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M. Hironaka

E. W. Tisdale

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RESEARCH MEMORANDUM

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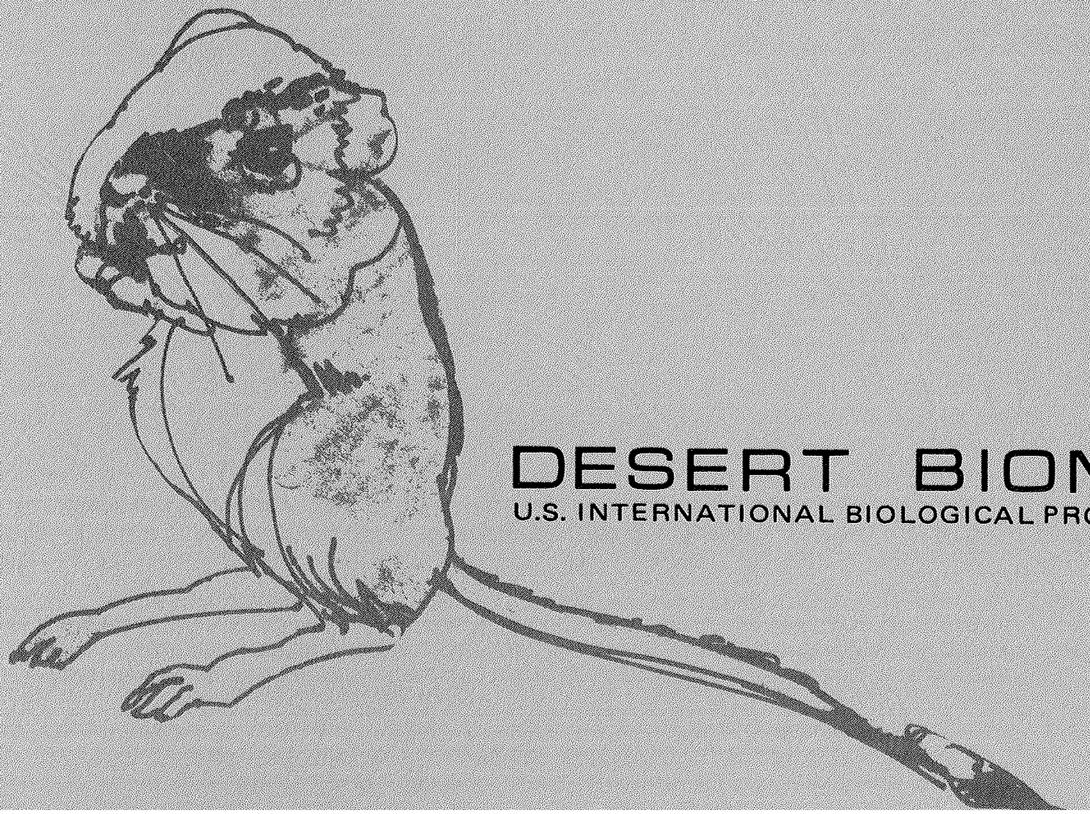

DESERT BIOME
U.S. INTERNATIONAL BIOLOGICAL PROGRAM

1972 PROGRESS REPORT

GROWTH AND DEVELOPMENT OF *Sitanion hystrix* AND *Poa sandbergii*

M. Hironaka, Project Leader

E. W. Tisdale

University of Idaho

Research Memorandum, RM 73-16

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ABSTRACT

Poa sandbergii seedlings produced more root biomass when grown in soil maintained at 15 C, but produced less shoot biomass. Poorest root development and lowest root:shoot ratios were obtained by seedlings grown in 32 C soil.

CO_2 compensation point of *Poa sandbergii* in relation to plant water stress was about -25 bars. The compensation point for *Sitanion hystrix* was near -35 bars. *Poa* development was found to be controlled by photoperiod. Long daylength (18 hours) induced dormancy and short daylength (12 hours) promoted growth. The critical daylength period was not determined.

Growth and development rates of *Poa sandbergii* from communities supporting *Sitanion hystrix* var. *hystrix* and var. *californicum* indicate that the later-developing "ecotype" is related to the distribution of var. *hystrix*.

INTRODUCTION

Poa sandbergii and *Sitanion hystrix* are perennial grasses that occur in varying amounts in most sagebrush-grass and other cold-desert plant communities. *Poa* is primarily a constituent of climax sagebrush communities but persists in deteriorated communities that have been highly disturbed. Recently-abandoned cultivated lands are exceptions, however.

Sitanion hystrix is a seral species and is one of the first perennial grasses to re-establish by seed as secondary succession progresses. In sagebrush vegetation *Sitanion*, being a short-lived perennial, is gradually replaced by long-lived climax grasses, such as *Agropyron spicatum*, *Stipa thurberiana* and *Festuca idahoensis*. *Sitanion*'s status in shadscale vegetation is unclear, but it is suspected that it may be climax and co-dominant with *Oryzopsis hymenoides*.

Both *Poa sandbergii* and *Sitanion hystrix* have broad ecological amplitudes. Only recently has *Sitanion hystrix* been recognized as being composed of at least two varieties, var. *hystrix* and var. *californicum* (Wilson,1963). The general distribution of the two varieties differs. Var. *californicum* occurs in mesic sagebrush communities, whereas var. *hystrix* occurs in the shadscale and xeric portion of the sagebrush zone.

Poa sandbergii has not been taxonomically divided although its distribution is as extensive as *Sitanion hystrix*. Because it was suggested that the *Poa sandbergii* which occurs in the same communities as *Sitanion hystrix* var. *hystrix* was different from the *Poa* in communities supporting var. *californicum*, two sources of *Poa sandbergii* were included in the study. The Crane Creek source represents *Poa sandbergii* from a mesic habitat and grows in the same communities as *Sitanion hystrix* var. *californicum*. *Poa sandbergii* from Saylor Creek represents the xeric form and grows in the same communities as var. *hystrix*.

This year's report emphasizes the research findings on *Poa sandbergii*, whereas last year's research concentrated on *Sitanion hystrix*.

OBJECTIVES

Objectives of study were basically the same for the two species. In most cases, results for *Sitanion hystrix* were reported previously (Hironaka and Tisdale, 1972). Additional information on *Sitanion* is included in this report.

The objectives were to study:

1. Growth and development of seedlings as affected by soil temperature.
2. Growth and development of vegetative growth as a function of soil moisture, plant water stress and photosynthesis.
3. Growth and development of the root system as a function of soil moisture.
4. Transpiration rate in relation to plant growth and moisture stress.
5. Carbohydrate root reserve in relation to plant growth.

Soil moisture determinations were not made in 1972.

METHODS

Seedling development in relation to soil temperature (DSCODE A3UHH03) was determined by growing seedlings in 200 cc containers placed in constant temperature baths maintained at 5, 15, 20, and 32 C. Seedlings were grown for 2 weeks in the greenhouse before being moved to water baths. Light source was provided by gro-lux fluorescent lights with an intensity of 1000 ft. candles. Daylength was 12 hours. At weekly intervals six seedlings from each treatment were monitored for CO_2 exchange rates in a closed system for 30 minutes. Leaf area determination was made with a photocell planimeter. Plant material was oven-dried at 70 C.

Field studies were conducted at the Saylor Creek Experimental Range (U.S. Forest Service) in southwest Idaho. The annual precipitation averages about 20 cm in the experimental area. Plants were grown in 10 x 600 cm tubes planted "flush" with the soil surface. Plant material was obtained from naturally occurring summer dormant *Poa* that were brought to the greenhouse in late September and divided into 2.0 - 2.5 cm squares and planted in small containers. These plants were permitted to "green up" and a month later they were transplanted to the field. *Poa* materials were from Saylor Creek (20 cm precipitation area) and Crane Creek (40 cm precipitation area). The first observation was made on March 28 and subsequently at periodic intervals throughout the growing season. Water in addition to which the area received naturally as rainfall was added periodically. At each sampling period 1/3 of the plants received no additional water; 1/3 received 1.0 cm and the remaining 1/3 of the plants received 2.0 cm of water at each of six visits. This amounted to 0 additional water, 4 cm of added water and 8 cm of added water for the season.

Carbon dioxide exchange rates (DSCODE A3UHH04) were monitored with a Beckman infrared gas analyzer connected in a closed system. The entire tube with plant was extracted from the field and placed in a close-fitting, metal cylinder. A water-cooled plexiglass chamber was attached to the top of the metal cylinder and sealed. Transpiration measurements were made in an open system with a dewpoint hygrometer.

Later in the season, plant water stress determinations were made with a sample chamber psychrometer. After gas exchange and transpiration measurements were obtained, a green leaf blade was cut into short segments and placed in the sample chamber. An equilibrium period of 15 minutes before measurement was observed.

Carbohydrate root reserve determinations were made from root and crown material of plants from which gas exchange measurements were made. Total nonstructural carbohydrate (TNC) was determined by the procedure outlined by Smith (1969).

RESULTS

Poa sandbergii

The growth of *Poa* seedlings in relation to soil temperature (DSCODE A3UHH03) demonstrated that higher root:shoot ratios were obtained when seedlings were grown in soil with temperatures maintained below 32 C (Table 1). *Poa* produced the most shoot biomass when grown in soil maintained at 20 C whereas root biomass tended to be greater for plants grown in 15 C soil. Higher root:shoot ratios were obtained at 15 C soil temperature than other temperatures tested. Plants grown in 32 C soil produced more top growth than those grown at lower temperatures but produced the least amount of root material. The cooler soil temperatures favored root development over shoot development.

Net photosynthesis rates as determined by measurement of CO_2 exchange were erratic and difficult to interpret (Table 1). In general, plants grown in soil of 32 C consistently showed negative net photosynthesis. This may be partially due to high water stress. Plants were watered whenever they appeared to be under stress. They were not watered prior to sampling, however. Plants in the 32 C bath required watering nearly daily because of high evaporation and transpiration. Unfortunately, plant water stress measurements were not obtained to test the hypothesis of the effect of plant water stress on seedlings in relation to photosynthesis. The relatively low net CO_2 exchange during photosynthesis may be partially attributed to the low light intensity of 1000 ft. candles.

Dark respiration CO_2 exchange measurements (Table 1) showed a decline in CO_2 release per unit leaf area as the seedling developed. Plants grown in 32 C soil showed the highest dark respiration rates, whereas the other plants showed no marked trend in response in relation to seedling age.

In the field, differences in growth and development characteristics of *Poa sandbergii* from two distinct habitats and grown in the same environment were obscured by the great variation of individual plants in this experiment (DSCODE A3UHH04). The effects of additional water on *Poa* from the two sources were masked and no detectible trend was noted (Fig. 1 and Fig. 2).

Table 1. Averages of leaf area, shoot weight, root weight, root:shoot ratios, CO_2 exchange rate measurements and tiller numbers of *Poa sandbergii* seedlings grown under conditions of constant soil temperature for 39 days DSCODE—A3UHH03

Soil Temperature	Days of Growth					
C°	0 Day	11 Days	17 Days	24 Days	31 Days	39 Days
			Leaf Area (cm^2)			
5°	1.7	2.6	2.9	3.9	4.3	4.3
15°	1.7	3.6	4.0	5.7	6.2	6.0
20°	1.7	3.0	6.2	5.0	7.8	8.1
32°	1.7	2.5	4.0	5.5	6.3	8.5
			Shoot Weight (mg)			
5°	4	9	9	15	17	25
15°	4	11	13	23	26	29
20°	4	10	24	22	35	43
32°	4	8	13	21	26	40
			Root Weight (mg)			
5°	3	17	20	37	52	79
15°	3	26	30	53	73	90
20°	3	14	41	43	70	57
32°	3	9	17	26	41	45
			Root:Shoot Ratios			
5°	.65	1.92	2.56	2.43	3.14	3.31
15°	.65	2.55	2.41	2.42	3.14	3.31
20°	.65	1.45	1.64	2.05	2.09	2.17
32°	.65	1.02	1.40	1.20	1.63	1.18
			Tiller Numbers			
5°	1.3	3.0	2.3	3.3	3.7	4.5
15°	1.3	3.0	3.2	4.7	5.7	5.8
20°	1.3	3.0	4.7	4.5	7.0	7.8
32°	1.3	2.8	3.8	4.8	8.0	7.3
			Net Photosynthesis (mg CO_2 /dcm^2/hr)			
5°	---	---	.29	.68	.17	.13
15°	---	---	-.32	.43	.02	-.17
20°	---	---	-.01	.42	.37	.86
32°	---	---	-.98	-.15	-.25	-.33
			Dark Respiration (mg CO_2 /dcm^2/hr)			
5°	---	---	15.15	7.17	9.16	8.19
15°	---	---	12.03	6.93	7.91	6.89
20°	---	---	8.00	9.61	6.37	8.02
32°	---	---	16.04	11.07	12.37	9.33

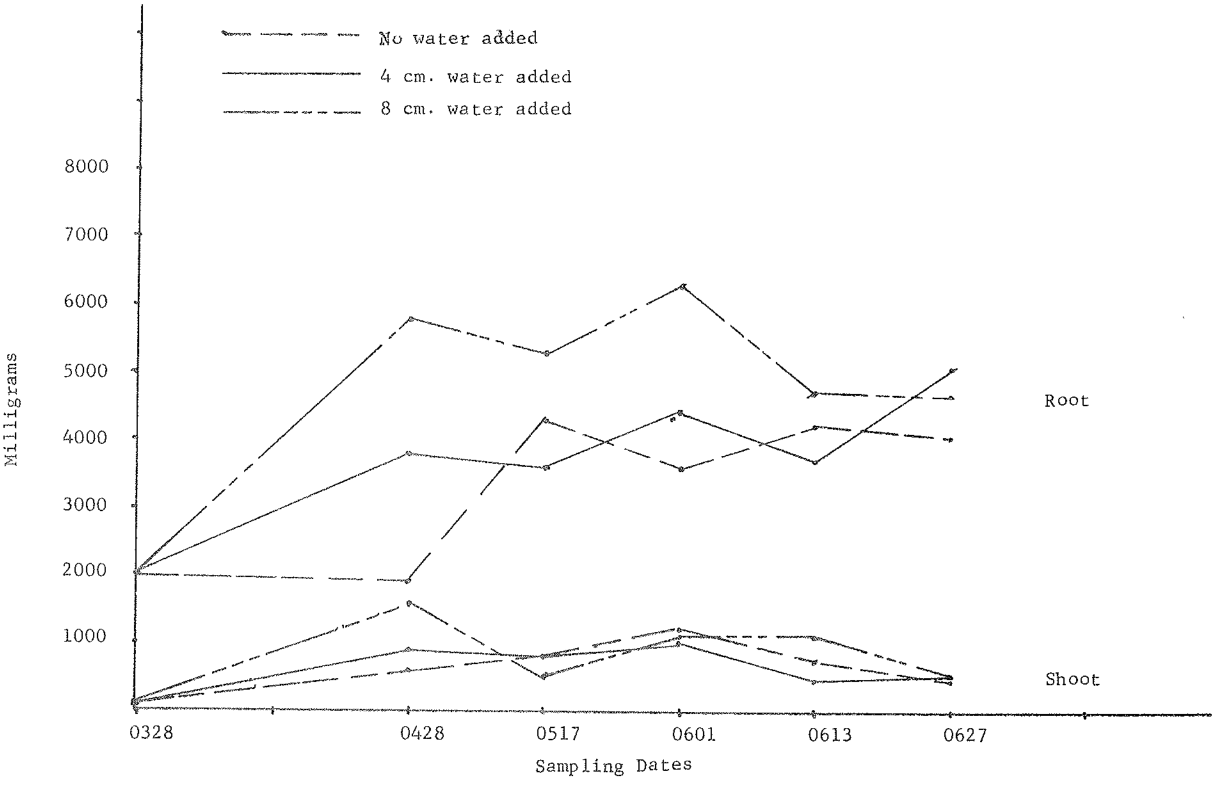

Figure 1. Averages of shoot and root biomass of Saylor Creek *Poa sandbergii* during the 1972 growing season (DSCODE A3UHH04).

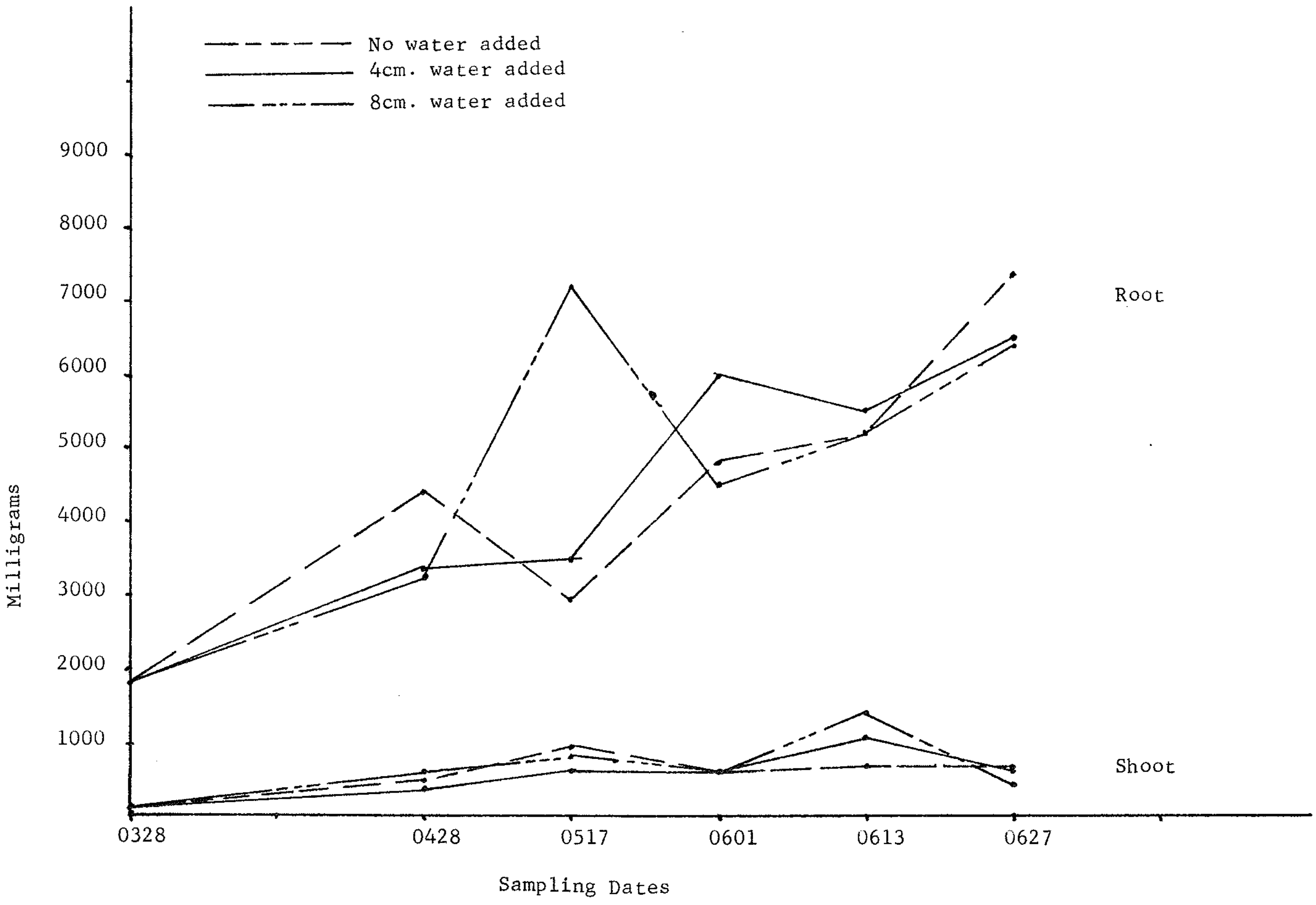

Figure 2. Averages of shoot and root biomass of Crane Creek *Poa sandbergii* during the 1972 growing season (DSCODE A3UHH04).

Comparison of *Poa* between the two sources showed that the Crane Creek plants produced greater root biomass than plants from Saylor Creek (Fig. 3). Root:shoot ratios of the Crane Creek plants tended to be higher, also (Fig. 4). The Crane Creek *Poa* was slower to develop and attained the seedhead stage 1-2 weeks later than the Saylor Creek plants. The Saylor Creek *Poa* had reached the seedhead stage during the subsequent 2 weeks. By June 27, the Saylor Creek plants had cured and were summer dormant while the *Poa* from Crane Creek had cast its seeds but still retained some green leaves and culms.

The monitoring of CO_2 exchange rates yielded data that were difficult to interpret. *Poa* from both sources responded similarly when positive net photosynthesis was indicated, i.e. the rates were low (Tables 2 and 3). An average of nearly 4 mg $CO_2/dcm^2/hr$ was the highest rate attained (from 9 individuals) for any single day. The response was erratic; some indicated positive net photosynthesis while others indicated negative rates.

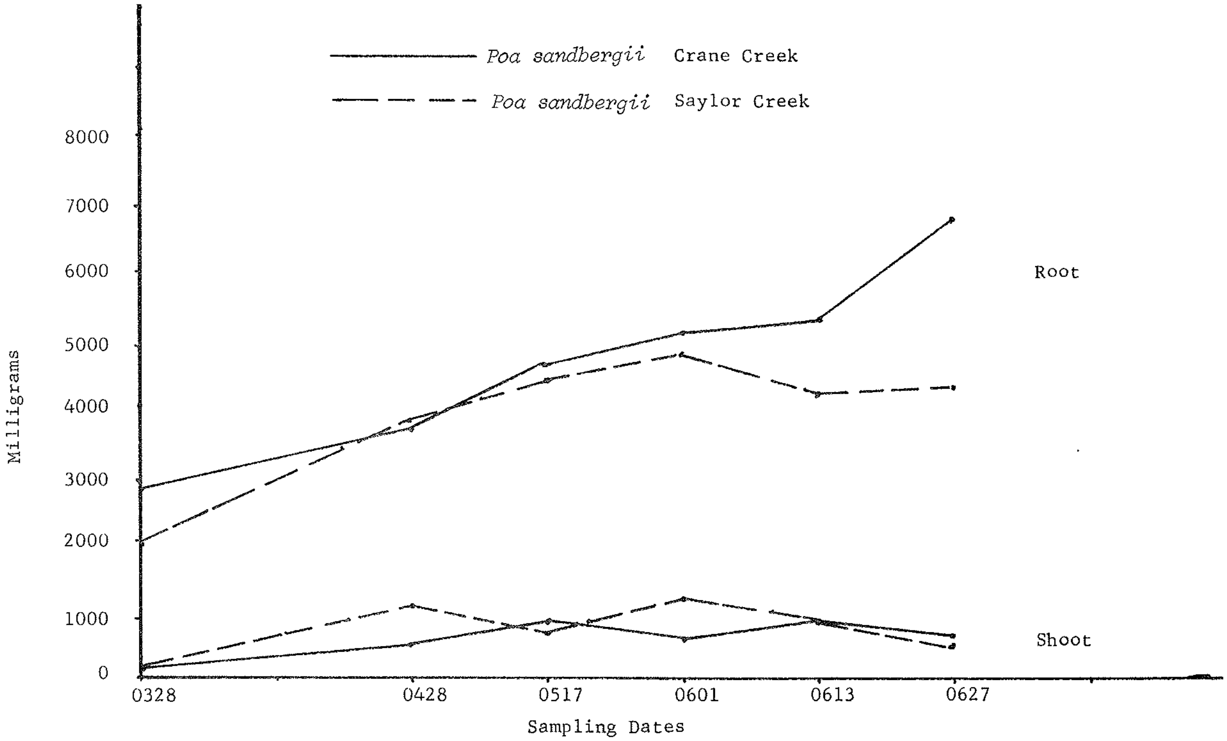

Figure 3. Averages of shoot and root weights of *Poa sandbergii* from Crane Creek and Saylor Creek sources during the 1972 growing season (DSCODE A3UHH04).

Table 2. Average CO_2 exchange and transpiration rates of Saylor Creek *Poa sandbergii* in 1972 DSCODE—A3UHH04

Date	Photo. mg $CO_2/dcm^2/hr$	Resp. mg $CO_2/dcm^2/hr$	Transp.* mg $H_2O/dcm^2/hr$	Transp.** mg $H_2O/g/hr$
3/28	3.68	33.80	3837	4546
4/28	-5.06	26.18	1715	979
5/17	2.91	20.45	1147	1196
6/01	-1.12	12.55	----	----
6/13	-24.62	26.07	1525	267
6/27	----	----	----	----

*Based on green leaf area
**Based on total shoot weight

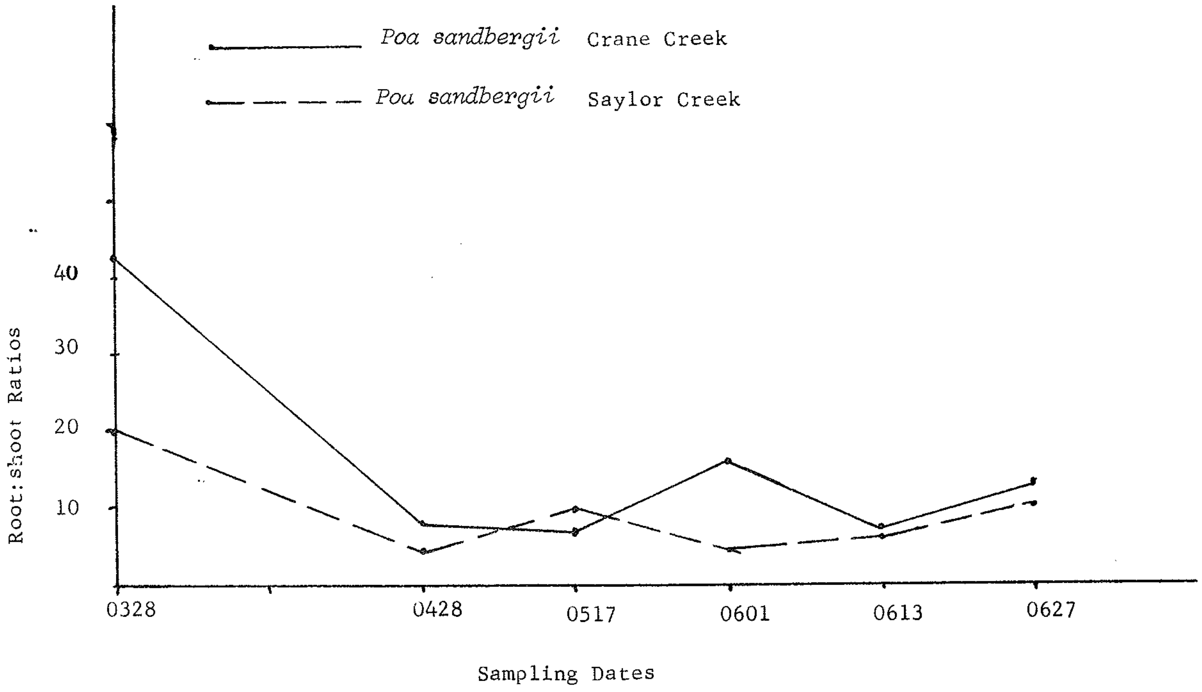

Figure 4. Averages of root:shoot ratios of *Poa sandbergii* from Crane Creek and Saylor Creek sources during the 1972 growing season (DSCODE A3UHH04).

Table 3. Average CO_2 exchange and transpiration rates of Crane Creek *Poa sandgergii* in 1972 DSCODE—A3UHH04

Date	Photo. mg $CO_2/dcm^2/hr$	Resp. mg $CO_2/dcm^2/hr$	Transp.* mg $H_2O/dcm^2/hr$	Transp.** mg $H_2O/g/hr$
3/28	-0.42	25.54	2731	6620
4/28	2.60	24.07	1415	1126
5/17	0.81	16.39	794	446
6/01	-0.98	14.29	----	----
6/13	-4.21	11.56	949	427
6/27	-13.37	16.97	1788	360

*Based on grean leaf area
**Based on total shoot weight

In late March and April, occurrence of morning frost was common and affected the plants. Plants that showed visible effects of frost from the previous night often indicated reduced or negative net photosynthesis. The duration of the effects of frost damage on net photosyntehsis was not determined.

The relation between plant water stress and net photosynthesis rate of *Poa* indicated that the CO_2 compensation level was near -25 bars, at least for plants in the late development stages (Fig. 5). It was observed that reduced or negative photosynthetic rate could be reversed by increasing the CO_2 concentration level, however. The effects of plant water stress in the range of 0 to -20 bars stress were not monitored so the maximum net photosynthetic rate in relation to plant water stress was not ascertained for *Poa sandbergii* under field conditions.

Transpiration rates based on green leaf area (Tables 3 and 4) showed a bimodal response. During early spring rates were high and as development and growth progressed transpiration sharply declined. A second high was recorded as plants approached dormancy and green leaf area was greatly reduced. A similar response was observed for *Sitanion hystrix* the previous year. On the basis of total shoot biomass, transpiration rates decreased as the season progressed and very low rates were recorded as plants became dormant.

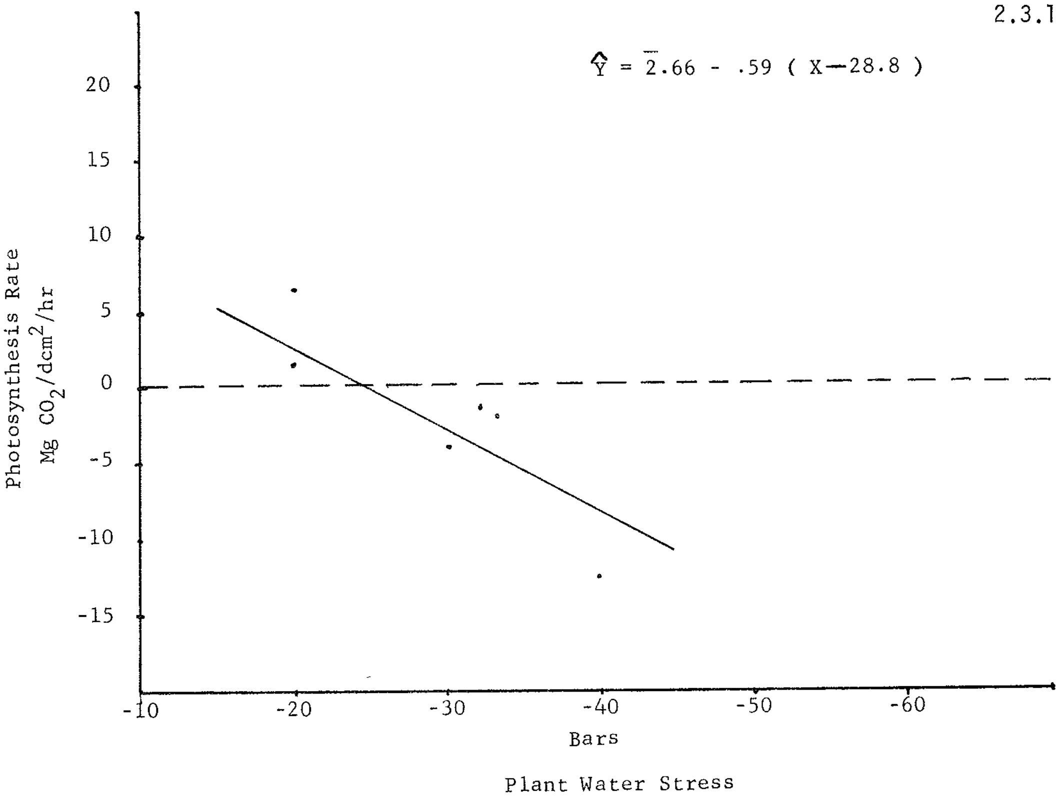

Figure 5. Relationship between net photosynthetic rates and plant water stress of *Poa sandbergii* during the 1972 growing season (DSCODE A3UHH04).

Table 4. Average CO_2 exchange and transpiration rates of 2nd season *Sitanion hystrix* var. *hystrix* DSCODE—A3UHH04

Date	Photo. mg $CO_2/dcm^2/hr$	Resp. mg $CO_2/dcm^2/hr$	Transp.* mg $H_2O/dcm^2/hr$	Transp.** mg $H_2O/g/hr$
4/28	2.07	8.0	----	----
5/17	9.36	9.0	----	----
6/01	-1.52	23.0	567	217
6/13	4.82	----	----	----
6/27	-19.67	30.0	----	453
7/11		CURED		

*Based on green leaf area
**Based on total shoot weight

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Sitanion hystrix

Measurements were made on second season *Sitanion* plants. Due to limited number, it was not possible to stratify for uniformity and much variability was encountered. In general, var. *californicum* produced larger plants than var. *hystrix* (Fig. 6). This was observed with the first season plants also. The root:shoot ratios for var. *hystrix* were higher than for var. *californicum* (Fig. 7) but were not greatly different from those during the first season (Hironaka and Tisdale, 1972).

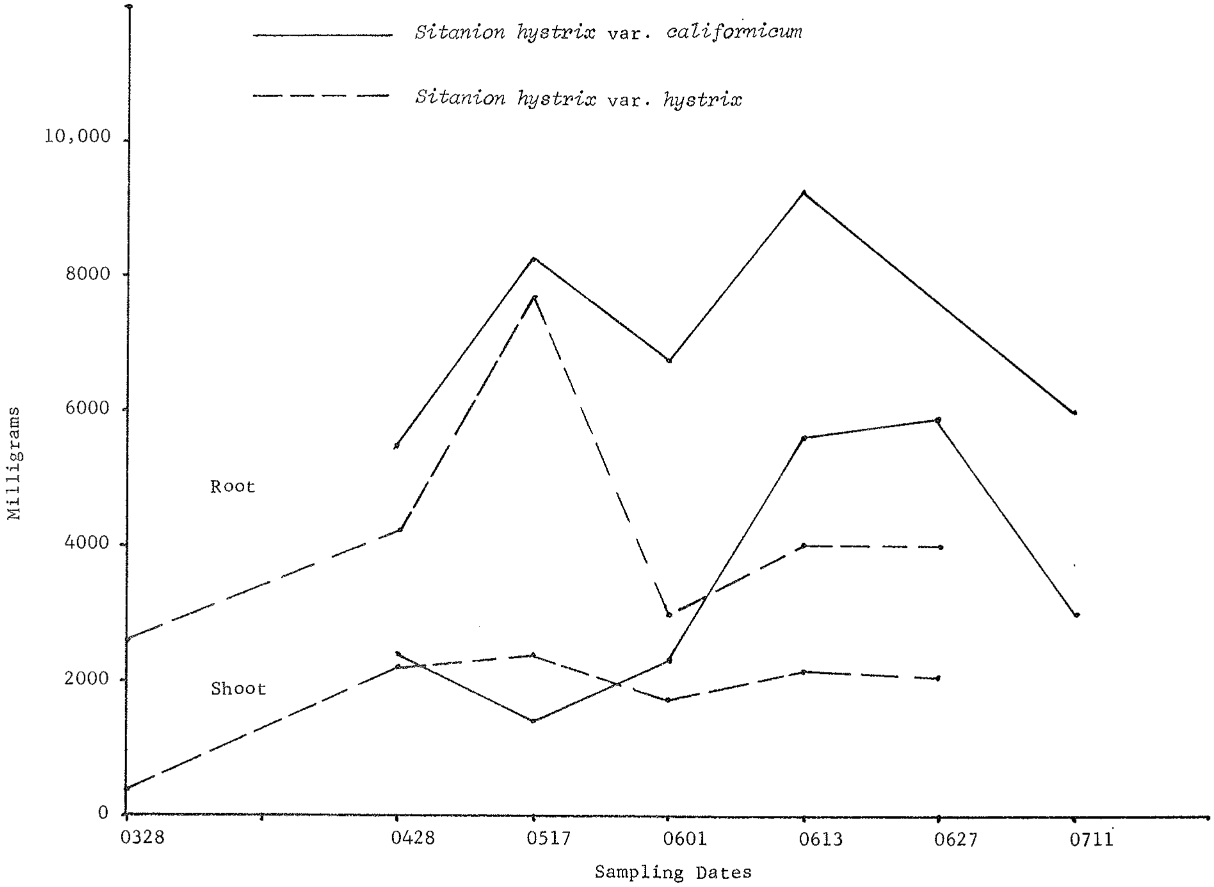

Figure 6. Averages of shoot and root weights of *Sitanion hystrix* var. *hystrix* and var. *californicum* during the second growing season (1972) (DSCODE A3UHH04).

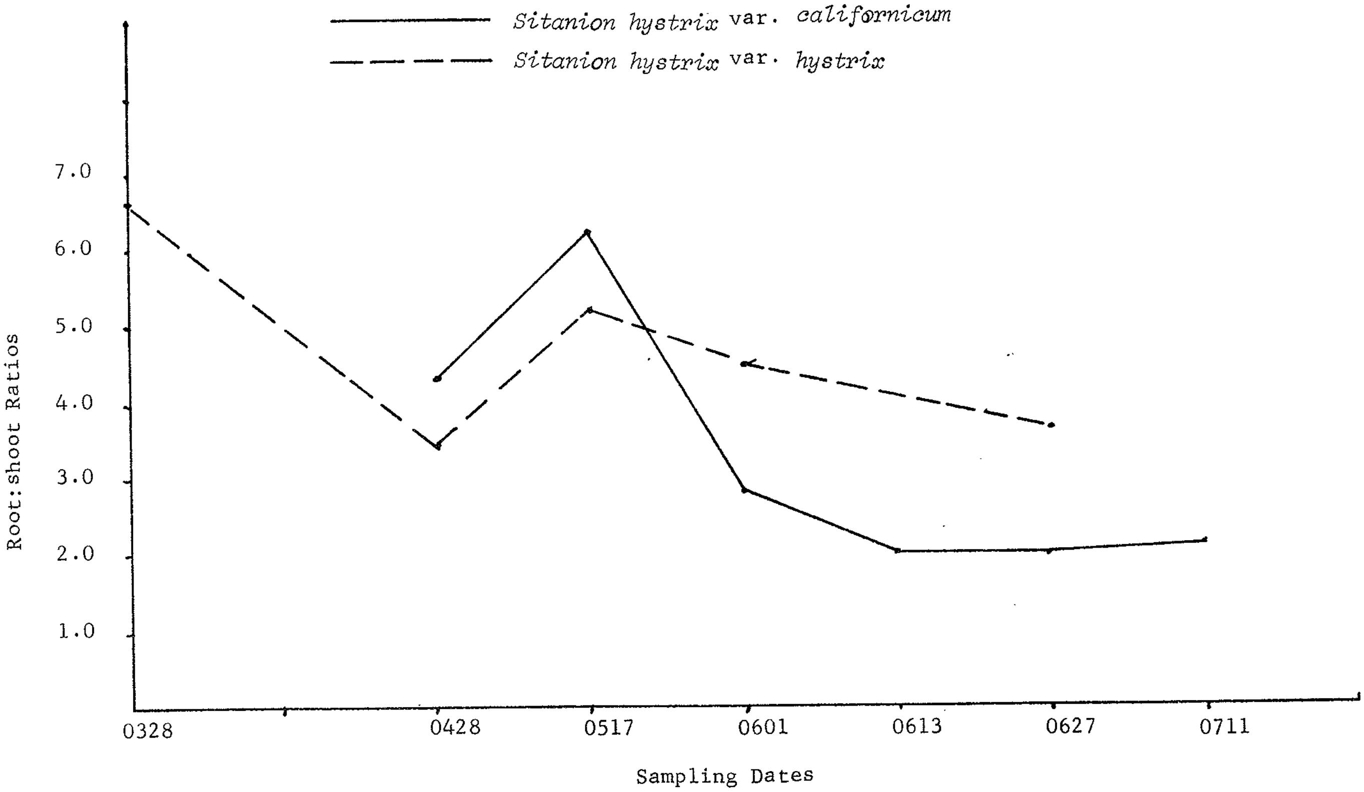

Figure 7. Averages of root:shoot ratios of *Sitanion hystrix* var. *hystrix* and var. *californicum* during the second growing season (1972) (DSCODE A3UHH04).

The net photosynthetic rates in 1972 did not attain the high rates obtained in 1971 when the plants were in their first season. In 1971, the maximum average measured was about 14 mg CO_2 fixed per dcm^2 per hour while in 1972 the maximum reading was less than 10 mg CO_2 (Tables 4 and 5).

Table 5. Average CO_2 exchange and transpiration rates of 2nd year *Sitanion hystrix* var. *californicum* in 1972 DSCODE—A3UHH04

Date	Photo. mg $CO_2/dcm^2/hr$	Resp. mg $CO_2/dcm^2/hr$	Transp.* mg $H_2O/dcm^2/hr$	Transp.** mg $H_2O/g/hr$
4/28	1.64	21.88	----	----
5/17	7.69	11.40	589	304
6/01	8.19	12.18	----	----
6/13	-2.41	8.50	1223	94
6/27	-10.25	15.92	924	84
7/11	-4.35	11.06	1294	121

*Based on green leaf area
**Based on total shoot weight

Var. *hystrix* showed its characteristic early development by as much as 2 weeks. Maximum photosynthetic activity occurred during the latter part of April for var. *hystrix*, whereas for var. *californicum* high activity was recorded two weeks later.

It appeared that the effect of plant water stress on photosynthesis rate was conditioned by the stage of development. Temporary high water stress did not appear to affect photosynthesis rate to the same degree in the early stages as compared to late developmental stages. The CO_2 compensation level in relation to plant water stress was near -35 bars (Fig. 8), which indicated that *Sitanion* can function under considerable plant water stress. When compared to the lower CO_2 compensation point of *Poa sandbergii* (about -25 bars), *Poa* must make its growth early in the spring when moisture is ample, whereas *Sitanion* is able to grow later in the season. This differential growth response is not entirely a function of plant water stress of *Poa sandbergii*. Another controlling factor was disclosed in a growth chamber experiment.

Poa sandbergii from Crane Creek was grown under two daylight periods, 12 and 18 hours. Plants under the short daylength treatment continued to produce vegetative shoots while plants under the 18-hour day went into dormancy. When the treatment was reversed, dormant plants resumed growth under the 12-hour day condition and the green plants went into dormancy within a period of 3 weeks.

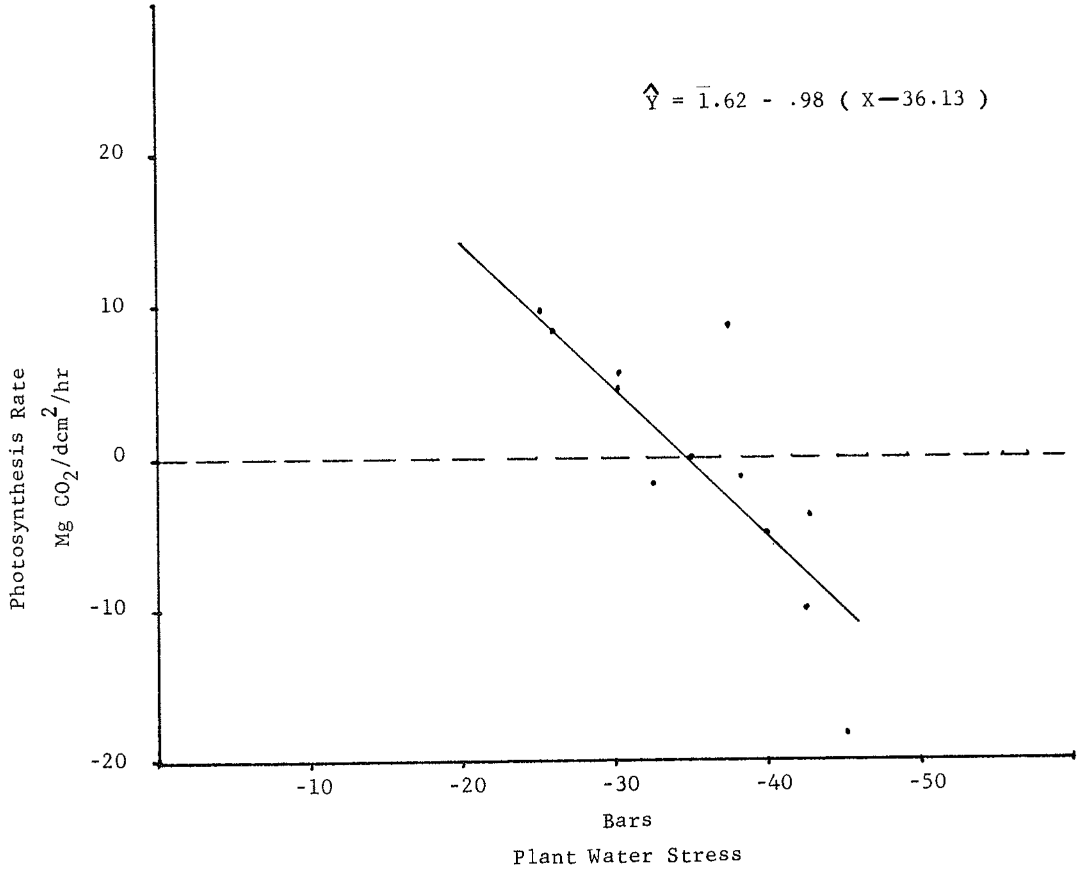

Figure 8. Relationship between net photosynthetic rates and plant water stress of *Sitanion hystrix* during the second season of growth (1972) (DSCODE A3UHH04).

Root carbohydrate reserve status (Table 6) as expressed by total non-carbohydrate (TNC) showed that *Sitanion* tended to accumulate less reserves than reported by Coyne and Cook (1970). *Poa* also indicated a relatively low root reserve accumulation. The TNC data may reflect the results of not stopping enzyme activity immediately after root recovery, however.

Table 6. Average total non-structural carbohydrate percentages (TNC%) of root crown of *Poa sandbergii* and *Sitanion hystrix* in 1972 DSCODE—A3UHH04

	Poa sandbergii		*Sitanion hystrix*	
Date	Saylor Creek	Crane Creek	v. *hystrix*	v. *californicum*
		TNC%		
3/28	----	3.8	----	----
4/28	5.9	7.6	7.5	4.8
5/17	10.9	7.8	11.2	5.2
6/01	6.9	8.0	5.1	6.4
6/13	8.1	6.0	10.3	9.0
6/27	8.5	7.7	8.3	8.7
7/11	----	----	----	9.4

DISCUSSION

Although plant growth and development of individuals of the two sources of *Poa sandbergii* included in this study were highly variable, the Crane Creek plants tended to produce more biomass but were slower in development than those from Saylor Creek. This supports the hypothesis that the slower-developing race of *Poa sandbergii* from Crane Creek tended to occur in similar habitats as *Sitanion hystrix* var. *californicum*. Whereas, the distribution of the early-developing race of *Poa sandbergii*, as represented by plants from Saylor Creek, tends to co-habit with *Sitanion hystrix* var. *hystrix*.

The reasons for the relatively low rates of net photosynthesis obtained for *Poa sandbergii* can only be speculated because of inadequate frequency of sampling during the rapid growth period. This period occurred while moisture was ample and temperatures were cool to moderate. It appeared that plant water stress affects rate of CO_2 exchange to a greater degree than most other species of the cold desert. The level of plant water stress at which depression in net photosynthetic rate was induced was not determined but the CO_2 compensation point occurred at a lower stress level for *Poa sandbergii* than for *Sitanion hystrix*. Furthermore, it was found that daylength governed plant development in *Poa sandbergii*. Long daylength induced dormancy, whereas short daylength promoted growth. The factors of light intensity and quality were not investigated.

Further research is recommended to ascertain the interactions of plant water stress, CO_2 exchange rates, plant development and daylength on the growth and development of *Poa sandbergii*.

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