FRESH WEIGHT AND FLOWERING OF TOMATO PLANTS AS INFLUENCED BY CONTAINER TYPE AND WATERING CONDITIONS

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Abstract

During propagation of tomatoes, sown November 5, 1971, watering was carried out in different ways : only if necessary (Dry), as much as was possible without spoiling water (Moist), and water saturation of the substrate in a 2 cm layer of water (Wet). Two types of container were used: plastic pots and soil blocks. Contents of both 1 L.

Fresh weight on February 8, 1972 was strongly influenced by watering conditions. The weight of the plants in plastic containers was 66.0-94.9-114.3 gram per plant in dry, moist and wet respectively and 64.3 - 96.9 - 74.0 gram in soil blocks. Drier conditions caused smaller plants except for saturated soil blocks. The smaller plants had higher dry matter percentages and better trusses which flowered normally. Bigger plants however, showed a quicker flowerbud initiation in the apex.

Plants grown under dry conditions had 3.6 flowers open, and 33.3 buds initiated in the growing point. Under moist conditions, 2.3 flowers were open, but 43.8 buds were counted in the growing point. The delay in flowering was caused by abortion of nearly 50% of the first trusses, but flower initiation was accelerated by better growth from 33.3 to 43.8 buds. The loss of fruit due to 50% abortion is 3-4 fruits per plant, but there is a regain of 10 fruits on the higher trusses.

Introduction

In winter, both in The Netherlands (Klapwijk and De Lint, 1969) and in Great Britain (Anon), failure of proper flowering of the first truss of tomato is a major problem. Growers and research workers are intensively trying to find a solution to this difficulty because of its economic implications.

An important aspect in control of flowering, is considered to be the water regime on which the plants are grown (Abdelhafeez and Verkerk, 1969), also the type of pot is under discussion. Reduced vegetative growth evidently causes flower quality on the first truss to rise above some critical level. However, this inhibition of growth results in small plants at flowering, and this seems to limit fruit size and total yield. One would like to have both, early yield, and heavy yield.

The present paper is to give data on the quantative relation between two effects of the water regime: quality of early flowering and plant fresh weight.

Material and methods

Tomato cv 'Moneymaker' was sown in pots on November 5, 1971.

The glasshouse in which the experiment was placed is not the latest with respect to light transmission, although it is built with a metal deck. Temperatures were maintained according to practice advice (thermograph registrations are available). Water was applied in three different ways. Each treatment was present 6-fold.

Watering procedures are indicated as :

1. D-(Dry), water administered on top of the pot to avoid temporary wilting.
2. M-(Moist), water applied frequently and amply from the top.
3. W-(Wet), pot permanently standing in a layer of about 1-2 cm water.

The water treatment W was fertilized to maintain the electrical conductivity at 25°C above 3 mmho with 13-5-13, a compound N-P-K fertilizer in which nitrogen is present as NO_3. Fertilizing was done 6 times. The total dosages of fertilizer mounted to 4.30 - 5.50 - 6.25 g/plant for treatment D-M-W respectively.

Each of the experimental plots was filled with two types of "container", viz. plastic pots and soil blocks. Both types contained 1 L of substrate. The substrate consisted of Finnish sphagnum peat (75%) and a commercial potting compost (25%). Some extra pots were filled with the same mixture and placed in the same glasshouse, but were not sown with tomato. These pots were used to determine initial evaporation from the pot surfaces. The experiment was started with 24 pots per plot (1.5 m^2). At the end 8 plants per plot were left.

Temperatures in the centres of the pots with plants, were registered a number of times daily from mercury thermometers.

Plants were harvested periodically to observe flowerbud developments and to determine fresh and dry weights.

Water was administered at known dosages, so that consumption could be calculated for various periods for plots (W) or separate pots (D and M). The salt content of the irrigation water used, was between 200-300 mg NaCl per litre.

Experimental

Data on containers : The containers without plants that were put in the glasshouse were weighed at intervals. The weights are presented in figure 1 for plastic pots and soil blocks separately. The graphs demonstrate that soil blocks initially contain much more water than plastic pots. However, soil blocks dry out very fast as compared with the contents of plastic pots. Due to these two effects it is seen that after 11 days, both container types hold the same amount of water. At November 18, for the first time, water was applied to the experimental pots M and W, which is 13 days after the start of the experiment (November 5). Treatment D, soil blocks, received water only from November 29 (after 24 days) and D, plastic pots, only after 39 days (December 14). From that day onwards, pots were kept as much as possible on their specific water contents. At the end of the experiment, weights of the pot contents were measured to determine the average water content at the various treatments. These data are given in table 1, which clearly indicate that the three treatments have been sufficiently equal for the two types of container. There may be one real difference, viz. that the soil blocks standing in water contain too much water compared to the plastic pots. If we assume the pot volumes to be 1.000 ml, then this difference would indicate a noticeable difference in air volume between the two pot types if standing in water (106 vs 189 ml).

As shown on figure 1, evaporation of water is much faster from soil blocks than from plastic pots, most likely due to much larger free wet surface of the soil blocks. It was checked whether this difference has an effect on the temperatures in the containers. For this reason, daily maximum temperatures in the centers of the containers were registered. The mean maximum temperatures at the various treatments are given in table 2, from which it can be concluded that soil blocks are about 2^{o}C cooler than plastic pots.

It seems that the difference between the soil block and air temperature is rather independent of the water content of the blocks. The temperature in plastic pots, however, seems to be further below air temperature if the pots contain more water. Thus, the dryer treatment results in a greater temperature difference between the two types of container.
Mean maximum temperatures calculated for periods of about a month (table 3), indicate that the absolute temperature differences between the types of container and of treatment, evidently are influenced by climatic factors as well, since the differences vary with the months. In mid-winter, the differences are relatively small, as compared with November and February.

Accumulated amounts of water consumed during the experiment, are given in table 4, for the various treatments. It is seen that with plastic pots, indeed considerably less water is used, than in soil blocks. Further it is evident that with the dryer treatment, less water is used. The latter effect can only be compared for the two dryer treatments D and M. The situation for treatment W was very much different, because the tray, in which the two types of container were placed, was kept to have always a layer of 1-2 cm water, whereas, in the other two treatments, the pot contents only were watered, each pot its own amount. This is also the reason for the fact that for treatment W, no separate figures can be presented for soil blocks and plastic pots.

Figure 2 shows how water consumption developed with time. Values are totals per week for each treatment. The initial differences in consumption remain till the end of the experiment. All figures are too small for the last week, because the plants were harvested in the middle of that week.

Salt accumulation in the sontainers, was in accordance with the consumption of water, and depended on whether the water was administered from the top or via the bottoms of the containers; there was also a connection with the wetness of the pots. The highest salt values were found in the top layer of pots that were permanently placed in water. The amount of salt in the tops of the pots was as high as 3% NaCl and 9% total salts on dry matter.

Data on plants: On several dates during the experiment, and finally at the last day of the experiment, plants were harvested and analysed. Table 5 shows the fresh weights on the day the experiment was terminated. Growth of plants in plastic pots is clearly favoured by more water. The wetter the treatment, the heavier the plants are. In soil blocks with treatments D and M, exactly the same growth was obtained as in plastic pots. For treatment W, however, plants were much smaller in soil blocks than in pots and also smaller than in moist blocks. It is likely that in these very wet soil blocks (see table 1), root, activity was limited due to shortage of oxygen. In this, and other experiments with comparable treatments, these retarded plants showed some, and sometimes even severe chlorosis.

The weight differences between plants in plastic pots of treatments M and W, developed only after January 20, at which date these plants had still the same weights.

With respect to plant quality, dry matter percentage is considered to be of importance. This percentage is known to be influenced by the watering regime. Therefore, these data are presented in table 6, for two harvesting dates. For all treatments, dry matter percentages increase markedly from January 6, to February 8. Furthermore, it can be noticed that the percentage was lower, the more water was available. Both these observations are true for plants in plastic pots and in soil blocks. The relation between the data of tables 5 and 6 seems to be that plants on more water, contain lower dry matter percentages and that this is accompanied by heavier fresh weights. There is one exception to this rule, viz. that treatment W on soil blocks gives small plants containing only a low dry matter percentage.

A second important plant quality aspect for November sowings of tomato, is quality of flowering, especially of the first truss. However, equally important seems to be the third aspect, viz. the rate at which new buds are formed. These two characteristics have been analysed for the various treatments at February 8. The total numbers of microscopically visible flower buds on the plants nicely run parallel with fresh weight (see tables 7 and 5). The heavier the plant, the more buds could be counted. An exception is that the very fast-grown extra large plants of treatment W in plastic pots had not differentiated enough buds in relation to their size.

For flowering there is a definite parallel with dry matter percentages. Plants with higher percentages had more open flowers. The percentages of failure in the first truss are in the opposite direction as flowering. These effects are practically identical for plants in soil blocks and in plastic pots. A deviating group again, is the slow growing group W in soil blocks.

Discussion

The experiment described in this report was fully succesful with respect to showing the problem of quality of flowering in winter culture of tomato. Treatments were chosen in such a way that differences in failure of first truss flowering were considerable. Clearly, the main cultural measure to control flowering indeed is water supply, Dry matter percentages are lower with more water. However, growth is strongly reduced due to these regimes of limited water availability. The interaction between these two plant growth aspects (growth/proper flowering) is such that "Dry" treated plants have opened some 3-4 flowers more than the wet ones, but the number of flower buds already differentiated at the same moment, in dry plants is about 10 less. And since all of these will develop into rather early fruit, the price/time curve has to be very steep indeed for the "Dry" treatment to be justified. The more so, since the wet plants not only will produce more early fruit, but also fruit that probably will be larger as well.

Too wet treatments are a little risky, not only because of flower quality, but chlorosis and reduced vegetative growth may be the result, probably due to shortage of oxygen in the root medium. The effect is especially to be expected in soil blocks. The water holding capacity of blocks is evidently very high.

The evapo-transpiration of water is about 50% higher from soil blocks than from plastic pots. This is a small difference relative to the ratio of the wet free surfaces of the two types of container used. The open surface of plastic pots is about 130 cm^2 and of soil blocks about 500 cm^2. Relatively low evaporation from blocks may be due to reduced temperatures in the blocks. Soil blocks may be cooler because of the greater evaporation energy needed, but also colour differences and consequent differences in absorption of radiant energy may have had an effect.

Growth and flower development are identical in plastic pots and in soil blocks. The difference in temperature does not seem to have been effecting the plant reactions.

The different evaporation rates between soil blocks and plastic pots could be in favour of soil blocks. If one would want to maintain rather dry containers, then fast drying out would correct temporary over-watering sooner. This may facilitate proper water management considerably. On the other hand, if limited water supply is not wanted, plastic pots may be better because of less frequent watering and because of somewhat higher temperatures in the pots.

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Discussion

Moe:- What is the reason for the high percentage of flower abortion of plants grown at wet soil condition ?

Klapwijk:- We only recorded this phenomenon, but did not make any analysis on e.g. hormonal composition of the tissue. The abcission of flowerbuds is clearly related to the light conditions. It is a sharp reaction of the tomato to poor light conditions. An interesting aspect is that leaves of plants growing in a layer of 1-2 cm of water were bending downwards. This may indicate that there is an influence of conditions in the rooting medium on ethylene or auxine activity of the roots.

Amsen:- Temperature was measured in the center of the pots and the blocks, and you found an average difference of 2°C. In soil blocks you might expect a greater temperature gradient than in the plastic pot, and therefore even a more pronounced temperature difference may have occurred. Have you tried to look at your experiment as a root-medium - temperature experiment ?

Klapwijk:- We only measured temperatures in the centre of the pots. One can assume that the temperatures in the centre of the pot are dependent on the situation at the wall of the pot. One may also assume temperature differences near the wall to be more pronounced. The black dry surface of the plastic pots is warmed up very quickly by solar radiation. But the temperature of the outer surface of a wet soil block will be cooled down by easier evaporation. These phenomena are more pronounced for dry pots than for wet pots. It first explains the greater temperature differences in dry pots (table 2) and we expect a greater temperature gradient in plastic pots.

Le Poidevin:- 1. Were nutrients added at every watering ? To what extend was nutrient concentration in pots considered as an effect, influencing flowering ?

2. To what extend did the early truss production, achieved by drying the substrate, effect subsequent development of the plant ?

Klapwijk:- 1. Nutrients were added to the plants in the wet conditions as soon as the electric conductivity was lower than 3 mmho at 25°C. This was measured two times every week. Frequency of fertilization became greater when plants grew. We tried to keep concentrations equal for all watering regimes by adding more fertilizer to the wet pots. We do not know what is the influence of the salt concentration on flowering. This will be the subject of next winter's experiments.

2. We did not grow these tomato plants till cropping. From other experiments we know that, with bigger transplants, production is earlier, but if one keeps the plants dry, the weight of the fruit will be lower.

References

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Table 1 - Weight of substrate with water and roots (g/pot) at the end of the experiment. 1 L soil blocks and 1 L plastic pots filled with the same mixture, each treated with three water regimes.

	Dry	Moist	Wet
Plastic pot	393	693	811
Soil block	358	663	894

Table 2 - Mean daily maximum temperatures in the centre of the pots (°C), in plastic pots and in soil blocks, each with three water regimes. Air temperature is added as a reference.

	Dry	Moist	Wet	Mean	Air.temp.
Plastic pot	21.4	20.8	19.6	20.6	21.2
Soil block	18.9	18.5	18.5	18.6	
Temp. difference	2.5	2.3	1.1	2.0	

Table 3 - Mean daily maximum positive temperature differences (°C) between plastic pots and soil blocks, with three water regimes, for 4 periods of about a month of the duration of the experiment.

	Dry	Moist	Wet	Mean
November	2.9	2.6	1.6	2.4
December	2.2	2.0	0.7	1.6
1/1 - 20/1	2.1	2.1	0.9	1.7
21/1 - 8/2	3.1	2.8	1.1	2.3

Table 4 - Water consumption(evapotranspiration) of tomato plants (ml/pot) during the propagation period, in winter, on a glasshouse bench. Plants in plastic pots and soil blocks each with three water regimes.

	Dry	Moist	Wet
Plastic pot	1946	3381	
Soil block	2855	5417	
Mean	2401	4399	9680

Table 5 - Fresh weight of tomato plants, (g/plant) cv 'Moneymaker' at harvest (February 8 1972), grown in plastic pots or soil blocks, with three water regimes.

	Dry	Moist	Wet
Plastic pot	66.0	94.9	114.3
Soil block	64.3	96.9	74.0

Table 6 - Dry matter (% of shoot fresh weight) on January 6 and February 8, 1972, and fresh weight of leaves (% of shoot fresh weight) on February 8, 1972 of tomato seedlings grown in plastic pots or soil blocks, with three water regimes.

	Plastic pot			Soil block		
	Dry	Moist	Wet	Dry	Moist	Dry
Dry matter %						
shoot, jan. 6	6.16	5.24	4.62	6.12	5.12	4.84
shoot, febr. 8	10.68	9.45	8.66	9.63	9.06	8.14
Leaves/shoot						
% fresh, febr. 8	40.0	41.3	40.7	40.7	39.2	37.2

Table 7 - Number of flower buds on the apex, open flowers in first and second truss, and percentage of aborted trusses on tomato plants grown in plastic pots and in soil blocks, with three water regimes.

	Plastic pot			Soil block		
	Dry	Moist	Wet	Dry	Moist	Wet
Flower buds	33.2	42.2	41.9	33.4	45.3	38.1
Flowers 1st truss	3.0	0.4	0.0	2.9	0.9	0.3
Flowers 2nd truss	0.7	1.4	0.4	0.6	1.8	0.0
% abortion 1st truss	4.2	54.2	95.8	-	45.8	45.8

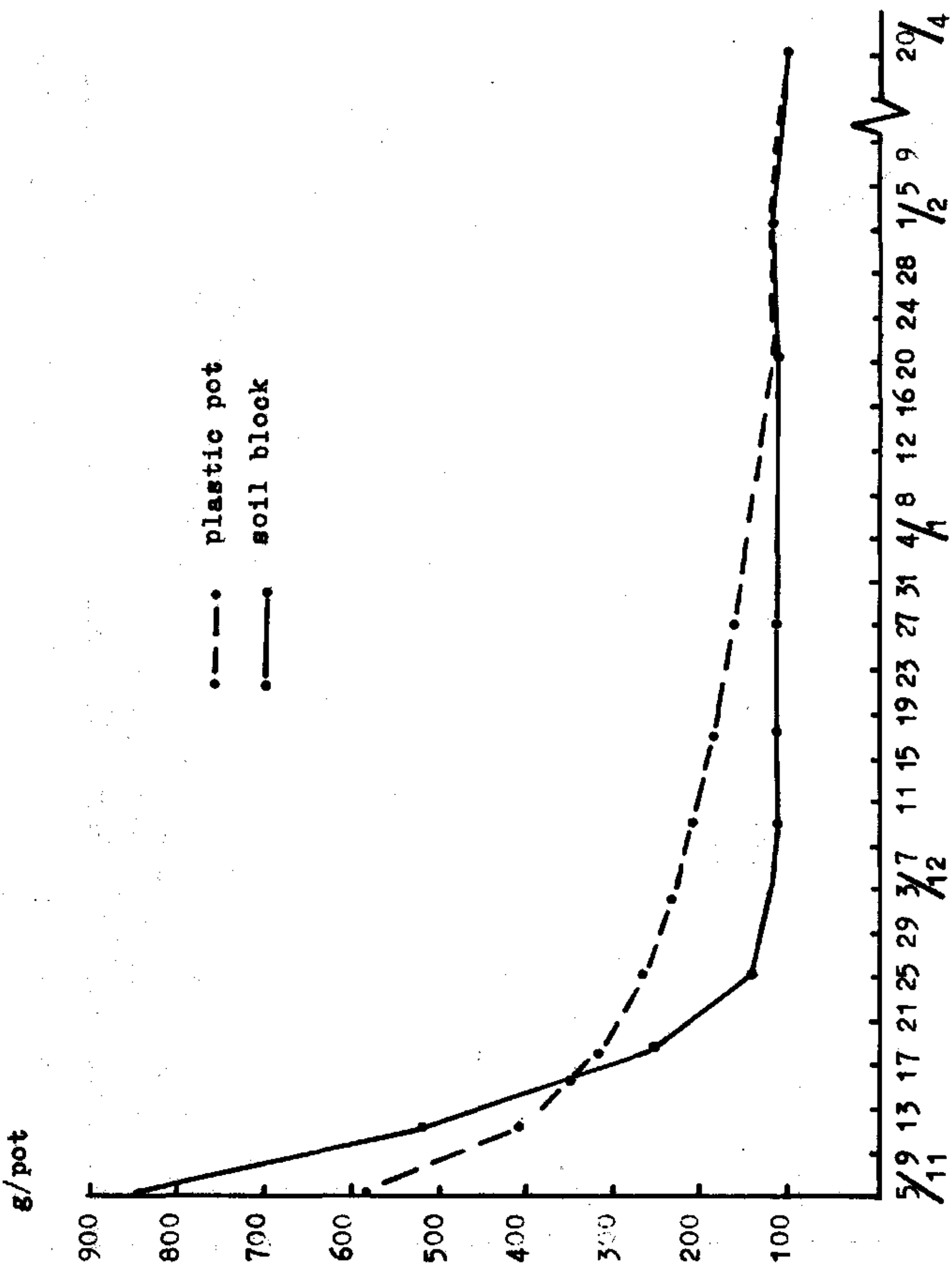

Figure 1 - Black plastic pots filled with 1 l volume of potting soil and soil blocks of 1 l made of the same mixture allowed to dry out on a glasshouse bench.

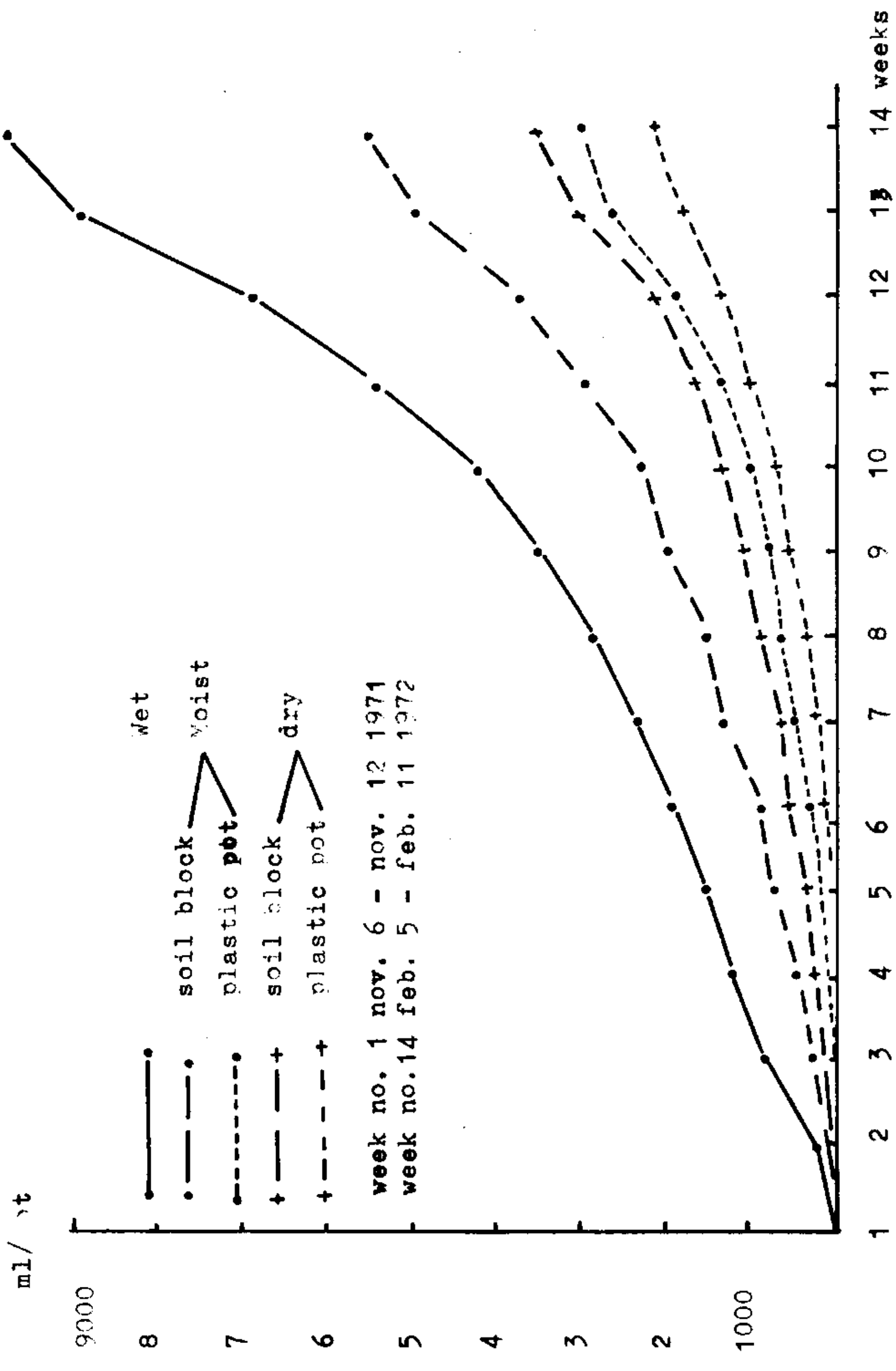

Figure 2 - Water consumption (evapotranspiration) of tomato plants in soil blocks and plastic pots during propagation in the winter period, on three levels of watering.