NUTRITIVE VALUE OF KOCHIA SCOPARIA AND PERFORMANCE OF CATTLE GRAZING KOCHIA AT TUCUMCARI, NEW MEXICO

BY

CHEIKH MBAYE BOYE, B.S., D.V.M.

A Thesis submitted to the Graduate School
in partial fulfillment of the requirements
for the Degree
Master of Science

Major Subject: Animal Science

New Mexico State University
Las Cruces, New Mexico
December 1983

"Nutritive Value of Kochia Scoparia and Performance of Cattle Grazing Kochia at Tucumcari, New Mexico," a thesis prepared by Cheikh Mbaye Boye in partial fulfillment of the requirements for the degree, Master of Science, has been approved and accepted by the following:

William H. Matchett
Dean of the Graduate School

Chairman of the Examining Committee

Date

Committee in charge:

Dr. Herman Kiesling, Chairman

Dr. Michael Galyean

Dr. Dennis Hallford

Dr. Mohammed Hussain

ACKNOWLEDGEMENTS

My thanks to:

my parents for raising me with love and understanding

my country for giving me the opportunity to express myself in all my potential and ability

Dr. Kiesling for all the advice and support he provided me during all my stay at NMSU

the members of my examining committee for honoring me by their presence

VITA

December 19, 1952 - Born at Kaolack, Senegal

1979 - Doctorate in Veterinary Medicine (D.V.M.), Inter-States School of Veterinary Science and Medicine

1979 - Scientist in Senegalese Agricultural Research Institute (I.S.R.A.)

PROFESSIONAL AND HONORARY SOCIETIES

American Society of Animal Science

ABSTRACT

NUTRITIVE VALUE OF KOCHIA SCOPARIA AND PERFORMANCE OF CATTLE GRAZING KOCHIA AT TUCUMCARI, NEW MEXICO

BY

CHEIKH MBAYE BOYE, B.S., D.V.M.

Master of Science in Animal Science

New Mexico State University

Las Cruces, New Mexico, 1983

Dr. Herman E. Kiesling, Chairman

Kochia scoparia is a forage abundant in the south midwest and used by many ranchers as forage crop. However, reports on its toxicological effects on livestockhave made some researchers interested in its study. In this study, forage samples from two pastures of Kochia collected by hand-clipping and esophageal fistula were analyzed, and performance of animals grazing those pastures were measured to evaluate (1) the nutritive value of Kochia, and (2) the animal response when grazing Kochia. Hand-clipped and esophageal fistula samples were collected every 28 days and analyzed for dry matter,

ash, crude protein, acid detergent fiber, lignin, nitrate and oxalate contents. Animal weights were measured every 28 days. Blood samples were taken from the animals grazing on Kochia three times during the experiment for serum chemistry analysis. Chemical analysis on hand-clipped samples showed a decrease ($P<.01$) in crude protein from the beginning to the end of the summer growing season; an increase ($P<.01$) in fiber and lignin as the season progressed; and no difference ($P>.10$) between before and after grazing. This indicates a high nutritive value of Kochia during the growing stages which decreases at maturity. Chemical analysis on esophageal fistula samples showed no difference ($P>.10$) in crude protein, fiber and lignin content of the forage as the season progressed, which is indicative of selective grazing habits in animals for a high nutritive value forage. Animals grazing on Kochia showed an appreciable weight gain during the growing stages of Kochia, but a loss of weight as Kochia matured. Increases of blood urea nitrogen and serum enzymes during the last period of grazing are indicative of kidney and liver disfunction, probably due to toxins contained in Kochia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX TABLES

its immature stage (before blooming), cut and ensiled or cut and

LIST OF APPENDIX TABLES

INTRODUCTION

Kochia scoparia (L.) Schrad (summer cypres, burning bush, fireweed, Kochia, fireball, belvedere, Mexican fireweed) belongs to the goosefoot family (Chenopodiaceae). It is a rapidly growing, annual cool season plant, found throughout most of the United States and Canada, being particularly abundant in parts of Texas, Oklahoma, Kansas, Colorado and New Mexico (Sprowls, 1981). It is mostly found in areas of old plowed fields and where grasses and herbs have been eliminated. It grows well in alkaline soils and is extremely drought-resistant. It is used as forage by many ranchers, being grazed in its immature stage (before blooming), cut and ensiled or cut and baled as hay. Few studies have been done on the value of Kochia as a forage for livestock. The objectives of this study were to evaluate the nutritive value of Kochia and to measure performance of yearling steers grazing Kochia pasture.

suggests that it could provide an acceptable forage in its early

INTRODUCTION

Kochia scoparia (L.) Schrad (summer cypres, burning bush, fire-weed, Kochia, fireball, belvedere, Mexican fireweed) belongs to the goosefoot family (Chenopodiaceae). It is a rapidly growing, annual cool season plant, found throughout most of the United States and Canada, being particularly abundant in parts of Texas, Oklahoma, Kansas, Colorado and New Mexico (Sprowls, 1981). It is mostly found in areas of old plowed fields and where grasses and herbs have been eliminated. It grows well in alkaline soils and is extremely drought-resistant. It is used as forage by many ranchers, being grazed in its immature stage (before blooming), cut and ensiled or cut and baled as hay. Few studies have been done on the value of Kochia as a forage for livestock. The objectives of this study were to evaluate the nutritive value of Kochia and to measure performance of yearling steers grazing Kochia pasture.

ses of clipped forage underestimated nutrient values.

INTRODUCTION

Kochia scoparia (L.) Schrad (summer cypres, burning bush, fireweed, Kochia, fireball, belvedere, Mexican fireweed) belongs to the goosefoot family (Chenopodiaceae). It is a rapidly growing, annual cool season plant, found throughout most of the United States and Canada, being particularly abundant in parts of Texas, Oklahoma, Kansas, Colorado and New Mexico (Sprowls, 1981). It is mostly found in areas of old plowed fields and where grasses and herbs have been eliminated. It grows well in alkaline soils and is extremely drought-resistant. It is used as forage by many ranchers, being grazed in its immature stage (before blooming), cut and ensiled or cut and baled as hay. Few studies have been done on the value of Kochia as a forage for livestock. The objectives of this study were to evaluate the nutritive value of Kochia and to measure performance of yearling steers grazing Kochia pasture.

REVIEW OF LITERATURE

Chemical composition changes with plant maturity are reasons for studying nutritive variability of forage throughout a growing season. Phillips et al. (1954) found a decrease in crude protein, acid-soluble ash and ether extract and an increase in crude fiber and lignin during the process of maturation. These workers also found a positive correlation between lignin, cellulose and crude fiber and a negative correlation between these and crude protein.

Jefferies and Rice (1969) found that during a year of average or below-average precipitation, nutrient analysis of clipped grasses reasonably approximated nutrient values on short-grass ranges. During a year of above-average precipitation, cattle diets changed and analyses of clipped forage underestimated nutrient values.

A study of Kochia scoparia showed that the dry matter and crude fiber contents increased while crude protein decreased as stage of maturity advanced (Sherrod, 1971). Forage from Kochia had comparatively high nutritive value particularly in the early growing stages (Finley and Sherrod, 1971) and it had a crude protein and digestibility comparable to alfalfa hay. Kochia also improved digestibility of energy components when mixed with alfalfa hay (Sherrod, 1973) which suggests that it could provide an acceptable forage in its early stages. Erickson (1947) showed that Kochia had a high forage value because of its high digestible crude protein and ash content.

Toxicological effects have been reported following Kochia consumption. Dickie and Berryman (1979) reported polioencephalomalacia and photosensitization and found pulmonary congestive edema, hepatic necrosis and necrosis of proximal convoluted tubular lamina of nephrons. Sprowls (1981) found similar effects in horses, cattle and sheep and suggested that the toxicological effects vary with the length of grazing time, initial condition of the animal and availability of other feed and minerals.

Lodhi (1979) isolated phenolics and flavanoids from leaves of Kochia and found that these phytotoxins do not inhibit germination but retard growth later, essentially explaining the high density but drastic reduction of growth in the second revegetation of Kochia. Kochia also contain saponins, nitrates, oxalates and alkaloids, which may also contribute to the toxicological effects (Coxworth et al., 1969). Davis (1979) found that Kochia forage accumulates oxalates which can be toxic depending on environmental conditions. However, in calves fed Kochia for 120 days, James (1980) did not find significant changes in calcium, phosphorus and serum glutamic oxaloacetic transaminase levels, although the calves did gain less weight than expected from animals of similar size and age.

Galitzer and Oehme (1979), in their review of Kochia toxicity in cattle, concluded that the toxicity syndrome occurs in the late summer, usually after the first rain following a drought; that although saponins, oxalates, alkaloids and nitrates have been identified in the plant, the specific etiologic toxin is unknown; that affected cattle are those that have not grazed lush green plants. These researchers also suggested that Kochia is not always toxic, but when toxic it affects only a small percentage of the herd and, therefore, the variability in toxicity could be due to disease or environmental conditions.

Sampling of forage for nutritive value has been with hand-clipped samples but the selective feeding habits of animals led to the use of esophageal-fistulated animals to allow a better assessment of the nutritive value of forage being consumed by the particular species. Scales et al. (1972) and Barth et al. (1970) found samples from esophageal-fistulated animals to have lower acid detergent fiber and lignin and higher crude protein than samples collected by hand-clipping. Mastication, salivary contamination and leaching have been shown to increase or decrease the crude protein level depending on the forage (Scales et al., 1974). High drying temperature (55°C) increases acid-insoluble and acid-detergent fiber levels of samples from esophageal fistula (Barth et al., 1970; Scales et al., 1974). Barth and Kazzal (1971) found that the selective behavior of animals for feeds results in intake of forage high in crude protein. Long fasting time had no effect on acid detergent fiber but decreased the crude protein level by eliminating selectivity of the animals (Grings and Morris, 1977).

MATERIALS AND METHODS

Field study was conducted at the Northeastern Branch Experiment Station at Tucumcari, New Mexico, which is located in a semiarid area with distinct seasonal changes and wide daily ranges in temperature. Summer temperatures are warm with daily maximum averaging above 32°C and rapidly falling after sunset to 15°C. Precipitation averages 382 mm a year with most falling from April to September. Rains are often heavy, of short duration and sometimes accompanied by hail. Even though most rain falls during the growing season, distribution is variable and erratic, resulting in conditions unfavorable for dry-land farming (Williams, 1977).

Two pastures (east and west) of 2.4 ha each were seeded during the 1982 spring season with Kochia scoparia on 76 cm rows at a seeding rate of 4.5 kg/ha. Pastures were fertilized just after seeding with 90 kg of nitrogen (N) and 22 kg of phosphorus (P) per ha. Each pasture was subdivided into 4 paddocks which were grazed for a 7 days "on" and 21 days "off" sequence. Each pasture was grazed by 18 yearling steers (averaging 182 kg ± 25.11 in the east pasture and 184 kg ± 22.41 in the west pasture). Cattle were weighed every 28 days during the study (summer 1982) with the initial and final weights being an average of weights obtained on two consecutive days.

Hand-clipped forage samples were collected every 28 days at three different locations (top, middle and far end of each paddock) of the paddock just grazed and the one to be grazed in each pasture. Samples were also collected by esophageal-fistulated cows (using screen wire bottom canvas bag and two cows per paddock for every collection) every

28 days. Collections were done early in the morning, then samples put in plastic bags were transported to Clayton in an ice-chest, where they were dried at 55°C in an oven, then put in a paper bag. Samples were then sent to Las Cruces at the university laboratory where they were grounded in 2-mm screen mill. A11 samples were analyzed for dry matter, ash, crude protein, acid detergent fiber and lignin, oxalates and nitrates (A.O.A.C., 1980). Chemical composition of Kochia was determined four times during the summer.

Blood samples were collected early in the morning using vacu-tube. Collection was done three times (at the beginning of the experiment, after 56 days and at the end of the experiment) for serum chemistry analysis. After collection, blood samples were put in an ice-chest and sent to Clayton, where they were centrifuged (2000 g) and stored frozen until analysis. Time between collection and spinning was 6 hours. All samples were evaluated by a simultaneous multi-channel computerized analyser[1] (SMAC).

Statistical analysis of the data collected was done using an analysis of variance with least-square means (LS means), a partial differential (PDIFF) in a completely randomized linear mode1 design. The mode1 used pasture, time of sampling (before or after grazing) and period of the summer as classes.

---

[1] John P. Thilsted, D.V.M., Ph.D. New Mexico Department of Agriculture, Veterinary Diagnostic Services, Albuquerque, New Mexico 87106.

RESULTS AND DISCUSSION

Hand-Clipping Sampling

Crude protein in the east pasture of Kochia forage showed a decrease ($P<.01$) from the beginning ta the end of the summer growing season with values (mean ± SE) ranging from 24.8 to 16.1 (± 1.6%). The same trend occurred in the west pasture of Kochia forage with values from 24.9 to 15.1 (± 1.6%) (table 1). There was no difference ($P>.10$) in crude protein content of forage between the two pastures for the same period of sampling except for the third period when the protein value was higher ($P<.01$) in the east pasture than in the west pasture. This may be due, as suggested by Lodhi (1979), to the fact that phytotoxins produced in the east pasture had more inhibitive action on regrowth than that produced in the west pasture. A higher level of nitrogen in the west pasture soil may have also caused a rapid growth, thereby showing a more rapid maturation of the plant and an early decline in crude protein value. The overall early high crude protein level has also been found by Sherrod (1971) and Finley and Sherrod (1971).

Fiber content of the forage varied from 21.3 to 32.3 (± 1.5) in the east pasture and from 22.3 to 35.7 (± 1.5) in the west pasture (table 1). The same trend in increased level of fiber content is shown in the two pastures. There was no difference ($P>.10$) in fiber content for a particular period between the two pastures. The slight decrease in fiber between the third and fourth period may be due to irrigation applied or rainfall at that time which would allow for a regrowth of fresh leaves, thereby decreasing the fiber content of the plant.

Table 1. Crude protein, fiber and lignin of hand-clipped Kochia scoparia throughout the grazing season for two pastures at the Northeastern Branch Experimental Station, 1982.[g]

	June 3rd	July 1st	July 29th	Sept. 16th	Standard error	Sample size
EAST PASTURE			Percent of organic matter			
Protein	24.8^{a}	21.8^{a}	23.9^{a}	16.1^{b}	1.68	24
ADF	21.3^{c}	22.5^{c}	32.2^{d}	31.6^{d}	1.52	24
ADL	4.1^{e}	4.4^{e}	10.7^{f}	7.9^{f}	0.75	24
WEST PASTURE						
Protein	24.9^{a}	20.0^{a}	16.1^{b}	15.1^{b}	1.68	24
ADF	22.3^{c}	26.8^{c}	35.7^{d}	33.1^{d}	1.52	24
ADL	4.2^{e}	4.5^{e}	8.4^{f}	8.1^{f}	0.75	24

[a,b]Means for protein values with different superscripts differ (P<.01).

[c,d]Means for fiber values with different superscripts differ (P<.05).

[e,f]Means for lignin values with different superscripts differ (P<.05).

[g] LS means values were used, and interaction between pasture and period of sampling was significant (P<.01).

Lignin content varied from 4.1 to 10.7 ($\pm$ .7) in the east pasture and from 4.2 to 8.4 ($\pm$ .7) in the west pasture (table 1). There was no difference (P>.10) between lignin content of forage collected at the same period in the two pastures. The same pattern of variation occurred in lignin as with fiber content throughout the maturation process. The increase in lignin and fiber and the decrease in crude protein as the plant matured agrees with the positive correlation between lignin and fiber content coupled with a negative correlation between these variables and crude protein reported by Phillips et al. (1954) .

The protein level before grazing (table 2) decreased (P<.05) as the season progressed from values of 26.3 to 13.7 ($1.6). The level of crude protein after grazing also decreased (P<.05) as the season advanced (table 2). There was no difference (P>.10) in protein level between before and after grazing for the same period of sampling.

Fiber content increased (P<.01) from 21.5 to 35.3 ($\pm$ 1.5) before grazing and from 22.1 to 32.6 ($\pm$ 1.5) after grazing (table 2). There was no difference (P>.10) in fiber content between before and after grazing for the same period of sampling.

Lignin values increased (P<.01) from the beginning of the study to the end of the experiment with values ranging from 4.2 to 10.1 ($\pm$ .7) before grazing and from 4.2 to 9.0 ($\pm$ .7) after grazing (table 2). There was no difference (P>.10 between before and after grazing.

This lack of difference in nutritive value of forage between before and after grazing may be due to a low stocking rate so that livestock were not able to graze enough of the forage to make a

Table 2. **Grazing effect** on **protein, fiber, lignin** content of hand clipped Kochia scoparia **during grazing season, 1982.**[g]

	June 3rd	July 1st	July 29th	Sept. 16th	Standard error	Sample size
BEFORE GRAZING		Percent of organic matter				
Protein	26.3[a]	21.4[a]	20.1[a]	13.7[b]	1.68	24
ADF	21.5'	26.2[c]	35.3[d]	34.4[d]	1.52	24
ADL	4.2[e]	4.5[e]	10.1[f]	8.3[f]	0.75	24
AFTER GRAZING						
Protein	23.4[a]	22.5[a]	20.0[a]	17.5[b]	1.68	24
ADF	22.1[c]	23.1[c]	32.6[d]	30.3[d]	1.52	24
ADL	4.2[e]	4.1[e]	9.0[f]	7.7[f]	0.75	24

[a,b] Means for protein values with different superscripts differ $(P<.01)$.

[c,d] Means for fiber values with different superscripts differ $(P<.01)$.

[e,f] Means for lignin values with different superscripts differ $(P<.01)$.

[g] LS Means values were used, and interaction between time of grazing and collection time was significant $(P<.01)$.

nutritional difference in forage value between before and after the animal had grazed on the pasture.

Nitrate content of plants in the east pasture did not change (P>.10) as the Kochia matured (table 3). In the west pasture nitrate levels decreased (P<.01) as the growing season progressed (table 3). Nitrate content differed (P<.01) between pastures during the growing stage (June 3, July 1) not (P>.10) at maturity (Sept.) (table 3). This difference may be due to a higher nitrogen content in the west pasture soil, which would allow higher nitrate drainage by the plant in the west pasture.

Oxalic acid and oxalate salt content of the forage were fairly high and decreased as the growing season progressed. There was no difference (P>.10) between pastures (table 3).

Nitrate levels decreased (P<.01) before grazing as the season progressed. An increase (P<.01) followed by a decrease (P<.01) was found in nitrate content after grazing as the experiment progressed (table 4). There was a difference (P<.01) between before and after grazing during the first period of sampling with higher nitrate values before grazing, This may be due to the fact that at the beginning of the growing season, there were enough leaves where the nitrate accumulated to be used; but as the experiment progressed and the animals used the leafy part, less nitrate may have been drawn from the soil and, therefore, no difference between before and after grazing.

Oxalate level decreased (P<.01) before and after grazing as the season progressed (table 4). However, there was no difference (P>.10) in oxalic acid content between before and after grazing at any ,

Table 3. Nitrate (ppm) and oxalate (percent) variation of hand-clipped Kochia during growing season for the two pastures.[e]

	June 3rd	July 1st	July 29th	Sept. 16th	St. err.	Sample size
NITRATE		Percent of organic matter				
East Pasture	80.5[a]	87.7[a]	115.2[a]	78.4[a]	76.11	24
West Pasture	348.2[b]	452.7[b]	47.3[a]	86.6[a]	76.11	24
OXALATE						
East Pasture	2.0[c]	1.2[d]	1.1[d]		0.16	18
West Pasture	2.3[c]	1.7[d]	1.2[d]		0.16	18

[a,b]Means for nitrate values with different superscripts differ (P<.01).

[c,d]Means for oxalate values with different superscripts differ (P<.01).

[e] LS Means were used, and interaction between pasture and time of sampling was significant (P<.01) for nitrate.

Table 4. Grazing effect on nitrate (ppm) and oxalate (percent) content of hand-clipped Kochia during growing season.[e]

	June 3rd	July 1st	July 29th	Sept. 16th	St. err.	Sample size
NITRATE		Percent of organic matter				
Before Grazing	315.3[a]	209.0[a]	54.6[b]	64.7[b]	76.11	24
After Grazing	113.3[b]	331.3[a]	107.8[b]	100.3[b]	76.11	24
OXALATE						
Before Grazing	2.4[c]	1.7[cd]	1.0[d]		0.16	18
After Grazing	2.0[c]	1.2[d]	1.3[d]		0.16	18

[a,b]Means for nitrate values with different superscripts differ (P<.01).

[c,d]Means for oxalate values with different superscripts differ (P<.01).

[e] LS Means were used, and interaction between time of collection and before and after grazing was significant (P<.01) for nitrate.

particular period of sampling, which suggests that the oxalates are uniformly distributed and accumulated in the whole plant.

Esophageal Fistula Sampling

Crude protein values varied from 18.2 to 14.1 (± 1.2%) in forage collected in the east pasture (table 5). There was no difference (P>.10) in crude protein between pastures or between the different periods of collection. Selective grazing habits of the animals leading to the intake of high protein forage may be responsible for this lack of difference in crude protein value throughout the growing season. These findings agree with those reported by Barth and Kazzal (1971).

Fiber was higher (P<.01) for the first period of sampling for both pastures (east and west) than for the rest of the sampling periods. There was no difference (P>.10) in fiber values between pastures for the same period of sampling (table 5). Moreover there was no difference (P>.10) in lignin content between pastures or between sampling periods (table 5).

There was no difference (P>.10) in crude protein before grazing as the season progressed. There was no difference (P>.10) in crude protein after grazing between the different sampling periods. Similar results were found for fiber and lignin content. However, a difference (P<.01) was found in crude protein, fiber and lignin between before and after grazing for the same period of sampling, with higher crude protein before grazing and higher fiber and lignin after grazing (table 6). This may be the effect of grazing animals

Table 5. **Crude protein,** fiber **and lignin of esophageal** fistula **collected** *Kochia scoparia* throughout the grazing **season for two pastures** at the Northeastern **Branch** Experiment Station, 1982.[e]

	June 3rd	July 1st	July 29th	Sept. 16th	Standard error	Sample size
EAST PASTURE		Percent of organic matter				
Protein	17.4[a]	18.2[a]	14.1[a]	15.6[a]	1.24	15
ADF	35.2[b]	29.8'	33.6[bc]	30.8'	2.11	15
ADL	5.7[d]	5.8[d]	5.4[d]	6.0[d]	0.48	15
WEST PASTUKE						
Protein	18.6[a]	18.1[a]	16.6[a]	17.4[a]	1.52	16
ADF	36.7[b]	29.7[c]	29.8[c]	29.7[c]	2.59	16
ADL	5.5[d]	5.9[d]	5.6[d]	5.8[d]	0.58	16

[a] Means for protein values with same superscripts are not different (P>.10).

[b,c]Means for fiber values with different superscripts differ (P<.01).

[d] Means for lignin values with same superscript are not different (P>.10).

[e] LS Means were used, and interaction between time of collection and pasture was significant (P<.01) for fiber.

Table 6. Grazing effect on crude protein, fiber and lignin of esophageal fistula collected Kochia during growing season.[g]

	June 3rd	July 1st	July 29th	Sept. 16th	Standard error	Sample size
BEFORE GRAZING		Percent of organic matter				
Protein	18.6[a]	20.1[a]	19.1[a]	20.5[a]	1.24	15
ADF	29.1[c]	26.3[c]	27.8'	25.4'	2.11	15
ADL	5.4[e]	5.4[e]	4.8[e]	5.6[e]	0.48	15
AFTER GRAZING						
Protein	17.4[b]	16.0[b]	11.6[b]	12.5[b]	1.52	16
ADF	42.8[d]	33.2[d]	35.5[d]	35.1[d]	2.59	16
ADL	5.9[f]	6.3[f]	6.3[f]	7.1[f]	0.58	16

[a,b]Means for protein values with different superscripts differ ($P<.01$).

[c,d]Means for fiber values with different superscipts differ ($P<.01$).

[e,f]Means for lignin values with different superscripts differ ($P<.01$).

[g] LS Means were used.

which have taken the high value forage and left the low quality one after their passage and collected for after-grazing nutrient values.

No difference (P>.10) in nitrate content was found between pastures for the same period of sampling (table 7). However, higher (P<.01) nitrate level occurred in the second period of collection than for the rest of the sampling periods in both pastures. This might be the effect of precipitation just before the second sampling period, which leads to an increase in nitrates drawn from the soil by the plant.

Oxalate content was higher (P<.01) for the first sampling collection in the east pasture. There was a gradual decrease (P<.01) in oxalate content in the west pasture as the experiment progressed. There was a difference (P<.01) in oxalate content between the two pastures during the third period of sampling with higher values for east pasture forage (table 7).

"Nitrate after grazing for the second period of sampling was higher (P<.01) than the rest of the sampling times either before or after grazing (table 8). This difference may also be the effect of precipitation before the second after-grazing collection time which increases the nitrate drawn from the soil, and it was at a time when there were not as many leaves available to utilize it due to grazing; therefore, nitrate will accumulate in the plant.

Oxalate content was higher (P<.01) for the first perfod of sampling in both before and after grazing than for the rest of the sampling periods either before or after grazing (table 8). However, there was no difference (P>.10) in oxalate content between before and after grazing for a particular sampling time.

Table 7. Nitrate (ppm) and oxalate (percent) content of esophageal-fistula Kochia during growing season for the two pastures.[f]

	June 3rd	July 1st	July 29th	Sept. 16th	St. err.	Sample size
NITRATE						
East Pasture	44.5[a]	261.2'	14.0[a]	50.2[a]	53.97	15
West Pasture	47.25[a]	244.5[b]	50.7[a]	25.5[a]	66.10	16
OXALATE						
East Pasture	1.9[c]	1.2[d]	1.6[d]		0.14	12
West Pasture	2.3[c]	1.5[d]	0.9[e]		0.14	12

[a,b] Means for nitrate values with different superscripts differ (P<.01).

[c,d,e] Means for oxalate values with different superscripts differ (P<.01).

[f] LS Means were used, interaction between time of collection and pasture was significant (P<.01) for nitrate.

Tab;le 8. Grazing effect on nitrate (ppm) and oxalate (percent) content of esophageal-fistula-collected Kochia during growing season.[e]

	June 3rd	July 1st	July 29th	Sept. 16th	St. err.	Sample size
NITRATE						
Before Grazing	21.2[a]	21.7[a]	32.5[a]	54.5[a]	53.97	15
After Grazing	70.5[a]	484.0[b]	32.2[a]	21.2[a]	66.10	16
OXALATE						
Before Grazing	2.1[c]	1.4[d]	1.1[d]		0.14	12
After Grazing	2.1[c]	1.3[d]	1.4[d]		0.14	12

[a,b] Means for nitrate values with different superscripts differ (P<.01).

[c,d] Means for oxalate values with different superscripts differ (P<.01).

[e] LS Means were used, interaction between time of sampling and after and before grazing was significant (P<.01) for nitrate.

Crude'protein and lignin values from hand clipping (tables 1 and 2) were higher ($P<.01$) than those from esophageal fistula (tables 5 and 6). Fiber'values from esophageal fistula were higher ($P<.01$) than those from hand clipping. Although these findings are not in accord with early reports from Barth et al. (1970) and Scales et al. (1972); they might have been due to the effect of salivary contamination and leaching on esophageal samples which decrease the crude protein level, as suggested by Scales et al. (1974) in their later report. The high fiber level in esophageal fistula samples may be due to the effect of high drying temperature which has an increasing effect on fiber value, as suggested by Barth et al. (1970) snd Scales et al. (1974). These differences in nutritive value between hand-clipped samples and esophageal fistula samples may also result from a decrease in animal selectivity leading to the intake of low nutritional forage value.

Animal Performance

Crossbred yearling steers grazed the Kochia pastures from June 3rd to September 16th. Steers in the east pasture gained weight (table 9) during the first two periods (average daily gain from 1.53 kg to 1.82 kg), followed by a gradua1 Poss of weight the remainder of the experiment (daily loss 0.23 kg to 0.11 kg). In the west pasture, steers gained 1.21 kg to 1.42 kg daily in the first two periods followed by a slight increase in weight (0.41 kg daily) for 28 days and then a drastic loss of weight (daily loss of 1.17 kg) during the last 21 days of the experiment. Steers in the east pasture gained more overall compared with steers grazing the west pasture.

	Sodium	Potassium	Chloride	Calcium	Phosphorus

Crude'protein and lignin values from hand clipping (tables 1 and 2) were higher (P<.01) than those from esophageal fistula (tables 5 and 6). Fiber'values from esophageal fistula were higher (P<.01) than those from hand clipping. Although these findings are not in accord with early reports from Barth et al. (1970) and Scales et al. (1972); they might have been due to the effect of salivary contamination and leaching on esophageal samples which decrease the crude protein level, as suggested by Scales et al. (1974) in their later report. The high fiber level in esophageal fistula samples may be due to the effect of high drying temperature which has an increasing effect on fiber value, as suggested by Barth et al. (1970) and Scales et al. (1974). These differences in nutritive value between hand-clipped samples and esophageal fistula samples may also result from a decrease in animal selectivity leading to the intake of low nutritional forage value.

Animal Performance

Crossbred yearling steers grazed the Kochia pastures from June 3rd to September 16th. Steers in the east pasture gained weight (table 9) during the first two periods (average daily gain from 1.53 kg to 1.82 kg), followed by a gradua1 loss of weight the remainder of the experiment (daily loss 0.23 kg to 0.11 kg). In the west pasture, steers gained 1.21 kg to 1.42 kg daily in the first two periods followed by a slight increase in weight (0.41 kg daily) for 28 days and then a drastic loss of weight (daily loss of 1.17 kg) during the last 21 days of the experiment. Steers in the east pasture gained more overall compared with steers grazing the west pasture.

Table 9. Average daily gain variation of animals grazing Kochia during the experiment in the two pastures.

	Period 1 (6/3 - 7/1)	Period 2 (7/1 - 7/29)	Period 3 (7/29 - 8/26)	Period 4 (8/26 - 9/16)
ADG (period) kg				
East	1.53	1.82	- 0.23	- 0.11
West	1.21	1.42	0.41	- 1.17
ADG (overall) kg				
East	1.53	1.68	1.02	0.79
West	1.21	1.32	1.01	0.60

Table 10. Blood mineral variations during the period animals were grazing on Kochia.[d]

	Sodium (mM/l)	Potassium (mM/l)	Chloride (mM/l)	Calcium (mM/dl)	Phosphorus (mM/dl)
June 1st	145.4^{a}	6.9^{a}	99.3^{a}	10.1^{a}	8.5^{a}
July 29th	144.7^{a}	5.4^{b}	95.0^{b}	11.1^{b}	6.0^{b}
Sept. 16th	142.0^{a}	5.4^{b}	91.3'	11.0^{b}	6.2^{b}
Standard error	1.68	0.22	1.48	0.48	0.27
Sample size	41	41	41	41	41

[a,b,c] Means in the same column with different superscripts differ (P<.01).

[d] LS Means were used

Serum sodium (Na) concentration (table 10) did not differ ($P>.10$) among the three sampling periods while a gradual decrease ($P<.01$) in potassium (K), chloride (Cl) and phosphorus (P), and a gradual increase ($P<.01$) in calcium. Comparison between animals which gained weight and those which lost weight during the time of the experiment only showed a difference ($P<.01$) in blood sodium and chloride level with higher values for animals which gained weight (table 11). Serum enzyme analysis (table 12) showed a decrease ($P<.01$) in alkaline phosphatase (AP) concentration during the last sampling time, a gradual increase ($P<.01$) in serum glutamic oxaloacetic transaminase (SGOT) level from the beginning to the end of the experiment, and an increase ($P<.01$) in lactic dehydrogenase (LDH) at the middle of the experiment followed by a decrease ($P<.01$) in LDH at the end of the experiment, although LDH was higher ($P<.01$) than the level at the beginning of the experiment. Increased ($P<.01$) blood urea nitrogen (BUN), total bilirubin (TBILI) and "direct bilirubin" (DBILI) occurred for animals grazing the west pasture during the last period of the experiment (table 13). Comparison of blood parameters (BUN, TBILI and DBILI) between animals which gained weight and those which lost weight in the two pastures showed an increase ($P<.01$) in those blood measurements for the animals which lost weight and grazing in the west pasture (table 14). Comparison of blood measurements (BUN, TBILI and DBILI) between animals which gained weight and those losing weight, during the time of the experiment, showed an increase ($P<.01$) in blood parameters for the animals losing weight during the last period of the experiment (table 15).

Table 11. Blood mineral variations between animals losing weight and animals gaining weight during the time of grazing on Kochia.[c]

	Sodium (mM/1)	Potassium (mM/1)	Chloride (mM/1)	Calcium (mg/dl)	Phosphorus (mg/dl)
Animal gainers	146.4[a]	6.0[a]	97.4[a]	11.1[a]	6.8[a]
Animal losers	141.7[b]	5.8[a]	93.1[b]	11.0[a]	7.0[a]
Standard error	1.41	0.18	1.25	0.40	0.23
Sample size	41	41	41	41	41

[a,b]Means in the same column with different superscripts differ (P<.01).

[c] LS Means were used.

Table 12. Blood enzyme levels in animals grazing Kochia.[d]

	Alkaline phosphatase (IU/1)	Serum Glutamic oxaloacetic transaminase (IU/1)	Lactic dehydrogenase (IU/1)
June 1st	149.6[a]	113.7[a]	904.3[a]
July 29th	145.9[a]	149.3[b]	1227.8[b]
Sept. 16th	129.3[b]	198.6'	985.6'
Standard error	15.60	25.20	99.24
Sample size	41	41	41

[a,b,c]Means in the same column with different superscripts differ (P<.01).

[d] LS Means were used.

Table 13. Variation between pastures during time of grazing of blood urea nitrogen (BUN) and bilirubin (TBILI; DBILI).[g]

	June 1st	July 29th	Sept. 16th	Standard error	Sample size
EAST					
BUN (mg/dl)	17.3^{a}	14.0^{a}	11.6^{a}	3.18	21
TBILI (mg/dl)	0.2^{c}	0.3^{c}	0.1^{c}	0.56	21
DBILI (mg/dl)	0.01^{e}	0.02^{e}	0.02^{e}	0.11	21
WEST					
BUN (mg/dl)	16.1^{a}	9.7^{a}	38.1^{b}	3.41	20
TBILI (mg/dl)	0.1^{c}	0.1^{c}	3.7^{d}	0.60	20
DBILI (mg/dl)	0.00^{e}	0.01^{e}	0.71^{f}	0.12	20

[a,b]Means for BUN with different superscripts differ ($P<.01$).

[c,d]Means for TBILI with different superscripts differ ($P<.01$).

[e,f]Means for DBILI with different superscripts differ ($P<.01$).

[g] LS Means were used, interaction between time of sampling and pasture was significant ($P<.01$).

Table 14. Variation between animals losing or gaining weight in the two pastures of blood urea nitrogen (BUN) and bilirubin (TBILH; DBILI).[g]

	EAST	WEST	Standard error	Sample size
GAINERS				
BUN (mg/dl)	14.8^{a}	14.6^{a}	2.78	18
TBILI (mg/dl)	0.2^{c}	0.1^{c}	0.49	18
DBILI (mg/dl)	0.01^{e}	0.00^{e}	0.09	18
LOSERS				
BUN (mg/dl)	13.8^{a}	28.0^{b}	2.41	23
TBILI (mg/dl)	0.2^{c}	2.5^{d}	0.42	23
DBILI (mg/dl)	0.03^{e}	0.47^{f}	0.08	23

[a,b]Means for BUN with different superscripts differ ($P<.01$).

[c,d]Means for TBILI with different superscripts differ ($P<.01$).

[e,f]Means for DBILI with different superscripts differ ($P<.01$).

[g] LS Means were used, interaction between pasture and variation of weight **was significant** ($P<.01$).

Table 15. Variation between animals gaining or losing weight for the grazing time on Kochia for BUN, LDH and bilirubin.[k]

	June 1st	July 29th	Sept. 16th	Standard error	Sample size
GAINERS					
BUN (mg/dl)	17.5[a]	13.3[a]	13.3[a]	3.41	18
LDH (IU/l)	934.0[c]	1029.7[d]	1164.0[d]	145.17	18
TBILI (mg/dl)	0.1[e]	0.2[e]	0.2[e]	0.60	18
DBILI (mg/dl)	0.00[g]	0.00[g]	0.01[g]	0.11	18
LOSERS					
BUN (mg/dl)	16.0[a]	10.4[a]	36.4[b]	3.18	23
LDH (IU/l)	874.4'	1425.9[a]	807.2'	135.35	23
TBILI (mg/dl)	0.2[e]	0.3[e]	3.7[f]	0.56	23
DBILI (mg/dl)	0.01[g]	0.01[g]	0.72[h]	0.10	23

[a,b]Means for BUN with different superscripts differ ($P < .01$).

[c,d]Means for LDH with different superscripts differ ($P < .01$).

[e,f]Means for TBILI with different superscripts differ ($P < .01$).

[g,h]Means for DBILI with different superscripts differ ($P < .01$).

[k]LS Means were used, and interaction between time of collection and variation of weight was significant ($P < .01$).

A comparison in LDH level between animals gaining weight and those losing weight during the experiment showed only a decrease (P<.01) in LDH level for the animals losing weight during the last period of the experiment, following a trend for an increase in LDH level (P<.01) (table 15).

The overall daily gain showed that forage production of Kochia can sustain an animal in production during its early growing stage but will only sustain an animal for maintenance or less during later stages of maturity. The high level of BUN compared to the normal range given by Galyean and Hallford (1983) (Appendix table), in the last period of the experiment especially in the animals which lost weight, may be an indication of kidney disfunction. Also the levels of TBILI and DBILI found in the last period of the experiment and especially for the animals which lost weight are high compared with the normal range given by Galyean and Hallford (1983) (Appendix table). The LDH levels throughout the experiment in all animals, were in the normal range given by Galyean and Hallford (1983). SGOT level was in the normal range given by Galyean and Hallford (1983) only at the beginning of the experiment and then increased (P<.01) throughout the experiment. Increased LDH is found during necrosis and high level of TBILI, SGOT and DBILI during hepatic disfunction; therefore, animals which lost weight during the last period of the experiment might have liver problems. These liver and kidney disfunctions, found in some animals grazing on Kochia pasture, corroborate with the findings of Dickfe and Berryman (1979) and Sprowls (1981). The high incidence of liver and kidney disfunction in the west pasture suggested that there was a greater toxicity effect from forage in the west pasture.

Possibly the forage in the west pasture had a more rapid growing rate than the forage in the east pasture, and so the animals would spend more time in the west pasture after maturation of Kochia forage. Long-time exposure to the mature plants may explain the severity of effects in animals grazing the west pasture. A correlation between length of grazing time and severity of toxicity was also suggested by Sprowls (1981).

SUMMARY AND CONCLUSION

Forage samples of Kochia scoparia collected by hand-clipping and esophageal fistula showed a high nutritive value of Kochia during the growing stages which decrease at maturity, and selective grazing habit in animals for a high nutritive value forage. Animals grazing Kochia showed an appreciable weight gain at the early growing stage of Kochia, and a loss of weight at Kochia maturity. Increases in blood urea nitrogen, serum enzymes and bilirubin during the last period of grazing may be indicative of kidney and liver disfunction.

Kochia scoparia, because of its high nutritive value and the performance of animals grazing it, can be used as a forage crop for livestock. However, because of its potential toxin content, especially at maturation, its use has to be restrained to its early stage of growth and for a short period of time.

LITERATURE CITED

A.Q.A.C. 1980. Methods of Analysis (13th Ed.). Association of Official Agricultural Chemist. Washington, D.C.

Barth, K. M., J. E. Chandler, M. E. Fryer and H. C. Wang. 1970. Effects of saliva and drying temperature on composition and digestibility of forage samples collected through esophageal fistulas. J. Anim. Sci. 31:794.

Barth, K. M. and N. T. Kazzal. 1971. Separation of true selective grazing by cattle from effects of the esophageal fistulas. J. Anim. Sci. 33:1124.

Coxworth, E. C. M., J. M. Bell and R. Ashford. 1969. Preliminery evaluation of Russian thistle, Kochia and Garden atriplex as potential high protein content seed crops for semiarid areas. Can. J. Plant Sci. 49:427.

Davis, A, M. 1979. Forage quality of Prostate Kochia compared with three browse species. Agro. J. 71:822.

Dickie, C. W. and J. R. Berryman, 1979. Polioencephalomalacia and photosensitization associated with Kochia scoparia consumption in range cattle. Am. Vet. Med. Assn. J. 175:463.

Erickson, E. L. 1947. Forage from Kochia. I - Some plant characteristics and forage production. So. Da. Agr. Exp. Sta. Bull. 384.

Finley, L. G. and L. B. Sherrod. 1971. Nutritive value of Kochia scoparia. II - Intake and digestibility of forage harvested at different maturity stages. J. Dairy Sci. 54:231.

Galitzer, S. J. and F. W. Oehme. 1979. Kochia scoparia (L.) Schrad toxicity in cattle: A literature review. Toxicol. Lett. pp. 421.

Galyean, M. L. and D. M. Hallford. 1983. Bovine hematology: Serum profiles of beef steers in different production situations. Agri-Practice. 4:33

Grings, E. E. and J. G. Morris. 1977. Effects of length of fasting and stocking rate on the chemical composition of esophageal fistula samples collected by cattle. Proc. West. Sect. Am. Soc. Anim. Sci. 28:152.

James, L. F. 1980. Toxicological effects of oxalates- containing plants on livestock. Toxicol. Res. Proj. Dir. pp. 10107.

Jefferies, N. W. and R. W. Rice. 1969. Nutritive value of clipped and grazed range forage samples. J. Range Manage. 22:192.

Lodhi, M. A. K. 1979. Germination and decreased growth of Kochia scoparia in relation to its autoallelopathy. Can. J. Botany. 57:1083.

Phillips, T. G., J. T. Sullivan, M. E. Loughlin and V. G. Sprague. 1954. Chemical composition of some forage grasses, 1 - Changes with plant maturity. Agro. J. 46:361.

Scales, G. H., C. L. Streeter and A. H. Denham. 1972. Chemical composition of esophageal fistula samples. Proc. West. Sec. Am. Soc. Anim. Sci. 23:192.

Scales, G. H., C. L. Streeter, A. H. Denham and G. M. Ward. 1974. Effects of mastication, salivary contamination and leaching on the chemical composition of forage samples collected via esophageal fistulae. J. Anim. Sci. 38:1278.

Sherrod, L. B. 1971. Nutritive value of Kochia scoparia. 1 - Yield and chemical composition at three stages of maturity. Agro. J. 63:343.

Sherrod, L. B. 1973. Nutritive value of Kochia scoparia. III - Digestibility of Kochia hay compared with alfalfa hay. J. Dairy Sci. 56:923.

Sprowls, R. W. 1981. Problems observed in horses, cattle and sheep grazing Kochia. Amer. Assn. Vet. Lab. Diag. 24th Annual Pro. pp. 397.

Williams, D. H. 1977. Weather observations at the Northeastern Branch Station, 1905-1975. New Mex. State Uni. Agr. Exp. Sta. Res. Report No. 351.

APPENDIX: Supplementary Data

Appendix Table 16, Reference range of serum constituents.

Items	Reference (Galyean & Hallford)	Reference (Vet-Path)
Ca, mg/dl	9.5 - 10.6	9.9 - 12.5
P, mg/dl	5.0 - 7.0	3.4 - 6.7
k, mM/liter	4.6 - 6.4	2.8 - 5.6
Na, mM/liter	127.9 - 142.1	133 - 143
Cl, mM/liter	95.0 - 105.5	91 - 105
BUN, mg/dl	8.0 - 21.8	5 - 21
SGOT, IU/liter	75.1 - 137.0	9 - 67
Alkaline Phosphatase, IU/liter	18.6 - 56.2	18 - 97
LDH, IU/liter	899.0 - 1404.4	357 - 756
Total Bilirubin, mg/dl	0.1 - 0.5	0 - 0.8
Direct Bilirubin, mg/dl	0.04 - 0.1	0 - 0.3

[a]BUN = Blood Urea Nitrogen; SGOT = Serum Glutamic-oxaloacetic transaminase; LDH = Lactate Dehydrogenase.