roots, upon leaving the tubes, generally did not grow upward into the soil profile (Figures 7A and B).

The absence of an upward bending of the roots was particularly remarkable from the plants grown through the 25-cm. tubes (Figure 7B). As is clear from our short profile description, these tubes neatly stood on the plowsole pan, a soil layer more compact and presumably less fertile than the plowlayer. Nevertheless the roots grew into the pan rather than upward into the plowlayer. Although the pan was easy to see and feel, its pore space was apparently not reduced to the extent of severely blocking the penetration of the oat roots. This is not surprising, for van Lieshout* has analyzed this pan and found 43.3% pore space.

In conclusion then, this work\(^2\) indicates that this new and simple technique might be a useful procedure for introducing plant roots into selected soil layers.—H. C. De Roo and L. K. Wiersum, Soil Scientists and Plant Physiologist, respectively. The Connecticut Agricultural Experiment Station, New Haven, Connecticut, U.S.A., and Institute for Soil Fertility, Groningen, Netherlands.

PROGRAMS FOR COMPUTING AGRONOMIC FORAGE DATA USING ELECTRONIC DATA PROCESSING TECHNIQUES

The investigator working with forage crops is faced with a large mass of data obtained in the field or at the drying oven, such as bag or sample weights, which are secondary to the main objective of arriving at a per acre yield of one or more of the constituents of the plots harvested. A series of programs was developed recently which accept as input such field data and process them to production per acre and to the form in which they can be further analyzed statistically.

As data from forage crops plots are collected, they are entered onto sheets (Figure 1) where the various columns and spaces are labeled both by name and by I.B.M. card column numbers, according to a code universal for all experiments. It can be noted from Figure 1 that the first 22 and the last 4 columns are used for identification, and columns 23 through 75 are reserved for data; column 76 is not used, but could be utilized for additional identification. When completed, these data sheets can be taken directly to the key punch for entering the information onto cards.

The programs developed to handle such data were written in FORTRAN\(^1\) and FORCOM\(^2\) computer languages. Although the programs are being used on an I.B.M. 1620 digital computer with 500 cards per minute input and 250 cards per minute output, they could be used with no or minor modifications with many electronic data processing equipment.

The data sheet presented in Figure 1 is amenable to use with either a desk calculator or the computer. This sheet was developed to handle most situations encountered in measuring yield and botanical composition of forage plots.

Mathematically, the series of computations involved in the computation of dry matter yield can be written as follows:

\[
\begin{align*}
(1) \text{GREEN} & = \text{GRNBG} - \text{BAG} \\
(2) \text{DRY} & = \text{DRYBG} - \text{BAG} \\
(3) \text{DMPC} & = \text{DRY/\text{GREEN}} \\
(4) \text{PLTDR} & = \text{PLTGR} \times \text{DMPC} \\
(5) \text{TONAC} & = \text{PLTDR} \times \text{ACFAC},
\end{align*}
\]

where GRNBG is the sum of the weights of the undried sample obtained for dry matter determination and the bag, DRYBG is the sum of the weights of the dried dry matter sample and the bag, BAG is the weight of the bag, GREEN is the net green weight of the dry matter sample, DRY is the net dry weight of the dry matter sample, DMPC is the dry matter percentage of the dry matter sample, PLTGR is the green weight of all material harvested from the plot, PLTDR is the dry weight harvested from the plot, ACFAC is the factor used to convert production per plot to production per acre.

TONAC is the yield of dry matter per acre.

Alternatively, \(6) \text{GRTON} = \text{PLTGR} \times \text{ACFAC} \) may be computed, where GRTON is the yield of green material per acre.

Due to the specific exigencies of particular experiments, facilities or procedures, it is possible that not all plots in all experiments can be handled in the manner suggested above. As a matter of fact, total yield per acre of dry matter (TONAC) and/or green weight (GRTON) can be computed for the 11 possible situations outlined in Table 1.

The TONAC program developed recently will consider all the alternatives mentioned above in the conversion of field data to production per acre from forage plots. In addition, dry matter samples may be taken from 1, 2, or several replications, but less than 1 from each plot; in that case, the average dry matter percentage for that treatment will be plotted to other plots of the same treatment. If several quadrats were used in each plot, or if PLTGR or PLTDR could not be determined in one weighing, but required several, the several measurements made for each plot will be summed if a sampling error is not desired.

The TONAC conversion can be accomplished for up to 99 samples per plot of up to 20 replications of an infinite number of treatments. The actual time required on the computer is, for example, of the order of 3.1 minutes to convert to TONAC the information from an experiment comprised of 4 replications of 25 treatments.

In actual practice, once the cards have been punched and the information entered on them verified, the various card decks are sorted by experiment number (columns 1–7), harvest number (columns 8, 9), sample number, if any (columns 14, 15), replication number (columns 10, 11), and treatment number (columns 16–22), and in that order.

Since forage plots are harvested numerous times during the year and often for several years, it seems more convenient to maintain the identity of plots by plot number (columns 10–13) alone, without identifying each further by entry or treatment number (columns 16–22) each time plots are harvested. Instead, a master deck of cards is prepared at the outset which consists of one card for each plot. Each card bears the experiment number, a plot number, and the corresponding entry or treatment number. The GANGPUNCHING program then introduces into each data card, which has the plot number only, the appropriate entry or treatment number. This procedure takes approximately 0.7 minute per 100 cards (4 data decks, 25 cards in master deck) and saves hours of matching plot and treatment numbers by hand from field maps.
