Bud Activity in the Stem, Crown, and Rhizome Tissue of Switchgrass[1]

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Highlight

Bud activity appears to be cyclic in nature in the switchgrass plant. Certain vegetative buds are dormant while others are active during the growing season. This study suggests that switchgrass should be grazed prior to floral initiation so that maximum forage production can be obtained from activated stem buds.

Switchgrass, *Panicum virgatum* (L.), is a perennial, native, warm-season grass of North America. The warm-season growth habit of switchgrass is advantageous for use in pasture rotation systems. It can be grazed during the hot summer months when most cool-season grasses are dormant or semi-dormant. However, early and medium maturing switchgrass decreases rapidly in nutritive value and palatability with maturation. On the other hand, when switchgrass is grazed so that the growing point is removed before emergence from the boot, regrowth may be initiated from the uppermost 2 or 3 axillary buds. Vegetative regrowth in mid-summer provides palatable forage for cattle, and they continue to gain satisfactorily. Heavy grazing too early in the summer may severely weaken the switchgrass plant and induce the invasion of weedy species.

Axillary buds located on the rhizomes, crown, and stem portions of the plant are important meristematic areas for vegetative reproduction in switchgrass. The initiation and development of these buds determine not only thickness of stand, but also the revegetative potential of the grass under grazing conditions. Preliminary investigations at Lincoln, Nebraska have shown that these buds display a seasonal variation in activity. Although several other perennial grasses also display dormancy during the growing season, little work has been done to characterize the nature of this dormancy.

The purpose of this study was to determine the seasonal activity of buds located on the rhizome, crown, and stem portions of the switchgrass plant.

Literature Review

In a review by Samish (1954) the term "dormancy" is defined as the temporary suspension of visible growth; which he further breaks down into two main types, "quiescence" and "rest." Quiescence is the type of dormancy exhibited by the plant when unfavorable external conditions such as high temperature or low water supply prevent growth. Rest is the type of dormancy referred to when external conditions are favorable, but growth is limited by unfavorable internal conditions.

Dormancy has been demonstrated primarily in buds and seeds of horticultural crops. Coville (1920) found that dormancy commonly occurred among trees and shrubs of cold climatic regions.

Evans and Ely (1935) studied the rhizomes of several species of grasses and found that both below and above-ground shoots develop, to a limited extent, at all times when weather conditions were favorable for growth. Laude (1953) reported that a number of perennial grasses in California become dormant during the summer even though supplied with adequate water. He associated summer dormancy with high temperature and a long photoperiod.

In a study of quackgrass rhizomes (*Agropyron repens* (L.) Beauv.), Johnson (1962) found a rest period in April and May which he described as "late-spring dormancy" rather than the more common "summer dormancy." This conclusion was reached because prevailing weather conditions before and during the period were relatively cool and moist and favorable for quackgrass growth.

The apical bud of nutgrass (*Cyperus rotundus* (L.)) has been reported to prevent growth of other buds on the same tubers (Loustalot et al., 1954). This phenomenon is commonly referred to as apical dominance. Another

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[1] *Published with the approval of the Director as paper No. 1948, Journal Series, Nebraska Agricultural Experiment Station.*

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example of apical dominance is that found in the potato tuber. When the intact potato tuber becomes active after a rest period, one or more apical buds elongate, but the lateral buds usually fail to grow. If, however, lateral buds and apical buds are cut out and grown separately, both start growing at the same time (Michener, 1942).

It is believed that the dormancy of buds in woody plants, tubers, and herbaceous perennials have similar fundamental processes (Samish, 1954). Therefore, since there are few basic differences between the buds of an underground stem and the buds of its above-ground counterpart, findings of any of these various forms may well be related to the others.

Materials and Methods

The experimental area (3200 ft²) was located on the Agronomy farm at Lincoln, Nebraska. Nebraska-28 switchgrass was seeded in April, 1959. A uniform stand was ready for sampling in the spring of 1962. The soil was a well-drained Sharpsburg silty clay loam which was fertilized annually with 55 lb/acre of elemental N as NH_4NO_3. The pH of the soil was 6.0. Seventy-one lb/acre of elemental P were applied as 42% concentrated superphosphate on February 20, 1962.

Axillary bud activity of rhizome, crown, and stem was determined by using an *in vitro* method similar to that described by Johnson (1961). Plant tissue was obtained bi-weekly by digging up 2 to 3 ft² of sod to a depth of three to four inches (Tables 1 and 2). Plants obtained from the field were washed free of soil with cold tap water. The plants were kept moist during the trip to the laboratory by first wrapping them in a moistened burlap sack, and then placing the entire bundle in a plastic bag. In the laboratory, the plant material was placed in a refrigerator at 5 C and removed as needed during processing. Plant material was again washed with tap water, and adventitious roots and scale leaves on the rhizomes were removed. The rhizomes were cut into 20 mm sections, each having several nodes with at least one noticeable bud and a root. The root was cut free of the rhizome during the sectioning process. A preliminary experiment indicated that rhizome bud activity was variable, but that sections with an attached root(s) consistently had the highest bud activity.

Lower stem buds and basal crown

Table 1. Elongation and dry weight of rhizome, crown, and stem buds of switchgrass grown in the dark at 28 C for 14 days during 1962.[1]

Sampling dates 1962	Rhizome		Crown buds		Stem buds	
	Length[2] cm	Dry Weight mg	Length[2] cm	Dry Weight mg	Length[2] cm	Dry Weight mg
3-10	5.32	—	9.94	—	0.55	—
3-22	3.66	—	11.14	—	0.13	—
4-5	5.25	98	11.69	325	0.74	31
4-19	5.39	95	12.26	310	0.42	5
5-3	4.39	64	7.34	115	0.60	13
5-17	2.65	28	0	0	2.32	100
5-31	3.30	45	1.07	6	2.18	35
6-14	0.61	7	3.78	32	2.16	21
6-28	2.07	32	5.30	75	2.93	31
7-12	2.68	48	6.72	101	2.90	44
7-26	4.13	66	7.69	157	4.29	95
8-9	1.72	34	10.60	304	1.84	40
8-23	0.32	6	9.87	240	1.63	38
9-6	1.99	34	9.34	342	0.50	12
9-20	1.81	38	6.85	244	0.23	5
10-4	3.30	64	7.16	243	0.75	23
10-18	3.87	70	6.46	170	0.76	16
11-15	1.98	37	5.17	214	0.28	9

[1] Implanted in agar and each bud value based on 25 sections for each sampling date.

[2] An average of the longest elongated bud of several which occurred on each rhizome or stem-crown section.

Table 2. Elongation and dry weight of rhizome, crown, and stem buds of switchgrass grown in the dark at 28 C for 14 days during 1963.[1]

Sampling dates 1963	Rhizome buds		Crown buds		Stem buds	
	Length[2] cm	Dry Weight mg	Length[2] cm	Dry Weight mg	Length[2] cm	Dry Weight mg
3-12	4.67	96	10.72	312	1.62	24
3-26	5.42	87	10.17	214	1.96	28
4-9	4.82	93	8.53	190	1.63	30
4-23	4.26	63	0	0	1.78	37
5-7	2.42	34	0	0	1.19	30
5-21	1.61	16	0	0	2.47	57
6-4	2.09	27	1.84	15	0.30	10
6-18	1.48	24	7.96	122	0.42	3
7-2	1.56	31	6.39	99	3.53	48
7-16	1.30	20	9.41	220	5.76	152
7-30	1.85	29	10.54	247	2.58	57
8-13	0.89	20	9.45	258	3.82	83
8-27	0.82	13	8.65	273	4.00	84
9-10	0.83	16	11.18	449	2.06	65
9-24	2.49	51	5.04	241	0	0

[1] Implanted in agar and each bud value based on 25 sections for each sampling date.

[2] An average of the longest elongated bud which occurred on each rhizome or stem-crown section.

buds are commonly located within 1.5 inches of each other on the average switchgrass plant (Fig. 1). Therefore, sections 1.5 inches in length were also sectioned for studying bud activity of the lower stem bases and basal crown buds. Stem and crown bud material consists of the lower 1.5 inches of the culm. Stem buds are referred to as the aerial section and crown buds as the basal portion of the 1.5 inch sections. Bud activity of the lower stem bases and basal crown buds were studied separately on the same section.

The rhizome and stem-crown sections were kept moist before implanting in agar by placing them on moistened blotters in plastic trays. Twenty-five sections of both the rhizome and stem-crown sections were selected at random each sampling date for determining bud activity. Erlenmeyer flasks with a 125 ml capacity served as culture vessels. Each flask contained 50 ml of a solidified 0.8% agar medium. Five sections were implanted per flask resulting in five replications for each type of plant material. The agar had been previously adjusted to a pH of 5.0 with 0.1 NH_2SO_4. Prior to implanting, the plugged flasks (Fig. 2 and 3) containing the medium were autoclaved for 30 min. at 15 psi. The rhizome and stem-crown sections were rinsed several times with distilled water, but no further attempts were made to sterilize them. Flaming of each flask at the time of implanting aided in reducing mold contamination. The flasks containing the plant material were then transferred to a 28 C dark room for 14 days.

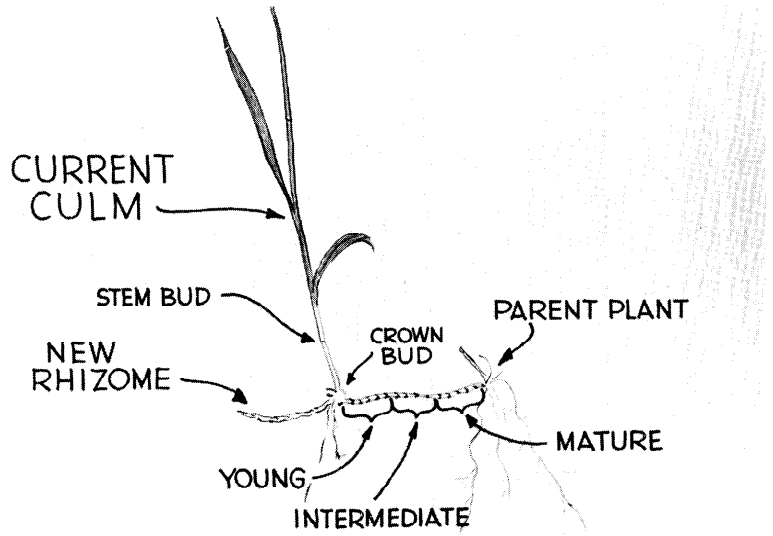

FIG. 1. A typical switchgrass plant showing the parent plant, its subsequent rhizome growth, the current culm, new rhizome growth, and crown and stem buds.

Upon completion of the 14 day growth period, the implanted rhizome and stem-crown sections were removed from the flasks. Rhizome or stem-crown sections having noticeable new growth were counted as having active buds. Bud activity was expressed as a percentage based on the number of active sections from the 25 sections originally implanted. The longest elongated bud on each section was measured and was expressed as growth in centimeters. The total weight of all elongated buds was obtained after the excised buds had been dried in an oven at 70 C for 72 hours.

Results

The percentage bud activity, elongation, and dry weights of switchgrass rhizome, crown, and stem buds were studied by using tissue culture techniques during two years, 1962 and 1963.

The average percentage rhizome bud activity (2-year average) was highest in the spring and in the fall (Fig. 4). Rhizome bud activity generally decreased from mid-April to mid-June when the plants were in the early boot stage of growth. A general increase was noted in July as new rhizome growth was

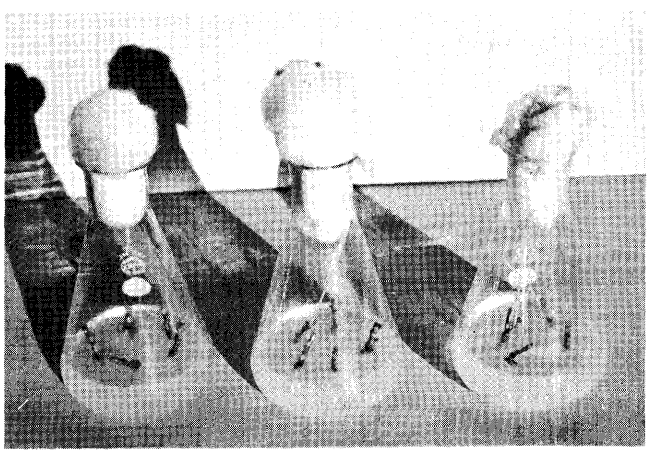

FIG. 2. Tissue cultures of 20 mm rhizome sections after 14 days of growth in the dark at 28 C.

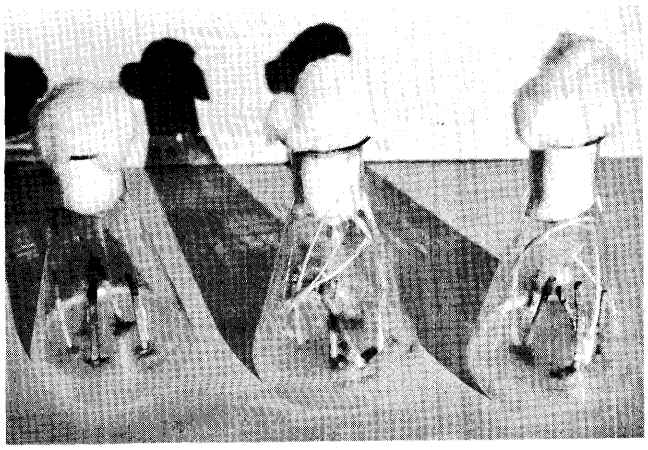

FIG. 3. Tissue cultures of stem-crown sections after 14 days of growth in the dark at 28 C.

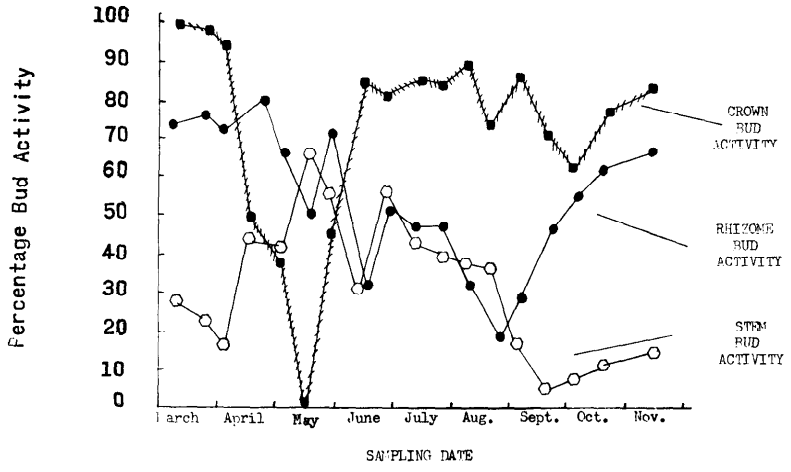

FIG. 4. The two-year average trend of axillary bud activity of rhizome, crown and stem buds of switchgrass.

also observed in the field. During August and early September a definite dormancy period was noted.

Crown and stem bud activity were inversely related to each other (Fig. 4). During March, crown bud activity was above 90% while stem bud activity was below 30%. However, in mid-May, crown bud activity was nonexistent whereas 66% of the stem buds were active. Crown bud activity averaged from 64% to 90% throughout the remainder of the sampling period while stem bud activity generally decreased from 58% during late June to 6% in mid-September.

Rhizome bud elongation measurements taken during 1962 (Table 1), indicated that maximum growth (3.66 to 5.39 cm) generally occurred during March, April, and early May. Minimum elongation (0.61 and 0.32 cm) was noted on June 14 and August 23, respectively. Maximum elongation (9.94 to 12.26 cm) of crown bud shoots was noted from March 10 to April 19. Minimal elongation (0 to 3.78 cm) occurred from May 17 to June 14. Medium elongation was generally noted the rest of the season. Stem bud elongation was greatest (1.63 to 4.29 cm) between May 17 and August 23. A minimum amount of stem bud elongation (<0.76 cm) occurred during the early spring and fall.

Dry matter determinations of elongated rhizome buds during 1962 (Table 1) indicated the most dry matter production (64 to 98 mg) occurred from April 5 to May 3, and on July 26, and during October. Minimum dry matter production (6 to 7 mg) was noted June 14 and August 23. Crown bud weight was the greatest (170 to 342 mg) during April and after August 9. Lower weights (0 to 157 mg) were noted during May, June and July. Dry weight from stem buds was high (35 to 100 mg) on May 17 and 31, and from July 12 to August 23. Lower weights were recorded during the spring and fall and in June.

Measurement of rhizome bud elongation during 1963 (Table 2) indicated maximum elongation (4.26 to 5.42 cm) occurred from March 12 to April 23, and that minimum elongation (0.82 to 0.89 cm) occurred from August 13 to September 10. Minimum elongation of crown buds (0 to 1.84 cm) occurred from April 23 to June 4 while longer measurements (5.04 to 11.18 cm) were recorded throughout the remainder of the sampling period. Maximum stem bud elongation (1.19 to 5.76 cm) occurred from March to late May and from July 2 to September 10. Minimum stem bud elongation (0 to 0.42 cm) was noted during June and on September 24.

Dry matter production from elongated rhizome, crown, and stem buds during 1963 is also presented in Table 2. Maximum weights from rhizome buds (51 to 96 mg) occurred from March 12 to April 23 and on September 24. Minimum weights (13 to 34 mg) were recorded the rest of the season. Minimum weights from crown buds (0 to 99 mg) were recorded from April 23 to June 4 and on July 2. Heavier weights (122 to 449 mg) were recorded throughout the remainder of the sampling period. Maximum dry weights from stem buds (48 to 152 mg) were recorded on May 21 and from July 2 to September 10. Minimum weights (0 to 10 mg) were recorded during June and on September 24.

In general, field observations on each sampling date during both years indicated that terminal rhizome buds were actively producing aerial shoots during late April and early May, and that elongation of new rhizomes occurred during midsummer from July to mid-August. Crown buds appeared to be active only during two periods. The first was in late April when a majority of the crown buds produced tillers, and the second period was in late June when crown buds initiated new rhizome growth. Stem buds appeared inactive throughout the entire sampling period.

Discussion

Bud activity appears to be cyclic in nature in the switchgrass plant. In general, activity appears to move upward (late April and early May) from the rhizome and basal crown areas into the stem until floral initiation in late June, then from the stem back down into the basal crown area, and finally into the rhizome late in the growing season.

Rhizome and crown buds possessed the highest potential for new shoot initiation during early spring in *in vitro* studies. And in field observations, in late April and early May, apical buds of rhizomes and basal crown buds became active and initiated aerial shoots. High activity (*in vitro*) was found in the axillary stem buds of these aerial shoots until seed heads began emerging from the boot in late June. At the same time, (*in vitro*) crown buds were largely absent and rhizome buds were semi-dormant. As the seed heads emerged in late June in the field, newly developed crown buds became active, and initiated new rhizome growth. The new rhizomes elongated and stem bud activity (*in vitro*) decreased until mid-August when rhizomes became dormant. During late September, high bud activity (*in vitro*) was once again evident primarily in the rhizome and crown buds with little activity found in stem buds.

Results of the field observations and the *in vitro* bud activity study failed to coincide during several periods of the growing season. For instance, new rhizome growth in the field was initiated largely from crown buds, and these rhizomes grew actively throughout July and early August. Rhizome elongation was not noted at other times during the growing season. However, *in vitro* studies indicated that rhizome buds were most active during early spring and fall. *In vitro* studies did substantiate field observations in that the least activity was noted during late August and early September.

Stem base and crown tissue cultures indicated that crown buds possessed high activity throughout the sampling period, except during the late spring period after the aerial shoots had emerged. However, field observations indicated that crown buds were largely inactive during the sampling period, except for two instances. The first was in late spring when a majority of the crown buds elongated and formed new tillers. The second period of activity in the field was noted when new rhizome growth was initiated from crown buds during late June.

The lack of continuity between field observations and tissue culture studies of bud activity serves to point out differences in types of dormancy. It is obvious that tissue cultures may have removed apical dominance thus promoting aerial shoots (Michener, 1942). The vertical implantation of normally horizontal rhizome material *in vitro* may have also resulted in promotion of aerial shoots (Palmer, 1954). However, high rhizome and crown bud activity noted in tissue cultures during the spring and fall from buds which were previously inactive in the fields suggested that "quiescence" may have resulted from an unfavorable external condition such as low temperature. When soil temperatures were favorable for growth during late spring and midsummer, apical dominance may have been present, causing buds to remain inactive in the field. Induced crown and stem bud activity may also be attributed to apical dominance. Since little rhizome bud activity was noted in both the field and in tissue cultures during late August and early September an internal factor alone may be suggested as the reason for dormancy during this time. This type of bud dormancy could be the true "rest" referred to by Samish (1954).

Dry matter determinations from shoots produced by rhizome buds prior to forage initiation in late April supports the supposition of Weaver (1963) that high carbohydrate reserves are available for new shoot growth in early spring. However, during late summer when carbohydrate reserves seemingly should be high, they appear to be unavailable in that dry matter production was reduced as well as bud activity. This suggests that respiratory enzymes may be inhibited by certain mechanisms and causes food reserves to become unavailable and consequently dormancy occurs.

Theoretically it appears that the grazing of switchgrass should begin in late May and early June prior to floral initiation in late June. Since maximum stem bud activity exists at this time, production of new palatable lateral shoots from the axillary buds on the stems should produce more forage over a longer period of time. Additional fertilizer coupled with adequate rainfall or supplemental irrigation during this period of regrowth should prevent the switchgrass plants from becoming severely weakened. Further management studies should be designed to test the findings from this study.

Summary

The percentage bud activity, shoot elongation, and dry shoot weights of switchgrass rhizome, crown, and stem buds were studied using tissue culture techniques during 1962 and 1963.

Bud activity appears to be cyclic in nature in the switchgrass plant. During early spring, rhizome and crown buds are active while axillary stem buds are inactive. During late spring, stem buds become active and the rhizome and crown buds are less active. Subsequent to flowering, rhizome and crown buds are reactivated and the stem buds once more become inactive.

Several types of dormancy were apparent in switchgrass rhizomes during the growing season. During early spring and late fall "quiescence" (due to external environmental conditions i.e., low temperatures) was apparent. During late spring, mid-summer, and early fall api-

cal dominance appeared to cause dormancy because buds which were inactive in the field initiated shoots under laboratory conditions when apical dominance was removed. A period of "rest" was observed in late summer in that buds were dormant both under laboratory conditions and in the field.

This study suggests that switchgrass should be grazed prior (late May and early June) to floral initiation (late June) so that maximum forage production from activated stem buds may be attained.

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