The relationship of plant morphology and seed processing to utricle fill and germination of fourwing saltbush (Atriplex canescens (Pursh) Nutt) seed
by Wayne Gregory Gamrath

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Agronomy
Montana State University

Abstract:
Morphological variations in plants and methods of improving utricle fill were studied. Seven accessions and a field planting at the Bridger PMC were used in these studies. Four stems per plant with four plants per collection, for the eight collections were tagged and the date of bloom recorded for each stem. At harvest time each stem was cut into three sections and each section evaluated for utricle weight, fill, protein, fiber, and seed germination and viability. Utricles from the 1967 harvest were pearled and separated on a gravity table into three separations. Utricles were collected at two week intervals from the field planting to determine a specific time of harvest for maximum utricle fill and seed viability.

Vegetative plant traits were uniform within plant collections, but varied among collections. The probable genetic variations found within and among plant collections warrants further genetic studies. Bisexual plants occurred in all collections observed and had three distinct types of female followers. The smallest utricles have the highest percentage of fill, Percent utricle fill can be increased by mechanical processing. To obtain the highest seed quality possible, fourwing saltbush should be harvested before October 1, at Bridger, Montana.

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ABSTRACT

Morphological variations in plants and methods of improving utricle fill were studied. Seven accessions and a field planting at the Bridger PMC were used in these studies. Four stems per plant with four plants per collection, for the eight collections were tagged and the date of bloom recorded for each stem. At harvest time each stem was cut into three sections and each section evaluated for utricle weight, fill, protein, fiber, and seed germination and viability. Utricles from the 1967 harvest were pearled and separated on a gravity table into three separations. Utricles were collected at two week intervals from the field planting to determine a specific time of harvest for maximum utricle fill and seed viability.

Vegetative plant traits were uniform within plant collections, but varied among collections. The probable genetic variations found within and among plant collections warrants further genetic studies. Bisexual plants occurred in all collections observed and had three distinct types of female followers. The smallest utricles have the highest percentage of fill. Percent utricle fill can be increased by mechanical processing. To obtain the highest seed quality possible, fourwing saltbush should be harvested before October 1, at Bridger, Montana.

INTRODUCTION

Fourwing saltbush (Atriplex canescens (Pursh) Nutt.) is a native browse species of the dry plains from South Dakota and Oregon to Texas and Lower California. It is medium-sized, has an evergreen habit and provides valuable food for livestock and game. This species has been cultivated since 1870 and planted quite extensively in the southwestern United States. Many of these plantings have failed due to poor germination. Low percentage of filled utricle, seed dormancy and poor environmental conditions have been used to explain these failures.

The improvement of seed germination and utricle fill seems almost impossible without first studying plant and flower morphology, the mode of pollination, flowering habit, distribution of sexes, and harvesting procedures.

The processing methods used today provide for the removal of wings from utricles and the separation of stems and leaves. These methods do not improve percent of filled utricles in a given seed lot.

This study was conducted to determine (1) variations in plant and flower morphology, (2) distribution of sexes, (3) variations within and between plant collections for seed quality factors, (4) processing to improve utricle fill, (5) and a specific time of harvest to obtain maximum utricle fill and viability.

LITERATURE REVIEW

At the turn of the century, Smith (11) recommended that fourwing saltbush be cultivated because of its high nutritive value and growth on poor and salty soils. Other characteristics which add to its importance are abundance, accessibility, size, large volume of forage, and evergreen habit.

Saltbush is one of the most palatable of the southwestern shrubs. Its leaves, stems, and utricles (fruit), are cropped by all classes of livestock and wild game. Its forage value is almost legendary; a large number of references testify to its nutritive quality and usefulness (3,5,6,7,8,9,16,19,20,22).

A comprehensive review on fourwing saltbush was compiled by Springfield (16) in 1970. This review considers the broad topics of plant characteristics, establishment of fourwing saltbush and gives specific information on germination and factors influencing it.

For the purpose of this review, the pertinent literature has been grouped into sections for each of the major plant and seed traits covered in this study. These traits are as follows: plant morphology; germination; time of maturation; and seed harvesting and processing.

Plant Morphology

Plummer (10) observed that fourwing saltbush has a wide assortment of growth forms (shape, and extent of branching); usually a particular form prevails within a given area. The color, height , and

form of plants on sites established from seeds conform to the parental stock (10,13.16).

Plants are reported to be generally dioecious (16) and the distribution of the sexes was about equal (10). The small yellowish staminate flowers are born in panicles at the ends of stems on current-years growth. The female plants produce conspicuous clusters of fourwing one celled pods called utricles (10,16).

The seed is formed inside the utricle. Springfield (16) has reported that seed and leaf size varies greatly from site to site, plant to plant, and on the same plant. The number of utricles per pound ranges from 7,800 to 76,800.

Pale grayish green leaves are mostly 2 to 5 cm long and 2 to 7 mm wide. The leaves are thick, glabrous, alternate and often clustered. The plant is classed as an evergreen. However, many leaves are dropped each year, especially during the winter at higher (6500 to 7500 feet) elevations (10).

The plants are relatively high in crude protein, calcium, and phosphorus throughout the year (21). Bidwell and Wooten (4) reported protein contents of 14 to 18 percent for samples collected in midwinter.

Germination

Beadle (2) found that optimum temperatures for germination of

five species of Atriplex fell between 15 and 20C. Results of germinations studies of Springfield (12,14), concurred with Beadle's findings. The optimum temperatures for fourwing saltbush were from 13 to 24C. Germination was delayed and slower at temperatures less than 13C. Seeds were fully imbided in 24 hours and germination was decreased and delayed by increased moisture stress. Light neither inhibited nor stimulated germination. Mechanical and chemical seed treatments have not consistently improved total germination, but removing the wings from the utricles facilitates handling fruits and hastens germination (12,14).

Seed fill is affected by the environment, and approximately half of the utricles contain seeds. Many of the seeds in the filled utricles fail to germinate immediately after harvest due to seed dormancy. Dormancy is usually dissipated after ten months of storage (15).

Time of Maturation

Time of seed collection was an important factor affecting germination (16). Plummer (10) determined seeds were mature when the wings of the utricle turned yellowish. Since utricles commonly remain on the bushes from October to April, they can be collected over a period of several months.

Seed Harvest and Processing

Utricles are readily harvested from mid-October through April

by pulling them off the stems onto canvasses or into tubs. Some utricles are also collected with a vacuum-type seed harvester (10, 16).

Stroh (17) reported that by manipulating the plant growth habit, utricles can be harvested with a combine.

Utricles are usually dewinged with a hammer mill to reduce bulk and facilitate handling and seeding. The utricles may be further cleaned with a fanning mill to remove chaff and other debris. The cleaned utricles generally amount to only 50 percent of the harvested matter following this process (10,16,18,19)

MATERIALS AND METHODS

Plant Morphology

Morphological measurements of fourwing saltbush were made on plants taken from three sites in 1971. Two sites were at the PMC, Bridger, Montana (Appendix 1), where seven accessions were planted in 20 foot rows and collection F in a one acre field. The other sites were native stands, one located on Wade Creek 12 miles south of Bridger, the other on a ridge adjacent to the Wade Creek drainage.

Plant height in dm was measured as the distance from the soil surface to the tip of an average stem. Extremely long and/or short stems were disregarded. From 30 to 60 plants were measured at each site.

Leaf, bark, and floral morphological traits, including coloring, were studied on material randomly sampled from the seven accessions and the field site at Bridger PMC. Leaves were stripped from stems, measured and photographed.

About 100 flowers from these sites were dissected, and representative samples of all floral parts measured and photographed. Mature utricles were collected, measured, dissected, and photographed.

The proportion of male, female, and hermaphroditic plants was determined by a JAVELIN Technique. This consisted of throwing a pointed lath into the one acre field. The sex of the plant closest to the point was recorded. One-hundred plants were selected in this manner on three different days.

Seed yields were determined from harvesting a one acre plot over a three year period at the Bridger PMC.

Utricle Processing to Improve Seed Quality

Utricles harvested in 1967 at the Bridger PMC from collection one (Appendix 1) were used in these studies. This lot of seed had been processed using the standard methods (15,17,18) and seed quality factors of germination, utricle fill and weight, had been determined.

Ten pounds of utricles were separated using a series of three screens to obtain four utricle sizes. Utricles were separated using a 6/64 x 3/4 inch slotted screen followed, in order, by a 5/64 x 3/4 inch and a number eight mesh screen. Utricles remaining on the top screen were designated as class one and those remaining on subsequent screens were designated as classes two and three, respectively. Those passing through the eight mesh screen were designated class four.

Three groups of 100 utricles (3 x 100) from each size class were weighed and then cut to determine percent fill.

After scoring the relationship of utricle size to fill, the utricle separations were bulked and passed through a "Strong South" barley pearler. They were pearled for 30 seconds and blown in a South Dakota blower to remove inert material. The cleaned utricles were separated into three weight classes by a "Sutton, Steel and Steel" gravity table. The classes were tailings, middlings, and heavy.

A fourth class was a mixture of half of the middlings and half of the heavy classes.

These separations were evaluated for seed quality by determining utricle weight, % fill, and seed germination. Four groups of 100 utricles were weighed to .001 gms on a mettler balance, treated with aresan, placed on blotters moistened with water, and germinated in a standard laboratory germinator under dark conditions at 15C.

Germination counts were made at three day intervals for 21 days. Germinated seeds were removed at each counting. When the final germination counts were completed, the remaining utricles were cut with a scapel to determine fill.

The effect of germination temperature was studied. The bulked sample of the middlings and heavy separations were used in this study. Three groups of 100 utricles were germinated at temperatures of 15,20, 30 and 15-25C[1/]. The germination procedures were similar to those described above.

Within and Between Plant Variations

The eight collections of fourwing saltbush at the Bridger PMC were used in this study. Four plants randomly selected in each collection were staked on June 14, 1971. On each plant four stems were tagged. The date of bloom was recorded for each stem. All

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1/ 15-25C- refers to an alternating temperature with 16 hours at the low temperature and eight hours at the high temperature.

collections were sprayed with malathione for control of insects.

The stems were harvested on October 26, 1971. Each stem was cut into three sections with the top eight cm designated as A, the second eight cm designated as B and lower eight cm designated as section C. Each section was placed in a paper bag and allowed to dry at room temperature for two weeks. Not all stems had sections A, B and C. Sections were hand threshed and cleaned to remove stems and leaves. Utricles were dewinged by rubbing them on a small rubbing board. Collection two was dropped from this study because none of the staked plants bloomed. Utricles from collections three, four, five, six, and seven were bulked. Bulking was necessary since many sections and stems failed to bloom or were mechanically injured.

Twenty-five utricles were selected at random from each section in collections F and one. Three lots of 100 utricles were selected from the bulked collections and weighed to .001 gms. The utricles were treated with aresan, placed on blotters moistened with water, and germinated in a standard laboratory germinator under dark conditions at 15C.

Germination counts were made at three day intervals for 21 days. Germinated seeds were removed at each counting. Following germination, the remaining utricles were cut to determine the percent of filled utricles. The seeds that had not germinated were placed in a 0.1% tetrazolium solution for 12 hours to determine if

they were viable or dead. Percent viability is determined by:

$$\% \text{ viability} = \frac{\text{germinated + viable}}{\text{total filled utricles}}$$

Protein content was determined for the bulked samples by the Kjeldhal method. Fiber content was determined by method 22.038 of AOAC (1).

The data for collections F and 1 was analyzed using a nested analysis of variance.

Date of Harvest

Plants in a one acre field at the Bridger PMC were used in this study. A randomly selected sample of 100 female stems was collected every 14 days.

Sampling began on July 22 and continued through October 26, 1971. The samples were placed in paper bags and air dried. The utricles and leaves were stripped from these stems by hand on November 15, 1971 and three groups of 100 utricles were germinated. Before germinating, the utricles were dewinged by rubbing them on a small rub board. A South Dakota blower was used to separate the wings from the utricles. Utricles were treated with aresan, placed on blotters moistened with water and germinated in a standard laboratory germinator under dark conditions at 15C.

Germination counts were made at three day intervals for 21 days. Germinated seeds were removed at each counting. When the final germ-

ination counts were completed the remaining utricles were cut with a scapel to determine utricle fill. All seeds found during the cutting process were placed in a 0.1% tetrazolium solution to determine seed viability. Percent seed viability was determined by:

$$\% \text{ seed viability} = \frac{\text{germinated + viable}}{\text{total filled utricles}}$$

An uncleaned portion of the harvest date samples was ground in a Wiley mill and tested for protein and fiber content. Protein was determined by the Kjeldahl method and fiber by method 22.038 of AOCA (1).

Germination and percent fill data were analyzed as a completely randomized design.

RESULTS

Plant Morphology

The stems were mostly erect, 3-12 dm tall (Plate 1). The extent of branching varies with the different plant accession (Plate 2,3,4,5, and 6). Male and female plants within accession displayed the same degree of branching (Plate 2,3,4, and 5). The previous seasons growth was woody with a scaley bark which varies in color from a light brown to a dark gray. The surface was roughened by small longitudal fissures, exfoliates and alternating cresent-shaped leaf scars. The new growth was whitish-gray in color and slightly scaley.

The mature grayish-green leaves were 2-15 mm wide and 10-50 mm long (Plate 7). They are sessile to subsessile and usually alternate, but may be clustered. The leaves are elliptic to linear, acute and slightly scurfy. They are mostly deciduous, but some persist through the winter.

The pistillate and staminate flowers are usually born on separate plants. There were 38 percent male, 42 percent female, and 20 percent bisexual plants in the population of a one acre field. Staminate flowers are formed in a cluster on a spike-like panicle at the ends of stems (Plate 3 and 5). There is no corolla on the staminate flower, only a membranous cup-shaped calyx. The calyx consists of five sepals united to near the top where they separate to form 5 teeth approximately .5 mm long. The entire calyx is about 3 mm long. Within the calyx there are five bright yellow anthers.

Plate 1. Typical fourwing saltbush plant found on a native site near Bridger, Montana.