THE ABSORPTION AND EVAPORATION OF MOISTURE FROM PLANT CONTAINERS[1]

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INTRODUCTION

The ordinary flowerpot made of clay and fired is familiar to everybody. Jones [2] has shown that plant containers of metal, glass, and paper will support plant growth equal to, and frequently better than that obtained in clay pots. The real difference between porous and nonporous pots is the property of the former to absorb and evaporate moisture. Soil aeration through the wall of the pot is not probable and is hardly possible.[3]

In seeking a scientific explanation for the inferiority of plants grown in clay flowerpots on a dry surface, the subject of water relations in the soil as influenced by the absorption of water by the pot and its evaporation from the pot seems to give a satisfactory answer. In nonporous plant containers, evaporation can take place only from the surface of the soil. In the porous pots, the pot itself acts as an evaporating surface; and as its area is considerably greater than that of the surface area of the soil, the effects of evaporation from such containers are accentuated. The plant container directly affects the water relationships in the soil mass. Jones, using high greenhouse temperatures, found that the loss of water from 3-inch porous flowerpots was twice as much as from nonporous containers of the same size, and that this increased loss of moisture by evaporation had a cooling effect on the soil mass.

PLAN OF THE INVESTIGATION

The investigation reported herein was planned to secure information that could be used as a scientific basis for the proper understanding of water movement in a clay flowerpot. The experiments were planned to determine the maximum absorbing capacity of clay flowerpots. Painted flowerpots and cement pots were included in the experiments concerned with evaporation. Though porous to air and moisture, the capillary structure of the cement pot is so coarse that unless the soil mass is quite wet, capillary continuity is broken between the cement pot and the soil and the pot will function as a nonporous one.[4]

ABSORPTION OF MOISTURE BY THE CLAY FLOWERPOT

When both the soil and the flowerpot approach dryness, any applied water is taken up by both. Apparently there are no figures to

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2 JONES, L. H. FLOWERPOT COMPOSITION AND ITS EFFECT ON PLANT GROWTH. Mass. Agr. Expt. Sta. Bull. 277, pp. [148]-161, illus. 1931.

3 ———. AERATION OF SOIL IN PLANT CONTAINERS. Florist Exch. and Hort. Trade World 79 (11): 39, illus. 1932.

4 JONES, L. H. CEMENT FLOWERPOTS . . . Florists' Exch. and Hort. Trade World 80 (2): 9, illus. 1932.

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suggest the approximate amounts of water that should be applied daily to satisfy the needs of potted plants in flowerpots of various sizes. Table 1 shows the maximum amount of absorption that can take place in a clay flowerpot and the relation of the absorbed quantities to the amount of water usually applied to a potted plant.

TABLE 1.—*Normal weight of water applied to clay flowerpots of different sizes, the weight of water that clay pots can absorb, and the weight of water available for the soil and plant*

[Average for 20 pots]

Size of pot (inches)	Normal watering [a] applied	Water absorbed by pot		Water available for soil and plant	
	Grams	*Grams*	*Percent*	*Grams*	*Percent*
2	15	9.10	60	5.90	40
2½	35	14.10	40	20.90	60
3	50	20.55	41	29.45	59
4	100	38.85	39	61.15	61
5	200	83.15	42	116.85	58
6	300	130.30	43	169.70	57

[a] The amount of water that constitutes a normal watering was determined by averaging data from several sources. The amount of soil in the pot and the human element in watering will cause these figures to vary slightly. However, they represent a fair basis for investigational work.

A cement pot made from a mixture of sand and cement does not have so large a water-holding capacity as a flowerpot made of fired clay, consequently a larger percentage of the water applied to the soil in a cement pot is available for the plant. Table 2 shows a comparison of the absorbing capacities of clay and cement flowerpots.

TABLE 2.—*Normal weight of water applied to clay and cement flowerpots of different sizes, the weight of water absorbed, and the weight available for the soil and plant*

[Average for 2 pots]

Size of pot (inches)	Type of pot	Dry weight of pot	Normal watering applied	Water absorbed by pot		Water available for soil and plant	
		Grams	*Grams*	*Grams*	*Percent*	*Grams*	*Percent*
4	Clay	390	100	37	37	63	63
	Cement	406	100	23	23	77	77
5	Clay	643	200	83	41	117	59
	Cement	618	200	44	22	156	78
6	Clay	1,060	300	121	40	179	60
	Cement	1,032	300	79	26	221	74

In order to determine the amount of water that could be absorbed by a clay pot in the presence of a growing plant, the following experiments were performed: Twenty-four 4-inch pots were dried for 1 day at an air temperature of 33° C. and weighed. Each pot was planted with a geranium plant and placed in a greenhouse on a moist soil bench. At the end of 6 weeks the potted plants were transferred to a dry surface and the watering adjusted so that the soil was almost dry as the plants began to wilt. (This procedure is analogous to the conditions under which house plants are grown and watered.) When all 24 plants were reacting nearly the same and needed watering, they were equally divided into two series. The plants and soil were removed from the A series and the pots weighed to determine how much water was retained by the pots. From table 3 it appears that the pots were as dry as when the experiment was started. To each pot of the B series 100 grams of water was applied and the series allowed to stand for 1½ hours. The pots with soil and plants were weighed and the loss of moisture by transpiration and evaporation determined. The soil and plants were then removed and the wiped pots weighed. Table 3 gives averages and calculations on which are based the conclusion that nearly one quarter of the water applied was absorbed by the pots. This figure represents about one half of the absorbing capacity of the pots (table 1). It was observed that in 1½ hours the water had penetrated the soil to a depth of but 1 inch and probably would not have penetrated more deeply as the capillary attraction of the pot for moisture was greater than that of the soil.

TABLE 3.—*Method of grouping the various weights of clay pots in order to obtain a general average of the percentage of water absorbed by them when containing plants*

Series and no.	Item considered	Weight
Series A (check):		*Grams*
1	Average initial weight of 12 pots	394.00
2	Average final weight of pots minus soil and wilted plants	393.00
Series B:		
1	Average initial weight of 12 pots	390.75
2	Average weight of pots plus soil when soil was dry and plants wilting	812.08
3	Average weight plus 100 grams of water	912.08
4	Average weight 1½ hours after water was applied	905.91
5	Loss in 1½ hours due to evaporation and transpiration	6.17
6	Average weight of empty pots 1½ hours after water was applied	413.33
7	Average weight of water in pots after 1½ hours (413.—33390.75)	[a] 22.58

[a] 22.58 percent of the total weight of water applied was absorbed by the clay pots in 1½ hours.

EVAPORATION OF MOISTURE FROM POROUS AND PAINTED FLOWERPOTS

Moisture loss from the soil in a porous pot takes place in two directions—the evaporation from the surface of the soil causes a vertical movement of soil moisture while the evaporation from the wall of the pot causes a lateral movement. If the porous pot is kept on a moist bench surface, some of this evaporated moisture is replaced from the moisture below the pot. The following experiment was conducted to determine the effect of pot environment (bench surface and air) on the quantity of water lost by evaporation from the surface of the soil and through the wall of the pot.

Flowerpots, 5-inch size, of clay, cement, and painted clay were placed on a dry bench surface of boards and on a moist bench surface of soft-coal cinders. Each type of pot for each condition was replicated six times. The soil, a compost, was sieved through a 1¼-inch mesh screen. The pots were filled level full and the soil firmed. The drainage hole in each pot was covered with a piece of broken pot, as is customary. The pots were allowed to remain on a moist surface for 20 hours for the natural adjustment of moisture through the soil before being weighed and were brought up to this initial weight every 24 hours, after first determining the weight lost. Table 4 shows the loss of weight for each one of the 14 days of the experimental period. Naturally, the amount of evaporation is affected by the weather conditions prevailing at the time. This influence is graphically represented in figure 1.

TABLE 4.—*Average loss of weight in 24-hour periods from clay, painted, and cement soil-filled pots on dry and moist surfaces*

Period (days)	Clay pots		Painted pots		Cement pots	
	Dry surface	Moist surface	Dry surface	Moist surface	Dry surface	Moist surface
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
1	53	18	13	11	27	5
2	63	29	17	16	30	21
3	64	28	15	11	27	18
4	66	36	19	18	31	25
5	69	41	18	18	33	23
6	53	26	15	11	27	18
7	54	18	16	11	30	[a] 2
8	56	23	18	14	29	14
9	28	5	10	8	19	[a] 10
10	53	17	17	12	27	5
11	44	15	14	11	24	7
12	48	14	14	12	22	5
13	11	[a] 6	4	4	5	[a] 10
14	20	5	7	5	11	[a] 1
Total	4,094	1,630	1,184	947	2,064	646

[a] Gain in weight.

The results indicate that the evaporation of moisture from porous clay pots on a dry surface was approximately three times greater

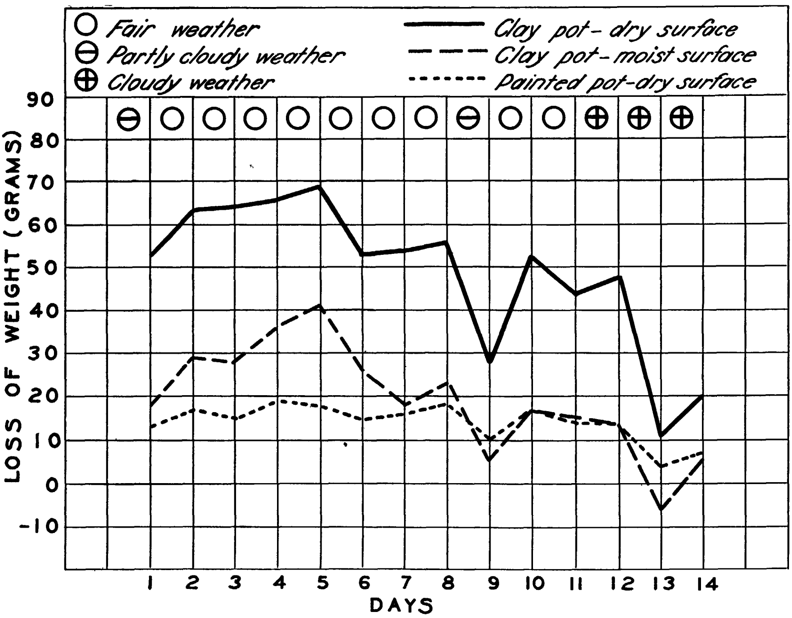

FIGURE 1.—Effect of weather on loss of weight of clay pots on dry and moist surfaces and painted pots on a dry surface. Average for six pots.

than that from painted pots. As the painted pots could evaporate moisture only from the soil surface, the data show that two thirds of the loss of moisture from the soil in a clay pot on a dry surface took place through the wall of the pot, indicating that there was twice as much movement of moisture laterally as vertically. When the porous clay pot was kept on a moist surface, a considerable proportion of the water lost by evaporation was replaced from the moist surface. It is also possible in humid weather for the porous clay pot to absorb more moisture from the moist bench than is lost by evaporation.

The cement pot, because of its coarse structure, influences loss of moisture according to the ability of soil moisture to leave the soil and enter the pot wall. When moisture was first applied at the beginning of a 24-hour period, the pot was able to absorb it. As the period progressed, the moisture-retaining power of the soil became more effective than the pull of the pot. Thus capillary contact between soil and pot was broken. Hence, soil-moisture movement in a cement pot is more like that in a painted pot, vertical, than in a porous clay pot, vertical and lateral. Table 5 shows the loss of moisture in 1-hour periods from the three types of pots. The transition period, when the cement pot (on a dry surface) changed over from behaving like a porous pot, occurred at about the end of the fifth hour.

TABLE 5.—*Loss of weight in hourly periods from clay, cement, and painted soil-filled pots on dry and moist surfaces*

Period (hours)	Dry surface			Moist Surface		
	Clay	Cement	Painted	Clay	Cement	Painted
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
0–1	5	1	4	1	0	1
1–2	8	8	2	4	5	1
2–3	2	4	3	5	4	2
3–4	12	7	2	3	3	3
4–5	10	6	2	6	5	2
5–6	10	2	2	7	1	3
6–7	1	5	4	2	5	3
7–8	5	1	0	2	3	0
8–24	45	12	10	22	14	13
Total loss	98	46	29	52	40	28

DISCUSSION

The absorption of moisture by the clay pot and its subsequent evaporation into the air is a continuous process as long as there is any capillary moisture in the soil mass. Tests with the rubber vacuum disk proved that the word "porous" as applied to moist clay flowerpots should be limited to mean porosity to moisture. Air does not pass though the wall of a moist clay flowerpot. The process of lateral movement of moisture transports more water in this direction than is moved vertically and should, therefore, be accompanied by a corresponding lateral movement of soluble plant food. Associated with the movement of water in plant containers is the distribution of the root system of the plant. Where lateral movement is possible through a porous pot, the root system, for the most part, is found between the wall of the pot and the soil mass. On the other hand, if lateral movement is not possible, the root system ramifies through the soil mass with only a few roots developing adjacent to the pot wall.

Water relations, water movement, and root distribution are entirely dependent on the structure of the plant container. The culture of potted plants should include practices that encourage a more or less even balance of water content in the environment of the roots. In a nonporous pot with a ramifying root system and lack of lateral movement of water, it is comparatively easy to maintain an even distribution of moisture in the soil mass. In a porous pot where the root system is almost entirely against the wall of the pot, it seems almost necessary to keep such pots on a moist surface. If a moist surface is not used, the pot itself will withdraw moisture from the nearest source which happens to be the very region where the roots have developed or are developing.

SUMMARY AND CONCLUSIONS

This investigation is concerned with the amounts of water usually applied to potted plants and the moisture-holding capacities of pots of various sizes. The loss of water by evaporation has been determined also for pots in certain specified environments.

Under conditions that frequently prevail with growing plants, nearly one quarter of the amount of water applied was absorbed by the flowerpots in 1½ hours.

Twice as much water was evaporated from the wall of a clay pot as from the surface of the soil. This would indicate that there was twice as much moisture moved laterally as was moved vertically.

When the clay pot was kept on a moist surface, a considerable proportion of the evaporated water was replaced from the supply of moisture beneath the pot.

Cement flowerpots did not have so large a water-holding capacity as those made of fired clay. The cement pot evaporated moisture from the wall as long as the wall could maintain a capillary connection with the soil mass. When such capillary contact was broken, the cement pot behaved as a nonporous painted pot.

The essential difference between a porous and a nonporous plant container is the ability of the former to evaporate moisture from its wall and replace this moisture from the soil moisture within the pot.