CHARACTERISTICS RELATED TO SUMMER GROWTH OF PRAIRIE THREE-AWN GRASS

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Prairie three-awn, *(Aristida oligantha),* is an annual bunch grass possessing the ability on California ranges to grow throughout the hot dry summers. In this winter rainfall climate such behavior is unusual, since most annual grasses terminate growth in May or June.

The species is reported capable of quick establishment on abandoned fields and disturbed sites in the Southern and Central Great Plains (Booth, 1941, and Osborn and Allan, 1949). In Nebraska, Voigt (1951) observed the species on land reverting to native pasture, and concluded from root studies that *A. oligantha* possessed a root system well adapted to poor soils. The plant often is associated with the dry rocky soils of valleys and foothills in California (Sampson, Chase, and Hedrick, 1951).

Lack of forage value probably has curtailed greater interest in this plant, although its ability to grow under stress of severe heat and dryness lends it considerable value for physiological study. The present work investigated tolerance of the species to these stresses.

Seed of prairie three-awn was obtained from native stands in the Sacramento Valley. Plantings were started in the greenhouse. For field observations seedlings were transplanted in rows at two-foot spacings in areas kept free of weeds. Soft chess *(Bromus mollis),* a desirable winter annual, and nodding stipa *(Stipa cernua),* a heat tolerant perennial growing to some extent into the summers, were selected for comparisons with the three-awn.

Results and Discussion

Under cool conditions prairie three-awn is delayed in emergence compared to soft chess. Plantings in steam-sterilized soil both in the greenhouse and outdoors were made in February when the average minimum temperature was 61° F. inside and 49° F. outdoors. Although an emergence of 96 percent or higher was obtained ultimately in both species, the soft chess reached 90 percent emergence outdoors in 11 days, while the three-awn required 37 days.

Early seedling development was observed by washing out potted plants during the six weeks following emergence. Prairie three-awn produced less top growth than the soft chess, but the primary difference appeared between the root systems. Soft chess developed a much-branched fibrous system, while prairie three-awn exerted a rapidly elongating and vigorous single root which reached a vertical length of over 20 cm. before branching.

Roots and Summer Growth

Seedlings of prairie three-awn were transplanted to the field April 13, 1957, to be used in clipping and root excavation studies. Forty-six days after transplanting trenches were dug beside four plants, and the root systems were excavated by careful use of a pen knife. The longest root was traced vertically downward for 48 inches and still the root cap was not reached. Growth in depth averaged something over an inch a day. There were sparse branch roots arising at depth. Each plant was anchored by 6 to 15 shorter roots arising from the crown at this stage.

By July the surface soil was dry, yet the plants were turgid and growing. To indicate the importance of roots at depth in supplying moisture, the soil around selected plants was trenched and cut laterally with a crosscut saw, so that intact roots of the plant were restricted to a soil block 8 inches wide, 8 inches long, and to depths of 12, 18, and 24 inches. One series of blocks was undercut, so that no intact roots extended below the 12-, 18-, or 24-inch depth.

The soil was cut on July 24. By July 31 plants undercut at 12 inches were wilting, by August 5 those undercut at 18 inches were wilting, and by August 12 those undercut at 24 inches were wilting.

All undercut plants died, but those not undercut continued growth similar to the controls. The moisture necessary for summer growth appears to be obtained at depth. This is supported further by the observation of three-awn growing vigorously in late summer in a heavy stand of annuals which had terminated growth in early summer, when moisture at shallow depths was depleted.

Table 1 presents root counts and regrowth measurements of prairie three-awn in response to light irrigation or clipping dur-

Table 1. Root initiation and regrowth of tops during July in spaced plants of prairie three-awn transplanted to the field April 13, 1957

Treatment	July 9			July 16	
	New roots from crown	Old roots from crown	Regrowth in inches	Total roots from crown[3]	Regrowth in inches
Unwatered, unclipped	0	14	—	7	—
Unwatered, clipped[1]	0	21	9.0	8	14
Watered[2], unclipped	27	23	—	83	—
Watered, clipped	41	6	6.5	68	16

[1] Clipped at 2 inches on July 3.

[2] Watered lightly on July 3, 5, 8 and 11.

[3] Total used, as separation into age groups was uncertain.

ing July. It should be noted that the last effective rain prior to these observations was one-quarter inch on May 19. Numerous new roots elongated quickly from the crown in the presence of surface soil moisture. However, these abundant shallow roots were not necessary for the maintenance of the plant. Unwatered plants produced nearly the same amount of regrowth as the watered, apparently by obtaining moisture at depth through the deeply penetrating root system.

Voigt (1951) described the root system of prairie three-awn in Nebraska as composed of a shallow, dense, widespread system and a deep penetrating thinner system. It would appear that the shallow system developed under the conditions of summer rains in Nebraska.

Heat Tolerance

The relative heat tolerance of prairie three-awn was compared with that of soft chess and nodding stipa in a controlled testing chamber having precisely regulated air temperature and humidity. Plantings were thinned to three plants per four-inch pot, and were watered to maintain available moisture at all times. Samples of no less than 15 plants per species were exposed to a heat stress of 130° F and 50 percent relative humidity for a sufficient duration to yield differential injury among the species. A five-hour exposure accomplished this at the younger ages, but because of the increased tolerance of older plants, longer exposures were used for them.

Two weeks after a heat exposure, the amount of tissue killed was clearly evident. An index of injury (percent tissue killed) was obtained by determining the percent of dead plants and adding a value for the dead tissue on plants partially injured. The value used for this was the percent dry matter based on the fresh weight of the sample. As more tissue was killed this value increased.

Several plantings were made over a period of four months to obtain the range in ages. Age was dated from the time of planting. As the greenhouse environment varied considerably during this period, each age group encountered somewhat different preconditioning prior to a test. Comparisons of injury, therefore, should be made only within an age group, and not between them.

Table 2 presents the results of these heat tests. Prairie three-awn exhibited high tolerance compared to soft chess. This might be expected in comparisons of summer with winter annuals. However, the tolerance of three-awn and stipa was similar. Since the latter is known to possess high heat tolerance, prairie three-awn also may be classed as highly heat tolerant.

Endurance of Soil Dryness

It appeared desirable to determine whether the prairie three-awn and soft chess differed in ability to endure periods of soil dryness and then to recover with the addition of water. Four plants of both species were established in each of 50 eight-inch glazed pots in the greenhouse. Planting the species in the same pot insured that both in any one pot were subjected to the same soil moisture condition.

On October 15, two weeks after emergence, the soil was brought to field capacity of moisture, and water was withheld until wilting was evident. On November 20, December 2, 7, and 10, a group of the pots were watered to field capacity. All plants of both species recovered turgidity after watering on the first two dates. Only 40 percent of both species recovered after the December 7 watering, and 1.5 percent after that of December 10. No difference was detected in ability to endure a period of soil dryness when these species were grown

Table 2. Average percent tissue killed by exposure to 130° F and 50 percent relative humidity measured two weeks after test.

Age of plants	Duration of exposure	Tissue killed		
		Prairie three-awn	Soft chess	Nodding stipa
Weeks	Hours	Percent	Percent	Percent
3	5	31	100	—
5	5	5	100	—
6	5	5	98	—
7	5	15	100	28
8	7	25	100	40
15*	7	20	91	55
17*	10	59	100	42

* Injury measured by visual estimates only.

in pots which restricted root depth.

Under summer field conditions both the deep penetrating root system and the high temperature tolerance would aid in the persistence and growth of the three-awn. It would be of interest to measure transpirational losses in this species under stress of heat and dryness.

Summary

The growth behavior of prairie three-awn, an annual bunch grass possessing unusual ability to grow during the hot dry summers on California ranges, was studied in comparison with soft chess and nodding stipa.

The root system of prairie three-awn consists of a few vertical and sparsely branched rapidly elongating roots in the field in the absence of summer rainfall. This is in contrast to the much-branched fibrous root system common among winter annual grasses.

Rapid regrowth follows clipping in the summer. The water for such growth is obtained at depth. If normal root penetration is prevented by growing the three-awn in pots, it has the same ability to endure soil dryness as soft chess.

Prairie three-awn possesses high heat tolerance as measured by survival of stresses in controlled chambers. The plant has tolerance much greater than soft chess and similar to nodding stipa.

Both deep rooting habit and high heat tolerance are characteristics of this species contributing to summer growth in winter rainfall areas.

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