ROOT DEVELOPMENT STUDIES ON COTTON

A study of root development of the cotton plant is being conducted under field conditions at the U. S. Cotton Research Station, Kern County, and the West Side Field Station, Fresno County. Since cotton is normally a deep-rooted crop, direct detailed measurements become difficult or impossible. In these studies radioactive phosphorus (P32) is used as a tracer to determine the rate and pattern of development, both vertically and laterally. The method consists of applying P32 solution to various points in the soil surrounding the plant. The presence of roots within an area of application is indicated by the presence of radioactivity in the aerial portion of the plant as a result of P32 uptake. The topmost leaves are selected for this determination since absorbed phosphorus moves rapidly into the new growth.

At any given stage of growth the amount of radioactivity in the plant is a reflection of the density or absorptive activity of roots growing in the area of application. By comparing the relative differences in radioactivity of plants growing above the various placements, it is possible to determine not only the presence or absence of roots in a given location, but also to estimate the relative abundance and absorptive activity in various parts of the root zone at any given time. Since the roots themselves are not disturbed in this determination, successive measurements can be made on the same plant as the season advances.

As an example of some of the results, roots have been shown to extend downward at an average of an inch or more a day to a depth of 6 feet on both a coarse and a fine textured soil at Shafter and Five Points respectively. Toward the end of the fruit setting period in late August, a nearly uniform development to a depth of 4 feet is indicated, with significant absorptive activity also at 5 and 6 feet. Lateral development is less rapid and is greatly affected by competing roots from plants in adjacent rows. A study of this effect, together with the effect of cultural practices on the development of the root system is being continued.—D. M. Bassett, Department of Agronomy, University of California, Davis.

The primary benefit of nitrogen fertilization to grassland areas of north coastal California was the increase in production of forage during the winter season when grass was short and legumes grew very slowly. According to these tests, not more than 80 pounds N per acre should be applied since near maximum forage yields were produced at this rate and little increase in winter production resulted from additional amounts. However, carryover into the second year was measurable only with applications of the 160-pound maximum used in these tests on two soil types. Protein percentages in the nonleguminous plants increased with increasing N application rates during the vegetative stage, but at maturity, the nitrogen percentages in these plants were less where 40 pounds of N per acre had been applied than on the non-treated check plots. The 160-pound rate increased the protein percentage in mature plants. Total nitrogen uptake of all forage species combined, increased during the winter with increasing rates of N applied. However, uptake on the unfertilized plots during the warm spring months, when the clovers grew rapidly, was about the same as that on plots fertilized with 40 pounds of nitrogen per acre.

M. B. JONES

Test plot at the Sutherlin soil site, Hopland Field Station, shows color and height variations resulting from different rates of nitrogen application.

CALIFORNIA AGRICULTURE, DECEMBER, 1963
C

A R I F I C A N ' S E N T R E S S I X , N O - I R R I-

gated, annual grassland areas are

characterized by a climate which is wet
during the cool period of the year and
dry during the summer months. The for-

gage has a high percentage of annual
glasses and herbs that germinate with
the first fall rains, grow slowly during the
cool winter period, and mature in the
spring after a short period of rapid
growth.

Much of the previous information on
the effects of nitrogen on California's an-
nual grassland came from experiments
where N was applied at a single rate. The
purpose of this study was to determine
the effect of N—applied at several rates—
on yield, protein percentages, and total
N uptake of various species at several
growth stages. Additional information
was obtained on the carryover of N into
the second year after application.

Testing procedure

In October 1956, N as urea was ap-
plied to annual grassland at the rate of
0, 40, 80, and 160 lbs N per acre, and
P was applied at the rates of 0, 18, 36,
and 72 lbs per acre as treble superphos-
phate in all possible combinations. The
experiment was conducted at California's Hopland Field Station, Men-
docino County. One experimental area
was a Yorkville soil site which sloped
south-southeast at an elevation of 900
feet. The other area was a Sutherlin soil
site which sloped northwest at about 1400
feet. Just prior to fertilization, the old
dry grass was removed by burning, and
the experimental areas were fenced to
prevent grazing by sheep and deer.

In October 1957 the fertilizer treat-
ments were reapplied to one-half of each
7 by 40-foot plot. The half to be refer-
tilized was selected at random. The other
half was left to measure fertilizer carry-
over into the second year. In October
1958, this half was refertilized, leaving
the area fertilized in 1956 and 1957 on
which to measure carryover. No fertilizer
was applied in the fall of 1959.

In 1957, forage production was meas-
ured in January, March, April and May
on 1 square foot of each plot, using a
different quadrat at each cutting. The
1957 results indicated that satisfactory
data could be obtained by cutting only
twice; once in late winter and once in
late spring. Therefore, in 1958, 1959, and
1960, cuttings were made in February
or March and again in May. To lessen
the degree of variability among plots,
production from 3 quadrats in each plot
was measured at both cuttings. In 1957,
the percent protein was determined on
forage samples that had been separated
by hand into component species. In sub-
sequent years determinations were made
on selected species.

Temperature and rainfall data were
recorded at the headquarters weather sta-
tion at the Hopland Field Station. These
data do not represent exact conditions
at the plot sites but indicate approximate
conditions and year to year variations.
Average seasonal rainfall for the 1951 to
1960 period was 36.82 inches. Rainfall
and temperature varied widely from year
to year during the four years of the ex-
periment. The 1956-57 growing season
was relatively cool and dry in the fall,
and warm and wet in the spring, with
total rainfall amounting to 29 inches. The
first rains sufficient to germinate plants
came in late October 1956. The 1957-58
season began with heavy rain in late Sep-
tember and continued relatively warm
and wet through April with rainfall total-
ing 60 inches. The 1958-59 season was
relatively warm throughout. The first
rains sufficient to germinate annual plants
came in late November and the total rain-
fall for the season was 26 inches. The
1959-60 season began with a 2-inch rain
on September 18; then no appreciable
rain fell until December 23. During the
remainder of the year soil moisture sup-
plies were generally adequate. Total rain-
fall for the season was 28 inches.

The scope of this article is limited to
the effects of nitrogen, since the phos-
phorus treatments resulted in relatively
small increases in production in these ex-
periments. Since the yields in January
and March were approximately equal,
only the March data are presented.

At the March clipping date, total yield
increased with increasing rates of N to
a maximum at the 80-lbs-per-acre rate.
Filaree (Erodium botrys) made the
greatest contribution to total yield at all
N rates on the Yorkville loam, but on the
Sutherlin loam the grass increased
more than the filaree with each added
increment of N. Thus, on Sutherlin loam
filaree was dominant when no N was ap-
plied, and grass was dominant at the 160-
pond per acre rate. Clover, in contrast
to grass and filaree, decreased with in-
creasing rates of N.

At the April harvest on the Sutherlin
loam, filaree made the greatest contribu-
tion to yield at all levels of N. Both filaree
and each of the grasses—soft chess (Brom-
us mollis), ripgut (B. rigidus), slender
wheat (Avena barbatu), and fescue
(Festuca spp.)—increased with increas-
ing rates of N, while legumes (Trifolium
spp., Medicago hispida, Lotus spp.)
decreased with increasing N. Maximum
production of total forage was reached
at 160 lbs N per acre; however, the yield
increase over the 80-lb level was not sig-
ificant. On the Yorkville soil, filaree also
made the greatest contribution to pro-
duction at all N levels. The yield of soft
cheese and ripgut increased with increas-
ing rates of N, but production of silver
hair grass (Aira caryophyllea) and stipe
(Stipa pulchra) changed little as N rates
increased.

Trends at the May harvest were similar
to those found in April on both soils,
except that filaree contributed relatively
less to yield than it did in April. This was
due primarily to early maturing and shat-
ttering of this species. Clover made a rela-
tively greater contribution to yield in the
zero N plots at the May harvest on the
Sutherlin soil. The high yield of the
“other forbs” category at 0 and 40 lbs N
on the Sutherlin soil was due to the con-
tribution of lupine (Lupinus spp.).

Total production in March and May
during the three years fertilizer was ap-
TABLE 1. YIELD OF ANNUAL GRASSLAND SPECIES DURING THE SEASON OF FERTILIZATION WITH INCREASING RATES OF N

<table>
<thead>
<tr>
<th>N applied</th>
<th>Yield, pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March clipping</td>
</tr>
<tr>
<td>0</td>
<td>630</td>
</tr>
<tr>
<td>40</td>
<td>950</td>
</tr>
<tr>
<td>80</td>
<td>1,330</td>
</tr>
<tr>
<td>160</td>
<td>1,320</td>
</tr>
<tr>
<td>LSD (.05)</td>
<td>280</td>
</tr>
</tbody>
</table>

SUTHERLIN LOAM

<table>
<thead>
<tr>
<th>N applied</th>
<th>Yield, pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March clipping</td>
</tr>
<tr>
<td>0</td>
<td>810</td>
</tr>
<tr>
<td>40</td>
<td>1,240</td>
</tr>
<tr>
<td>80</td>
<td>1,650</td>
</tr>
<tr>
<td>160</td>
<td>1,680</td>
</tr>
<tr>
<td>LSD (.05)</td>
<td>420</td>
</tr>
</tbody>
</table>

* Only one replication clipped in May 1958. Therefore, each yield is an average of 4 P levels. At the other clipping dates each yield is an average of 4 P levels and 4 replications.

YORKVILLE LOAM

<table>
<thead>
<tr>
<th>N applied</th>
<th>Yield, pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March clipping</td>
</tr>
<tr>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>40</td>
<td>1,200</td>
</tr>
<tr>
<td>80</td>
<td>1,650</td>
</tr>
<tr>
<td>160</td>
<td>1,680</td>
</tr>
<tr>
<td>LSD (.05)</td>
<td>420</td>
</tr>
</tbody>
</table>

* Only 1 replication clipped in May 1958. Therefore, each yield is an average of 4 P levels. At the other clipping dates each yield is an average of 4 levels and 4 replications.

1957–58 season, enabling the plants to utilize larger quantities of N. No such response to 160 lbs N per acre was noted on the Yorkville site in 1958—possibly because the Yorkville site faced more southerly, had a steeper slope and was more gravelly and shallow than the Sutherlin soil.

**Carryover year**

The effect of increasing rates of N on forage production the second year after fertilization is given in table 2. Generally carryover into the second year was measurable only with application of 160 lbs N per acre. There were differences in carryover responses at the different locations and at different dates of harvest. On the Sutherlin soil, the carryover into the second year from 160 lbs N per acre increased yields 18% in 1958, 17% in 1959, and 13% in 1960. In May, the same treatment increased yields 17% in 1958, 14% in 1959 and 61% in 1960. Possibly much of the N carried over was tied up in organic form and became available more rapidly during the spring when temperature and moisture conditions were favorable for nitrification. On the more shallow and drier Yorkville site, the marked increase in response to carryover N in May compared to March did not occur.

All rates of N increased the protein percentage in the plants early in the season. As the plants matured, N applied at the lower rates was utilized in additional growth to the extent that the protein in the nonleguminous species was usually decreased with the addition of 40 lbs N per acre. Plants fertilized with 80 pounds N per acre generally had percentages of protein equivalent to that of unfertilized plants; 160 lbs N per acre generally increased the percent protein of the nonleguminous plants.

The effect of the applied N was reflected in the increased uptake of nitrogen by the grasses and filaree and decreased N uptake by clover with each additional increment of nitrogen applied. The clovers made their largest gains in total N from March to April where no nitrogen was applied. Each increment of N applied reduced the legume contribution of N to the forage.

Milton B. Jones is Assistant Agronomist, Hopland Field Station, University of California.