Availability of Nitrogen, Phosphorus, and Sulfur After Brush Burning

J. VLAMIS AND K. D. GOWANS

Department of Soils and Plant Nutrition, University of California, Davis

The conversion of brushland area to vegetative types more suitable for livestock grazing has become an important range improvement practice. One of the means used to effect this conversion is fire. Alternatively, brush may be burned in place, or bulldozed first and burned broadcast or after piling (Love and Jones, 1952).

Many studies have been made of the effect of such burning on soil properties. Some of the changes noted have been a rise in surface reaction (pH), an increased nitrogen supply, greater phosphate availability, and higher base status, especially calcium and potassium (Barnette and Hester, 1930; Fowells and Stephenson, 1934; Isaac and Hopkins, 1937; Burns, 1952).

This report describes the results of greenhouse pot tests to determine the effect of broadcast brush burning on the nutrient supply of a soil as measured by plant growth.

The soil tested was a Parrish loam situated on the east slope of the Coast Range in western Tehama County at an elevation of 1700 feet. The average annual rainfall is about 30 inches.

The Parrish soils have developed from hard sedimentary rocks. They have brown, slightly acid, medium textured surface soils, and reddish brown, slightly to medium acid, fine textured subsoils. The soils are two to three feet deep. They occur on hilly to steep foothills with a dense stand of shrubs. The area sampled supported a dense cover of chamise *(Adenostoma fasciculatum)* and buckbrush *(Ceanothus cuneatus)*, about 6 feet high. Part of the area was burned in the fall of 1955 and the soil was collected shortly thereafter.

Procedure

About 100 lbs. of soil was taken from a depth of 8 inches. A similar quantity of soil was taken from an unburned area located about 200 feet from the burned site but similar to it in soil, slope and vegetative cover.

The soils were brought to the greenhouse, sieved in a half-inch mesh, and placed in painted 6-inch pots holding 1600 grams of soil each.

A check series of pots was set up to measure the inherent fertility of the soil. Appropriate chemicals were added to other pots so as to give a complete treatment containing nitrogen, phosphorus, potassium, and sulfur. Further treatments were made omitting one nutrient at a time in order to measure the nutrient supplying power of the soil for each element in the presence of adequate amounts of the others.

The test plants used were Romaine lettuce, planted as 21 day old seedlings, three in each pot, and Atlas barley planted as seed and thinned to 5 per pot. The plants were irrigated with distilled water and grown for 6 weeks. At the end of that time they were harvested, ovendried, and dry weights taken.

The yields of lettuce and barley grown on soil taken from the burned and unburned area are shown in Table 1. (Photographs of the plants prior to harvesting are shown in Figure 1.) The same pots were replanted to determine the magnitude of any carry-over effect beyond the first crop as a result of the burn. However, the differences observed in the first planting between the burned and unburned areas had largely disappeared in the second planting.

Results

The data in Table 1 show several interesting relationships. In the first place, the control soil indicates distinct deficiencies of nitrogen, phosphorus, and sulfur. This is shown by the poor growth on the unfertilized treatment and the ones in which each of these nutrients was omitted. The treatments which received the combination of N, P, and S gave satisfactory yields and produced plants healthy in appearance. The addition of potassium seemed to make no difference.

Now looking at the data from the burned area, we still find deficiencies of the same three elements but of a much smaller

Table 1. Average dry weight in grams of lettuce and barley produced by nutrient applications on burned and unburned soil.

	Lettuce			Barley		
Treatment	Unburned	Burned	Ratio B/U	Unburned	Burned	Ratio B/U
Check	0.3	1.1	3.67	0.3	0.7	2.33
NPKS*	2.7	3.1	1.15	3.1	3.9	1.26
PKS	0.3	1.0	3.33	0.4	0.9	2.25
NKS	0.1	1.1	11.0	1.6	3.3	2.06
NP	1.5	2.7	1.80	1.3	3.0	2.31
NPS	2.8	3.3	1.18	3.0	4.1	1.37

*Nutrients added at the rate of 200 lbs. N, 300 lbs. P_2O_5, 200 lbs. K_2O, and 68 lbs. of S per acre. Salts added as ammonium nitrate, calcium monobasic phosphate, potassium sulfate, and sodium sulfate.

magnitude. This can be seen by comparing the absolute weights produced in each case, or by noting the ratios of the dry weights from the burned to the unburned soil for each treatment. This ratio is greater than one in each case and tells us that the effect of brush burning was to increase the supply of nitrogen, phosphorus, and sulfur in the soil.

There is no doubt that the potash was also increased but this would not be shown by a growth test on this soil which is already well supplied with K.

Discussion

The stimulating effect of prescribed or even accidental burning has been observed in the field and confirmed by greenhouse and laboratory studies (Sampson, 1944; Vlamis et. al, 1955). Some of this has been attributed to increased nitrogen and phosphorus in the soil. This has been found to be true in this study, also. In addition, the supply of sulfur was found to be greater as a result of the burn.

The unburned soil was found to be acutely deficient in nitrogen, phosphorus, and sulfur. This was indicated by both lettuce and barley since the yield where N, P, and S were added in combination was substantially higher than each case with one of these elements missing.

The soil from the burned area produced more growth than the corresponding treatments from the unburned soil. This would indicate the effect of the burn has been to increase the available supply of nitrogen, phosphorus, and sulfur.

Leaving aside the still controversial origin of the nitrogen stimulation, it is quite reasonable to assume that the phosphorus and sulfur increase was contributed by the ash. Some organic sulfur may be volatilized from plant tissues in the burning process and lost as sulfur dioxide, but pre-existing sulfates should be returned to the soil in the ash just as the phosphate.

The nitrogen story has complications all its own, of course. Nitrogen is present in plants in many forms such as nitrates, ammonium compounds, amino acids, proteins, and still others. Burning vegetations would be expected to lose a large part of this nitrogen as various oxides. The effect of burning a vegetative cover may also have conse-

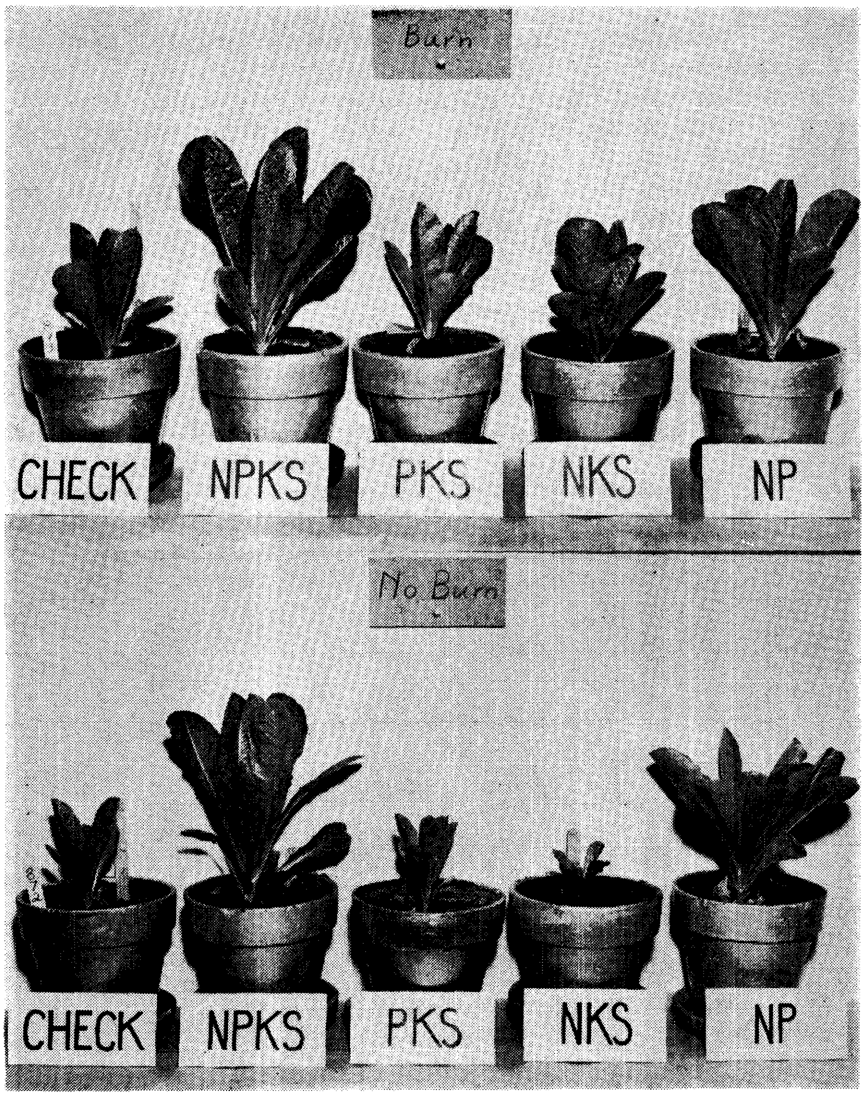

FIGURE 1. Lettuce growing on Parrish soil sampled from burned and unburned areas.

quences on the nitrogen-fixing bacteria in the soil, as may also the presence of ash as it affects the pH of the soil, and because of its mineral constituents.

From these and other studies it is apparent that burning a vegetative cover releases a measureable amount of nitrogen, phosphorus, and sulfur to the soil. This is bound to have a stimulating effect on the succeeding crop, especially where the soil was initially deficient in these nutrients.

A practical conclusion to be drawn from this is that the addition of fertilizers to a soil directly following a burn may be unnecessary. It may be more useful to make the application of fertilizer the following year when the stimulating effect of the burn has worn off and the soil is returning to a lower fertility level. This should be determined where possible by actual testing, either by plant growth technique as used in this study or by suitable chemical methods.

The sulfur effect is of special interest because greenhouse tests for fertility of many upland soils from Glenn and Tehama Counties have shown sulfur deficiency to be fairly widespread (in manuscript).

As far as this soil is concerned, the results indicate that on the unburned area applications of nitrogen, phosphorus, and sulfur would be needed for maximum growth of lettuce and barley. After the burn, however, the lettuce responded to both phosphorus and nitrogen, whereas barley responded primarily to nitrogen.

Since it is more likely that grasses rather than lettuce will be grown on this soil, we may assume that the prognosis given by barley will be more applicable. Therefore, this situation would appear to call for a nitrogen application following the burn. The rate to be applied will depend, of course, on the intensity of cropping. This can only be estimated after considering climatic and topographic factors.

Summary

A Parrish loam soil from the foothills of western Tehama County was sampled from the surface 8 inches of a brush burned area and tested in the greenhouse for mineral deficiencies by means of pot tests. An unburned area adjacent to the burn was also sampled as a control.

Lettuce and barley plants were grown for six weeks in 6-inch pots containing 1600 grams of soil each. Nutrient combinations of nitrogen phosphorus, potassium and sulfur were used.

The unburned soil showed distinct responses to the application of nitrogen, phosphorus, and sulfur with both crops. The burned soil showed only slight responses to these nutrients. Likewise, the unfertilized soil from the burned area gave substantially higher yields than the unburned soil. It was concluded that burning a vegetative cover increases the supply of nitrogen, phosphorus, and sulfur available for plant growth in the soil.

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