Root and Shoot Growth of Five Range Grasses

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Highlight

Five range grasses were studied at relatively young ages. Sideoats grama had the most rapid root and shoot increase and produced the most quantity. Root growth of all species was initially rapid. Root: shoot ratios were consistently above 1.0 for all grasses.

Various characteristics of forage plants have been frequently observed in the past. However, most of the available information pertains to mature plants under natural conditions. Little information is available on characteristics of forage grasses of relatively young ages.

Types of grass roots have been reported by Larin (1962), Weaver (1947), Weaver and Albertson (1943), and Weaver and Zink (1945). The roots varied from dense, very fine roots of sideoats grama *(Bouteloua curtipendula)* to coarse roots of big bluestem *(Andropogon gerardi)*. Root depth in the soil was generally 5 to 7 ft. The roots varied in degree of branching, rhizome type and number, and other factors. Larin also discussed types of top growth, particularly generative and vegetative tops.

Annual grasses usually contain less roots than tops by weight. The reverse is true of perennials grown in virgin soil. Root: top ratios of 0.40 to 0.47 for mature big bluestem and 0.21 to 0.29 for mature blue grama *(Bouteloua gracilis)* were reported by Weaver and Zink (1946).

Roots of grasses grew slowly the first year, but much more rapidly the following year according to Larin (1962). The root volume continued to increase for five years. Cheatgrass brome *(Bromus tectorum)* and medusahead *(Elymus caputmedusae)* roots reached maximum development near inflorescence formation (Hironaka, 1961).

Blue grama, little bluestem *(Andropogon scoparius)* and big bluestem can produce up to 1.6, 2.7 and 5.5 tons/acre of roots, respectively (Weaver and Zink, 1946). Total root length of a given plant may reach hundreds of feet (Weaver, 1954).

Perennial darnel *(Lolium perenne)* root death due to clipping was greater at higher temperatures (Sullivan and Spragel, 1949). The best top growth occurred at 60 to 70 F.

Newell, et al. (1962) found that strains of a given species differed in photoperiod response and that temperature was important in association with photoperiod. Northern strains required more days to reach flowering stage under naturally increasing photoperiods.

The objectives of the study were to observe and compare range grasses at various ages. Periodic records were made on root and shoot growth characteristics and other plant stages.

Materials and Methods

Five species of range grasses were selected for study. Four were improved varieties of native species: Kaw big bluestem, Caddo switchgrass *(Panicum virgatum)*, Western indiangrass *(Sorghastrum nutans)*, and Coronado sideoats grama and one was an unimproved native little bluestem. All seed was produced within 75 mi of the study area, Stillwater, Oklahoma.

Plantings were made in one-gallon metal containers containing Norge fine sandy loam. The soil moisture was brought to field capacity prior to planting the grass seed. The grass seed was hand sown on the soil surface and covered with ⅛ inch of moist soil. To reduce soil crusting and moisture evaporation, ⅛ inch of vermiculite was spread evenly over the soil surface.

Successive planting dates were near the first and middle of each month from January 12 to April 3. Each species was replicated five times at each planting date.

All containers were kept in a greenhouse with average low and high temperatures of 65 F. and 85 F. Temperature extremes were 40 F. to 90 F. Light control was not practiced.

Plants were watered as needed to maintain adequate soil moisture levels. Small holes were punched in the container walls near the bottom to allow excess water to drain from the container.

After emergence the seedlings were thinned to five per container. The April 3 planting had not been thinned to five. In some replications less than five seedlings emerged. Data calculations are based on an average plant basis. The plants were not crowded in the containers.

Shoot height was determined at approximately two-week intervals which coincided closely with planting dates. Plants in each replication were measured to the tip of the uppermost leaf or the tip of the inflorescence, whichever was the tallest. Periodic notes were taken of leaf, tillering and inflorescence stages.

At the end of the study the soil-root mass was removed from the container and placed on an 18 mesh supported steel screen. The soil was washed from the roots with moderate water pressure from a hose. The broken roots caught by the screen were retained as a portion of the given root system. The roots were clipped at the culm base after

completing the washing. Rhizomes were considered as roots.

The root and culm portions were oven-dried for 24 hours at 105° C. Gram weights were then determined on each replication. Using this data, average per plant shoot and root weights were determined and converted to root: shoot ratios.

Results and Discussion

Shoot and Root Weights— Shoot and root weights per plant varied among the species (Table 1). Young plant weights did not differ greatly, however. As age increased, the variation among the shoot and root weights became more pronounced.

Shoots of sideoats grama made a very rapid initial growth but slowed during the last six to eight weeks. At this age the plants were nearing flowering. Sideoats grama produced the most shoot growth. Shoots of all other species made slow but generally regular growth increments throughout the study.

Species other than sideoats grama appeared to have a stunted growth habit at all planting dates from January to April. This may have been due to the short day length of winter. The short day length did not appear to inhibit root growth or type typical of a given species.

Roots were considered as all subsurface plant parts including the limited rhizomes. Root production increased for all species as age increased. Initial root growth was rapid, then slowed during the middle of the study and increased during the last of the study (Table 1). Rapid initial root growth is very important for species establishment under range conditions.

There was no readily apparent explanation for the great difference in root and shoot production between the 12 and 15-week old plantings. The degree to which day length affected growth under the various planting dates could not be ascertained. Except for switchgrass, the maximum production of shoots and roots was the 15 week old plants, planted January 12. Sideoats grama produced the greatest quantity of roots and shoots (Fig. 1).

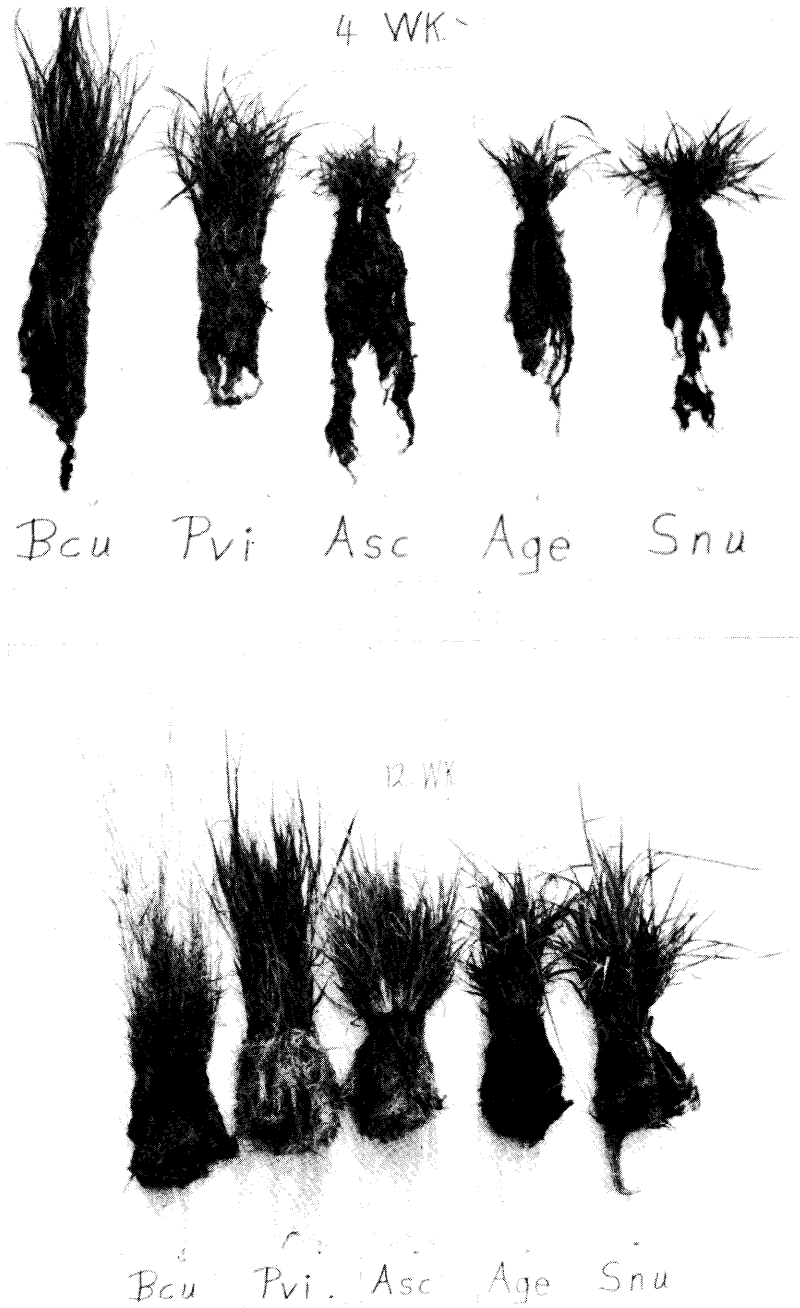

FIG. 1. Comparison of study grasses, shoots and roots, at four and 12 weeks of age. (Bcu-sideoats grama, Pvi-switchgrass, Asc-little bluestem, Age-big bluestem and Snu-indiangrass).

Root length of the grasses could not be measured because they often reached the bottom of the container in three weeks. They were compact and entangled by the end of the study.

Root:Shoot Ratios — Root production was greater than shoot production in all instances (Table 1). All ratios were highest at three weeks and varied from 1.2 to 28.0. Ratios were increasing rapidly as the study terminated. The increase was due to more rapid root growth of the

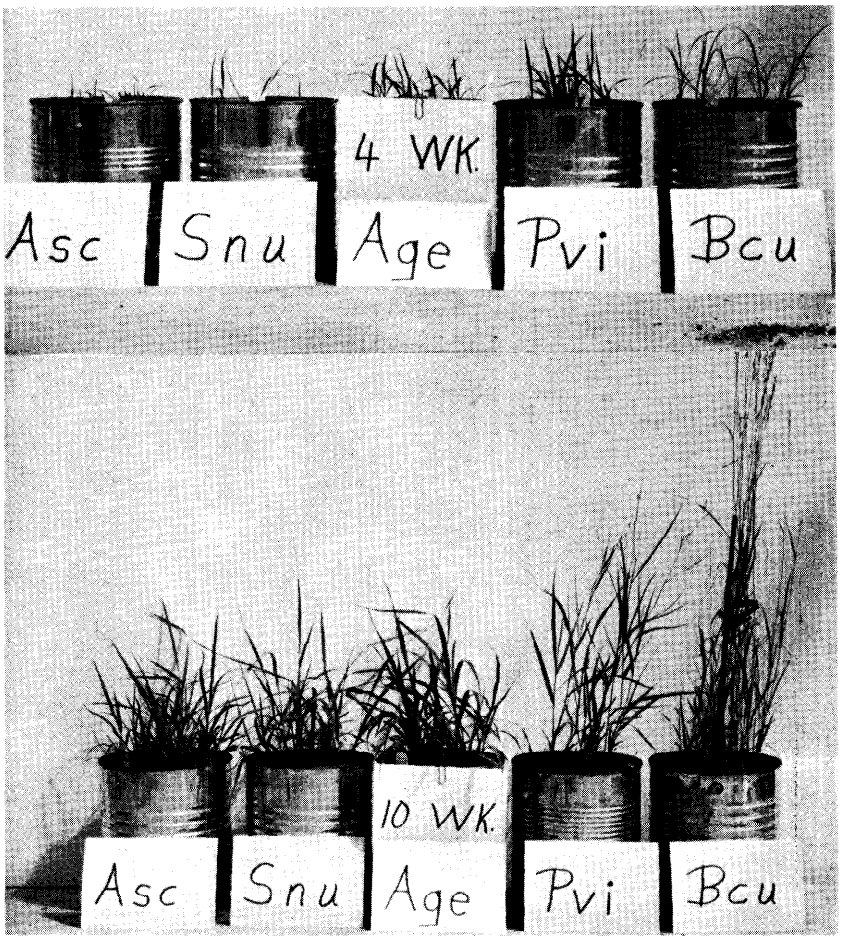

FIG. 2. Comparison of study grasses at four and 10 weeks of age. (Asc-little bluestem, Snu-indiangrass, Age-big bluestem, Pvi-switchgrass and Bcu-sideoats grama).

plants. The root:shoot ratio of 28.0 for little bluestem was apparently the result of initial slow top growth (Table 2) but rapid root growth.

Initial root:shoot ratios were higher than those during the 6 to 12-week period (Table 1). This was caused by steadily increasing topgrowth and a reduced root growth for the plants 6 to 12 weeks old. As the 15-week period approached, the ratios began to rise. The data indicates there was a period of rapid root growth during the first three weeks, then a 6 to 12-week period following when root growth was slower than shoot growth. After 12 weeks of age root growth again appears to exceed shoot growth as the root:shoot ratio increases.

Shoot Growth—Rate of shoot growth varied among species at each planting date (Table 2). Sideoats grama made the most rapid growth at each planting date (Fig. 2). Switchgrass responded in growth similar to sideoats grama. Big bluestem and indiangrass were about the same and intermediate in growth rate with little bluestem being the slowest of all the grasses to grow.

The grass shoots differed somewhat from their general appearance encountered under field conditions. With the exception of sideoats grama, all plants had short, large stems. Sideoats grama had tall, fine stems.

Other Characteristics — The grasses varied considerably in other characteristics (Table 3). Sideoats grama emerged first and generally developed various leaf and tiller stages first, thus was established first. Other species varied in this respect.

Inflorescences were formed on big bluestem, switchgrass and sideoats grama. Those on sideoats grama appeared normal (Fig. 1 and 2) and produced seed. The inflorescence of big bluestem was normal appearing with the exception of being somewhat small and supported by a short peduncle. Switchgrass inflorescence contained only two to four spikelets and was very small and malformed. Caryopses were produced by sideoats grama, but none were noted on any other species. The caryopses were not checked for viability.

Rhizomes were formed on switchgrass and indiangrass. In-

Table 1. Average per plant root and shoot production (grams) and root: shoot ratios of five grass species at various ages.[1]

Weeks	Big Bluestem			Little Bluestem			Switchgrass			Indiangrass			Sideoats Grama		
	Shoots	Roots	Ratio	Shoots	Roots	Ratio	Shoots	Roots	Ratio	Shoots	Roots	Ratio	Shoots	Roots	Ratio
3	0.02	0.16	8.0	0.01	0.28	28.0	0.02	0.11	5.5	0.02	0.09	8.0	0.05	0.40	8.0
6	0.30	0.59	2.0	0.18	0.34	1.9	0.24	0.57	2.4	0.20	0.96	4.8	0.58	1.74	3.0
8	0.24	0.42	1.8	0.26	0.31	1.2	0.25	0.97	3.9	0.30	0.62	2.1	0.63	3.05	4.8
10	0.74	1.91	2.6	0.46	0.72	1.6	0.39	1.43	3.7	0.46	1.43	3.1	0.51	1.06	2.1
12	0.54	1.24	2.1	0.80	1.51	1.9	0.83	1.58	1.9	0.65	1.05	1.6	0.23	0.88	3.8
15	1.04	2.95	2.8	1.03	4.31	4.2	0.74	1.49	2.0	0.97	4.27	4.3	1.54	7.55	4.9

[1] All data in this table was obtained on April 26.

Table 2. Average height of five grass species (cm) at various ages under different planting dates.

	January 12[2]					February 1					February 15				
Weeks[1]	Age[3]	Asc	Pvi	Snu	Bcu	Age	Asc	Pvi	Snu	Bcu	Age	Asc	Pvi	Snu	Bcu
3	2.3	1.8	2.8	3.3	6.6	2.3	2.0	3.3	2.3	4.1	2.5	2.3	3.1	4.1	7.9
5	4.6	4.3	9.7	6.1	21.6	4.8	3.1	10.2	2.8	7.4	4.1	4.8	9.4	9.9	18.8
7						6.6	5.6	22.4	11.4	18.8					
8	9.1	7.4	16.3	8.6	46.0						11.4	13.0	21.3	16.3	58.7
9	14.5	11.7	20.3	9.1	49.5										
10						13.5	16.8	27.2	16.3	49.5	21.9	18.8	28.5	21.3	60.7
12						21.1	22.4	30.0	20.8	52.6					
13	19.6	17.8	24.9	15.8	52.1										
15	28.7	23.4	32.5	24.9	54.6										

	March 1					March 15					April 3				
Weeks	Age	Asc	Pvi	Snu	Bcu	Age	Asc	Pvi	Snu	Bcu	Age	Asc	Pvi	Snu	Bcu
1						0.5	0.3	0.8	1.0	3.1	1.5	1.3	1.3	2.0	3.3
3	3.8	1.5	4.6	3.6	7.9						5.1	4.6	5.6	8.9	21.3
4						7.6	4.1	16.8	11.9	17.3					
6	11.2	6.4	18.3	11.4	33.5	17.3	13.0	29.5	22.9	32.8					
8	21.8	14.0	26.2	24.6	54.9										

[1] Age to the nearest week.
[2] Planting dates, final measurements were made on April 26.
[3] Age = big bluestem, Asc = little bluestem, Pvi = switchgrass, Snu = indiangrass, Bcu = sideoats grama.

dian grass had rhizomes at 30 days, switchgrass at 60 days. No other grass had developed rhizomes at the close of the study.

Summary and Conclusions

This study was conducted to obtain information five grass species at relatively early ages. Big bluestem, little bluestem, switchgrass, indiangrass and sideoats grama were the species studied. Greenhouse plantings were made at approximately two-week intervals from January 12 to April 3. Data was taken on shoot and root growth and various plant stages.

Shoot and root weights varied among the species. Sideoats grama had the most rapid increase of shoots and roots and produced the greatest quantity. Other species had fairly regular and steady growth from seedling emergence to 15 weeks of age. Root growth was rapid initially but from 6 to 12 weeks of age, it was noticeably slow. Then it appeared to increase above the shoot growth rate from 12 to 15 weeks of age.

Root: shoot ratios were above 1.0 in all cases. The ratios varied from 1.2 to 28.0. They were always highest when the plants were youngest. Ratios were generally high initially, moderate at 6 to 12 weeks and moderately high at 15 weeks.

Shoot growth was most pronounced with sideoats grama which produced rapid and abundant topgrowth at all planting dates. The growth of sideoats grama appeared to be normal at all stages, but other species appeared stunted with malformed inflorescences. This may have been due to the short day length, but day-length effects could not be accurately ascertained. Shoot growth of little bluestem was slow initially but root growth exceeded three of the other four species. Big bluestem, switchgrass and indiangrass were considered intermediate in growth

Table 3. Number of days to various plant growth stages of five grass species.

Growth State	Age[1]	Asc.	Pvi.	Snu.	Bcu.
Seedling Emergence	6	6	6	5	3
Leaf Stages—2 to 3 leaves	16	19	28	29	17
3 to 4	31	**	**	23	23
4 to 5	**	53	**	**	53
7 to 8	**	**	**	**	53
Tillering Stages— 1 tiller	31	32	34	35	**
2 to 3	47	39	52	47	31
3 to 4	49	56	54	70	32
4 to 5	69	66	**	74	47
6 to 8	90	61	**	104	47
8 to 10	85	90	90	**	69
10 to 12	104	85	104	85	**
15 to 25	***	***	***	***	84
Inflorescence Formation	61	***	63	***	41
Rhizome Formation	***	***	60	30	***

[1] Age = Big bluestem, Asc = Little bluestem, Pvi = Switchgrass, Snu = Indiangrass, Bcu = Sideoats grama.
**No data.
***Grasses did not reach these stages.

rate. As the planting date neared spring, grasses began to grow more normally. Sideoats grama was the only species that produced a normal appearing inflorescence.

Sideoats grama was first in development of seedling emergence, various leaf and tiller stages and inflorescence formation. These are important features of a grass used in reseeding. All grasses except little bluestem showed good seedling vigor. This could be because all species except little bluestem were improved varieties.

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