4 plants each from Milford and W. Delta were planted and only 8 each from W. Hanksville and Newcastle. All other sources originally consisted of 24 plants. Some sources contained fewer plants in the fall of 1972 due to disease.

2 Temperatures are for the plant source. Extreme minimum temperature in parentheses.

3 Temperatures were obtained from Elvado Dam which are probably lower than at Canjilon.

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injury when planted on the Nephi Station than at the Snow Station. This was also true of plants from the west Ephraim source, many of which winterkilled completely when planted at the Nephi Station. These latter plants had made excellent growth at Ephraim during the previous 6 years.

A small planting of transplants collected near Fry Canyon, Utah, were completely killed on the Nephi Station, while only 48% were killed at the Snow Station. The Nephi Station generally has a 2-week longer growing season and is several degrees warmer than the Snow Station.

Data presented here indicate the need to obtain seed destined for specific areas from strains that are environmentally adapted to that area, since even indigenous strains may suffer injury during unusually severe winters. This ties in with Springfield’s (1970) finding on adaptability. Plummer et al. (1968) have indicated that cold-tolerant strains can be planted successfully in warmer climates, but the reverse obviously may be hazardous.

Temperatures are a definite factor in winter injury, but other climatic conditions as well as soil characteristics and availability of moisture may also be involved. Winter hardiness varies between individual plants having the same point of origin, as demonstrated by our several plantings of different aged plants from diverse locations.

Literature Cited
