Responses of Annual Range to Gibberellic Acid

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During the past several years scientists have devoted considerable study to the effect on plants of the recently available plant growth substance, gibberellic acid. Among the numerous responses reported are some appearing to have possible application to forage production on range, although these responses usually have not been studied using range species. Increased dry weight and stimulated growth at low temperatures are reported behaviors of this type.

Freitas, McClung, and Quinn (1957) reported significant fresh and dry weight increases in the Brazilian pasture grass, *Panicum maximum,* during winter months following foliar sprays with gibberellic acid. Leben and Barton (1957) obtained significant dry weight increases in Kentucky bluegrass in Indiana when harvested November 10, having been sprayed 15 days earlier with this chemical. Wittwer and Bukovac (1957a) found that winter dormant Kentucky bluegrass resumed vigorous growth in Michigan within a few days after being sprayed in March. These investigators (1957b) also noted that adequate fertility, particularly nitrogen, aided in stimulating growth following the hormone spray, and that the effect of spraying might persist for 2 to 6 months.

Other work provides less promise that beneficial uses may be found for range. Marth, Audia, and Mitchell (1956) surveyed the response of many plants to the hormone and found that behavior differed pronouncedly among species with some being little affected by treatment. Youngner (1958) reported that although dry weight of clippings was increased in Zoysia grasses, treatment with gibberellic acid did not improve the rate of turf establishment. Field applications have been made in England by Morgan and Mees (1956) who found that although the dry weight of forage cut after gibberellic acid application was increased at the first cut, it decreased at the second cut resulting in no significant increased yield from the sward.

Both the stimulation of growth at seasons when low temperatures normally retard growth and the increases in dry weight of forage frequently reported following treatment with gibberellic acid, appear to be features warranting additional study on range species growing under range conditions. The present study was undertaken with these objectives in mind.

Materials and Methods

Throughout these studies the potassium salt of gibberellic acid[1] was used at 100 p.p.m. in water to which detergent[2] at 1 c.c. per liter was added as a spreader. A single spray was applied to the foliage. Plants in the greenhouse were wetted with the spray to the point of slight run-off from the leaves. Seventy-three gallons of solution per acre was used in the field spraying which resulted in an application rate of 1 ounce of gibberellic acid to the acre.

A number of species were screened for response in the greenhouse. These were planted in 7-inch clay pots, in steam-sterilized soil, and sprayed when approximately 3 weeks old. Controls were sprayed with water containing detergent only. Temperatures ranged from 68° to 80° F. Observations were made to 6 weeks after spraying when dry weight, maximum plant height (to the tip of longest leaf), and number of culms were recorded.

Field applications were made on native annual range at two locations in California; namely, at the Forest Service San Joaquin Experimental Range and at the University's Hopland Field Station. At both sites the effect of spraying range fertilized at several levels was studied.

Vegetation at the San Joaquin Range consisted primarily of soft chess *(Bromus mollis)* and broadleaf filaree *(Erodium botrys)*. The area was burned over before autumn rains on September 25, 1957. A split plot design was established using ammonium nitrate at rates of 0, 30 and 100 pounds of N to the acre, with gibberellic acid either not applied or sprayed on November 7, 1957, or March 7, 1958. The fertilizer was applied October 12, 1957. Individual plots were 10 by 25 feet and replicated 6 times. Relative vigor and plant height was recorded during growth. On May 6-9, 1958, 3 square-foot quadrants were cut at ground level from each plot, air dried on benches in a warm greenhouse, and weighed.

At Hopland, where a similar procedure was planned, the vegetation consisted primarily of soft chess, ripgut brome *(Bromus rigidus)*, slender wild oats *(Avena barbata)*, and broadleaf filaree with scattered clumps of purple stipa *(Stipa pulchra)*. The proportion of filaree was much less than at the San Joaquin

[1] *Gibberellic acid, bearing the trade mark "Gibrel" was kindly supplied by Merck and Co., Inc.*

[2] *Either Tween-20 (Atlas Powder Co.) or X-77 (Colloidal Products Corp.)*

Range. The vegetation was mowed before treatments were applied. Since it was known that this site responded to both nitrogen and phosphorus, both were employed in the fertilizer treatments. Again gibberellic acid was applied at one of two dates, either November 5, 1957, or April 10, 1958. Fertilizer applications were made on October 29, 1957, using urea as the source of nitrogen and treble superphosphate for the phosphorus. Nitrogen levels of 0, 30, and 100 pounds of N per acre were applied with and without phosphorus at 200 pounds per acre. A factorial design was employed having four replications with individual plots being 10 by 25 feet in size.

Alteration of the schedule at Hopland was required by the abnormally warm wet winter of 1957-58 which resulted in unusually abundant growth and by persistent rain which prevented field operations. Lodging of the rank growth necessitated mowing and raking the area after the first sampling of 3 quadrats per plot on March 3. Rains delayed the spring spraying until April 10, and these plots were then sampled on May 13. All samples at Hopland were dried in a forced draft oven before being weighed.

Results and Discussion

Greenhouse Study

Five species were selected for evaluation of response to gibberellic acid in the greenhouse. These were planted at a minimum of 10 replications in a soil-sand mix to which no fertilizer was added. At the time of spraying, approximately 3 weeks after planting, the filaree was in the 10-leaf stage (a rosette), annual ryegrass *(Lolium multiflorum)* had 6-8 leaves, nodding stipa *(Stipa cernua)* had 4-7 leaves, and two bromes had 3-4 leaves. In the grasses the younger visible internodes elongated noticeably after spraying, and treated plants appeared paler in color though outgrew this condition in time. The filaree responded to treatment by a broadening of leaf blades and increase in petiole length with petioles assuming an upright habit.

The resulting measurements are presented in Table 1. All except annual ryegrass responded with increased plant height, while the ryegrass exhibited an increase in culms per plant. Only in the case of prairie bromegrass *(Bromus catharticus)* was a significant increase in top weight obtained. Roots were not included in these weights, though it is recognized that in future studies they should be considered. The appearance and growth habit of prairie bromegrass treated with gibberellic acid is shown in Figure 1.

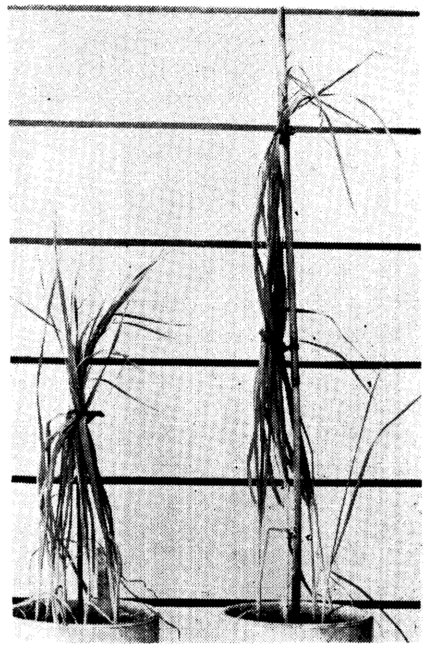

FIGURE 1. Prairie bromegrass seven weeks after spraying at the 2-leaf stage with gibberellic acid. Left-hand pot is the control. Background lines are 6 inches apart.

Plantings at other seasons were observed in the greenhouse. The same growth response by a species was not always obtained, indicating that variables such as temperature, age of plant when treated, and perhaps light, influence the response to spray application.

San Joaquin Range Field Trial

At the San Joaquin Range moisture and temperature conditions were favorable for plant development and growth was approximately normal. Twenty-nine inches of rain was received, well distributed from November through April. Temperatures were low enough to retard growth until March. The vigorous spring growth, though rank, remained erect until harvest in May.

Results of this trial are presented in Table 2. No significant difference was obtained at harvest in the November 7 spray

Table 1. Weight, height, and number of culms per plant for five species unsprayed and sprayed with gibberellic acid (100 p.p.m.) 23 days after planting and harvested 48 days after spraying.

	Species				
Item	Broadleaf filaree[1]	Soft chess[1]	Annual ryegrass	Nodding stipa	Prairie bromegrass
Plants per replication	5	8	8	6	8
Dry weight gms., treated	3.81	3.50	6.88	2.90	6.68*
Dry weight gms., untreated	4.20	3.24	6.76	2.42	5.47
Height[2], cm., treated	11.6**	43.0**	36.8	48.7**	100.6**
Height[2], cm., untreated	4.6	31.5	31.7	40.3	59.7
Culms, treated	....	4.8	22.3*	16.2	2.0
Culms, untreated	....	5.8	17.3	14.8	2.2

*Significantly greater than untreated at 5 percent level.
**Significantly greater than untreated at 1 percent level.
[1] Harvested 41 days after spraying.
[2] Height to tallest left tip.

Table 2. Average air-dry weight in grams of top growth of replicated square-foot samples at the San Joaquin Range clipped May 6-9, 1958, following fertilizer treatments on October 12, 1957, and gibberellic acid application on November 7, 1957, or March 7, 1958.

Gibberellic acid	Nitrogen, lbs. per acre 0	30	100
0	40.25	55.00	76.57
1 oz. per acre on Nov. 7	44.67	54.34	71.21
1 oz. per acre on Mar. 7	59.84	79.17	95.39

Gibberellic acid treatments, LSD (5%) = 8.22; (1%) = 11.08.
Nitrogen treatments, LSD (5%) = 9.14; (1%) = 12.99.
Interaction not significant.

treatment. In late November and December these plants exhibited evidence of response, mainly in height, but this increase was not maintained during the ensuing months. The March 7 spray, however, resulted in highly significant increases in dry weight at all nitrogen levels. The responses to fertilizer were significant, but no significant interaction between fertilizer and gibberellic acid was obtained. The March application of gibberellic acid produced height increases in the soft chess which persisted until harvest. These ultimately averaged from 3 to 4 inches. The greatest percentage increase in total dry weight occurred in the unfertilized plots, with progressively less increase attributable to the spray being obtained as the nitrogen level was increased. The actual dry weight gain per plot, however, was very similar at all fertilizer levels.

There was a noticeable increase both in size of filaree and in its earliness of flowering in the plots of the March 7 spraying. To evaluate differences in response among species, samples of this date and of the controls were separated into grasses, filaree, and forbs other than filaree. The separations revealed that the grass and forb-other-than-filaree components, although slightly increased in weight, contributed proportionately less to the total harvest following spraying on March 7 than they did to the controls. The filaree component, however, increased in weight, and in percent of the total yield by 13 to 15 percent regardless of the fertilizer treatment. This accounted for much of the gain in dry weight shown by the sprayed herbage. The conditions which contributed to this increase by filaree are not known. The species does not always respond in this manner to gibberellic acid as evidenced in Table 1.

Hopland Field Trial

Autumn rains commenced at Hopland in September and continued into May. Forty-nine inches of precipitation was received from November through April, with 28 inches of this coming in January and February. Temperatures were unusually warm with only an occasional light frost. When fertilizer was applied in late October, the grasses were approximately 3 inches high. By the end of February, at the high fertilizer levels, growth was rank and lodged with some rotting commencing in the rain-packed herbage. A few clear days permitted samples to be clipped on March 3.

Dry weights are presented in Table 3. The only significant differences obtained were between fertilizer levels. This was not unexpected, since the sole detectable effect of the November 5 treatment had been the characteristic light green color of sprayed plants, a condition which disappeared after a few weeks. Separation of the herbage into components as used at the San Joaquin Range did not reveal noticeable response by particular species.

Following the first sampling, the entire area was mowed and raked, in preparation for the second spray which was delayed by rain until April 10. The dense growth of the "100 N-200 P" plots had crowded out smaller plants so that only scattered stubble of the larger species remained for the second spray. However, uniform vegetation was available in the control and 30 N plots.

Samples were clipped on May 13. By this time the fertilizer treatments had leached and little difference appeared among the fertilizer applications of the previous October. The gibberellic acid spray did not produce significant differences in regrowth of the plots.

The 1957-58 season was too mild at both test sites to gain reliable information on the growth of treated plants at low temperatures.

Range vegetation in the field appears to offer several obstacles to the successful use of gibberellic acid. Areas are so extensive that the use of more than a single application is not feasible. Furthermore, the vegetation is composed of numerous species in various stages of development. The likelihood of producing growth stimulation in most of these by a single spraying is remote, when we recognize that species differ in response, and also that within a species stage of development may affect response. It is possible that as more information is obtained concerning the action of gibberellic acid in relation to temperature, moisture, light, fertility, and to stage of plant development, more specific uses may be suggested.

Summary

The growth of range species was studied both in the greenhouse and in the field in re-

Table 3. Average oven-dry weight (grams) of herbage from replicated square-foot areas at Hopland clipped March 3, 1958 following fertilization on October 29, 1957 and gibberellic acid application on November 5, 1957.

Fertilizer	Gibberellic acid 1 oz. per acre	Gibberellic acid None
(Pounds per acre)		
None	19.41	18.89
30 N	26.83	25.41
100 N	35.18	34.41
200 P	24.10	28.23
200 P, 30 N	30.72	36.91
200 P, 100 N	33.14	31.72

Fertilizer treatments, LSD (5 percent) = 5.54; (1 percent) = 7.45

sponse to a single foliar spray of gibberellic acid in solution at 100 p.p.m. The field tests were at two locations on sites fertilized with nitrogen alone or nitrogen and phosphorus.

Following spray treatment plants generally responded by showing a paler green color and a tendency toward greater height. The effect of fall spraying in the field did not persist overwinter. In one instance spraying in early March resulted in significant increases in dry weight of herbage when harvested two months later. Though responses to fertilizer were marked, no significant interaction between gibberellic acid and fertilizer was obtained.

Species differed in response to the foliar spray and the same species was not consistent in response. In the greenhouse trials, significant increase in dry weight of top growth was obtained with prairie bromegrass but not broadleaf filaree. The one significant increase in dry weight of herbage obtained in the field was attributed primarily to an increased growth of broadleaf filaree.

With our present state of knowledge the use of gibberellic acid on range to increase forage production does not appear justified. On such extensive areas the use of more than a single application is not feasible, and the likelihood of inducing growth stimulation at the same time on a sizeable proportion of the range flora is remote. As more information is accumulated on gibberellic acid it is possible that specific uses may be indicated.

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