Chenopod Cultivation Increases the Forage Base for Domestic Grazing Animals in Turkmenistan

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Abstract: Rapid increase of livestock numbers urgently demands ways of improving and increasing the forage base for domestic livestock in Turkmenistan. Progressive technologies and new innovations are needed to provide necessary increases in forage production and quality. Currently, extensive areas of saline and sodic soils as well as mineralized tailwater from large irrigation projects are underutilized. Halophyte species development offers the potential to increase forage productivity on saline affected lands in Turkmenistan and other Central Asian countries. In this study, Salicornia europaea, Suaeda acuminata, Climacoptera turcomanica, Atriplex micrantha and A. ornata showed potential as cultivated forage species on irrigated salt affected soils.

Key Words: Chenopod cultivation, Halophyte forages, Irrigation, Saline water, Turkmenistan.

1. Introduction

Increasing numbers of livestock throughout Turkmenistan are placing new and greater demands on rangelands and grazing lands due to a higher standard of living and more economic wealth. All classes of livestock will require additional forage, especially cattle breeding stock, a very important sector of Turkmenistan’s national economy. Within Turkmenistan, vast areas of salt affected soils occur where large scale irrigation projects were developed. Often these areas are underutilized as a potential grazing resource. Turkmenistan also has large reserves of mineralized tailwater from irrigation drainage collectors. This water resource is also currently underutilized. The combination of available lands and irrigation water could serve to increase the amount of forage available for domestic grazing animals.

Prior to development and recent activation of Altyn Asyr Lake, a large irrigation collector lake in northwest Turkmenistan, irrigation drainage water was disposed of by spreading it over about 3000 km² of desert rangelands. This procedure resulted in over wetting, leading to the creation of bogs and shallow reservoirs, and salinization of rangeland soils. Once Altyn Asyr Lake was put into operation in 2009, these salt marsh areas began to dry out and are once again available for grazing animal access. After drying, Tamarix spp. and Kalidium capsicum are the first colonizing plants; however they are almost completely avoided as forage by grazing animals. Eventually, other more palatable plant species may colonize these areas, but accelerating and directing the successional process will provide site stabilization and a grazeable resource in a more reasonable time period.

The introduction of more productive, nutritious, and palatable halophytic species, combined with the use of weakly saline irrigation tailwater (1-5 g/L), is of great interest in Turkmenistan. Palatable halophytic species are drought tolerant and able to survive saline substrate conditions, are often grazeable for long periods during the grazing season, and frequently produce as much or more forage than recognized agricultural forages (Rozema and Flowers, 2008). Grazeable halophytes are utilized by many domestic animals and have long been recognized as an important component of the forage cycle in Central Asian rangelands. In Turkmenistan, reclamation of former salt marshes with palatable halophytes is important not only for site stabilization, but also to improve and increase the forage base for economically important domestic animals. Palatable halophytes have the ecological adaptability, productivity, and value as grazing (and sometimes medicinal) resources making them excellent candidates for improving the productivity and value of these reclaimed lands. These important characteristics of halophytes, combined with new research using non-traditional sources of irrigation water such as saline water, greatly increases the potential for halophyte cultivation (Malash et al., 2008).

A small body of research has been conducted on the cultivation of halophytes in Central Asia (Khamzina et al., 2008; Rozema and Flowers, 2008; Shamsudinov et al., 2000; Kandiah, 1990; Jefferies, 1986; Aronson, 1985; Frank, 1982; Kubanskaya, 1980; Chapman, 1968). However, many aspects need new study. In general, it is not certain how different species will react to irrigation and cultural plantings. New technologies for halophyte field cultivation are needed to reclaim salt marsh areas and support expanding livestock operations in Turkmenistan.

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2. Materials and Methods

The research was conducted in Dashoguz Province of northern Turkmenistan, representing about 2560 ha, of saline affected soils. Ground water depth ranged between 65 cm in spring to 55 cm in fall, and groundwater salinity ranged between 22-27 g/L. Three irrigation treatments were included in the study: 1) no water; 2) saline water (1-5 g/L); and 3) fresh water (<1 g/L). Plant species were seeded on 5 x 5 m² plots with 3-5 replicates. Eight species of annual halophytes were assessed: Salicornia europaea, Suaeda arcuata, Suaeda altissima, Suaeda acuminata, Climacoptera turcomanica, Atriplex micrantha, Atriplex ornata and Bassia hyssopifolia. Species were seeded by hand at the locally recommended rate each year as a dormant fall seeding (October). Flood irrigation was implemented when plants reached 3-5 cm of height in the spring. The irrigation cycle was 7-10 days in spring and 14 days in summer until plant maturity. Aboveground productivity or standing crop (air dried kg/ha) was measured for each species and irrigation regime at the end of the growing season in 2004, 2005 and 2006. Plant density at the end of each growing season was also measured. Descriptive statistics were used to assess species responses since seeding rates were based on local recommendations rather than an equivalent pure live seed rate.

3. Results and Discussion

Little is known about germination requirements and dormancy of annual chenopods (Lalymenko 1974). Initial observations indicated that Suaeda altissima, Suaeda arcuata, and Bassia hyssopifolia provided no seedlings and so were excluded from further data collection and analysis. Aboveground biomass production (standing crop) results are displayed in Table 1.

3.1. Salicornia europaea

An annual chenopod of medium height (10-50 cm), it is well adapted to ephemeral salt marshes (solonchaks) and a variety of soil textures. Sown at a rate of 6.5 kg ha⁻¹, average density yields were 550-1700 plants m⁻² across all irrigation treatments and years. Even though S. europaea is adapted to heavy saline soils and high groundwater levels, it responded well to irrigation. Across the three study years, no water, saline and fresh water treated standing crop was 2,676-3,950, 7,500-9,600 and 6,892-8,860 kg ha⁻¹, respectively. Production was 2.5 times greater with irrigation than without. The saline irrigation treatment produced more standing crop than the fresh water treatment in two of three years of observation, indicating that the use of saline irrigation water had variable but often beneficial impact on this species. Without irrigation, S. europaea had the greatest production of all species when averaged over all three years. Halliday (1997) recognized that S. europaea is capable of maintaining stable stands with appropriate livestock grazing management, and so has important potential.

3.2. Suaeda acuminata

An annual chenopod of medium height (10-50 cm), it is adapted to salt desert, loamy to sandy oasis zones areas. Sown at a rate of 6.5 kg ha⁻¹, average density yields were 420-1420 plants m⁻² across all irrigation treatments and years. On average, standing crop was 2.5-3 times greater in the irrigated plots than non-irrigated. Part of the reason for greater production under irrigation was activation of basal meristems. Individual plants in the non-irrigated treatment tended to have a single basal stem whereas plants in irrigated treatments often had 4-5 lateral branches at the stem base. Across the period of record, the saline irrigation treatment consistently provided more standing crop than the fresh water treatment, with the average increase in production at 12% over the three years. Thus, use of saline irrigation water was especially beneficial. S. acuminata also has potential as a high quality oil seed crop (Wang et al., 2011). Given its potential as both a forage and oil seed crop, and its propensity to perform well under non-traditional irrigation, this species should receive a great amount of research and development attention.

3.3. Climacoptera turcomanica

An annual chenopod of medium height (10-60 cm) common to all regions of Turkmenistan including: saline affected sands, solonchaks, takyrs, and up to higher elevation foothill valleys. The genus Climacoptera includes 10 species.
found in the flora of Turkmenistan, and all may have potential for cultivation as forage plants. *Atriplex micrantha* has been recognized as an important forage plant in wild populations where seed biomass often comprises 25-30% of the standing crop (Kurochkina et al., 1986).

Sown at a rate of 15 kg ha\(^{-1}\), plant density was 63-75 plants m\(^2\) across years and irrigation treatments. Irrigation treatments provided >3 times more standing crop than non-irrigation, and fresh water irrigation resulted in the highest standing crop in 2004 and 2006 (12,100 and 8,842 kg ha\(^{-1}\), respectively). In 2005, the saline irrigation treatment resulted in the greatest standing crop, but averaged across the 3 year period of record, fresh water irrigation provided the greatest yields. Over all species, irrigated *Atriplex micrantha* provided the greatest production in each year, and fresh-water irrigated *Atriplex turcomanica* provided the greatest production in two of three years.

### 3.4. *Atriplex micrantha*

An annual chenopod of robust height (50-100 cm) adapted to solonchak meadows and coastal margins with saline soils. Sown at a rate of 14 kg ha\(^{-1}\), plant density was 65-214 plants m\(^2\) with no irrigation, 66-241 with saline irrigation, and 68-214 with fresh water irrigation. Irrigation significantly increased standing crop, with fresh water irrigation providing an average 49% greater effect than saline irrigation. Standing crop averaged 238, 5,567 and 8,309 kg ha\(^{-1}\) over the study period for no, saline, and fresh water irrigation treatments, respectively. Caution should be maintained if this species is selected for widespread cultivation. *A. micrantha* is a known carrier of Iris Yellow Spot Virus (genus: *Tospovirus*), which is an economically important pathogen for onion and garlic production (Evans et al., 2009).

### 3.5 *Atriplex ornata*

An annual chenopod of medium height (20-50 cm) adapted to foothill plains, solonchaks, saline sands and clays. Sown at a rate of 17 kg ha\(^{-1}\), mean plant density was 67-137 plants m\(^2\) across years and irrigation treatments. Standing crop was consistently greater in the fresh water irrigation treatment than saline irrigation during all three years with a mean of 4,687 kg ha\(^{-1}\), whereas saline irrigation provided a mean of 3,680 and no irrigation 219. *Atriplex ornata* with no irrigation consistently had the lowest production of all species.

### 3.6. Potential of halophytes as forage crops

Recently, halophytes have become recognized as both an important crop (Rozema and Flowers, 2008; Ruan et al., 2010) and for their potential to reclaim saline lands (Ravindran et al., 2007; Manousaki and Kalogerakis, 2011). Our results add to this growing body of literature. Five of the eight species in our study established vigorous stands of forage. Productivity with no irrigation was relatively high for three halophytes, *Atriplex turcomanica*, *S. europaea* and *S. acuminata*, with the first two species producing over 2000 kg ha\(^{-1}\) in all three years. All five species greatly increased productivity, by 156% to over 2200%, when irrigated with saline water. Three species, *Atriplex turcomanica*, *A. micrantha* and *A. ornata*, had additional increases in productivity when irrigated with fresh water, but the relative increase in productivity from saline to fresh water were small, varying between 10-50%. In contrast, *S. europaea* and *S. acuminata* production decreased when irrigated with fresh water, relative to that of saline water. Although *C. turcomanica*, *S. europaea* and *S. acuminata* show great potential for a wide variety of conditions in Turkmenistan, more studies are needed to determine their potential for land reclamation and forage use. Three species, *S. altissima*, *S. arcauta* and *B. hyssopifolia*, did not establish well in our study.

### 4. Conclusions

Results of this case study indicate that annual chenopods have great potential value as forage crops for domestic grazing animals in Turkmenistan and other parts of Central Asia. Because these halophytes can be planted on former salt marsh lands as they dry out with the diversion of saline tailwater to Altyn Asyr Lake, this value is further magnified as a valuable forage resource that can now be grown on lands that were formerly unusable. When the planting of grazeable annual chenopods is combined with the use of low saline concentration irrigation water (another otherwise unused or underused resource), forage production is dramatically increased. Although three of the five species responded better to freshwater than saline water irrigation, production with saline irrigation was at least twice and up to 20 times greater than that with no irrigation for all five species. Thus, given the relative abundance of saline irrigation water derived from tailwater collection drains, saline tailwater is a better candidate for irrigation.

All five species are readily grazed by domestic animals at some physiological stage of plant development during the annual grazing season. Chenopods may hold the potential to not only reduce the need for mineral supplementation of livestock, but under specific conditions can actually improve animal carcass quality (Pearce and Jacobs, 2004). Results from this study are very promising, and future research should involve more intensive statistical designs, seeding trials and forage quality analyses. Nonetheless, it is clear that grazeable, annual chenopods can play significant roles in increasing the domestic animal forage base, in the
reclamation of former salt marshes, and in more efficient uses of saline irrigation tailwater in Turkmenistan and other Central Asian countries.

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