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Growth and Development of Sitanion Hystrix and Poa Sandergii

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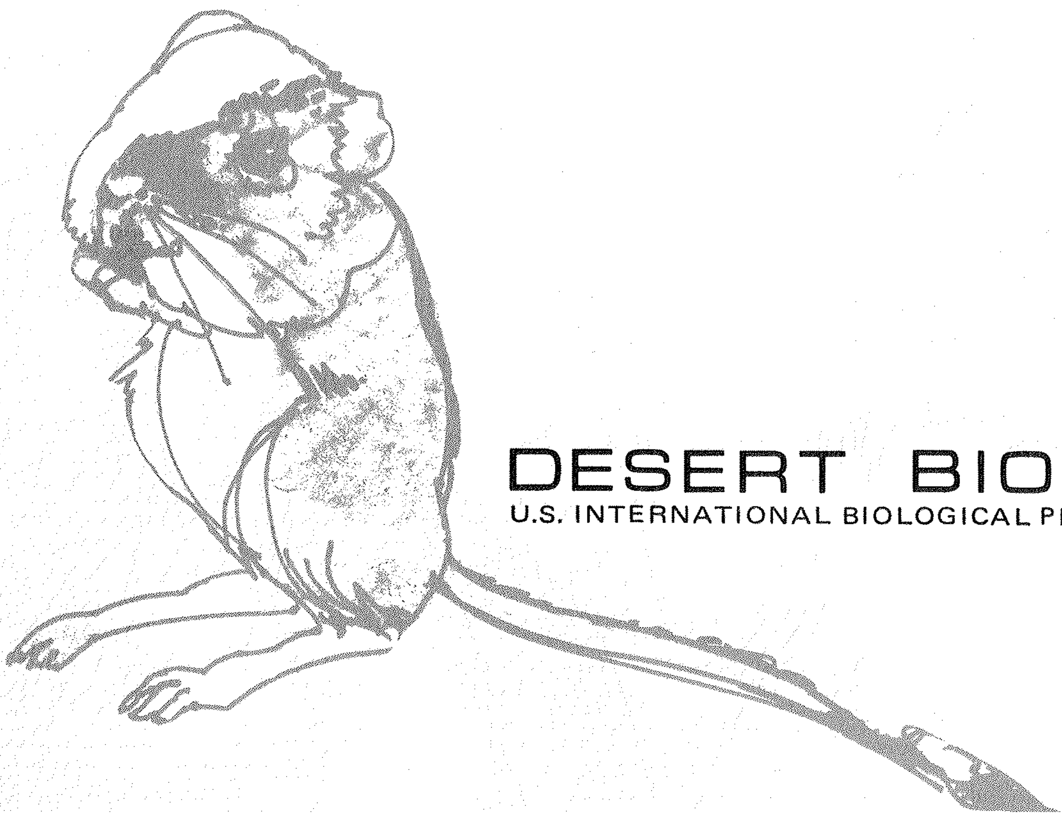

DESERT BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

1971 PROGRESS REPORT

GROWTH AND DEVELOPMENT OF *SITANION HYSTRIX* AND *POA SANDBERGII*

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ABSTRACT

Comparisons in growth and development of *Sitanion hystrix* var. *hystrix* and var. *californicum* showed considerable differences in biomass and rate of development characteristics. Var. *hystrix* was earlier in development by 10-14 days, but smaller in biomass. Physiologic activity rates (net photosynthesis, respiration and transpiration) per unit leaf area were higher for var. *hystrix* than var. *californicum* but less on a whole-plant basis due to smaller size. Root growth was arrested during the boot to pre-anthesis stages in development whereas shoot biomass continued to increase for both varieties.

Optimum soil temperature for seedling growth was at 25°C. Soil temperature of 32°C produced plants with lower root:shoot ratios than those grown at lower temperatures. Continuous root growth of seedlings grown in soil maintained at 5°C may be a partial explanation for the ability of *Sitanion hystrix* to become naturally established in communities dominated by annual grasses in the Intermountain Region.

INTRODUCTION

Sitanion hystrix and *Poa sandbergii* (formerly *Poa secunda*) are important species in cold desert vegetation of North America. *Sitanion* is a particularly important bunchgrass in the shadscale and lower portion of the sagebrush zones. Its role in sagebrush vegetation is primarily seral, being replaced by longer-lived bunchgrasses such as *Agropyron spicatum* or *Stipa thurberiana* in secondary succession (Tisdale et al., 1970). The status of *Sitanion* in the shadscale zone is less certain, as *Sitanion* appears to be either the climax dominant grass or subdominant to *Oryzopsis hymenoides* in the original vegetation.

Poa sandbergii is a small bunchgrass that occurs throughout the sagebrush zone and the northern, cooler portion of the shadscale zone. In the original sagebrush vegetation it was subdominant to the taller climax bunchgrass and filled the interspaces between them, providing protection to the soil from erosion. In the *Artemisia tridentata/Poa sandbergii* habitat-type, it is the dominant understory species (Daubenmire, 1970). Often *Poa sandbergii* is the only perennial grass present on severely abused sagebrush range.

OBJECTIVES

Research in 1971 was confined primarily to *Sitanion hystrix*. Because significant response differences were suspected between var. *hystrix* and var. *californicum*, both taxa were studied.

The specific objectives were as follows:

1. Growth and development of vegetative growth as a function of soil moisture, soil and air temperature, and net photosynthesis.

2. Growth and development of root system as a function of soil moisture, soil and air temperature, and net photosynthesis.

3. Transpiration rate in relation to plant growth and moisture stress.

4. Growth and rate of seedling development as affected by soil temperature.

METHODS

Field studies were conducted at the Saylor Creek Experimental Range (USFS) in southern Idaho. Studies (DSCODE A3UHH03) on growth and development of *Sitanion hystrix* in relation to soil moisture and net photosynthesis utilized plants that were transplanted the previous fall as seedlings. Transplants were grown in 4" x 24" tubes. In addition to the natural precipitation that fell on the area, one-third of the plants received 0.5 cm of water, another one-third received 1.0 cm, and the remaining one-third received 2.0 cm of water every 2-3 weeks. These amounts totaled to 2.5, 5.0 and 10.0 cm, respectively. Water was applied during the visit previous to the time of sampling. Nine individuals of each variety were sampled on each sample date. The entire tube was lifted from its place in the field and placed in a slightly larger tube which was sealed at the base. A cylindrical acrylic plastic assimilation chamber was fitted over the end of the larger tube and sealed air-tight. To minimize release of gases due to soil respiration, a layer of dry sand was used to cover the exposed soil. CO_2 exchange rates were monitored with an infrared gas analyzer. A dewpoint hygrometer monitored the humidity changes in the chamber due to transpiration. For CO_2 measurements, both open and closed systems were used. Water vapor was measured using the open system. After gas exchange measurements were obtained, the plant was harvested and leaf area was determined with a photocell planimeter. The tube was opened and soil samples for gravimetric moisture determination were obtained at 6", 12", 18", and 24" depth. The roots were recovered by washing. The plant material was air-dried in the field and later oven-dried at 70°C in the laboratory.

Seedling development (DSCODE A3UHH03) in relation to soil temperature was determined by growing seedlings in 200 cc containers placed in constant temperature baths maintained at 5°C, 15°C, 26°C and 32°C. Seedlings were grown for two weeks in the greenhouse before being placed in the water baths. At periodic intervals, six seedlings in each treatment were measured for leaf area and harvested to obtain biomass information. Leaf area determination was made with the use of a photocell planimeter. Plant material was oven-dried at 70°C.

Detailed phenological development records (DSCODE A3UHH01) were kept on 82 plants of *Sitanion hystrix* var. *hystrix* and 71 individuals of var. *californicum* grown in a common garden. All plants were two years old. On each sampling date, total shoot counts were made and each shoot was classified as to its stage of development.

The only study dealing with *Poa sandbergii* in this report has to do with the duration of the after-ripening period (DSCODE A3UHH02). Seed was harvested on June 22 at the Saylor Creek Experimental Range and a series of germination trials were begun in August and continued until November. Three replications of 100 seeds were tested under laboratory conditions at room temperature.

FINDINGS

Approximately 19.3 cm (7.6") of precipitation fell on the study area during the October-March period, and the subsequent April-July period received 6.1 cm (2.4"). *Sitanion* plants received an additional 2.5 cm (1"), 5.0 cm (2") and 10.0 cm (4") of water under the three treatments during the April-July period.

Sitanion hystrix.

Development and growth of the two varieties of *Sitanion hystrix* differed considerably, although much variability occurred within populations. On the average, var. *californicum* produced more biomass than var. *hystrix* (Figs. 1, 2, 3, and 4). The effect of added water on plant production was masked by individual variability and no clear-cut effect on growth was discernible. It is possible that the least amount of moisture added (approximately 28 cm) was more than sufficient for normal growth and the plants were not severely stressed and did as well as those receiving 7.5 cm more water.

Root:shoot ratios of both varieties showed similar trends (Fig. 5). Highest ratio coincided with the late leaf stage in development. A reduction in ratio occurred during the early head development stages. At the end of the season the ratio increased as plant maturity was reached, seed heads disarticulated and dried leaves were lost.

Photosynthetic activity of the two varieties were similar (Fig. 6). Var. *californicum* tended to have a slightly lower assimilation rate per unit leaf area than var. *hystrix*. The large negative assimilation value obtained on June 22 was primarily due to high temperature. Temperatures at 3" above the ground surface were in excess of 45°C during most of the day.

The phenological development of var. *hystrix* was 10-14 days earlier than that of var. *californicum*. By July 6, var. *hystrix* had already cast its seed while var. *californicum* was in the soft-to-hard dough stages. During the boot to pre-anthesis stage of development, root growth was greatly reduced for both varieties (Figs. 1 and 2).

Dark respiration activity was similar for both varieties, but var. *californicum*'s respiration rate was slightly less per unit leaf area (Fig. 7).

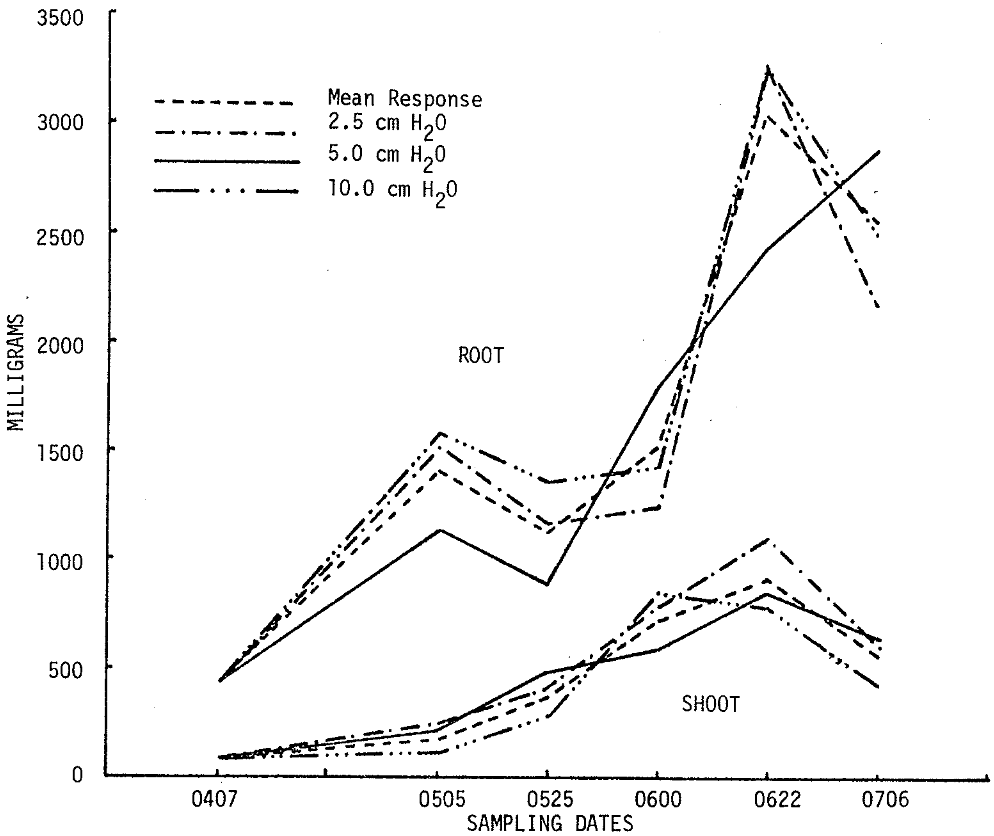


Figure 1. Shoot and root weights of var. *hystrix* in response to three levels of added water during the 1971 season.

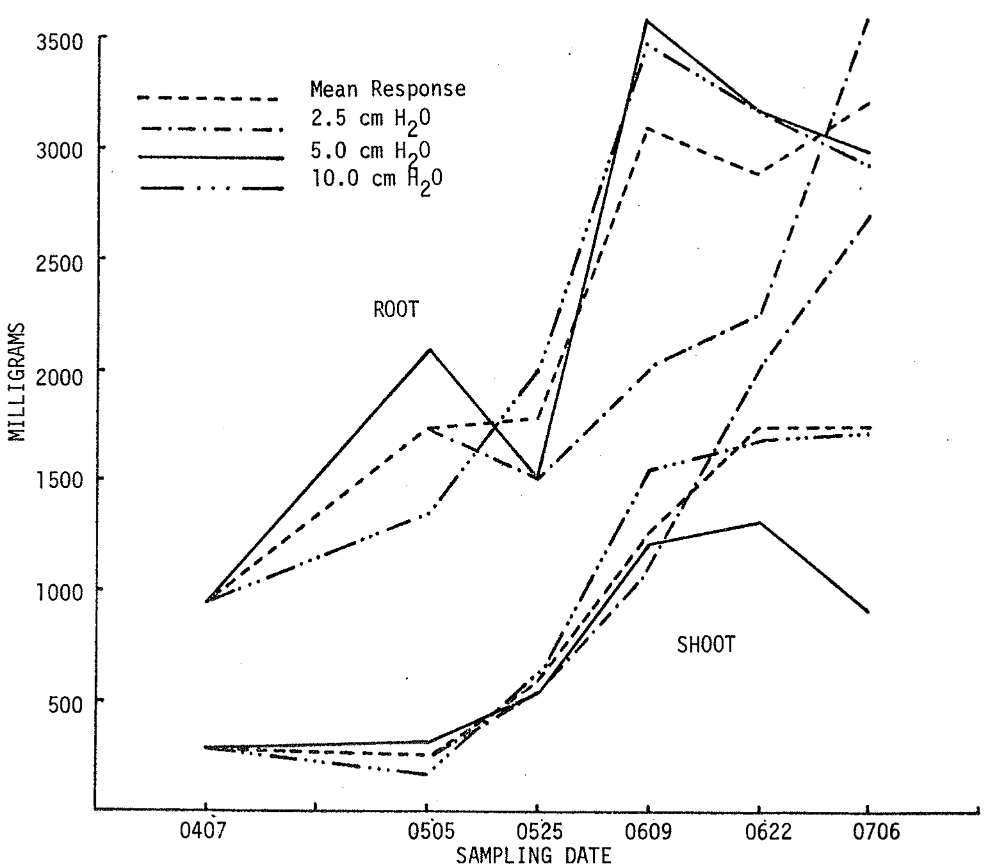


Figure 2. Shoot and root weights of var. *californicum* in response to three levels of added

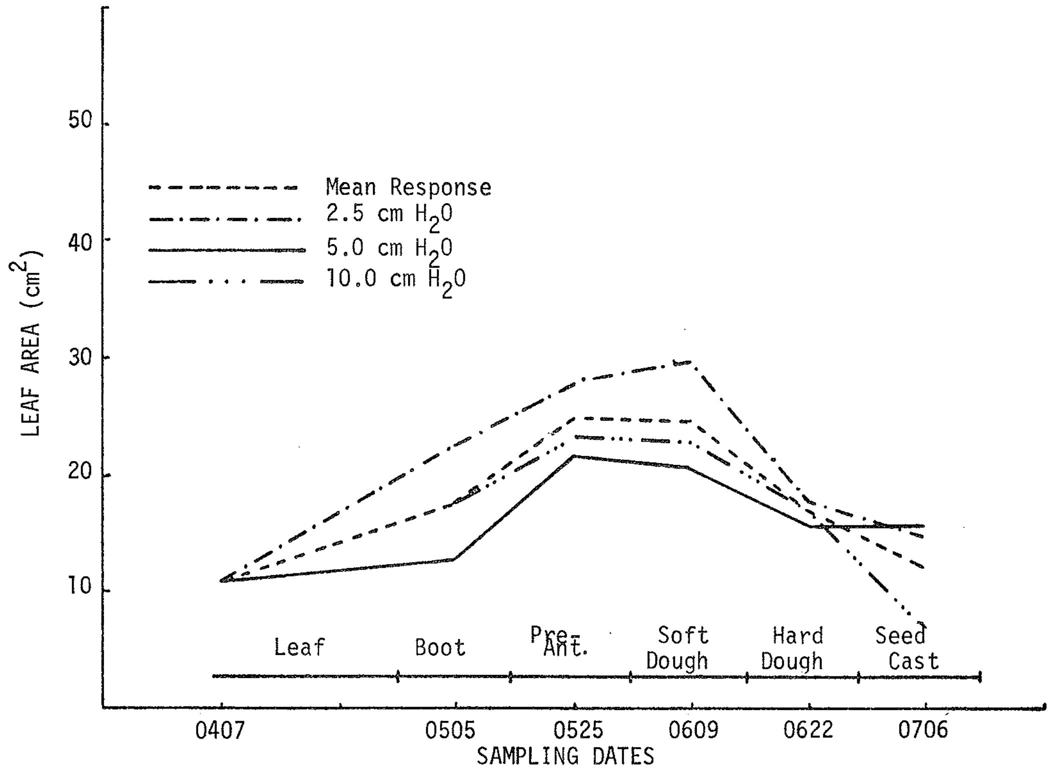
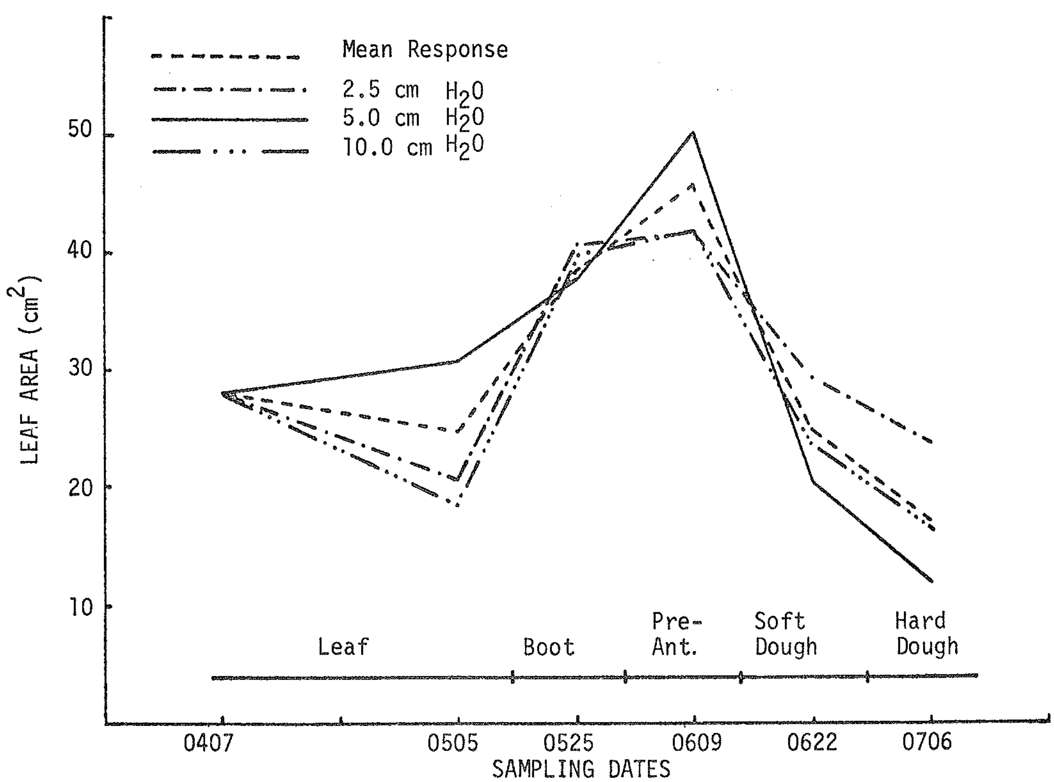


Figure 3. Changes in leaf area (green) of var. *hystrix* in relation to development and three levels of added water during the 1971 season.



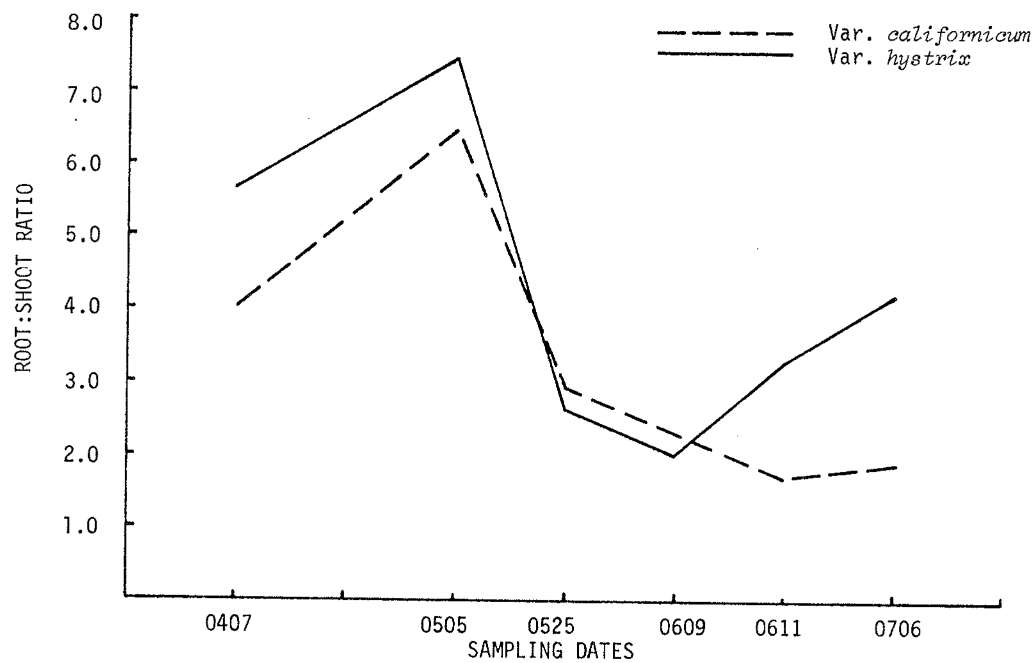


Figure 5. Root:shoot ratio of two varieties of *Sitanion hystrix* during the 1971 growing season.

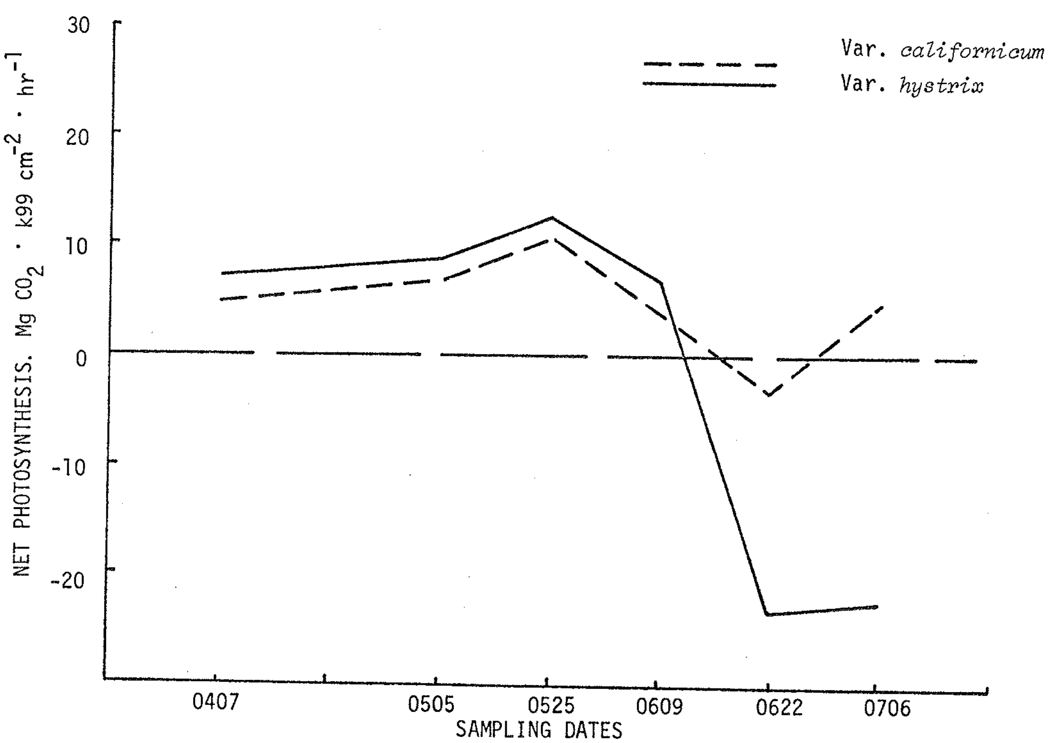


Figure 6. Net photosynthetic rate of two varieties of *Sitanion hystrix* during the 1971 growing season.

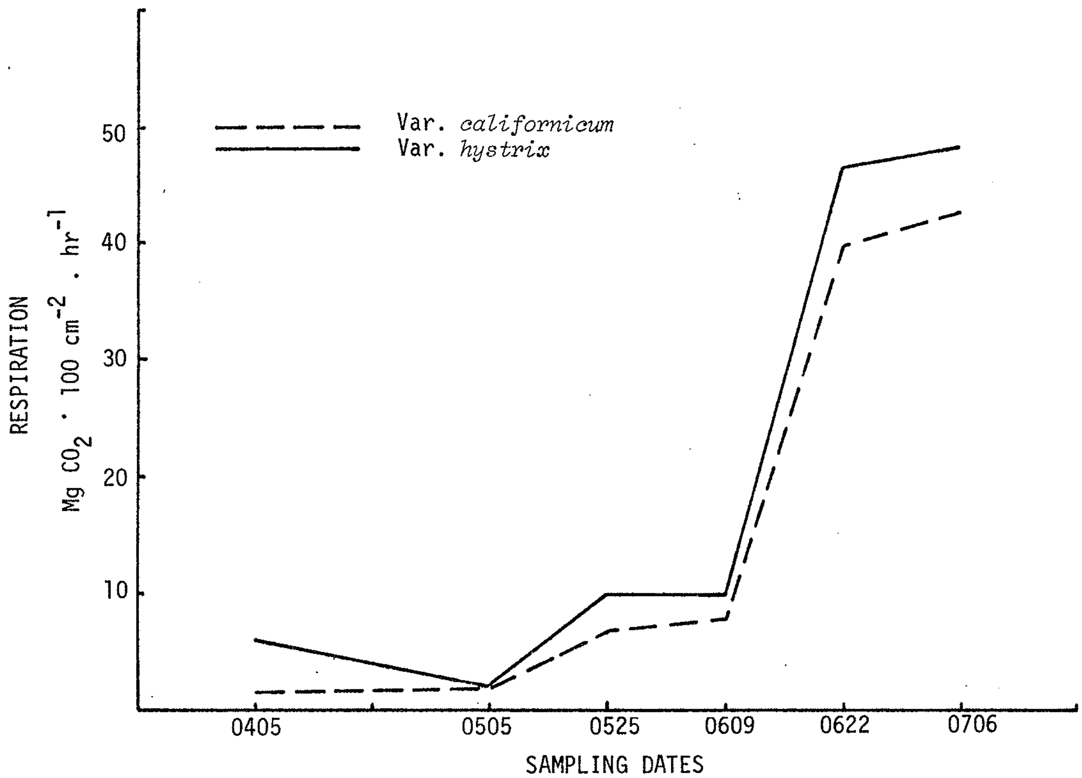


Figure 7. Respiration rates of two varieties of *Sitanion hystrix* during the 1971 growing season.

Transpiration rate was determined from changes in dewpoint temperatures with and without plants in the chamber. Dewpoint temperatures were converted to the amount of water vapor in saturated air. Flow rates varied from 500 cc to 1000 cc/min. depending upon the size of chamber used. Var. *hystrix* had a higher transpiration rate than var. *californicum* (Figs. 8 and 9). The decrease in transpiration rate measured on June 6 remains unexplained. The greatly increased transpiration rate per unit/leaf area toward the end of the growing season for var. *hystrix* was due in part to production of new tillers during later stages of development. The high transpiration rate at the end of the season was due to high temperatures and stage in development. Although soil moisture was low, root mass in relation to leaf area was high, thus offsetting the apparent effect of low soil moisture. When the data are viewed in terms of whole plant response, the transpiration rate at the end of the season was less than in June (Fig. 10).

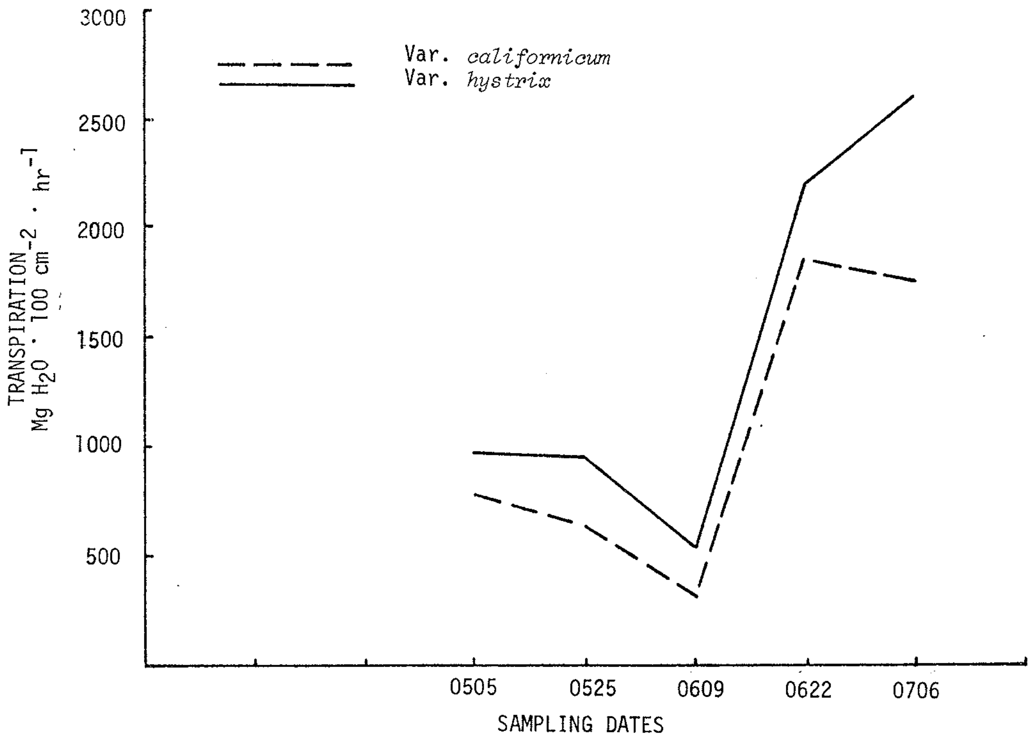


Figure 8. Transpiration rates during photosynthesis per 100 cm^2 of leaf area.

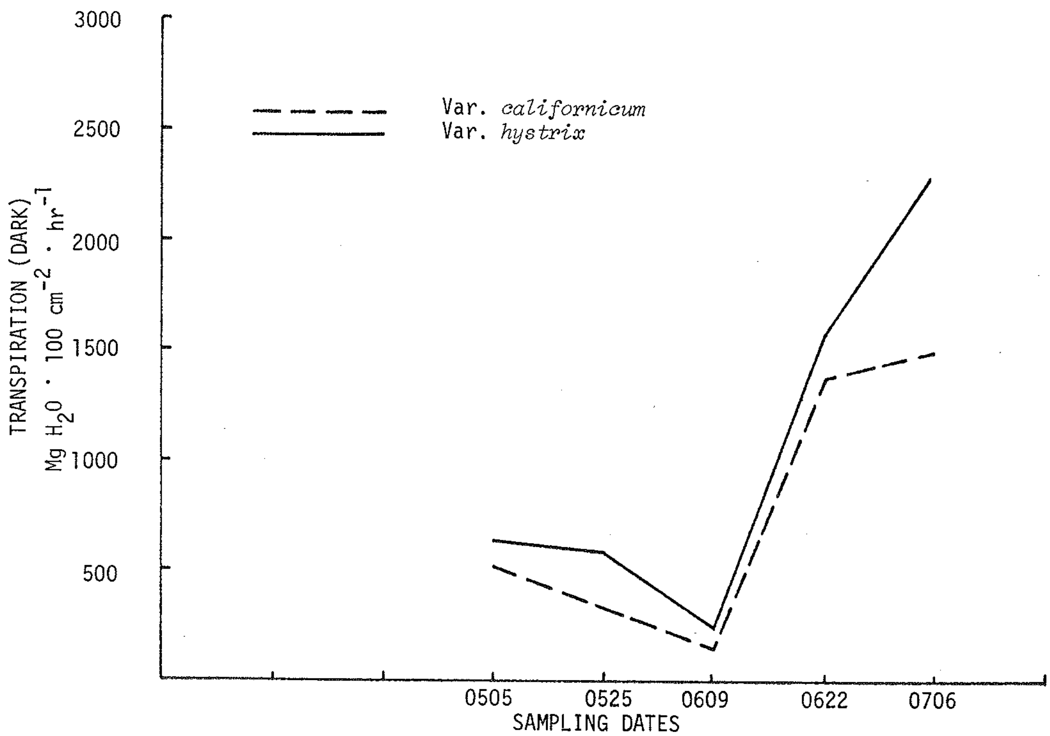


Figure 9. Transpiration rates during dark respiration of two varieties of *Sitanion hystrix* during the 1971 growing season.

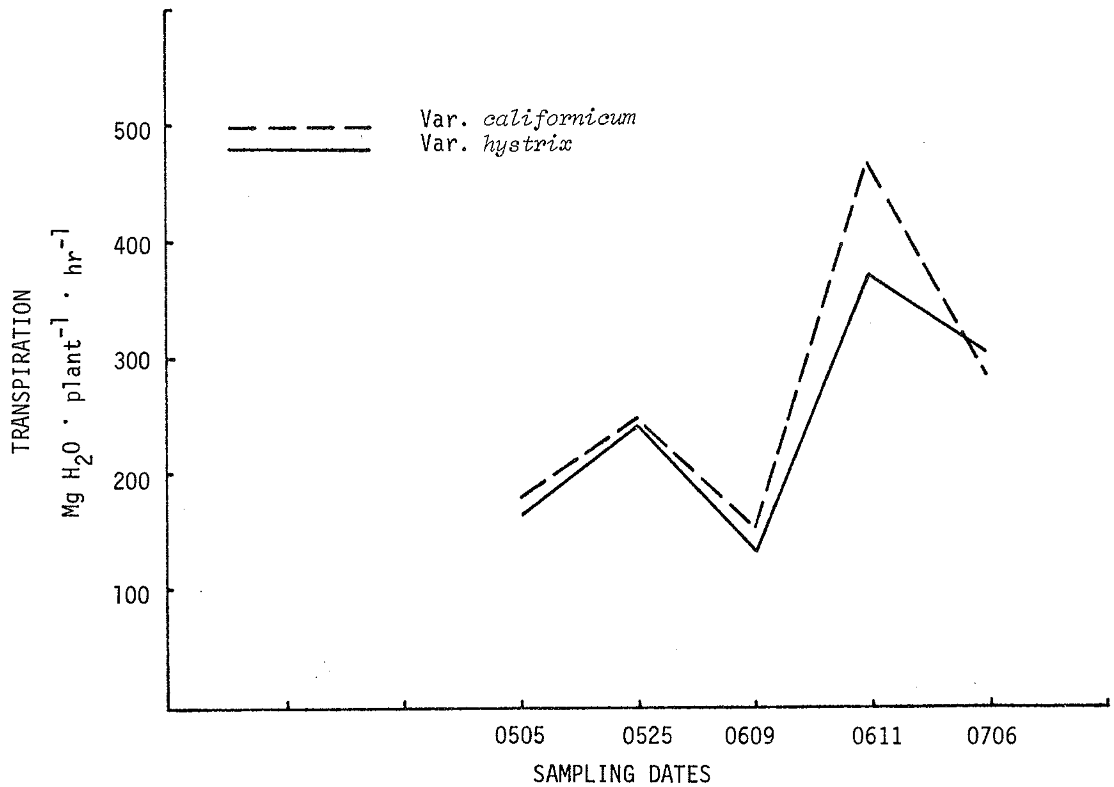


Figure 10. Transpiration rates during photosynthesis of whole plants of two varieties of *Sitanion hystrix* during the 1971 growing season.

In the growth chamber study of seedling growth in relation to soil temperature, greater rate of growth was attained by those plants grown at 26°C than at higher or lower soil temperatures (Table 1). At the end of 40 days, shoot weight of plants in the 32°C bath was greater than those grown at 15°C but with less root biomass. The highest average root:shoot ratio was obtained from plants grown at 15°C whereas the lowest ratio was from those in the 32°C bath.

In a similar experiment, the two varieties were grown together for comparative purposes. Minor differences in the second experiment included a substitution of 20°C for the 26°C treatment of the first experiment and the seedlings were smaller. The results show similar trends, with the major discrepancy between the two experiments being that shoot weight was greater in the 32°C treatment than in the 20°C treatment (Table 2). The root weight of plants in the warmer treatment was less than the root weight at 20°C, however. Considerable differences between the two varieties were obtained in all measurements. Var. *californicum* produced more vigorous seedlings in all treatments as indicated by larger root and shoot weights and leaf area.

Table 1. Growth measurements of *Sitanion hystrix* var. *hystrix* seedlings grown in soil maintained at prescribed temperatures. Values are averages of six seedlings.

Soil Temp. C°	Days in Growth Chamber 0	7	14	24	31	40
			Total Biomass (mg)			
5	15.0	17.0	36.0	58.3	92.5	141.6
15	15.0	20.0	40.0	89.2	80.7	215.4
26	15.0	32.0	52.0	179.4	160.6	377.0
32	15.0	29.0	45.1	96.3	108.4	194.4
			Shoot Weight (mg)			
5	5.0	9.0	16.0	25.0	35.0	43.3
15	5.0	7.0	14.0	22.5	22.1	56.1
26	5.0	11.0	22.0	49.4	48.9	119.8
32	5.0	11.0	21.3	45.0	47.8	89.4
			Root Weight (mg)			
5	10.0	8.0	20.0	33.3	57.5	98.3
15	10.0	13.0	26.0	66.7	58.6	159.3
26	10.0	21.0	30.0	130.0	111.7	257.2
32	10.0	18.0	23.8	51.3	60.6	105.0
			Leaf Area (cm^2)			
5	1.5	1.7	2.0	1.7	3.5	5.4
15	1.5	2.0	2.2	2.6	2.9	3.6
26	1.5	2.8	2.8	5.6	5.9	10.9
32	1.5	2.9	3.1	5.1	5.8	9.9

Table 2. Growth measurements of *Sitanion hystrix* var. *hystrix* and var. *californicum* seedlings grown in soil maintained at prescribed temperatures. Values for the two varieties are paired (ex:110-150) for var. *hystrix* and var. *californicum* respectively. Values are averages of three seedlings.

Soil Temp. C°	Days in Growth Chamber 0	13	19	27	33	40
			Total Biomass (mg)			
5	7-19	19- 56	23- 75	56-109	57-206	83-201
15	7-19	50- 81	59-137	94-174	125-283	149-217
20	7-19	72-116	94-215	211-295	243-346	214-426
33	7-19	50-109	60-124	161-281	264-350	222-403
			Shoot Weight (mg)			
5	4-11	11- 32	14- 38	26- 47	22- 65	30- 69
15	4-11	20- 33	28- 54	36- 57	41- 86	56- 77
20	4-11	23- 48	39- 94	57- 94	65-110	68-135
33	4-11	22- 58	27- 65	67-142	100-185	109-250
			Root Weight (mg)			
5	3- 8	8- 24	9- 37	30- 62	35-141	53-132
15	3- 8	30- 48	31- 83	58-117	84-197	93-140
20	3- 8	49- 68	55-121	154-201	178-236	146-291
33	3- 8	28- 51	33- 59	94-139	164-165	113-153
			Leaf Area (cm^2)			
5	1.7-3.5	2.4- 5.9	2.0- 4.9	3.4- 5.7	3.5- 8.8	3.3- 5.8
15	1.7-3.5	4.2- 7.6	4.6- 7.4	4.7- 7.0	7.1-12.6	5.8- 7.0
20	1.7-3.5	5.0- 9.0	5.8-10.8	7.8-10.3	13.9-17.9	9.5-13.2
33	1.7-3.5	4.8-12.6	5.2- 9.5	8.4-14.9	18.7-29.0	17.3-32.0

Rate of phenological development of the two varieties of *Sitanion hystrix* differed by 10-14 days in the field (Fig. 11). Var. *hystrix* developed more rapidly than var. *californicum*. The more uniform development of var. *californicum* was in part the result of using a single seed source, as the data for var. *hystrix* were collected from plants of three seed sources. Nonetheless, var. *hystrix* tended to produce late tillers during the seed development stages while var. *californicum* did not.

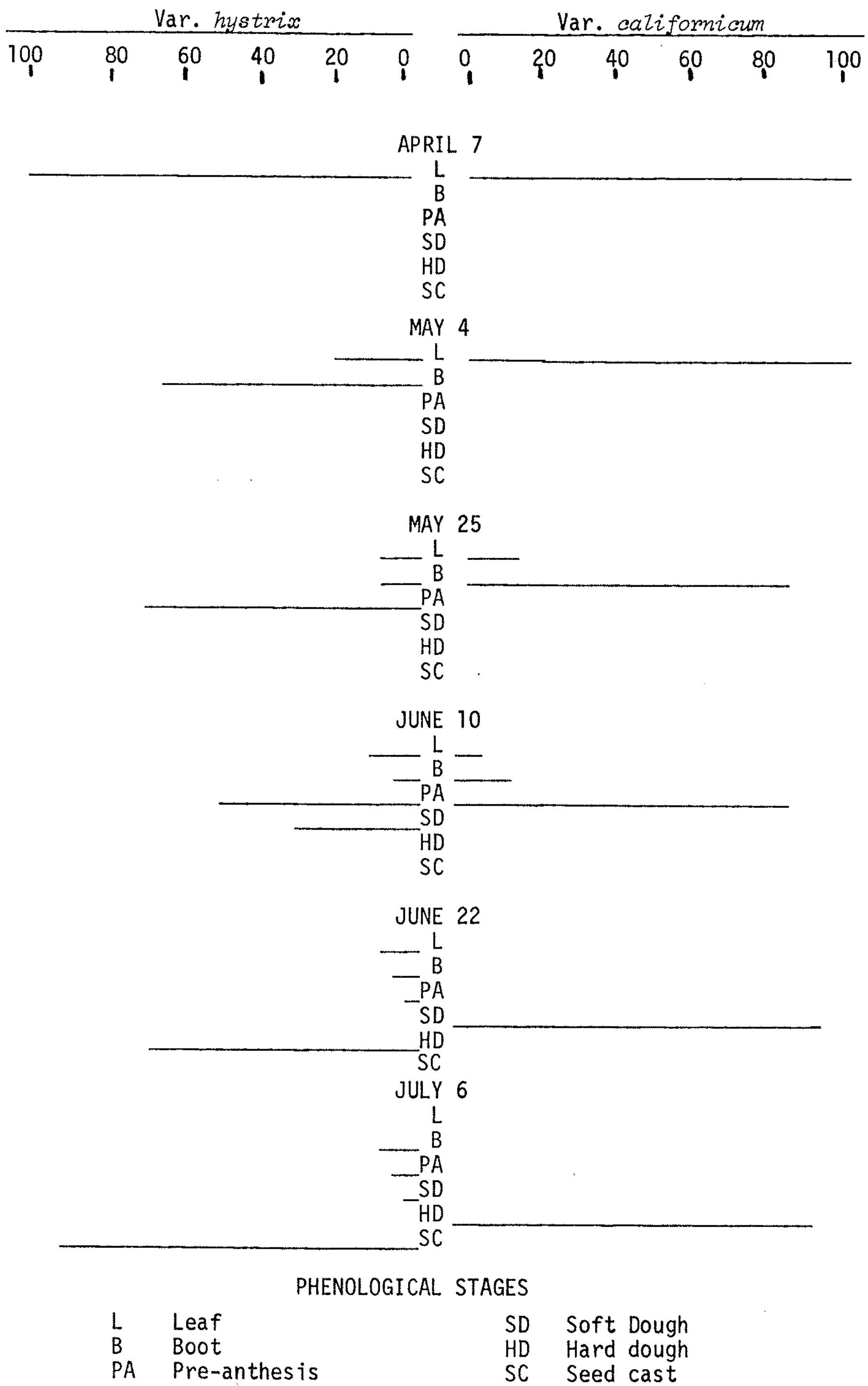


Figure 11. Percentage of shoots in various phenological stages of two varieties of *Sitanion Hystrix* grown in a common garden at Saylor Creek Experimental Range (1971).

Poa Sandbergii.

Poa sandbergii seeds harvested in late June were found to germinate within a few months (Table 3). An after-ripening period of three months was required before 50 percent germination was attained. An after-ripening period of approximately three months has been reported for several other grasses that occur commonly in the sagebrush region, e.g.: *Bromus tectorum, Sitanion hystrix, Taeniatherum asperum, Agropyron* ssp. and *Festuca idahoensis*.

Table 3. Average germination percentage of *Poa sandbergii* seed from Saylor Creek Experimental Range harvested on June 22, 1971. Trials were conducted during the summer and fall months of 1971. Each trial consisted of three replications of 100 seeds.

Start of Trial		Days to 25% Germination	Days to 50% Germination	Days to 75% Germination
August	9	77	86	--
August	16	67	77	--
August	23	56	63	77
August	30	9	56	70
September	8	40	58	--
September	15	30	44	--
September	22	12	23	40
September	29	7	12	26
October	6	9	16	19

DISCUSSION

Growth and development rates of the two varieties of *Sitanion hystrix* were quite different. Var. *hystrix* developed more rapidly than var. *californicum* but produced smaller plants. The difference of 10-14 days in development rate is a characteristic that would favor success of var. *hystrix* in more xeric habitats. On a per unit leaf area basis, var. *hystrix* had higher rates of photosynthesis, respiration and transpiration. The higher activity rate of var. *hystrix* may be related to its earlier development rate.

Root:shoot ratio changed with stage of development. The highest ratio was attained during the leaf to boot stage. Soil temperature also affected root:shoot ratio. Cool to moderate soil temperatures favored root growth whereas high temperatures favored shoot growth. Optimum temperature for both shoot and root growth appeared to be about 25°C for both varieties. Considerable root growth was produced by seedlings grown in soil temperatures maintained at 5°C and 15°C. The continuous growth of roots at 5°C would permit seedlings of *Sitanion hystrix* to grow during the early spring, before moisture stress became significant. Root growth at 5°C would enable *Sitanion* to become established in competition with *Bromus tectorum* whereas *Agropyron spicatum* is unable to accomplish this (Harris, 1967).

The method employed to obtain different levels of moisture stress was unsatisfactory. Above-normal precipitation offset the anticipated effects of added moisture on plant growth. A treatment of no water received during the growing season, whether naturally or artificially provided, should have been included. This would have insured a state of severe moisture stress for some plants.

To obtain information on photosynthetic activity in relation to moisture stress, plant water potential instead of soil water potential should be measured. It would be more meaningful to relate plant water potential to physiologic function because both measurements are instantaneous, whereas soil mositure measurements do not measure the moisture status of the rhizosphere. Selection of suitable depth(s) and/or soil volume to be included in the relationships is a problem also. In turn, plant water potential may be correlated with soil water potential, taking into consideration the diurnal behavior of plant water potential.

Study of an individual species' response to, or behavior during, environmental stresses yields no information on its competitive ability. It is obvious that species cannot be grown under all possible combinations of environmental conditions and their performance documented. Species must in some way be ranked by how rapidly and/or efficiently they are able to use available resources, particularly light, water and nutrients, under various temperature and root environment conditions. The requirements of the species must be considered also.

The competitive factor would be essential information if changes in species composition are to be predicted or simulated (due to environmental manipulation). This is presented with no ready solution, but it is considered to be of sufficient importance to have others involved in process studies give it some thought.

EXPECTATIONS

In 1972, emphasis will be on *Poa sandbergii*. Growth rate and behavior of *Poa* are expected to be quite different from those of *Sitanion*. Optimum soil temperature for *Poa* growth is expected to be in the 10°-15°C range rather than the 25°-30°C range for *Sitanion*.

Physiologic activity (photosynthesis, respiration and transpiration) of *Poa* will probably be more affected by moisture and temperature stresses than *Sitanion* because of its natural adaptation to growth in the cool-moist portion of the growing season.

Poa will probably have a higher relative root reserve storage than *Sitanion* because of its extended summer dormant period.

Seedling establishment of *Poa* is anticipated to be more difficult because of low seedling vigor due to small seed and slow growth.

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