Range fertilization of

Annual Forage Plants

aids plant use of available soil moisture

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Seed germination and early plant growth of most annual forage species on approximately 18 million acres of California's rangeland take place soon after the first fall rains, but the greatest growth is in late winter and spring when temperatures and soil moisture supplies are favorable.

Fertilization of annual rangelands is an important range improvement technique. Fertilization increases plant growth and therefore should stimulate plant use of soil moisture. The amount of available moisture and its distribution throughout the growing season are critical factors in plant growth on annual rangelands and may be significantly altered by fertilizer application.

The pattern of soil moisture depletion under moderately high rates of nitrogen and phosphorus fertilization was studied in a completely randomized block experiment in Solano County that included four fertilizer treatments replicated four times. Treatments applied before the first fall rain consisted of 150 pounds of nitrogen per acre, 200 pounds of phosphorus per acre, a combination of 150 pounds of nitrogen and 200 pounds of phosphorus per acre, and an untreated check plot. Ammonium nitrate and treble superphosphate were the fertilizer materials applied.

The test area is on the west slope of the Sacramento Valley near the Coast Range and has an average annual rainfall of 18″ to 20″ from September through May. The topography is slightly undulating and soils are derived from alluvium and old valley terraces. Soil of the study site is a mosaic of Olcott fine sandy loam and Clear Lake clay adobe. Vegetation consisted of resident annual grasses and forbs.

The experimental area was fenced, and plots 10′ × 11′ were centrally equipped with Bouyoucos resin-impregnated gypsum blocks so that soil moisture depletion at the 6″, 12″, 20″, and 36″ depths could be measured. In April, 20″-deep columns 6″ × 12″ were excavated from the variously treated plots, and plant roots were removed by washing.

Forage yield was measured at the peak of growth by clipping, at the 1″ height, one square foot of area from each of the plots.

Within two weeks after the first rain—2.5″—a plant growth response was noted, and the growth continued during the cool winter months at a greater rate than that on non-fertilized or phosphorus-fertilized plots.

Forage yield on plots fertilized with nitrogen was significantly greater than the yield on non-fertilized plots or on plots receiving only phosphorus. The combination of nitrogen and phosphorus produced a greater forage yield than did any other treatment. The nitrogen treatment produced more than twice the yield of plots given no treatment, and on the nitrogen-phosphorus-treated plots the yield was about four times as much as on the non-fertilized check plots.

Yield and Moisture Use Efficiency of Annual Range Following Various Fertilizer Treatments

Item	Treatment			
	No fertilizer	Phosphorus 200 lbs./a	Nitrogen 150 lbs./a	Nitrogen 150 lbs./a + phosphorus 200 lbs./a
Inches of rainfall (October–June)	17.01	17.01	17.01	17.01
Forage yield in lbs./a	1,440	1,704	3,169	5,929
Differences			1,465*	2,760*
Lbs. forage/inch of rainfall	84.7	100.2	186.3	348.6
Differences		15.5	86.1*	162.3*

* Indicates significance at the 1% level.

A comparison of forage yield in relation to soil moisture used for each treatment indicates that fertilization enables more efficient plant use of rainfall. In range areas, where rainfall is usually the only source of water for plant growth, fertilization produces more forage with a given amount of moisture.

Root excavations on April 15 indicated that a majority of the plant roots in the non-fertilized plots were located within the upper 12″ of soil. Excavation for a soil profile pit to the 6′ depth at the end of the summer in a non-fertilized area revealed that roots were present in abundance at the surface and gradually diminished toward the bottom of the pit. In the nitrogen-phosphorus plots roots were uniformly abundant to the 20″ depth. A large number of roots in this plot were severed when the soil columns 20″ deep were removed. No deeper excavations were made in the fertilized plots. The over-all reactions of the vegetation to fertilization were illustrated by the course of soil moisture depletion during the growing season.

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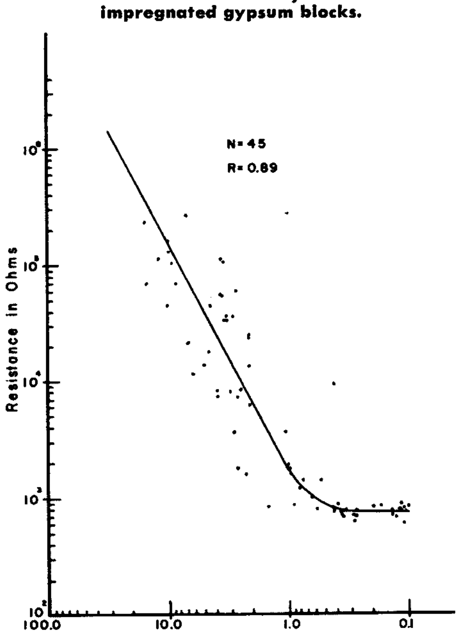
Calibration curve for Bouyoucos resin-impregnated gypsum blocks.



FORAGE PLANTS

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All plots were at field capacity on March 12 even though the nitrogen and nitrogen-phosphorus plots were supporting luxuriant stands of annual grasses and forbs. Therefore, the increased plant growth in winter did not appreciably drain the moisture reserve in the soil, and moisture was equally available on all plots for the rapid growth that occurred as soon as spring temperatures were favorable.

No summer-growing annual weeds, such as turkey mullein, spikeweed, and tarweed, were noted on the nitrogen-phosphorus plots. Observations indicated that a greater number of plants matured earlier on the nitrogen and nitrogen-phosphorus plots than on the unfertilized plots.

The graphs below give the moisture-extraction pattern for each of the treatments and the rainfall, in inches, as a function of time. The extraction patterns are expressed in terms of suction, in bars, and as the suction force increases the availability of water to the plants is reduced. Plants on the nitrogen and nitrogen-phosphorus plots were subjected to higher suction forces in general than were those on the phosphorus or the non-fertilized plots. These suction forces ranged from 15 bars to 25 bars and were associated with extent and time of maturity.

Plants that received an application of nitrogen reduced the soil moisture below the field capacity—0.3 bar—earlier in the season, near the first of April, than did the phosphorus or non-fertilized plots. Also, the rate of soil-moisture use was higher in these plots, particularly at the lower depths. It appears that, in the nitrogen-phosphorus plots, root development was greater to the 36″ depth than in plots with the other treatments as indicated by the rate and time of moisture extraction. Removal of available soil moisture from the 36″ depth began in the nitrogen-phosphorus plots on March 28; in the nitrogen plots, on April 8; in the phosphorus plots, on April 12; and in the non-fertilized check plots, on April 26.

A rainfall of 1.90″ and an accompanying low transpiration period during the last half of April were major causes of a reduced rate of moisture depletion. Toward the end of April, moisture use at the shallow depth in all plots increased because of warmer weather, but on the nitrogen-phosphorus and the nitrogen plots moisture use began increasing at all depths.

At the 6″, 12″, and 20″ depths the nitrogen-phosphorus and nitrogen plots reached the wilting point—15 bar suction—by May 10. However, on nitrogen plots the plants continued to use moisture at all depths but, in general, were later in maturity than those on nitrogen-phosphorus plots. On phosphorus plots the pattern of water use was similar to that on nitrogen plots, but water-use rates were slightly lower, particularly at the 36″ depth. The rate of water use at the 6″ depth, on the non-fertilized plot, was similar to that on fertilized plots, but rate of water use at the 12″, 20″, and 36″

Rainfall and moisture extraction patterns for fertilizer treatments as a function of time. *Left*—Non-fertilized and phosphorus-fertilized plots. *Right*—Nitrogen and nitrogen plus phosphorus plots.