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TILTING AUTO-WATERING POT SYSTEM (TAPS)

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SUMMARY

Cheap simple automatic pot watering systems which add water at a specific pot weight are not available. An inexpensive system which relies on a tilting siphon principle is described. Undrained pots are used. A prescribed volume of water is automatically added when the pot reaches a selected weight. The movement of a cog records water use. Unit specifications and comments on advantages and disadvantages of the system are given.

I. INTRODUCTION

Various methods of automatically watering pots have been developed (Osborn and Hanger 1969; Maynard, Barker and Vernell 1970; Dolar and Keeney 1971; Andrew and Cowper 1972). None of these combines the following functions in the one unit.

1. Use of undrained pots.
2. Variable water addition according to treatment requirements.
3. Addition of water after a predetermined quantity has been removed from the pot.
4. Record of water use.

This paper describes a system which incorporates all these functions, is simple to construct, is cheap, and requires very little maintenance.

The tilting auto-watering pot system (TAPS) was tested at Emerald during the early summer of 1974.

II. METHOD OF OPERATION

A plastic pot without drain holes **a** (Figure 1) is fixed between wooden blocks **b** on one end of a wooden board **c** that is pivoted about its centre **d** on hardened steel points (masonry nails). These points are in contact with a hardened steel plate (hacksaw blade) embedded in a baseboard **e**. The pot contains soil previously brought to a moisture content equal to the driest level required in the subsequent wetting and drying cycles.

A sealed rigid plastic pipe **h** is attached in a vertical position to the opposite end of the board. A constant water drip **i** fills the upper portion of this pipe **j**, to a level where further water overflows through a polythene tube **k** attached to a bracket **l**. An insert **m** of hydrophilic glass (with maximum wetting characteristics) at the overflow point ensures that surface tension characteristics are not changed by any subsequent algal growth. Rotation of a wing nut **n** on the bracket allows fine vertical adjustment of the overflow tube to a height just lower than the siphon tube opposite **o.**

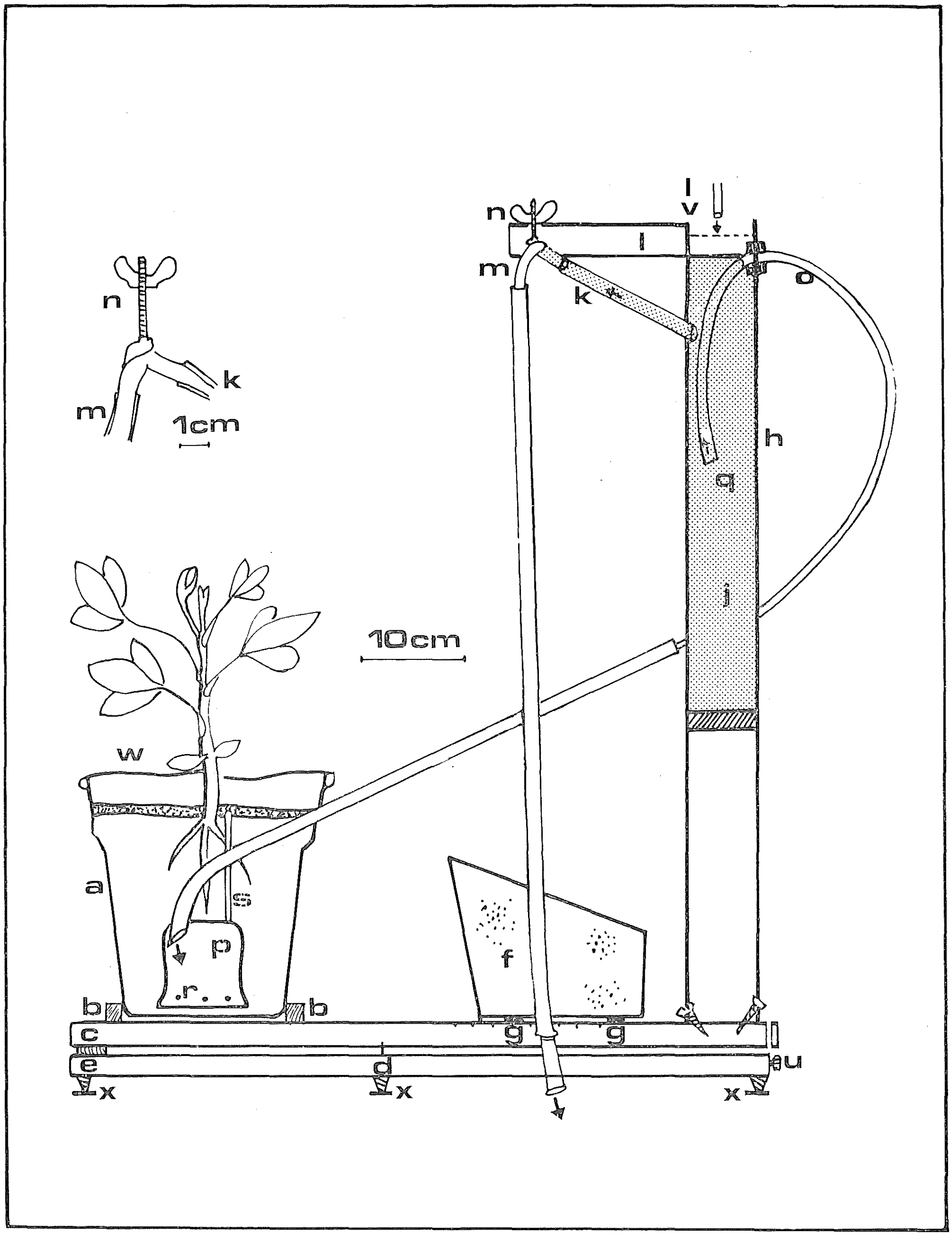

Figure 1.—Scale diagram of the Tilting Auto-watering Pot System, shown in the overflow position.

a plastic pot, **b** wooden block, **c** wooden tiltboard, **d** pivot point (fulcrum), **e** wooden base-board, **f** concrete counterweight, **g** counterweight locating holes, **h** plastic pipe, **i** water drip, **j** water, **k** polythene overflow tube, **l** bracket, **m** glass insert, **n** overflow adjusting nut and bolt, **o** polythene siphon tube, **p** chamber, **q** siphon tube inlet, **r** distribution holes, **s** air tube, **t** alkathene beads, **u** cog, **v** mesh screen, **w** plastic cover, **x** point contacts.

The weight of the pot is counterbalanced by this mass of water and by a movable asymmetric concrete block **f**. Coarse balance adjustment is achieved by placing the block over the appropriate locating hole **g**, and fine adjustment by rotating the block about an embedded pin that fits neatly into this hole. Because the centres of gravity of these masses are well above the fulcrum point **d**, the balance position is unstable. Since, in operation, the unit is balanced at the driest point of the wetting and drying cycle, further loss of water from the pot causes an immediate tilting of the board towards the concrete counterweight.

When the board tilts, further loss of water through the overflow tube ceases because of a shift in the water level of the pipe. Consequently the quantity of water (previously constant) in the reservoir increases until the small bore polythene syphon tube **o** is filled with water to its overflow point. This level is reached well before the overflow tube **k**, which removes excess water in the untilted position, becomes functional. Because of the hydrophobic nature of this tubing, addition of more water from the drip feed causes the water from the reservoir to be siphoned off through this tube into an empty chamber **p** embedded in the pot of soil. It is emphasized that consistent automatic siphon development will occur only in thoroughly cleaned polythene tubing where hydrophobic forces are at a maximum.

Following siphoning, the chamber in the pot receives a fixed amount of water previously set by the length of the siphon tube **q**, in the reservoir. This water is distributed through holes **r**, and then by capillarity through the mass of soil. The moisture content of the soil is now at a maximum. An air tube **s** connecting the chamber with the surface prevents the development of any air lock in the chamber which would interfere with the rapid and complete delivery of water from the pipe. The chamber (an upturned plastic container) is large enough to accommodate the total quantity of applied water of each cycle, and distributes water at a rate which does not interfere with rapid removal of water from the reservoir.

Evaporation of water and subsequent nutrient concentration at the soil surface is reduced to a minimum by a layer of alkathene beads **t**. Thus water used by the plant accounts for almost all the water lost from the pot.

The delivery of water from the reservoir to the pot represents a movement in mass which causes the board to return to the untilted position. The constant drip refills the pipe with water, with excess flowing to waste. A cog wheel **u** records the number of tilts which occur. From this record, the amount of water used by the plant can be calculated. A cycle is thus completed.

Calibration of the counterweight with known test weights in the pot can be carried out before the start of the cycles. Periodic adjustment of the counterweight to compensate for increasing plant weight is thus possible, provided some relationship between a non-destructive variable and total wet plant weight is known.

The overhead drip feed **i** is adjusted to a rate that fills the reservoir well before the nominated quantity of water has been lost from the pot. Because the drip rate is much slower than the delivery rate into the pot, its selection requires some knowledge of the rate of water use by the test plant, since the reservoir should be filled before the next cycle begins. Since water is rapidly removed from the reservoir, a varying drip rate introduces only a small error in the amount of water added to the pot. Nevertheless, this rate should be maintained by regular adjustment and cleaning.

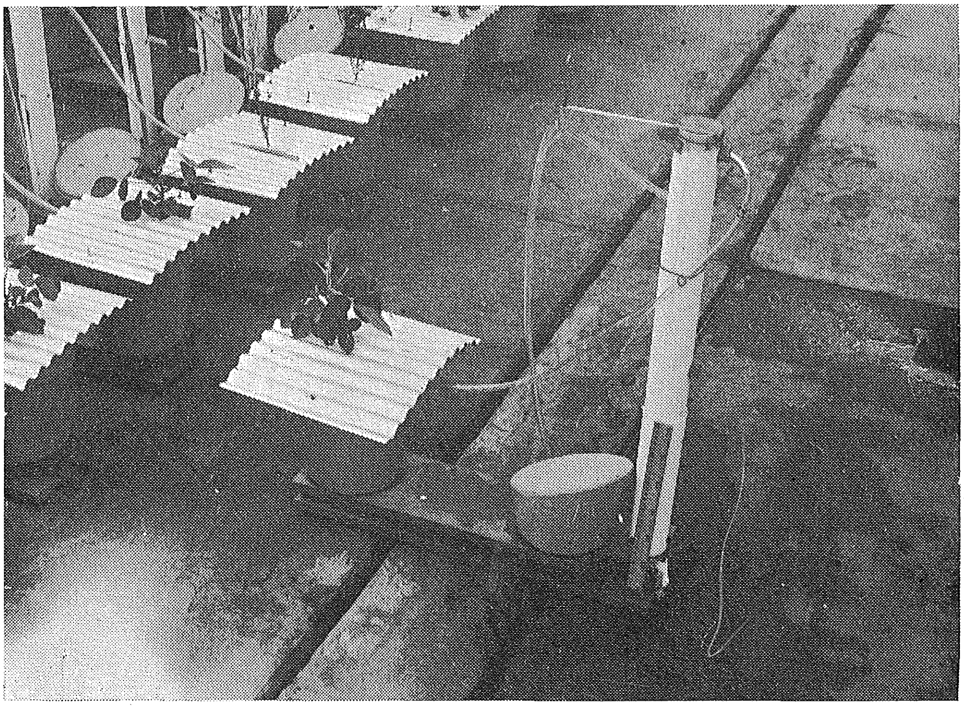

Figure 2.—The Tilting Auto-watering Pot System. Overhead drip omitted.

Algal growth may occur in the glass overflow tube **m** and this may require periodic cleaning. Prevention of this growth can be achieved by wrapping the tube in black plastic tape or painting it black. Since the overflow point of the siphon tube is wetted only intermittently, algal growth does not occur in this area.

A mesh screen **v**, placed at the top of the pipe, prevents interference from frogs and insects. A reflective corrugated plastic cover **w** attached to the top of the pot sheds rain. Rainfall on the rest of the system is of no concern. Since the baseboard **e** only makes a three point contact **x** with the underlying concrete surface, it is unnecessary to make this surface very smooth. It is also unnecessary to ensure that the baseboard is perfectly level.

Windy weather, birds and other small animals may cause premature tilting. Although this may slightly modify treatment effects in any one cycle, the error is not continually present and is probably adequately covered by treatment replication. The premature cycling has no influence on subsequent cycling since the same predetermined pot weight must still be reached before a further cycle begins.

Since the siphon development is critical, it is necessary to select tubing with the appropriate hydrophobic properties and internal bore. Polythene tubing of 6 mm internal diameter has been used successfully. Larger bore tubing 9 mm internal diameter is necessary for water delivery into the pot since the retention of a plug of water at the outlet end in smaller bore tube will interfere with siphon development.

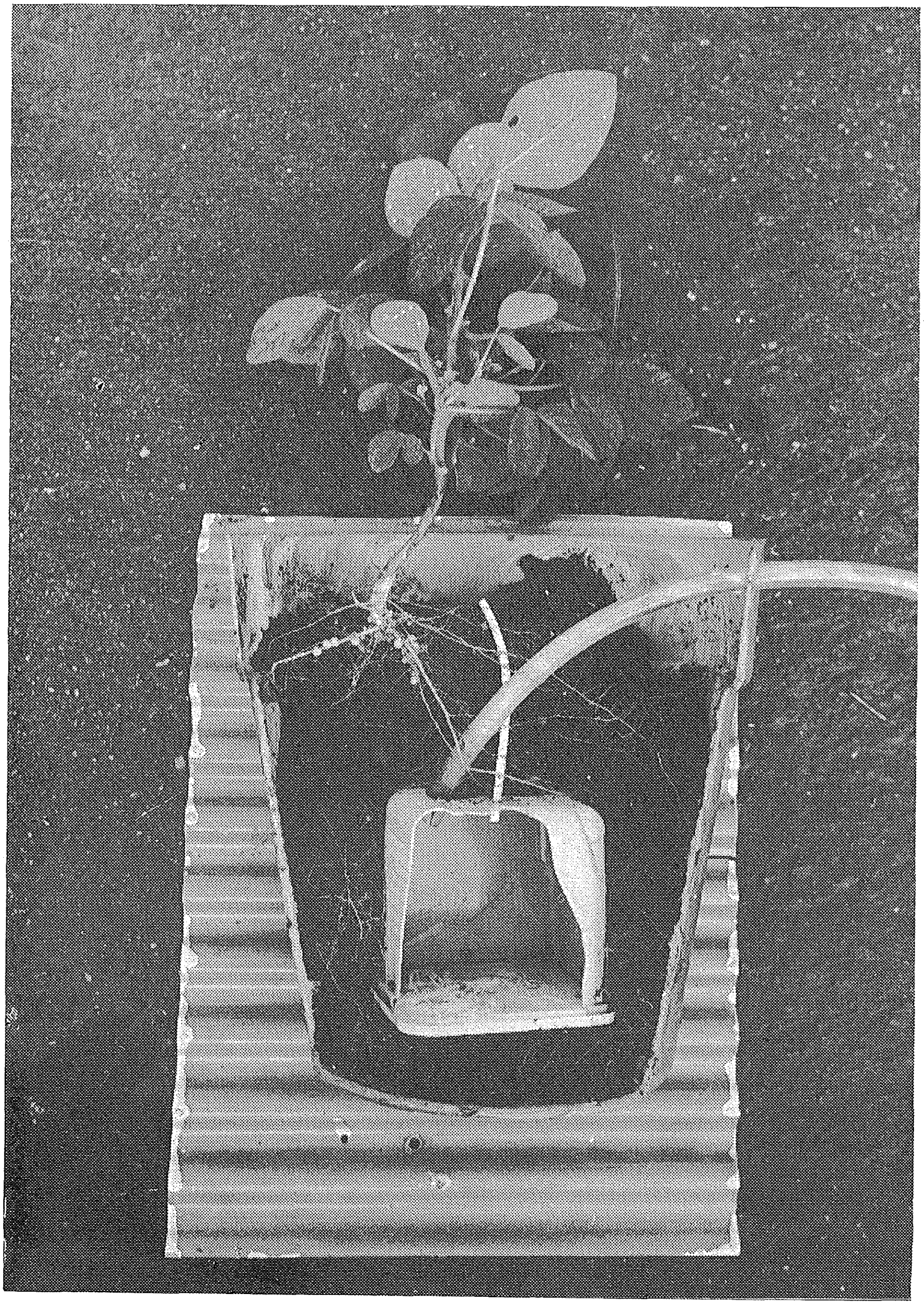

Figure 3.—Vertical section through pot to show distribution of soybean roots in heavy black clay soil, kept at moisture contents close to field capacity.

III. DISCUSSION

The system offers an important option in pot studies at very low cost—that of water addition almost immediately the pot of soil has reached a predetermined weight. This aspect may stimulate new interest in many fields where pot studies are critically related to soil moisture status, but rarely carried out because of the prohibitive costs of automation.

Being simple and cheap (approximately $4 per unit for materials), the system falls well within the budget constraints of isolated research centres. Better water control is possible, together with reduced labour costs.

The following advantages and disadvantages of this system can be summarized.

Advantages

1. Except for failure in water supply, the single unit operation is not subject to whole system failure.
2. The system is not motorized or electrified.
3. A fixed quantity of water is automatically added to a pot of soil when its mass is reduced to a predetermined level.
4. Progressive total water use can be recorded.
5. The principle may be extended to any sized pot.
6. Each unit is relatively cheap and can be made with unskilled labour.
7. The system can be set up outside.
8. Labour requirements for maintenance and operation are very low, and week-end work can be easily eliminated.

Disadvantages

1. The system is not suitable for tall growing plants which sprawl, lean or lodge, that is, where centre of gravity changes occur.
2. Winds and small animals may cause premature cycling. Very strong winds may blow units over unless supports are incorporated.
3. The system occupies more space than the conventional non-automated systems.
4. Pots cannot be re-randomized readily.
5. The actual balance point may be affected by wet weather, but the error would be slight.

Unit specifications

Baseboard and tiltboard—Length	66 cm
—Width	15 cm
—Thickness	2 cm
Height of reservoir	72 cm
Diameter of reservoir	5.6 cm
Diameter of plastic pot	22 cm
Weight of dry soil in pot	3 500 g
Weight of concrete counterweight	5 500 g
Range in amount of water added	200-550 ml
Lateral movement of reservoir	13 mm
Vertical movement of reservoir	5 mm
Internal diameter of siphon tube	6 mm
Quantity of polythene tubing—6 mm ID	100 cm
—9 mm ID	60 cm
Sensitivity of balance	±5 g
External diameter of glass insert	7 mm

IV. ACKNOWLEDGEMENTS

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REFERENCES

ANDREW, C. S., and COWPER, J. L. (1973). Automatic plant pot watering machine *Laboratory Practice,* May 1973.

DOLAR, S. G., and KEENEY, D. R. (1971). A self-watering system for growing plants in potted soil. *Agron. J.* 63:334-36.

MAYNARD, D. N., BARKER, A. V., and VERNELL, H. F. (1970). A semi-automatic sand culture system for green house plant nutrition research. *Agron. J.* 62:304-06.

OSBORN, R. K., and HANGER, B. C. (1969). A simple automatic irrigation system for growing plants in sand culture. *Aust. J. exp. Agric. Anim. Husb.* 9:367-68.

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