" Advances in Horticultural Science and their Applications " Volume I.
Reprinted from
OXFORD · LONDON · NEW YORK · PARIS
PERGAMON PRESS
1961

Raising Tomato-plants for an Early Crop in Hothouses

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Abstract—This paper deals with the problems of lack of light and phosphorus-deficiency. By applying artificial light the big difficulty is the repercussion after ending the illumination. At that moment the amount of daylight is often quite insufficient. To get over this period there are two possibilities:

1. After two weeks of continuous illumination a gradual diminishing of the duration and intensity of illumination.

2. After ending the illumination a frequent spraying with sugar and urea.

The phosphorus-deficiency is connected with a too low soil-temperature. This is caused by the low air-temperature, which is necessary in connection with the low supply of light. Experiments with radioactive phosphorus have shown that between 12 and 18 °C each lowering of the temperature by 2 °C reduces the phosphorus-uptake to 50%. There are two possibilities to solve this problem:

1. Applying phosphorus as a starter-solution.

2. A separate control of the soil-temperature by electric heating.

Production de tomates de primeur sous serres chauffées

Sommaire—Cette étude concerne les problèmes du manque de lumière et de carences en phosphore. La grande difficulté dans l'utilisation de lumière artificielle réside dans la répercussion consécutive à la fin de l'éclairement. A ce moment, la quantité de lumière naturelle est souvent tout à fait insuffisante. Pour surmonter ce passage difficile, il s'offre deux possibilités:

1. Après deux semaines d'éclairement continuel, diminution graduelle de la durée et de l'intensité de l'éclairage.

2. Après la fin de la période d'éclairement, pulvérisations fréquentes de sucre et d'urée.

La carence en phosphore est en relation avec une température du sol trop basse. Celle-ci résulte elle-même d'une température ambiante qui doit être maintenue basse en raison de la faible intensité lumineuse. Des essais utilisant du phosphore radio-actif ont montré que chaque fois que la température baisse de 2 °C, entre 12 et 18 °C, l'absorption du phosphore diminuait de 50%. Deux solutions peuvent être envisagées:

1. Application de phosphore.

2. Chauffage séparé du sol, à l'électricité.

Printed in Great Britain by Page Bros. (Norwich) Ltd., Norwich, England

Der Anbau früher Tomatensorten im Warmhaus

Zusammenfassung—Diese Untersuchung befasst sich mit den Fragen des Licht- und Phosphormangels. Die Hauptschwierigkeit bei der Verwendung von Kunstlicht liegt in dem Lichtabfall, der nach Beendigung der Beleuchtung eintritt. Zu diesem Zeitpunkt ist die vorhandene Menge an natürlichem Licht oftmals völlig unzureichend. Zur Überbrückung dieser kritischen Stelle bieten sich 2 Möglichkeiten:

(1) Nach 2 Wochen ununterbrochener Beleuchtung wird die Dauer und die Stärke der Beleuchtung stufenweise verringert.

(2) Nach Beendigung der Beleuchtungsperiode wird öfters Zucker und Harnstoff zerstäubt.

Der Phosphormangel steht in Zusammenhang mit der niedrigen Bodentemperatur. Diese ihrerseits kommt von der geringen Lufttemperatur, die wegen der schwachen Lichtintensität so niedrig gehalten werden muss. Versuche mit radioaktivem Phosphor haben gezeigt, dass bei jeder Temperaturabnahme um 2 °C (im Bereich zwischen 12 °C und 18 °C) die Phosphoraufnahme um 50% zurückgeht. Zwei Möglichkeiten stehen zur Auswahl:

(1) Zusätzliche Phosphorgaben;

(2) Getrennte Erwärmung des Bodens mit elektrischem Strom.

LACK OF light during the raising-period in midwinter is a great problem in growing tomatoes for early cropping. In Holland raising of the plants is possible to some extent without the use of artificial illumination. In more northern countries however it is necessary to illuminate the plants artificially. In Holland special propagation-houses are being used more and more. These houses are situated in the direction East–West and have a steep slope on the southern side to get as much light as possible.

The Use of Artificial Illumination

The use of artificial illumination in practice is increasing gradually. As several difficulties occur, the results of irradiation are inconstant. The better the other growth-circumstances,

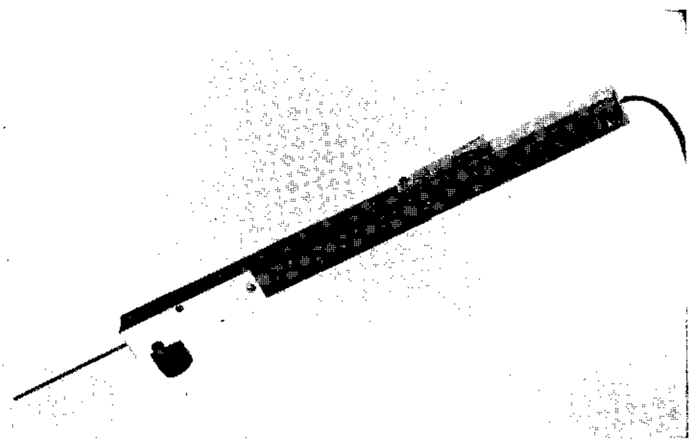

FIG. 1. Truss-vibrator

the better the results of illumination. The good results of the artificial illumination may be nullified by a check of growth, caused for instance by bad potting-soil, a too low soil-temperature, phosphorus-deficiency or planting out too old plants.

TABLE 1.
PRODUCTION OF TOMATOES (IN KG PER 16 PLANTS)

Treatment ↓	harvest-period	
	20/4–17/5 (early yield)	20/4–19/6 (total yield)
non-illuminated non-vibrated	15·0	61·5
illuminated non-vibrated	19·3	60·0
non-illuminated vibrated	20·4	65·6
illuminated vibrated	26·4	66·4

Only one example of the interaction between irradiation and other growth-circumstances will be mentioned here. In the experiment in question artificial illumination was combined with the use of a truss-vibrator from the U.S.A. With this apparatus (Fig. 1) all trusses are vibrated 2 or 3 times a week during the blossom-period in order to get a better pollination.

TABLE 2.
PRODUCTION OF TOMATOES (IN KG PER 16 PLANTS)

Treatment ↓		Harvest-period	
		8/5–11/6 (early yield)	8/5–9/7 (total yield)
Non-illuminated		26·9	72·3
Illuminated	16 hours 80 W/m^2	34·4	73·4
	2 weeks 24 hours 200 W/m^2 afterwards 16 hours 80 W/m^2	37·3	82·1

The use of the truss-vibrator has become a common practice in the Netherlands. From the figures in Table 1 it appears that the increasing of the early yield caused by artificial illumination was higher when the truss-vibrator was used too. On the other hand, the effect of the truss-vibrator on the yield was greater at the irradiated plants.

Although artificial illumination advances the crop, it appears from the same table, that the total yield is not higher. Undoubtedly this is connected with the fact, that after planting out in January the amount of daylight is insufficient and the growth of the plants is checked severely. To meet these difficulties there are two possibilities. Promising results have been obtained by a gradual diminishing of the illumination, coupled with an increase of the area needed, as the propagation-period proceeds. Table 2 shows the results of one of the experiments. The normal treatment, 16 hours 80 W/m^2 applied in practice up till now, gave a higher early yield but about the same total yield. The new treatment, consisting of a continuous illumination with 200 W/m^2, followed by 16 hours illumination with 80 W/m^2, not only advanced the yield, but also gave a higher total yield.

Spraying with Sugar + Urea

Another possibility to overcome the unfavourable period after planting out, is to spray the plants with a sugar + urea solution. In the first experiments plants were sprayed with a 10 per cent sugar-solution only. The harvest-period was however retarded instead of advanced, especially if sprayings were carried out frequently. As Table 3 shows, this retarding effect can be nullified by adding 0·5 per cent urea to the sugar solution. However in this experiment the total yield did not increase. It may be possible to get a higher total yield by spraying more than 4 times with sugar + urea solution.

FIG. 2. *Left:* 0·75% urea
Right: 0·75% urea + 10% sugar

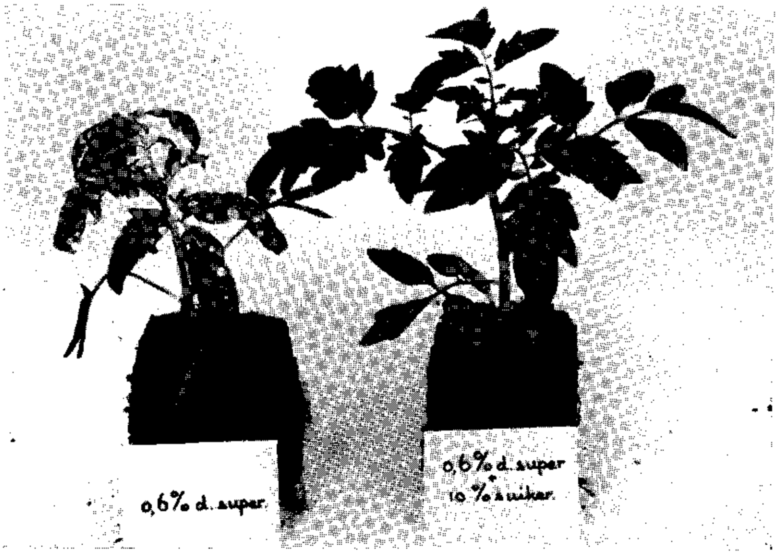

FIG 3. *Left:* 0·6% superphosphate
Right: 0·6% superphosphate + 10% sugar

FIG. 4. *Left:* 0·5% urea + 0·4% superphosphate
Right: 0·5% urea + 0·4% superphosphate + 10% sugar

The results of sugar + urea treatments are also inconstant. Several factors seem to influence the uptake. A high air-humidity is favourable, as the solution dries up less quickly and the sugar does not crystallise on the leaf-surface. The turgescency of the leaves is probably of more importance. There are indications, that spraying on less turgescent leaves (e.g. on a sunny day in the late afternoon) is most effective. In one of our experiments 50 per cent of the radiation of the sun was intercepted by shading with green plastic. At the shaded plants the spraying-treatments were ineffective (Table 4).

TABLE 3.
PRODUCTION OF TOMATOES (IN KG PER 16 PLANTS)

Treatment ↓	Harvest period	
	1/5–28/5 (early yield)	1/5–30/7 (total yield)
Untreated	16·8	61·4
4 times sprayed with sugar	15·6	59·9
4 times sprayed with sugar + urea	20·6	58·0

FIG. 5. Autoradiogram of tomato-plant 18 days after application of P32 (soil temperature 12 °C)

TABLE 4.
EARLY YIELD OF TOMATOES (IN KG PER 16 PLANTS)

Treatment→ ↓	untreated	4 times sprayed with sugar + urea
Shaded	37·6	36·6
Non-shaded	36·9	41·2

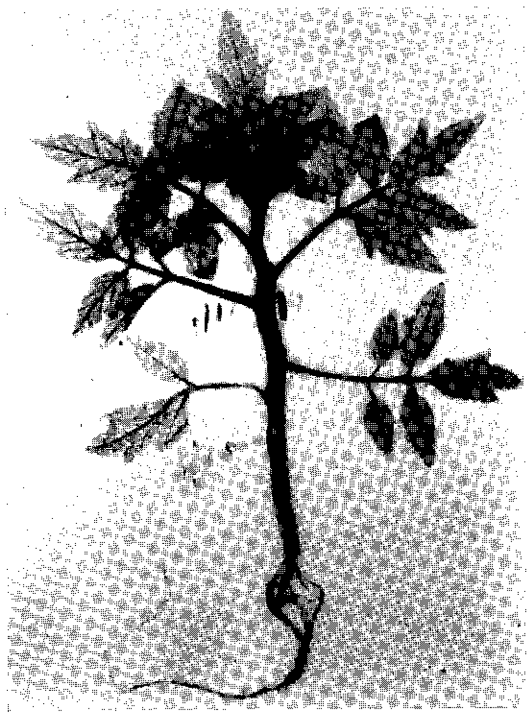

FIG. 6. Autoradiogram of tomato-plant 18 days after application of P32 (soil temperature 18 °C)

The sugar-sprayings have important by-effects. Damage caused by spraying with fertilizer-solutions can be avoided greatly by adding sugar. At the same time practically no visible residue remains on the leaves. In this way it is possible to spray the plants with high concentrations of urea and phosphate, as it is shown in the Figures 2, 3 and 4.

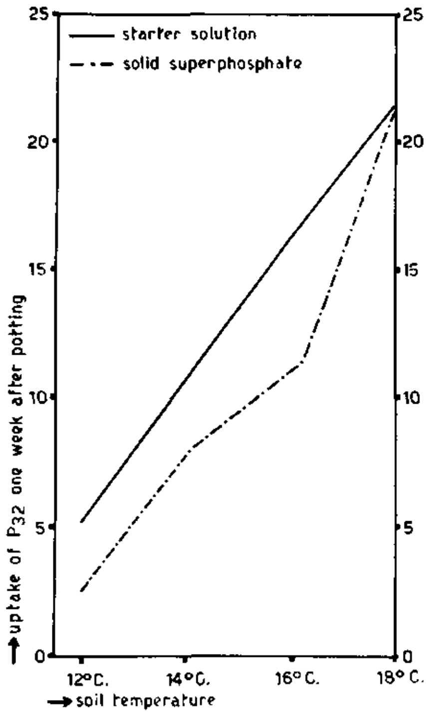

FIG. 7. Phosphate-uptake by young tomato-plants at different soil-temperatures

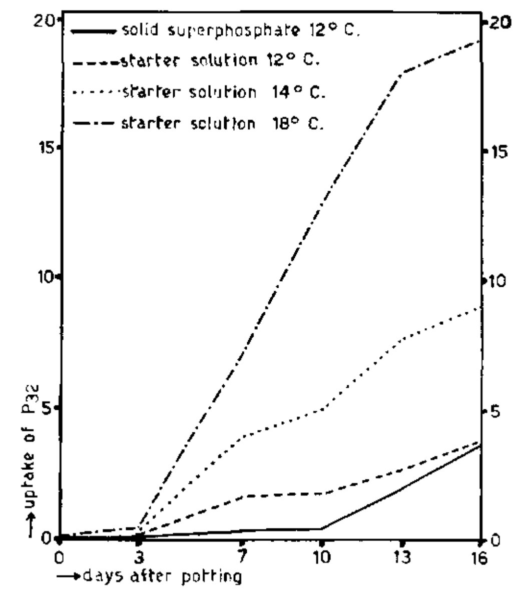

FIG. 8. Phosphate-uptake by young tomato-plants at different soil-temperatures

Soil-temperature and Phosphate-uptake

One of the main causes of a disappointing result of artificial illumination in practice is a too low soil-temperature combined with phosphorus deficiency. As the amount of light in winter is small one should keep the air temperature relatively low. Consequently the soil often stays too cold, e.g. 12–14 °C and sometimes still lower. The phosphate uptake is strongly checked then, especially a short time after transplanting, e.g. after pricking out, potting and planting out.

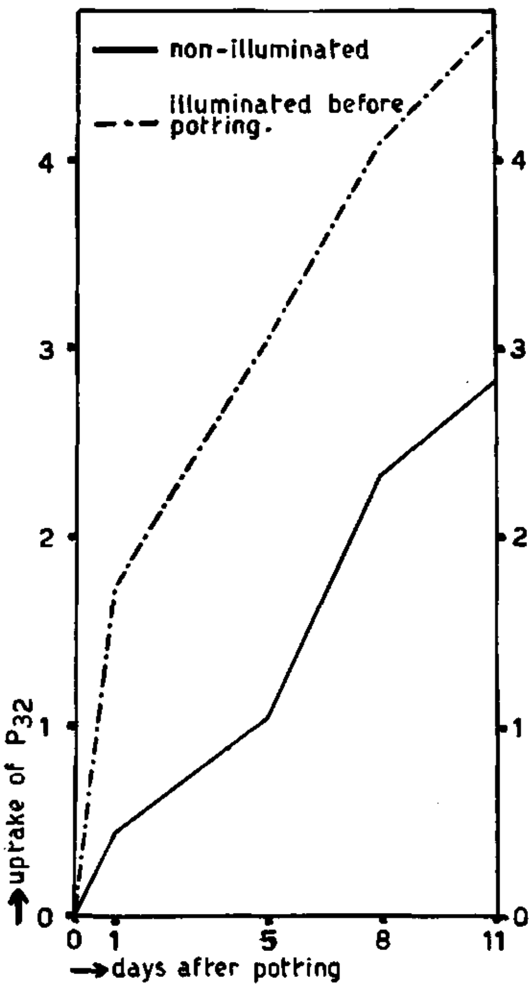

FIG. 9. Influence of artificial illumination on phosphate-uptake by young tomato plants

By using radioactive phosphorus (P32) the relation between soil temperature and phosphate uptake in the period immediately after potting has been studied. In the earlier experiments radioactivity was measured in the growing tops only; in later experiments this was done in all the leaves, while at this moment the total amount of P32 is analysed too. All methods give similar results. Auto-radiogrammes have been made to show the location of the P32.

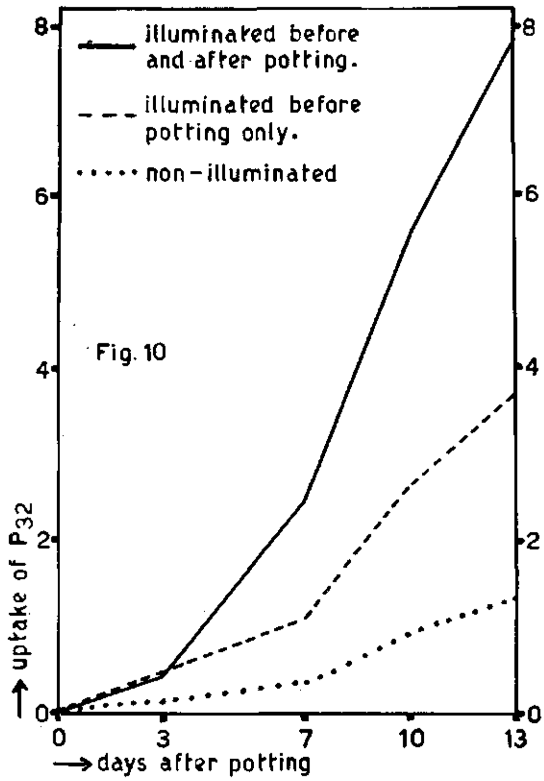

FIG. 10. Influence of artificial illumination of phosphate-uptake by young tomato-plants

The influence of the soil temperature between 12 and 18 °C is demonstrated clearly by Figs. 5, 6 and 7. By every 2 °C rise in temperature the phosphate uptake is nearly doubled during the first week after potting, at least when P32 is applied as solid superphosphate. A somewhat better uptake at low temperature can be obtained by applying the P32 as a starter solution (mono-ammoniumphosphate). The effect of soil temperature is also shown in Fig. 8, in which the curves of phosphate uptake from starter solution at different temperatures are drawn. At higher temperatures the phosphate uptake was much better.

Particularly in irradiated plants phosphorus deficiency often occurs. Probably these plants need more phosphorus because they grow quicker. Fig. 9 shows that the uptake of P32 is much quicker in plants that have been irradiated before potting than in the non-irradiated plants, provided that the soil temperature is high enough. They are able to do this because they have a more extended root system. If the plants are illuminated after potting too, the uptake of P32 may proceed still quicker after some days (Fig. 10).

A sufficiently high soil temperature (+16 °C) is however necessary. To realize this in Holland a separate system for soil heating is used more and more for the propagation of tomato plants in practice. This is also done for the propagation of non-irradiated plants. One has to take care that the soil temperature does not become too high. Therefore the best system of soil heating is an electric system, which can be controlled automatically. Sometimes a kind of wire-netting is used with a low-voltage transformer. With this automatic system too high soil temperature can be avoided easily.