MOLE IRRIGATION

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INTRODUCTION

Distribution of irrigation water through unlined underground channels or moles has a number of theoretical advantages over other irrigation methods. These include:

- Low capital requirements and operating costs;
- Elimination of the need for precise land leveling;
- Uniform water distribution despite uneven topography;
- Simultaneous irrigation of all land for which water is available;
- Elimination of downfield borders and ditches with their associated weed and traffic problems;
- High irrigation efficiency through elimination of evaporation and runoff losses;
- Little surface ponding, soil crusting, or erosion.

According to Israelsen (4), success in irrigating through underground conduits depends upon a soil condition that permits free lateral movement of water, rapid capillary movement in the root zone, and a restricted downward movement in the subsoil. An unlined distribution system has the additional requirement that soil conditions permit the formation of a continuously stable mole. Unlined moles have been used for more than 15 years in the Sutter Basin in California (3) to irrigate beans. The combination of a clay soil and a crop susceptible to excess water damage has made the practice feasible in that area. Studies in Saskatchewan (5) involving a large-diameter mole at depths between 16 and 23 inches showed that water moved downward and outward from the mole much more rapidly than upward and consequently provided poor watering in the upper portion of the root zone.

In 1962 the mole method of irrigation was used on several hundred acres in southern Alberta. The main crops were established stands of grass and alfalfa but a considerable acreage of annual cereals was included. Because these farm trials were only partially successful, tests were initiated at the Lethbridge Research Station to determine optimum mole placement and spacing and to assess the practicability of the method for the soils and cropping practices of the area.

EQUIPMENT AND PROCEDURE

The mole-forming machine (figure 1) consisted of a 2¼-inch-diameter, torpedo-shaped, mole-former rigidly mounted on a shank attached to a two-wheeled carrier. Mole depth and alignment were controlled by hitch and wheel height adjustment. A coulter produced the clean kerf required for satisfactory mole formation (figures 2 and 3).

Soil moisture was determined at the midpoint of the 400-foot-long moles by a combination of neutron scattering and gravimetric sampling techniques. A tensiometer grid installed in a plane perpendicular to the moles was used to supplement the other moisture-measuring procedures in defining the advance of the wetting front.

Water supplied to the test moles was maintained at a constant head equivalent to that in a field ditch; the amount of water was metered. Irrigation was continued until instrumentation showed that most of the water was percolating below the fourth foot. Trials to evaluate the distribution of moisture were conducted at several depths and initial soil moisture contents but only on a sod-covered Lethbridge loam soil.

Moles for stability evaluation were installed at several depths in both Chin and Lethbridge loam soils of various moisture contents and in both grassed and fallowed fields. Their stability was checked visually before they were filled with water. After filling, a collapse of the mole was indicated by reduction or stoppage of flow.

RESULTS AND DISCUSSION

The moisture distribution from a mole 14 inches deep in a grassed field of Lethbridge loam soil was plotted against time (figure 4). Initial moisture content of the top four feet of soil varied from 17 percent by volume in the first foot to 28 percent in the fourth
foot or between 46 and 75 percent of field capacity. Water applied through the mole moved downward much more rapidly than laterally; its total upward movement was less than one foot. After about 10 hours an increasing proportion of the water penetrated beyond the fourth foot. This is deeper than the effective rooting depth of most of the commonly irrigated field crops. Upward movement did not progress appreciably with time and, except in some places along the kerf, did not reach the soil surface during or after the 30-hour irrigation. The increase in soil moisture due to irrigation is shown by the lower graph in figure 4. Little moisture was contributed beyond two feet on either side of the mole. This 4-foot spread required an application time of about one day but, after less than 10 hours, loss due to deep percolation occurred. Other trials, which differed in depth of mole placement, length of time of irrigation application and initial soil moisture, produced similar moisture distribution patterns. Drier soils required a longer irrigation time but the initial differences in soil moisture content had little influence on the lateral spread of soil moisture and on desirable mole spacing.

The efficiency of water application, designated as the increase in moisture in the 4-foot profile compared with the amount of water applied, was 80 percent after two hours and 88 percent after four hours. It then decreased progressively to 79, 64, and 58 percent after 10, 28, and 66 hours, respectively. The reduction in efficiency after four hours is a result of percolation of moisture below the 4-foot depth. Further drainage, with a consequent efficiency decrease, occurred between the time irrigation was discontinued (30 hours) and the final moisture measurements were made (66 hours) but very little additional lateral movement is indicated in the lower graph in figure 4. Water was required to fill the mole initially and this amount is reflected in the slightly lower efficiency obtained after two hours than after four hours.

The success of mole irrigation was completely dependent upon the formation of a continuously stable mole. In the two soils on which experiments were conducted a satisfactory mole could be formed only if there was sufficient weight of soil above the mole to compact the soil around the mole-former. An accumulation of roots in the soil helped to prevent collapse of the mole, and consequently in sod a good mole could be formed at depths as shallow as nine inches. In annually cropped or fallowed fields a minimum depth of 12 to 14 inches was required. Dry soils tended to shatter rather than to pack. Unless the soil moisture was at least 50 percent of available, the mole, though upon inspection apparently satisfactory, was not stable when water was introduced into it.

Numerous problems were strictly mechanical in nature. In dry soils the machine tended to ride out of the ground. The impact upon striking a stone was usually sufficient to destroy mole continuity; once the standard was bent. Horizontal and vertical alignment had to be exact or mole continuity was affected. Draft increased markedly in dry soil. Heavy trash previously plowed into the soil was difficult for the coulter to sever, dragged on the mole standard, and interfered with mole formation. Gophers, apparently delighted with this low-cost housing development, promptly added exits and partitions.

The mechanical problems are generally surmountable. Those associated with soil moisture are more difficult to overcome. Their solution may require that a field be prepared for irrigation well before the crop needs water. It may be necessary to preirrigate the field by a surface method to create soil conditions suitable for mole formation. Thus many of the advantages of mole irrigation would be lost. The stability problems may be partially solved by using a larger diameter mole. This would require deeper installation, increased costs, and a probable reduction in irrigation efficiency. A recent method of solving stability problems is the installation of perforated plastic pipe as a subirrigation conduit (1, 2, 6, 7). An expensive but permanent method of stabilizing moles, it permits introduction of water at shallow depths. The similarity of recommended pipe spacings in the field study conducted by Pohjakas (6) to the unlined mole spacing found desirable in this study is not surprising as moisture distribution is governed by the hydraulic properties of the soil. An aspect of all mole systems still to be defined for southern Alberta soils is the effect of continued subirrigation on the location and quantity of salts in the upper portion of the soil profile.

CONCLUSIONS

High efficiency in mole irrigation will be achieved by close spacing of moles rather than by prolonged application of water. On the basis of these trials a 4-foot spacing provided the most practical choice between lateral spread and percolation loss. This required an irrigation time partially dependent upon initial soil moisture content but not exceeding 24 hours. Moles should be formed as near the surface as soil and crop conditions permit; for the soils studied this depth was 9 inches in sod and 12 or more inches in cultivated fields.

REFERENCES