# YIELD AND COMPOSITION OF KOCHIA FORAGE AS AFFECTED BY SALINITY OF WATER AND PERCENT LEACHING

by

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## ABSTRACT

New Mexico has some 15 billion acre-feet of saline to brackish underground water. Salt tolerant crops are necessary to utilize this resource. *Kochia scoparia* (L.) was grown under controlled conditions to determine its yield and forage composition under various watering regimes. Irrigation waters of 1,000, 4,250, 7,500, 10,750 and 14,000 ppm total dissolved solids were applied at 5, 15, 25 and 35 percent leaching for three harvest cycles.

Dry matter yield and protein content were not significantly affected by the water treatments applied. This finding indicates and confirms that kochia is a very salt tolerant plant that may provide a good source of livestock forage through use of saline irrigation water. Oxalate levels were significantly decreased by increasing salt levels. Alkaloid levels were increased in the first clipping but tended to be decreased in the second and third clippings, indicating a general lowering of toxicity levels as the salt levels increased.

Key words: salt tolerance, brackish water, groundwater

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## JUSTIFICATION OF WORK PERFORMED

New Mexico has an estimated 15 billion acre-feet of slightly saline to brackish underground water (Governors Council of Economic Advisors, 1977). This water is not usable for irrigating commercial crops but may be usable for irrigating salt tolerant species. Kochia has proved to be a salt tolerant, drought resistant, and water efficient plant. Exploiting these characteristics and using substandard water for irrigation may lead to kochia becoming a viable source of good forage.

Erickson and Moxon (1947) found kochia to be very comparable to alfalfa hay with respect to forage quality, especially in its early growth stages, as did Sherrod (1973). Bell et al. (1952) commented on kochia's outward appearance as a good forage crop as well as on its high nutritive value and high yields. Finley and Sherrod (1971) conducted digestibility studies with sheep, which indicated the comparatively high nutritive value of kochia forage.

Galitzer and Oehme (1978) reported that kochia has had a history of toxicity problems for cattle since 1938, especially at and subsequent to the blooming stage, during prolonged droughts, or following a heavy rain after a prolonged drought. Dickie and Berryman (1979) found kochia fed cattle to exhibit polioencephalomalacia and photosensitization. Dickie and James (1983) reported these symptoms as well as icterus in kochia fed animals. They also found evidence of a thiamine destructive principle in kochia. Kiesling et al. (1984) conducted serum chemistry profiles on kochia fed steers and found evidence for the involvement of hepatotoxicants; they also concluded that oxalate does not appear to be the primary toxicant. Durham and Durham (1979) reported no problems with poisoning during seven years of grazing cattle and horses on kochia. Saponins, oxalates, alkaloids and nitrates have all been postulated to be toxic components of kochia (Galitzer and Oehme 1978).

Erickson (1947) and Galitzer and Oehme (1979) reported kochia as being very drought resistant. Durham and Durham (1979) wrote of kochia growing during a drought which dried up pastures of native grasses. Bell et al. (1952) recorded kochia yields three times that of alfalfa. Baker (1974) reported dryland yields of 12 metric tons per hectare in Montana while similar results were obtained at NMSU Agricultural Science Center at Clovis, New Mexico (Fuehring 1984).

Salinity of soils and irrigation water is a problem affecting approximately one-third of the earth's irrigated land (Norlyn and Epstein 1984). Bower and Tamimi (1979) reported that crop species vary in their salt tolerance with barley being relatively tolerant and rice intolerant. Francois et al. (1984) reported sorghum as being moderately salt tolerant; Francois (1981) recorded drastically reduced alfalfa yields after salt buildup in the upper root zone; and Keck et al. (1984) reported that alfalfa growth is limited by both salt and water stress. Kochia has displayed a high degree of salt tolerance, giving good yields with water treatments up to one-third the salinity of seawater (Fuehring 1983).

Reeve and Fireman (1967) define the term leaching requirement as the percentage of irrigation water that must be leached through the root zone in order to keep the salinity of the soil below a specified value. Hoffman and Van Genuchten (1983) state that the concept of efficient water use must include an increment of water to meet the leaching requirement. They evaluated leaching requirements by a crop's salinity threshold value and the average maximum salt concentration in the root zone that does not reduce yield. Wagenet et al. (1980) conclude that frequent irrigation produced greater amounts of salt at the lower soil levels. Chaudhary et al. (1974) reported that wheat fields should be leached when conductivity exceeds 5 to 6 mmho/cm.

The overall objectives of the research were to determine yield and composition of kochia forage as affected by a range of irrigation water salinities and to determine the amount of leaching that must be allowed in order to manage the plant effectively.

The objectives were:

1. To set up a controlled environment in which a population of *Kochia scoparia* could be maintained for research purposes;
2. To apply irrigation water of known salinities in amounts calculated to achieve specific leaching percentages;
3. To harvest plant material for determination of dry matter yield and analyses for oxalate, protein, total digestible nutrients, and mineral content; and
4. To analyze the results to determine the relationship between salt concentration of irrigation water, leaching percentage, and forage composition of kochia.

# METHODOLOGY

The study site was located at the Roswell Test Facility, Roswell, New Mexico. A 78.5 square meter room was used as a growth chamber, within which 100 208-liter drums were arranged into five rows. Each drum had approximately 2.5 cm of gravel to allow for bottom drainage and soil was added to within 10 cm of the rim. The top 20 cm of soil was later reworked with a 1:1 mixture of sand and peat to allow for better aeration of the surface. An aluminum access tube, stoppered at both ends, ran down the center of each drum to allow determination of soil moisture content, utilizing a neutron probe.

A total of 5,760 watts of flourescent lighting and 800 watts of incandescent lighting provided illumination 24 hours per day. Temperature was maintained at 21 to 27°C through the use of a steam radiator and an evaporative cooler, both controlled thermostatically. Relative humidity was a consistently high 70 to 80 percent when the evaporative cooler was running, dropping to 20 to 50 percent when the heater was on.

Five salt water treatments were administered at four leaching percentages. These treatments included undiluted Roswell city water (1,000 ppm), undiluted brackish well water (14,000 ppm), and three city water:well water mixtures of 1:3 (10,750 ppm), 1:1 (7,500 ppm), and 3:1 (4,250 ppm). A split-plot Latin square design allowed each of these five treatments to be replicated five times. Within each plot were four drums, each having a different leaching level. Originally, these leaching levels were 10, 25, 40 and 55 percent but were reduced to 5, 15, 25 and 35 percent after three weeks due to difficulty in applying the larger volumes of water.

Undiluted Roswell city water and undiluted brackish well water were available from pressurized lines. The three water mixes were prepared and stored in separate tanks placed on an elevated platform. Each water treatment was applied, utilizing separate garden hoses, and was metered at the terminal end of the hose through a small residential water meter calibrated to 0.01 cubic feet (0.2835 l).

After the establishment of relatively vigorous stands of kochia, using undiluted city water, each drum was thinned to 20 plants and the individual treatments were begun. The soil moisture content of each drum was determined by neutron probe readings taken at three depths. This information, along with the specified leaching percentage for the particular drum in question, determined the volume of water to be applied. After each treatment, approximately 2.5 grams of urea fertilizer (46-0-0) was added to each drum. Treatments were administered on a weekly basis (table 1).

Seven weeks after treatments were begun, the plants were judged to be ready for the first harvest. All plants were then clipped by hand, leaving approximately 15-20 cm to allow regrowth for subsequent harvests. All plant material was dried for three to four days in ovens set at 70°C, then weighed to determine dry matter yield.

All dried plant material from a specific drum was treated as a single sample and was run through a Thomas-Wiley standard cutting mill with a 2 mm aperture screen. This material was thoroughly mixed and a representative sample was then run through a Udy Cyclone sample mill to obtain a fine powder in enough quantity to run subsequent analyses.

An infrared analyzer was used to determine the percent protein, percent oxalate, and percent total digestible nutrients present in each sample. In addition, a 100x dilution in distilled water was made from each sample, allowed to stand for 30 minutes, centrifuged, and tested with a conductivity bridge to determine the total soluble salt content. Harvesting and subsequent

Table 1. Average weekly water treatment for each irrigation water

| Approx. Salt Conc. | Leaching | Week No. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ppm | % | applied water, cm | | | | | | | | | | | | |
| 1,000 | 5 | 13.81 | 6.16 | 4.79 | 11.30 | 4.57 | 6.28 | 5.02 | 6.39 | 5.14 | 5.82 | 5.14 | 5.36 | 5.71 |
| | 15 | 16.78 | 7.19 | 6.05 | 12.67 | 5.82 | 7.53 | 6.28 | 7.42 | 5.94 | 6.85 | 6.16 | 6.28 | 6.62 |
| | 25 | 21.00 | 7.99 | 7.31 | 17.24 | 6.28 | 9.47 | 6.51 | 7.99 | 6.51 | 7.65 | 6.51 | 6.85 | 7.31 |
| | 35 | 30.36 | 11.53 | 10.84 | 20.55 | 5.82 | 11.19 | 9.70 | 11.30 | 8.68 | 9.93 | 9.13 | 9.13 | 10.05 |
| 4,250 | 5 | 14.15 | 6.16 | 5.36 | 9.36 | 6.05 | 6.16 | 6.39 | 7.42 | 6.28 | 6.96 | 6.39 | 6.28 | 6.85 |
| | 15 | 18.04 | 7.76 | 6.85 | 12.21 | 6.51 | 8.45 | 6.62 | 8.10 | 6.96 | 7.88 | 6.96 | 7.31 | 7.88 |
| | 25 | 21.69 | 8.68 | 8.10 | 15.41 | 6.96 | 9.47 | 7.65 | 9.02 | 7.53 | 8.56 | 7.88 | 7.88 | 8.68 |
| | 35 | 28.77 | 12.44 | 11.76 | 22.94 | 8.33 | 9.70 | 9.25 | 11.19 | 9.25 | 10.50 | 9.59 | 9.25 | 10.27 |
| 7,500 | 5 | 14.61 | 7.42 | 6.73 | 11.64 | 7.42 | 8.79 | 7.42 | 8.45 | 7.42 | 7.88 | 7.08 | 7.42 | 7.88 |
| | 15 | 16.55 | 7.76 | 7.19 | 13.81 | 7.19 | 9.25 | 8.22 | 9.36 | 7.88 | 8.56 | 8.22 | 8.10 | 8.68 |
| | 25 | 20.43 | 8.79 | 6.62 | 18.26 | 5.94 | 9.47 | 7.65 | 9.70 | 8.33 | 9.36 | 8.56 | 8.56 | 9.25 |
| | 35 | 27.85 | 13.01 | 10.84 | 22.14 | 6.73 | 13.13 | 9.47 | 11.30 | 10.05 | 10.84 | 10.16 | 10.27 | 10.84 |
| 10,750 | 5 | 14.38 | 6.16 | 4.68 | 10.39 | 5.82 | 6.51 | 6.85 | 8.10 | 7.08 | 7.53 | 7.08 | 7.19 | 7.76 |
| | 15 | 17.01 | 7.08 | 7.08 | 11.99 | 6.85 | 8.22 | 7.31 | 8.79 | 7.53 | 8.45 | 7.65 | 7.65 | 8.33 |
| | 25 | 21.46 | 10.16 | 8.45 | 18.38 | 5.71 | 10.62 | 8.90 | 10.73 | 9.25 | 10.50 | 9.47 | 9.59 | 9.93 |
| | 35 | 28.54 | 12.21 | 12.56 | 22.37 | 10.39 | 12.44 | 10.27 | 11.99 | 10.27 | 11.76 | 10.39 | 10.84 | 11.48 |
| 14,000 | 5 | 14.15 | 6.62 | 6.39 | 11.64 | 6.51 | 8.56 | 7.31 | 8.33 | 7.53 | 8.22 | 7.53 | 7.53 | 8.10 |
| | 15 | 17.35 | 8.79 | 6.73 | 12.78 | 9.02 | 9.93 | 8.33 | 8.45 | 8.68 | 9.70 | 9.02 | 9.02 | 9.36 |
| | 25 | 21.57 | 9.13 | 8.90 | 17.58 | 8.10 | 10.39 | 9.25 | 10.73 | 9.47 | 10.16 | 9.47 | 9.82 | 10.05 |
| | 35 | 28.88 | 13.13 | 11.76 | 22.03 | 7.76 | 11.76 | 10.39 | 12.21 | 10.84 | 12.10 | 11.07 | 11.30 | 11.76 |

Week Nos. 1, 2 and 3 had treatments applied at 10, 25, 40 and 55% leaching

continued

Table 1. Continued

| Approx. Salt Conc. | Leaching | Week No. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | Total |
| ppm | % | applied water, cm | | | | | | | | | | | | |
| 1,000 | 5 | 5.94 | 7.42 | 4.57 | 4.45 | 4.23 | 4.00 | 4.34 | 4.22 | 4.34 | 4.22 | 4.00 | 4.34 | 141.56 |
| | 15 | 6.96 | 8.79 | 5.36 | 5.48 | 5.03 | 4.57 | 5.02 | 4.45 | 4.79 | 4.68 | 4.22 | 4.91 | 165.85 |
| | 25 | 7.42 | 9.70 | 5.82 | 5.82 | 5.48 | 5.14 | 5.25 | 4.57 | 5.02 | 5.02 | 4.91 | 5.25 | 182.77 |
| | 35 | 9.70 | 12.56 | 8.10 | 8.10 | 7.82 | 7.53 | 7.42 | 5.36 | 7.76 | 7.76 | 6.96 | 7.76 | 254.94 |
| 4,250 | 5 | 6.39 | 8.33 | 5.48 | 5.14 | 4.97 | 4.79 | 5.14 | 4.68 | 5.25 | 4.91 | 4.34 | 5.14 | 158.37 |
| | 15 | 7.08 | 9.47 | 6.51 | 6.73 | 6.22 | 5.71 | 5.94 | 5.59 | 5.94 | 5.82 | 5.25 | 5.94 | 187.73 |
| | 25 | 8.45 | 10.50 | 7.19 | 7.19 | 6.85 | 6.51 | 6.51 | 6.28 | 6.51 | 7.08 | 6.05 | 6.73 | 213.36 |
| | 35 | 9.13 | 12.33 | 7.99 | 7.42 | 7.25 | 7.08 | 7.31 | 6.73 | 7.08 | 6.85 | 6.73 | 7.08 | 256.22 |
| 7,500 | 5 | 7.88 | 9.47 | 6.39 | 6.28 | 6.12 | 5.95 | 6.16 | 5.94 | 6.28 | 5.82 | 5.82 | 6.05 | 188.32 |
| | 15 | 8.10 | 10.27 | 6.73 | 6.16 | 6.05 | 5.94 | 6.05 | 5.59 | 6.51 | 5.94 | 5.82 | 6.39 | 200.32 |
| | 25 | 8.68 | 11.07 | 6.96 | 7.08 | 6.68 | 6.28 | 6.62 | 6.16 | 6.96 | 6.96 | 6.05 | 6.51 | 216.93 |
| | 35 | 10.27 | 12.78 | 8.22 | 7.19 | 7.31 | 7.42 | 7.76 | 7.08 | 7.65 | 7.88 | 6.73 | 7.53 | 264.45 |
| 10,750 | 5 | 6.96 | 8.90 | 5.82 | 5.59 | 5.42 | 5.25 | 5.71 | 5.25 | 5.59 | 5.59 | 5.02 | 5.59 | 170.22 |
| | 15 | 7.76 | 9.93 | 6.28 | 6.05 | 6.13 | 6.05 | 6.05 | 5.94 | 5.94 | 6.05 | 5.59 | 5.59 | 191.30 |
| | 25 | 9.47 | 11.76 | 7.88 | 7.65 | 7.48 | 7.31 | 7.65 | 6.96 | 7.53 | 7.42 | 6.96 | 7.65 | 238.87 |
| | 35 | 10.96 | 13.36 | 9.25 | 8.79 | 8.56 | 8.33 | 8.68 | 8.33 | 8.68 | 8.45 | 7.88 | 8.45 | 285.23 |
| 14,000 | 5 | 7.65 | 9.59 | 5.82 | 5.94 | 5.83 | 5.71 | 5.71 | 5.59 | 5.71 | 5.71 | 5.36 | 5.82 | 188.57 |
| | 15 | 8.68 | 10.62 | 7.08 | 6.96 | 6.79 | 6.62 | 7.19 | 6.73 | 7.08 | 6.96 | 6.96 | 7.31 | 216.14 |
| | 25 | 9.47 | 11.76 | 7.65 | 7.65 | 7.42 | 7.19 | 7.42 | 7.08 | 7.31 | 7.19 | 7.08 | 7.65 | 239.49 |
| | 35 | 10.84 | 13.24 | 8.22 | 8.45 | 8.39 | 8.45 | 8.33 | 8.22 | 8.79 | 8.33 | 8.10 | 8.56 | 282.91 |

analyses were repeated at 17 and 25 weeks.

At 6, 17 and 25 weeks after treatments were begun, the plant growth in each drum was tested for relative alkaloid content. Plant juices were introduced onto filter paper which had been impregnated with Dragendorff's reagent as per Burns, 1964. After drying, these papers were rated on a scale of 1 to 6 (relatively low to relatively high alkaloid content).

At 25 weeks, soil samples were taken from each drum at depths of 0 to 25 cm, 25 to 50 cm, and 50 to 75 cm, utilizing a soil auger. This material was air dried and then pulverized, using a mortar and pestle. A 10x dilution in distilled water was made from each sample, allowed to stand for 30 minutes, centrifuged, and tested with a conductivity bridge to determine the total soluble salt content.

The water applied each week is shown in table 1 along with the total.

## RESULTS AND DISCUSSION

Dry matter yield (table 2) was only slightly affected by the concentration of salt in the irrigation water as no statistically significant differences in yields between water treatments were observed (P  0.05). Yields tended to increase with increased salt concentration of irrigation water, peaking out at the 10,500 ppm level. This phenomenon is consistent with results obtained from pot experiments conducted at the NMSU Agricultural Science Center at Clovis (Fuehring 1983). These results confirm that kochia is a very salt tolerant species with no reduction in yield up to a salt level of approximately 40 percent that of seawater (3.5 percent salt).

Conductivity of kochia forage (table 3) tended to increase with higher salt concentrations of the irrigation water with an increase of 40 percent at the highest salt level. Increased conductivity indicated that some of the increased salt was being taken up by the plant, resulting in greater soluble salt levels. However, this trend was insignificant at $P = 0.05$ except at the second clipping.

The oxalate levels (table 4) of the dried forage were significantly reduced by 10 to 17 percent by the highest concentration of salt in the irrigation tion water. In addition, the alkaloid level of the forage (table 5) also tended to be reduced in the second and third clippings at the greater salt levels. However, alkaloid in the first harvest was significantly increased by increasing salt. These trends indicate an improvement in the toxicity hazard of kochia grown under saline conditions as both oxalates and alkaloids may prove toxic to grazing animals (Galitzer and Oehme 1978, Dickie and James 1983).

The percent protein (table 6) and percent TDN (table 7) remained fairly constant over the range of salt concentrations of the applied irrigation water with no significant differences noted at the $P = 0.05$ level except that the TDN level of the first clipping was significantly increased by increasing salt levels.

Table 2. Yield of kochia forage as affected by salinity of irrigation water and percent leaching

| Leaching | Salinity of Irrigation Water, ppm 1,000 | 4,250 | 7,500 | 10,750 | 14,000 | Average |
|---|---|---|---|---|---|---|
| % | ----------------yield of dry matter, g/drum---------------- | | | | | |
| 1st clipping | | | | | | |
| 5 | 62.32 | 60.31 | 50.80 | 81.39 | 59.17 | 62.80 a* |
| 15 | 51.75 | 33.27 | - | 127.50 | 37.47 | 62.50 a |
| 25 | 44.19 | 57.61 | 56.02 | 63.05 | 41.97 | 52.57 a |
| 35 | 37.62 | 55.42 | - | 60.81 | 43.40 | 49.31 a |
| Average | 48.97 a | 51.65 a | 53.41 a | 83.19 a | 45.50 a | 56.66 |
| CV, % = 31.4 | | | | | | |
| 2nd clipping | | | | | | |
| 5 | 23.79 | 27.74 | 33.21 | 36.13 | 31.53 | 30.48 a |
| 15 | 38.98 | 35.05 | 30.26 | 41.03 | 22.76 | 33.62 a |
| 25 | 35.42 | 29.34 | 34.65 | 28.50 | 30.35 | 31.65 a |
| 35 | 40.00 | 23.36 | 27.69 | 21.46 | 31.01 | 28.70 a |
| Average | 34.55 a | 28.87 a | 31.45 a | 31.78 a | 28.91 a | 31.11 |
| CV, % = 51.4 | | | | | | |
| 3rd clipping | | | | | | |
| 5 | 38.5 | 42.7 | 54.4 | 55.1 | 56.9 | 49.5 a |
| 15 | 64.4 | 49.7 | 66.9 | 63.4 | 49.0 | 58.7 a |
| 25 | 41.3 | 57.9 | 46.1 | 49.3 | 51.2 | 49.2 a |
| 35 | 53.4 | 42.4 | 47.0 | 51.4 | 51.6 | 49.2 a |
| Average | 49.4 a | 48.2 a | 53.6 a | 54.8 a | 52.2 a | 51.65 |
| CV, % = 43.7 | | | | | | |

*Averages followed by the same letter are not significantly different (5% level)

Table 3. Conductivity of kochia forage as affected by salinity of irrigation water and percent leaching

| Leaching | Salinity of Irrigation Water, ppm 1,000 | 4,250 | 7,500 | 10,750 | 14,000 | Average |
|---|---|---|---|---|---|---|
| % | ---------------conductivity of forage, mmho/cm--------------- | | | | | |
| 1st clipping | | | | | | |
| 5 | 1.21 | 1.08 | 1.20 | 1.20 | 0.81 | 1.10 a* |
| 15 | 1.08 | 1.00 | 0.98 | 0.87 | 1.03 | 0.99 a |
| 25 | 0.96 | 1.14 | 1.09 | 0.98 | 1.03 | 1.04 a |
| 35 | 0.81 | 0.87 | 0.84 | 1.21 | 0.90 | 0.93 a |
| Average | 1.02 a | 1.02 a | 1.03 a | 1.07 a | 0.94 a | 1.02 |
| CV, % = 27.6 | | | | | | |
| 2nd clipping | | | | | | |
| 5 | 0.60 | 0.69 | 0.67 | 0.72 | 0.76 | 0.69 a |
| 15 | 0.56 | 0.66 | 0.61 | 0.87 | 0.85 | 0.71 a |
| 25 | 0.74 | 0.72 | 0.69 | 0.85 | 0.87 | 0.77 a |
| 35 | 0.56 | 0.65 | 0.70 | 0.83 | 0.93 | 0.73 a |
| Average | 0.62 a | 0.68 a | 0.67 a | 0.82 b | 0.85 b | 0.73 |
| CV, % = 35.0 | | | | | | |
| 3rd clipping | | | | | | |
| 5 | 0.53 | 0.64 | 0.74 | 0.70 | 0.91 | 0.70 a |
| 15 | 0.61 | 0.71 | 0.63 | 0.75 | 0.85 | 0.71 a |
| 25 | 0.62 | 0.73 | 0.66 | 0.69 | 0.76 | 0.69 a |
| 35 | 0.57 | 0.68 | 0.64 | 0.86 | 0.73 | 0.70 a |
| Average | 0.58 a | 0.69 a | 0.67 a | 0.75 a | 0.81 a | 0.70 |
| CV, % = NA | | | | | | |

*Averages followed by the same letter are not significantly different (5% level)

Table 4. Oxalate content of kochia forage as affected by salinity of irrigation water and percent leaching

| Leaching | Salinity of Irrigation Water, ppm | | | | | |
|---|---|---|---|---|---|---|
| | 1,000 | 4,250 | 7,500 | 10,750 | 14,000 | Average |
| % | --------------------------oxalate, %-------------------------- | | | | | |
| 1st clipping | | | | | | |
| 5 | 6.02 | 5.64 | 5.31 | 4.94 | 4.97 | 5.38 a* |
| 15 | 5.95 | 5.84 | 5.21 | 4.88 | 5.11 | 5.40 a |
| 25 | 6.07 | 5.89 | 5.25 | 4.99 | 4.78 | 5.40 a |
| 35 | 5.95 | 5.77 | 4.30 | 5.05 | 4.95 | 5.20 a |
| Average | 6.00 a | 5.79 a | 5.02 b | 4.97 b | 4.95 b | 5.35 |
| CV, % = 5.9 | | | | | | |
| 2nd clipping | | | | | | |
| 5 | 7.32 | 6.72 | 6.36 | 6.10 | 6.28 | 6.56 a |
| 15 | 7.06 | 6.68 | 6.80 | 5.63 | 5.94 | 6.42 a |
| 25 | 6.97 | 6.97 | 6.14 | 6.05 | 6.38 | 6.50 a |
| 35 | 7.03 | 6.84 | 6.70 | 6.29 | 5.98 | 6.57 a |
| Average | 7.10 a | 6.80 ab | 6.50 bc | 6.02 d | 6.15 cd | 6.51 |
| CV, % = 6.3 | | | | | | |
| 3rd clipping | | | | | | |
| 5 | 4.97 | 5.37 | 5.20 | 4.52 | 4.65 | 4.94 a |
| 15 | 5.05 | 5.11 | 5.16 | 4.74 | 4.88 | 4.99 a |
| 25 | 5.13 | 4.94 | 4.62 | 5.07 | 4.10 | 4.77 a |
| 35 | 5.31 | 5.21 | 4.97 | 4.93 | 4.87 | 5.06 a |
| Average | 5.12 a | 5.16 a | 4.99 a | 4.82 ab | 4.63 b | 4.94 |
| CV, % = 9.1 | | | | | | |

*Averages followed by the same letter are not significantly different (5% level)

Table 5. Alkaloid content of kochia forage as affected by salinity of irrigation water and percent leaching

| Leaching | Salinity of Irrigation Water, ppm | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | 1,000 | 4,250 | 7,500 | 10,750 | 14,000 | Average |
| % | alkaloid, rating | | | | | |
| 1st clipping | | | | | | |
| 5 | 2.80 | 3.20 | 3.20 | 3.80 | 3.60 | 3.32 a* |
| 15 | 3.00 | 3.60 | 3.60 | 3.60 | 3.60 | 3.48 a |
| 25 | 3.20 | 3.60 | 3.80 | 3.40 | 3.80 | 3.56 a |
| 35 | 3.20 | 3.40 | 3.60 | 4.00 | 4.00 | 3.64 a |
| Average | 3.05 a | 3.45 ab | 3.55 b | 3.70 b | 3.75 b | 3.49 |
| CV, % = 20.2 | | | | | | |
| 2nd clipping | | | | | | |
| 5 | 3.20 | 4.20 | 4.00 | 4.00 | 3.60 | 3.80 a |
| 15 | 3.40 | 3.60 | 4.20 | 3.60 | 3.80 | 3.72 a |
| 25 | 3.40 | 4.20 | 3.60 | 4.00 | 4.00 | 3.84 a |
| 35 | 4.00 | 4.20 | 4.40 | 3.80 | 4.00 | 4.08 a |
| Average | 3.50 a | 4.05 a | 4.05 a | 3.85 a | 3.85 a | 3.86 |
| CV, % = 15.3 | | | | | | |
| 3rd clipping | | | | | | |
| 5 | 3.8 | 3.6 | 3.4 | 3.8 | 3.8 | 3.68 a |
| 15 | 4.0 | 4.6 | 4.0 | 4.0 | 3.4 | 4.00 a |
| 25 | 3.2 | 4.0 | 4.2 | 3.6 | 3.4 | 3.68 a |
| 35 | 4.0 | 3.8 | 4.2 | 3.6 | 3.8 | 3.88 a |
| Average | 3.75 a | 4.00 a | 3.95 a | 3.75 a | 3.60 a | 3.81 |
| CV, % = 18.0 | | | | | | |

*Averages followed by the same letter are not significantly different (5% level)

Table 6. Protein content of kochia forage as affected by salinity of irrigation water and percent leaching

| Leaching | Salinity of Irrigation Water, ppm | | | | | |
|---|---|---|---|---|---|---|
| | 1,000 | 4,250 | 7,500 | 10,750 | 14,000 | Average |
| % | protein, % | | | | | |
| 1st clipping | | | | | | |
| 5 | 20.35 | 20.39 | 19.97 | 19.93 | 19.78 | 20.08 a* |
| 15 | 20.70 | 19.79 | 19.46 | 19.04 | 20.00 | 19.80 a |
| 25 | 20.72 | 20.32 | 20.23 | 20.06 | 19.17 | 20.10 a |
| 35 | 21.16 | 20.29 | 18.77 | 19.90 | 20.40 | 20.10 a |
| Average | 20.73 a | 22.70 a | 19.61 a | 19.73 a | 19.84 a | 20.30 |
| CV, % = 5.6 | | | | | | |
| 2nd clipping | | | | | | |
| 5 | 24.93 | 24.11 | 23.93 | 23.47 | 24.36 | 24.16 a |
| 15 | 23.89 | 24.06 | 24.49 | 21.74 | 23.97 | 23.63 a |
| 25 | 24.43 | 24.69 | 22.68 | 21.13 | 24.96 | 23.58 a |
| 35 | 24.18 | 23.93 | 24.16 | 24.23 | 23.81 | 24.21 a |
| Average | 24.36 a | 24.20 a | 23.82 a | 22.64 a | 24.28 a | 23.88 |
| CV, % = 5.7 | | | | | | |
| 3rd clipping | | | | | | |
| 5 | 18.48 | 20.01 | 19.12 | 17.87 | 18.14 | 18.72 a |
| 15 | 17.82 | 18.99 | 18.60 | 18.31 | 20.15 | 18.77 a |
| 25 | 18.57 | 18.88 | 17.78 | 19.39 | 19.15 | 18.75 a |
| 35 | 18.64 | 18.45 | 17.76 | 18.32 | 20.10 | 18.85 a |
| Average | 18.38 a | 19.08 a | 18.32 a | 18.47 a | 19.39 a | 18.74 |
| CV, % = 6.6 | | | | | | |

*Averages followed by the same letter are not significantly different (5% level)

Table 7. Total digestible nutrient (TDN) content of kochia forage as affected by salinity of irrigation water and percent leaching

| Leaching | Salinity of Irrigation Water, ppm | | | | | |
|---|---|---|---|---|---|---|
| | 1,000 | 4,250 | 7,500 | 10,750 | 14,000 | Average |
| % | TDN, % | | | | | |
| 1st clipping | | | | | | |
| 5 | 74.5 | 76.0 | 73.3 | 78.6 | 77.4 | 76.0 a* |
| 15 | 75.3 | 73.6 | 77.5 | 80.9 | 76.4 | 76.7 a |
| 25 | 69.9 | 75.1 | 72.8 | 80.1 | 73.7 | 74.3 a |
| 35 | 71.6 | 72.6 | 76.9 | 76.0 | 77.5 | 74.7 a |
| Average | 72.8 a | 74.3 ab | 75.1 abc | 78.9 c | 76.3 bc | 75.5 |
| CV, % = 5.9 | | | | | | |
| 2nd clipping | | | | | | |
| 5 | 83.5 | 89.6 | 84.0 | 86.7 | 92.5 | 87.3 a |
| 15 | 71.6 | 85.8 | 93.0 | 85.0 | 71.8 | 81.4 a |
| 25 | 73.7 | 88.0 | 85.3 | 88.4 | 86.3 | 84.3 a |
| 35 | 70.3 | 87.5 | 86.7 | 88.0 | 84.8 | 83.5 a |
| Average | 74.8 a | 87.7 a | 87.3 a | 87.0 a | 83.9 a | 84.1 |
| CV, % = 15.9 | | | | | | |
| 3rd clipping | | | | | | |
| 5 | 69.3 | 71.2 | 75.4 | 71.5 | 71.7 | 71.8 a |
| 15 | 70.9 | 70.8 | 75.2 | 72.4 | 69.8 | 71.8 a |
| 25 | 64.4 | 70.2 | 70.7 | 74.5 | 71.4 | 70.2 a |
| 35 | 68.0 | 72.0 | 66.2 | 74.1 | 65.5 | 69.2 a |
| Average | 68.2 a | 71.1 a | 71.9 a | 73.1 a | 69.6 a | 70.8 |
| CV, % = 9.3 | | | | | | |

*Averages followed by the same letter are not significantly different (5% level)

Table 8 presents the average soil salinity for each irrigation water and leaching percentage applied at the three depths sampled. Soil salinities tended to be higher with the application of more saline water while increased leaching percentages resulted in lowered soil salinities. In addition, average soil salinity tended to increase with the sample depth. These trends were not significant at the P=0.05 level as indicated by the given LSD values.

Table 8. Average soil sample salinity for each irrigation water and percent leaching at three sample depths

| Irrigation Water Salinity | Leaching | Sample Depth, cm 0-25 | 25-50 | 50-75 | |
|---|---|---|---|---|---|
| ppm | % | | ppm | | |
| | 5 | 2197 | 1911 | 2366 | |
| | 15 | 1456 | 1846 | 1694 | Average of all 1,000 |
| 1,000 | 25 | 1469 | 1703 | 1781 | ppm treatments = 1846 |
| | 35 | 1443 | 1911 | 2379 | |
| | Average | 1641 a* | 1849 a | 2055 a | |
| | 5 | 2938 | 3718 | 3991 | |
| | 15 | 2938 | 3289 | 2899 | Average of all 4,250 |
| 4,250 | 25 | 2561 | 2795 | 3419 | ppm treatments = 3043 |
| | 35 | 2383 | 2695 | 2912 | |
| | Average | 2705 b | 3074 b | 3305 b | |
| | 5 | 3393 | 4069 | 4160 | |
| | 15 | 3263 | 3861 | 3627 | Average of all 7,500 |
| 7,500 | 25 | 3666 | 3835 | 3614 | ppm treatments = 3638 |
| | 35 | 2804 | 3731 | 3631 | |
| | Average | 3281 b | 3874 c | 3758 bc | |
| | 5 | 4132 | 5356 | 5291 | |
| | 15 | 4407 | 4238 | 4758 | Average of all 10,750 |
| 10,750 | 25 | 3679 | 4332 | 3939 | ppm treatments = 4189 |
| | 35 | 3861 | 4121 | 4160 | |
| | Average | 4169 c | 4511 cd | 4537 c | |
| | 5 | 4732 | 5499 | 6110 | |
| 14,000 | 15 | 4884 | 5807 | 6045 | Average of all 14,000 |
| | 25 | 4810 | 5070 | 5499 | ppm treatments = 5241 |
| | 35 | 4459 | 4602 | 5135 | |
| | Average | 4721 c | 5230 d | 5697 d | |
| | 5 | 3598 a | 4071 a | 4344 a | |
| Average | 15 | 3390 a | 3813 ab | 3857 b | |
| | 25 | 3237 a | 3547 b | 3650 b | |
| | 35 | 2990 a | 3401 b | 3602 b | |
| Average at each depth | | 3274 | 3720 | 3870 | |

Average of all drums at 5% leaching = 4005
Average of all drums at 15% leaching = 3534
Average of all drums at 25% leaching = 3478
Average of all drums at 35% leaching = 3348

Average of all drums = 3591

*Averages in each column followed by the same letter are not significantly different (5% level)

## SUMMARY AND CONCLUSIONS

Kochia was proved to be a very salt tolerant species, showing no significant reduction in yield even with an irrigation water of 14,000 ppm total dissolved solids applied at only a 5 percent leaching level. The quality of the resultant dried forage was also unaffected with no significant differences in percent protein over the range of salt concentrations and leaching percentages observed. Total digestible nutrients tended to increase with increasing salt up to the 10,750 ppm level.

Conductivity of the dried forage tended to increase with increasing levels of salt in the irrigation water, indicating an increased uptake of soluble salts by the kochia. Oxalate levels decreased significantly with higher salt concentrations, indicating a lowering of the toxicity hazard of kochia for grazing animals. While alkaloid levels were increased in the first clipping by increasing salt, the levels tended to decrease in the second and third clippings.

Kochia appears to hold a good degree of potential as a forage crop in New Mexico, especially in areas where available irrigation water is too saline for use on conventional crop species.

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