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INTERCEPTION OF RAINFALL BY PRAIRIE GRASSES, WEEDS, AND CERTAIN CROP PLANTS

by

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INTRODUCTION

Much attention has been given to loss of water through runoff, evaporation from the soil, and by transpiration. Water loss sustained through interception by herbaceous vegetation has received very little consideration.

Studies at forest meteorological stations in Europe, as early as 1855, included comparisons of rainfall in evergreen and deciduous forests with precipitation in the open (Zon, 1927; Horton, 1919). Marloth (1903, 1905), in South Africa, found that the amount of moisture deposited in a rain gauge screened by reed-like plants exceeded the amount caught in one unscreened. During normal precipitation the interception gains were 300 per cent or more, but during misty weather they ranged from 1,000 to 1,500 per cent. Horton (1919) measured interception by trees, crops, and other herbaceous vegetation. He calculated interception losses on a drainage basin near Seneca Falls, New York. The percentage of loss varied with intensity of rainfall from nearly 100 during light showers to an average of 25 for most trees during heavy rains. Interception losses from needle-leaved trees were found to be greater than from broad-leaved trees, because of greater storage capacity and evaporation. The total interception losses from cropped areas were much less than from trees because of the short time during which the crops were on the ground.

Phillips (1926, 1928), working in South Africa, found that rain gauges under vegetation registered from 0.0025 to 0.015 inch during foggy or misty weather when no actual rainfall had occurred in the open. Gauges screened with branches of a broad-leaved conifer (Podocarpus thunbergii) registered from 158 to 181 per cent greater precipitation than those in the open, except when the precipitation occurred in the form of normal, heavy showers. In Maryland, de Forest (1923) found, during a growing season of four months, that a gauge screened by imitation reed pieces of tin registered an interception gain of nearly 30 per cent over a control gauge. Mitchell (1930) reported that a forest cover in Wisconsin prevented about 20 per cent of the total rainfall from reaching the ground. Interception losses were greater in jack-pine forest than in hardwood-hemlock forest. In the latter, they were greater during the spring when the trees were in leaf than in the fall when the leaves had been shed. Holch (1931) found that an oak forest in eastern Nebraska intercepted 16.1 per cent of the rainfall. A linden forest, because of the denser canopy, intercepted 27.2 per cent.

Beall (1934) compared penetration of rainfall through the canopy of a mixed white pine and red pine forest in Canada with that of a mixed hardwood forest, consisting mainly of beech, sugar maple, and yellow birch. In spite of nearly equal density of canopy, interception (40 per cent) was greater in the pine forest than in the hardwood forest, where it was 20 per cent. The softwood species afforded a

greater number of sharp angles and rounded surfaces than did the hardwoods whose smoother surfaces shed droplets readily. The presence or absence of hardwood foliage was not found to have any marked influence upon the percentage of rainfall reaching the ground. Studies by the United States Forest Service, compiled by Munns and Sims (1936), have been reported in "Forests and Flood Control." Interception during significant rains was found to be from 1 to 37 per cent of the total rainfall, depending upon the composition, age, and condition of stand and season of year. Wood (1937) found that the average catch of gauges in a mixed forest of oak, pine, and gum was 87 per cent of that in the open. The amount of precipitation reaching the ground in a forest was found to vary with character of the forest, nature of the precipitation, velocity of wind, etc. The proportion of precipitation penetrating the crown of a chestnut oak did not increase after the leaves fell. McMunn (1936) reported that the foliage of an apple tree shed a considerable amount of rain, thus building up a large volume of water at the periphery of the tree.

A study of interception by the vegetative canopy of crop plants has been reported by Haynes (1937). Interception varied from 6.9 to 35.8 per cent of the total precipitation, increasing directly with increase of vegetative cover. Part of the rainfall reaching the ground under corn, alfalfa, and soybeans was conducted down the stems. In other crops the amount reaching the soil in this manner was not significant.

Kittredge (1938) has calculated the sum of water losses caused by transpiration and interception by the vegetation, evaporation from the soil, and seepage into rock strata. The most important of these are the losses influenced by vegetation. Water losses in two types of grassland were as large as those in certain forest regions.

Interception of rainfall by vegetation is important in the control of surface runoff and soil erosion. There is an inverse relation between interception losses and the water supply of the soil. It has been shown that, under certain conditions, absorption of water by the aerial portions of plants is possible, although favorable conditions for absorption by mesophytes probably occur only rarely in nature (Maximov, 1929; Williams, 1932; Purer, 1936). Interception gains have been recorded under vegetation when the precipitation occurred in the form of misty rains (Marloth, 1903, 1905; Phillips, 1926, 1928). It is a matter of common observation that the ground beneath a tree may be moistened by drip from branches and leaves during a fog while beyond the crown the soil is dry.

The present investigation was undertaken in order to develop and test the suitability of various methods for studying interception by native prairie vegetation, certain crop plants, and weeds and to determine the magnitude of the water losses sustained. Preliminary work was done during 1936. This was followed by extensive experiments throughout the growing seasons of 1937 and 1938. All the plant materi-

als were secured within a radius of 20 miles of Lincoln, Nebraska. The season of 1937 was one of severe drought. This made necessary the development of a method by which water could be sprinkled upon the plants in a manner resembling natural rainfall (Clark, 1937). These experiments were continued during 1938 and extended to include interception of natural rainfall by certain prairie grasses and field crops.

METHODS

Since rainfall interception was measured during a long period of drought, it was necessary to devise a method of applying water to the plants in a manner closely resembling natural rainfall. After a number of trials, two methods were developed and used in the collection of data, one in the field trials and the other in experiments in the greenhouse and laboratory. While these experiments do not simulate all the conditions existing during a shower or rainstorm, yet the results obtained closely followed those secured from natural rainfall.

For experiments in the field, special pans were constructed to catch some of the water which was not intercepted by the plants. The pans were 100 cm. long, 4 cm. wide, and 5 cm. deep, and were made of 24-gauge galvanized iron, soldered at the corners so as to be watertight. Five pans thus had a surface area of one-fifth of a square meter. Permanent cross wires at intervals of an inch near the top of each pan and a removable strip of wire mesh in the bottom made it possible to support cut stems of plants

in their natural position. By means of tall stakes, a square meter quadrat was located in the vegetation to be studied. Five of the interceptometer pans were placed on the surface of the soil beneath the plants, care being taken to space the pans uniformly with minimum disturbance of the vegetation. Where crops, such as wheat or oats, were drilled they were placed across the drill rows. Whenever necessary to permit proper placing of the pans, plants were cut off at the soil surface and inserted in them in the same position that they originally occupied. After some experience it was possible to place the pans so that the foliage cover closely resembled that of adjacent undisturbed areas. A quadrat in big bluestem prairie with these interceptometers in position is shown in Figure 1. They are partly withdrawn to show something of their construction in Figure 2.

Water was applied to the plants from two-liter glass bottles equipped with fine sprinkler tops and glass tubing so that it issued from the sprinklers in steady streams but struck the plants in the form of drops. A total volume of water equivalent to 1 or 2 inches of rainfall upon the area or some fraction of an inch per hour or half hour was calculated and kept on hand. It was then sprinkled upon the plants uniformly during the predetermined time interval. The amount of water caught in the five pans equalled one-fifth of the water penetrating the foliage cover and reaching the ground. From the result obtained it was possible to calculate the amount of water intercepted by the plants and to express it as a percentage of the total amount applied.

Fig. 1. Interceptometers in position in a square meter of big bluestem prairie.

Fig. 2. Interceptometers partly withdrawn to show something of their construction.