SMALL PLOT IRRIGATION APPLICATOR*

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Purpose of the Investigation

The application of water by rotary sprinklers in irrigation research on small experimental plots has not proved to be satisfactory. It is not possible to achieve uniform coverage because the geometery of the plots does not provide the proper overlap, and wind is a variable factor affecting the water distribution. The large border areas necessary with rotary sprinklers make inefficient use of the available land. The use of small plots has an advantage for adequate replication, as soils may be more uniform over a smaller area. A small plot irrigation applicator was developed at the Ontario Agricultural College to meet these conditions as no other suitable equipment was available.

Review of Literature

Several attempts have been made to construct a satisfactory small plot irrigator for the precision application of water. The machines have generally been large and not readily maneuverable in the field (1). The rates of application of water were usually too high for medium to fine textured soils (2) and the coefficient of uniformity has varied considerably. Bean and Wells (1) designed an irrigator that operated on fixed rails with a movable boom. Myers (2) and Sparrow (3) designed a large machine having an overhead track with a single spray boom. The spray boom was operated by an outside power source such as a gasoline engine. Sparrow et al (4) developed a unit to irrigate tobacco plots 22.5 feet by 52 feet which was quite large and required two men to operate.

Design of the Equipment

For irrigation experiments in rod row ranges, staff agronomists stated the minimum size for a suitable individual plot should be 20 feet by 12 feet. This machine is designed for such a plot size. The primary design requirements for the machine were:

(a) The application of water within the infiltration capacity of the soil.

(b) A high coefficient of uniformity of application.

(c) To not be adversely affected by wind.

(d) To operate at a constant pressure.

(e) To be highly maneuverable in the field.

(f) To not have an adverse affect upon the crop or soil.

The small plot irrigation applicator as shown in Figure 1 consists of an inverted U-shaped member at each end which is held vertical by two parallel tracks twelve feet in length. By a unique design arrangement the spray booms are always the same distance over the crop on sloping ground, as the boom assembly is adjustable for height at each end and may also be moved to accommodate a five degree slope at right angles to the track assembly. This feature considers the stage of growth or height of the crop, as the boom may be positioned at the proper spray height. The main frame is mounted on four swivel-type rubber tired wheels. The rear pair has a lock to be used when the machine is being transported for some distance. This swivel feature makes the machine highly maneuverable in the field. A tongue is provided for transportation.

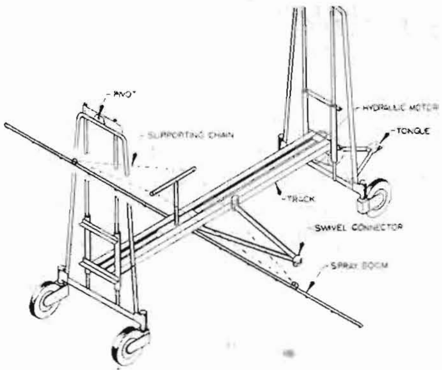

Fig. 1. Schematic view of Small Plot Irrigator.

A two member $1\frac{1}{2}$ inch diameter aluminum boom, each member 10 feet long, is suspended below and normal to the track assembly. Each boom may be folded back along the machine for transporting. There are 14 Spraying System $\frac{1}{4}$TT fan pattern even, nozzles spaced 20 inches apart on each boom from which the water sprays upon the plot.

Water is supplied to the machine from an irrigation main line through a length of $\frac{3}{4}$-inch hose. A Watts 135HW combination pressure regulator and strainer reduce the main line pressure and maintains a constant pressure at the machine. The water is fed to the moving booms through swivel connectors. Rubber hose would probably serve as well and be more economical.

A Skinner System, Type C Oscillator was modified to supply the power required to move the boom. This is a positive power, water driven motor which was modified to operate at a forward speed twice as great as the original design and provided a forward motion of 0.8 feet per minute to the spray booms. This was accomplished by adding an additional dog to operate the segment on both strokes of the piston. The water motor had a volumetric efficiency of 53 per cent and the discharge water is removed from the plot area by a small rubber hose. The speed of operation is adjustable over a narrow range.

The water motor turns a gear and chain as shown in Figure 2. This in turn moves a long roller link chain which moves in a groove on the main track. The carriage for the boom assembly is attached to a pin on the roller chain and is thereby moved back and forth along the track.

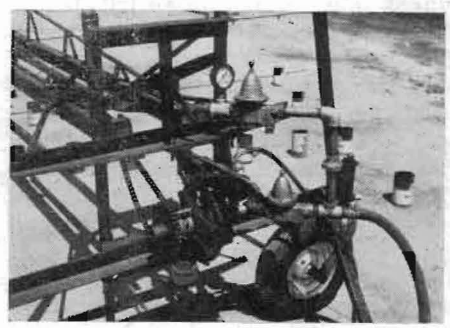

Fig. 2. Detail of the motor assembly.

Test of Equipment

Laboratory tests of commercially available nozzle tips showed that there was a seven per cent variation from the mean discharge between individual nozzle tips. Many individual nozzle tips were then tested and 14 were selected having a variation within one per cent.

The selected nozzles were attached to the spray boom which was then tested in the laboratory for uniformity of overlap and discharge. This was tested by catching the runoff in a series of small cans from a corrugated metal sheet upon which the spray from the boom was falling. The coefficient of uniformity was determined from the relationship.

$$Cu = 1.0 - \frac{x}{m\,n}$$

where Cu is the coefficient of uniformity, n is the number of observations and x is the deviation from the mean value m. A series of Spraying System nozzles 1/4TT–80015E, gave a coefficient of uniformity of 0.96 at 40 pounds per square inch and at a spray height of 25 inches. These are the nozzle tips that were chosen for the field trials.

The machine was moved to the field and the spray was measured for uniformity by collecting the water in a rectangular pattern of 35 open topped cans. The resulting depth of water was then calculated for uniformity of application. Test runs were made for varying wind conditions, operating pressures and spray height. It was not possible to duplicate the laboratory results in the field. The wind was responsible for a drop in the uniformity coefficient to about 0.70 as the fine spray drifted considerably. Reducing the pressure to obtain larger drop sizes did not result in any appreciable improvement. A shield was then constructed to reduce the wind action with the result that a uniformity coefficient of 0.90 was easily obtained in the field with moderate wind speeds. This was an acceptable value.

The computed precipitation rate of 0.84 inches per hour did not result in puddling of an almost bare, loam soil. The application rate of 0.21 inches every 15 minutes to a small section of soil apparently did not exceed the infiltration capacity of the soil. This application rate may be changed by using other nozzle tips.

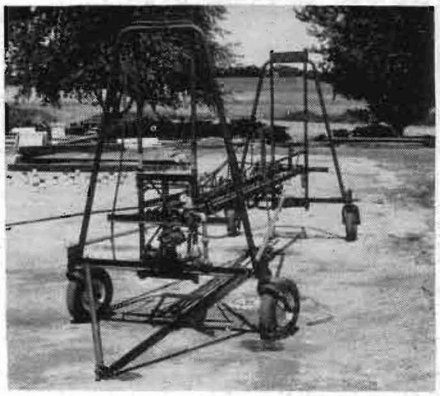

Fig. 3. Small plot irrigator in transport position.

Conclusions

This machine was constructed primarily for irrigation research work on small plots. The machine is highly maneuverable in the field and may be moved by hand by not more than two men from plot to plot. In many situations one man is adequate. The irrigation water is applied uniformly over the plot for all stages of plant growth. The rate of application may be varied to suit the crop and soil conditions. The power source requires little skill to operate and uses the same water supply as that for the spray booms. Some care must be taken to see that the discharge water is carried away from the experimental area. This machine under average irrigation conditions should cover three or four replicates per day. This would appear to be adequate for many experiments.

References

1. Bean, A. G. M., Wells, D. A. Design of a precision plot irrigator. Nat. Inst. Agr. Eng. Report 30. Undated.
2. Myers, E. A. A field plot irrigator. Penn. State College. Prog. Report 83, 1952.
3. Sparrow, G. N. Carter, R.L. A field plot irrigator. Paper presented at the A.S.A.E. Winter Meeting, Chicago, 1955.
4. Meyer, L.D., McCune, D.L. Development of a rainfall simulator for runoff plots. Paper presented at A.S.A.E. Winter Meeting, Chicago, 1957.
5. Sparrow, G.N. et al. Irrigator for research plots. Trans. A.S.A.E. Vol. 1:43 - 44, 47. 1958.

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spectrum with variations depending on the chemical coatings. All tubes of this type require ballasts or converters.

"Daylight" or "Cool White" fluorescent units provide a broad spectrum of light and these are used extensively for plant growth purposes in greenhouses and growth rooms. To obtain more energy in the red sector some incandescent lights are frequently used with the fluorescent tubes.

Light Intensity

As noted, the maximum intensity of sunlight (50° Lat.) is about 10,000 while moonlight is less than one-tenth of one foot candle. With a concentrated assembly of incandescent bulbs an intensity of roughly 10,000 can be obtained but about ninety percent of the energy is released as heat and this presents certain problems in

When fluorescent tubes are installed in solid panels they produce 3,000 to 4,000 foot candles and with im-

growth rooms.

provements in equipment this may be exceeded. Mercury bulbs will provide 15,000 f.c. and higher intensities in solid panels.

For special investigations it is desirable to measure energy in gram calories per square centimeter for each section of the spectrum under consideration but foot candles are satisfactory as routine tests. However, a proper technique must be secured in obtaining foot candle data and the characteristics of equipment (cosine corrections) should be noted or the information is of little value.

Light and Plant Growth

The relationship between the characteristics of light and plant is so complex that current knowledge of this subject is in effect primitive or elementary. Accordingly, all data must be presented in general terms with provision for modifications.

In general, light has a photo period effect on many plants involving flowering and some features of vegetable growth. However, varieties of soybeans may range from long to neutral to short day plants. Helicopters with electric lights are being used to promote vegetable growth in sugar cane.

For photosynthesis some plants seem to prefer blue and red light according to the Hoover curve. However, some type of photosynthesis may take place in evergreen trees without light.

Wheat seems to desire an intensity of 2500 foot candles at 25 degrees centigrade, but many plants require much less light. In general, lower temperatures seem to be associated with lower light requirements for many plants.

Red and infra-red light affects seed germination in lettuce and ultra-violet light may cause conditions which are not yet understood.