Tiller Development and Growth in Switchgrass

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Highlight: Switchgrass accessions collected from throughout the Southeast were grown without harvesting for 8 years. Measurements were made on tiller generation, rate of clone spread, time of tiller initiation, and number of tillers per given area. Data collected show that tillers are true biennials, buds at the base of shoots growing as rhizomes the first year and growing as green leaf bearing shoots the second when an inflorescence is produced. Rate of clone spread is determined by rhizome length. Ecotypes with short rhizomes produce tight clones which are pushed above the soil line by roots. In some of these varieties, actively growing tillers will be found only at the edges of the clones, not within the central region. Accessions which have both short and long rhizomes tend to spread much faster and stands are more stable than accessions which produce only short rhizomes. Tiller density ranged from 12-30 per dm^2 on sod forming ecotypes to 20-35 per dm^2 on bunch types.

Switchgrass, *Panicum virgatum* (L), grows over a sizable portion of the United States and is a major species in the tall grass prairie. Various ecotypes grow throughout the Southeast but few data are available that characterize growth of the plants. Switchgrass is a highly variable species, and if more were known about its growth, possibly selections could be made that would make useful additions to the forage resources.

In the South, switchgrass shoots start rapid growth in March, and early grazing could significantly reduce the need for stored feed by cattle producers. Tolerance of switchgrass to clipping is lower than that advocated for other grasses, as Bahiagrass (*Paspalum notatum* Flugge) (Sampaio and Beaty 1976) or Bermudagrass (*Cynodon dactylon* Poir) (Ethredge et al. 1973).

After growing as a rhizome for one season, a switchgrass tiller emerges in March and produces leaves in a rosette in April and May. After a number of leaves have been initiated, the lower internode begins to elongate and successive internodes up the shoot elongate in turn until the inflorescence is produced. Accessions differ in the length of time required for inflorescence emergence and in length of the shoot after the inflorescence has elongated (McMillan 1965).

Apparently all switchgrass shoots are typical reproductive tillers capable of producing seedheads. The vegetative buds of switchgrass are located at or below the soil surface. A tiller generally emerges from the encircling leaf sheath in one of two ways. In tufted or bunch accessions, first year growth of the rhizomes (potential shoots) is upward within the leaf sheath and first appears externally near the base of the parent lamina (intravaginal branching). The bud may also break through the protecting sheath and the stolon or rhizome (extravaginal branching) grows horizontally for the first year. This growth type is associated with sod-forming grasses (Langer 1972). Eberhard and Newell (1959) have described two growth types of switchgrass in Nebraska, but both types tended to be bunch formers and differed mainly in stem length and diameter.

For a number of years, the interest in switchgrass for conservation, grazing, and haying in the South has been increasing. As early as 1950, accessions of switchgrass were assembled at the Americus Plant Materials Center. In 1966 and 1967, vegetative material from switchgrasses growing throughout the Southeast was assembled at the Center and planted in rod rows for initial observation. Following 2 years of evaluation, it was concluded that additional information on development and growth would be useful. Between 1973 and 1976 an investigation was conducted to document some of the growth parameters. This manuscript reports rate of spread, tillers per area (density), and axillary bud growth of representatives of the bunch and sod types.

Materials and Methods

In the fall of 1968, 79 accessions of switchgrass assembled from throughout the Southeast by the Soil Conservation Service and growing in rod rows on the Plant Materials Center were vegetatively cloned on 30 cm centers in rows 23 m long with 2 m between rows. To simulate replications rows were divided into 5.5 m-long segments for data collection. The soil was a Orangeburg loamy sand, a member of the fine-loamy, siliceous, thermic Rhodic Paleudults. No fertilizer was applied at the time of cloning and none has been applied since. Weeds were controlled by spraying with 2,4-D at 0.56 kg/ha. In January of each year, except 1976, the area was burned.

On September 8, 1973, the diameters of four clones per accession were determined. Clone diameter measurements were repeated on May 5 and November 11, 1975, December 15, 1976, and June 11, 1977. The measurements were made 10 cm above the soil surface and a different clone per row segment was measured at each date.

On May 25, 1976, shoots on segments of randomly selected clones within selected accessions were clipped to a height of 10 cm and stems within a 11-cm diameter circle were counted. In 1976 and in 1977 sod pieces large enough to have at least 10 tillers each were collected on numerous dates. The number of rhizomes per tiller was counted and the length of rhizomes measured. Some buds were dried, weighed, and N concentration determined by an auto analyzer. In 1976 tillers on random 10-cm^2 areas for selected accessions were counted on March 6, April 1, April 29, and June 1.

In January 1977 sod pieces were randomly selected from each ecotype and rhizome length was determined by measuring from the point of shoot attachment to rhizome tip on 20 or more culms per sample (N=60+).

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Table 1. Switchgrass clone diameters (cm*) at Americus Plant Materials Center, Americus, Ga., 1973-1976.

Accession no.	Date					Average
	Sept.73	Mar.75	Nov.75	Dec.76	Apr.77	
Sod types						
1679	41	47	68	69	121±14	69
1680	101	150	110	125	164± 6	130
2281	70	83	90	98	99± 4	88
2270	80	98	117	132	116± 7	109
2249	31	45	38	48	55± 4	43
2280	54	72	84	84	89± 6	77
2262	45	58	55	71	71± 5	60
2265	49	74	82	84	105± 3	79
2260	40	51	46	55	66± 7	52
2253	41	45	41	61	37± 2	45
Bunch types						
1678	36	48	34	59	50± 3	49
2267	30	39	43	59	53± 4	45
314	40	43	51	67	55± 4	51
760	35	39	47	62	60± 3	49
1307	30	35	37	61	64± 9	45
2268	51	55	61	65	58± 3	58
2258	36	44	62	61	41± 2	49
845	44	49	53	57	56± 3	52

*Numbers are averages for 4 measurements. Apr.77 data are averages ± SE.

Results and Discussion

Clone diameters of selected accessions on five dates ranged from a low of 30 cm for accessions 1307 and 2267 in 1973 to a high of 164 cm for accession 1680 in 1977 (Table 1). Bud growth of spreading types, such as accessions 1680 and 2270, differed from that of the tight bunch primarily by producing extravaginal tillers with varying rhizome lengths (Figs. 1 and 2). Switchgrass accessions which formed tight bunches produced primarily intravaginal tillers (Figs. 2 and 3); spreading types produced both intravaginal and extravaginal tillers (Figs. 1, 4, and 5). Rhizome length averaged 1.6 cm on accession 2267, which had a clone diameter of 45 cm. On accession 180, which had an average clone diameter of 130 cm, rhizomes averaged 3.4 cm long, with individuals up to 11 cm. When measured at the end of the season, average rhizome length for bunch types was 1.4 cm and for sod formers 2.35 cm. These differences in average rhizome length between bunch and sod types were significant ($P<0.05$). Both vertically and horizontally growing

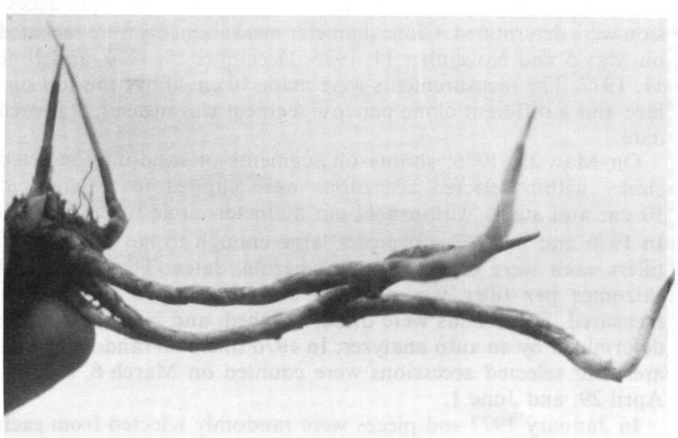

Fig. 1. *Extravaginal and intravaginal rhizomes of sod forming switchgrass ecotype in March 1977. Rhizome elongation is vertical.*

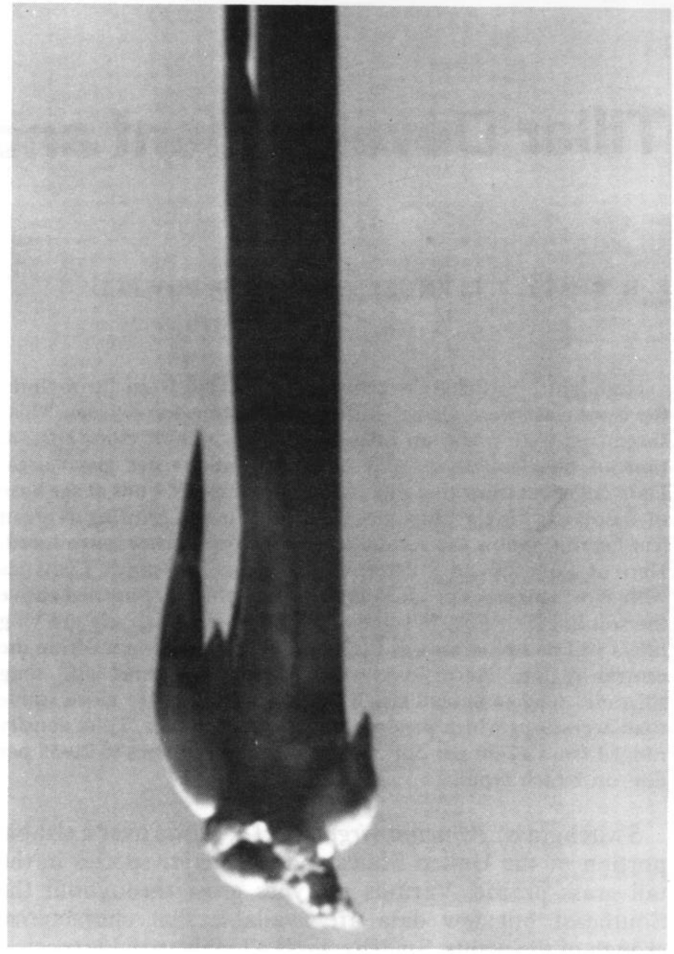

Fig. 2. *Intravaginal rhizomes of bunch forming switchgrass in January 1977.*

rhizomes were produced by sod type switchgrass, and those that grew horizontally were two to four times longer than the ones that had a more vertical orientation. Had only the horizontally growing rhizomes been measured, differences in rhizome length between the sod and bunch types would have been larger.

Accessions with short rhizomes tended to produce tight bunches and the center of the clone 'crown' was pushed above the soil surface. In some cases the clone center was 10 to 13 cm higher than the edge (Fig. 6). Crowing was considered to be undesirable for stand retention. In a number of these accessions no tillers were produced in the center of the clone, resulting in a bare area surrounded by tillers, producing a condition sometimes referred to as 'birdnesting' (Fig. 7). A relationship between crowning and birdnesting was not established. Neither crowning nor birdnesting developed in sod types.

Of the accessions studied, bunch types tended to produce shoots which grow taller, ranging in height from 1.2-2.7 m and with larger stems. Spreading types were usually 1.3-1.5 m in height after the inflorescence had emerged and stems were generally much smaller in diameter. On a unit area basis, tillers on spreading types averaged 12-30/dm^2 and tillers on bunch types ranged between 20 and 35/dm^2 (Table 2). On spreading types, tiller density could be established with little difficulty as stands were uniform over sizable areas. The concept of tiller density in bunch types

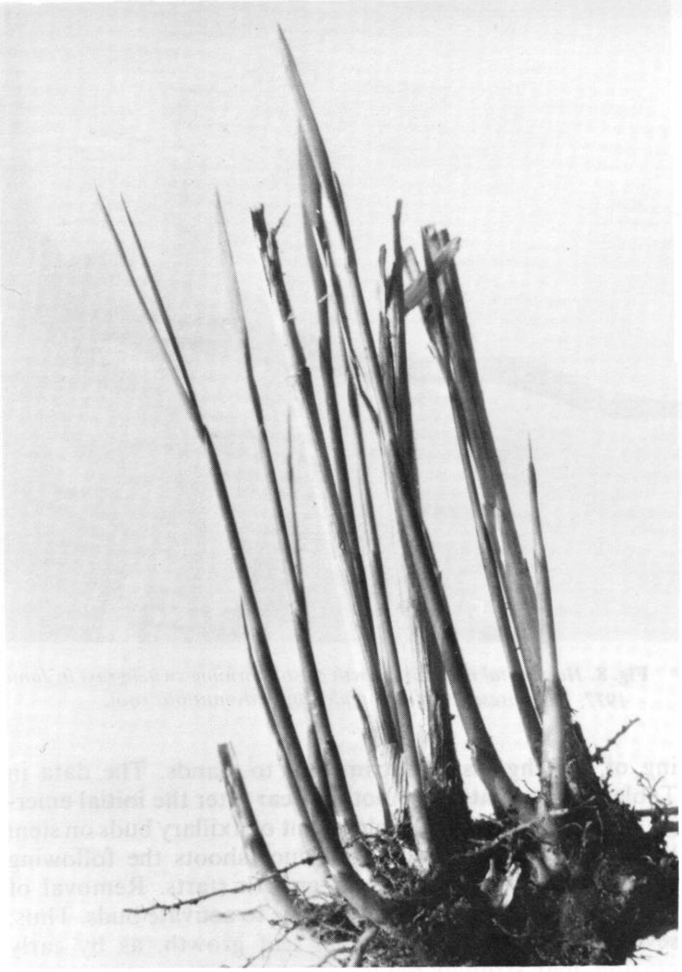

Fig. 3. *Tillers of tight bunch-forming switchgrass in April 1977.*

Fig. 4. *Switchgrass tillers of sod forming ecotype. True leaves are being formed.*

was more complex, since the distribution of clumps was highly variable. Density was measured within individual bunches.

The axillary buds which initially produce rhizomes that ultimately develop into tillers are located at the short internodes at the bases of currently elongating stems. Stem bases averaged 2.27 buds which would develop into rhizomes. These buds initiate enlargement during May or June, becoming rhizomes whose growth continues slowly through the summer and fall. The rhizomes are covered with scale leaves and may produce roots (Fig. 8). Intravaginally developing rhizomes do not elongate horizontally. By late February (in Georgia) tips of the rhizome begin vertical growth. Shoots typically emerge above the soil surface in March and start producing green leaves (Fig. 4). By late April buds

Fig. 5. *Open sod cover produced by long rhizomes.*

Fig. 6. *'Crowning' of bunch type switchgrass. Soil line indicated by shoe in lower left of photograph.*

Fig. 7. *'Birdnesting' of bunch type switchgrass caused by death of tillers in center of bunch.*

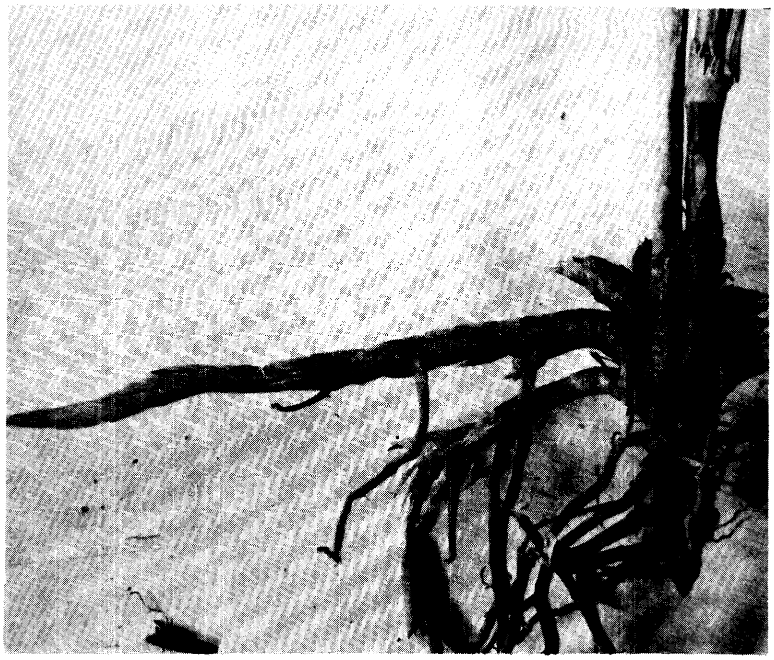

Fig. 8. *Horizontal rhizome growth of sod forming switchgrass in January 1977. Note presence of leaf scales and adventitious root.*

which had formed rhizomes have been growing for approximately 1 year and have developed into vertically growing shoots. New buds are forming at the base of the vertical portion.

The initial shoot emergence is as a slightly elongated rosette of leaves. During May internodes start elongating, beginning with the lowest and continuing upward phytomer by phytomer, the internodes elongating consecutively until the inflorescence is produced. If the terminal meristem of the shoot is removed, a few of the axillary buds on the stem may initiate growth but few new shoots grow from buds on the crown (Beaty and Powell 1976). Generally, switchgrasses must be cloned while rhizomes are dormant. Cloning developing tillers usually kills them. New shoots grow primarily from previously inactive buds on the stem base and a full season is required for growth to be initiated. Not enough bud nitrogen content measurements were made during the season to be conclusive; however, the N content of rhizomes during the first summer of growth was approximately 0.5% until leaves on the supporting shoot died, when it increased to 1.25%. This increase in rhizome N coincided with death of the leaves on the mature shoot and indicates that N was being translocated from mature and dying to new growth. The effect N translocation from mature and dying leaves will have on the number of buds that form rhizomes the following spring has not been established.

The findings of this investigation provide a biological explanation for ranchers' experience that heavy early grazing of switchgrass is detrimental to stands. The data in Table 2 show that few shoots appear after the initial emergence in early spring. Development of axillary buds on stem bases into rhizomes which produce shoots the following year begins shortly after leaf growth starts. Removal of leaves probably reduces N available to activate buds. Thus, severe interference with initial leaf growth, as by early grazing, may strongly reduce quantity of forage in the current crop of shoots and reduce the number of buds forming rhizomes for the next year's tillers. Heavy early grazing by decreasing available photosynthate may also reduce rhizome initiation and shoot growth. A previous report of Beaty and Powell (1976) suggests that the effects of early defoliation on both clone survival and number of tillers per clone can be counteracted by allowing vegetative growth after the first harvest.

The effect of time of N application on initiation of bud rhizome growth was not studied. However, N increases in the buds at the time of leaf death in the summer and fall

Table 2. Tillers per dm² of selected switchgrass ecotypes, PMC, Americus, Ga., 1976.

Accession no.	Clone type	Date				Average
		5 Mar	1 Apr	29 Apr	1 June	
77	sod	9.5	14.3	14.4	11.3	12.4
1677	sod	20.6	34.5	45.5	48.0	37.2
1678	bunch	26.0	32.5	34.7	36.7	32.5
1679	sod	18.9	31.7	24.2	23.8	24.7
1680	sod	12.7	19.1	19.6	18.0	17.4
2253	sod	12.6	15.1	16.5	13.1	14.3
2258	bunch	23.1	34.2	27.3	26.2	27.7
2260	sod	32.8	39.2	34.0	33.6	34.9
2262	bunch	26.3	24.5	26.0	28.5	26.3
2268	bunch	16.4	23.3	22.3	21.5	20.9

Table 3. Average rhizome lengths (n+60) and maximum rhizome lengths of switchgrass ecotypes. Samples collected Jan 22, 1977, Americus, Ga.

Accession	Growth form	$\bar{X}$ rhizome length	Max rhizome length
78	Bunch	1.2 cm	2.7 cm
459	Bunch	0.8	1.8
1307	Bunch	1.3	3.5
2258	Bunch	1.4	3.2
2267	Bunch	1.6	5.0
2268	Bunch	2.3	5.9
$\bar{X}$		1.4	
77	Sod	2.0	7.3
180	Sod	3.4	11.0
1677	Sod	2.1	9.2
1679	Sod	2.1	9.8
2017	Sod	2.8	8.5
2280	Sod	1.7	8.5
$\bar{X}$		2.35	

may mean that fall N applications would be more effective in increasing bud development and rhizome growth than spring N applications. If internally recycled N is important for initial switchgrass bud growth, it is possible that N removed from the plant by heavy grazing during the summer can be compensated for by an application of N at approximately the time the leaves die. Biologically, it is difficult to understand how late spring or summer N applications would be directly effective for anything other than current leaf growth.

During the investigation a number of clones died even without clipping. Such stand losses were not found on the sod-forming ecotypes. Examination of some of the dead clones showed charred roots, particularly in the center of the clone. The possibility that the root mass pushed growing buds above the insulation provided by the soil cover and they were killed by heat at time of burning, is suspected, as high temperatures in ranges being burned were reported by Conrad and Poulton (1966). It is also reasoned that clones which crown are also more susceptible to freeze damage, as clone centers would have less soil protection.

Southern switchgrasses such as those used in this investigation would probably be more susceptible to freeze damage if moved north. Susceptibility of buds on crowned ecotypes to fire damage may be the reason why many of the southern ecotypes are sod formers: the buds are protected by soil cover until after the threat of fire and heat damage associated with winter burning is past. The possibility that fire may damage switchgrass stands by preventing initial bud growth or by killing the rhizomes as they are developing into shoots and thereby decreasing forage production in the tall grasses should not be ignored (Anderson 1965).

The influence time and severity of defoliation had on bud/rhizome growth initiation and elongation was not investigated. Both would appear to be important in management for stand permanence. Equally important is the role of applied and internally cycled N in bud/rhizome development. The data reported here suggest that visible shoot growth responses to management appear approximately 1 year following the time the bud actually initiates growth as a rhizome.

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