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SHORT COMMUNICATION

Effect of steaming on yield and nutrient content of tomatoes grown in three substrates and on physical properties of the substrate

Summary

Steam sterilization increased the yield of tomatoes grown on peat over 3 years. The increase becomes more pronounced with time. The effect of steaming was greater in the summer crop which has a duration of 6 months than in the autumn crop which has a duration of 4 months. Similar yield patterns were evident in tomatoes grown in sand and soil. Manganese levels in the growing media and in the foliage rose as a result of steaming, but toxic levels were reached only in plants growing on steamed soil which caused yield reduction. Leaf nitrogen content was increased as a result of steaming. Steaming over three years did not cause a breakdown of the structure of the peat.

Introduction

Annual steam sterilization of glasshouse soil to reduce the incidence of pathogenic organisms is a common cultural practice resulting in increased yields. Peat has already been shown to be a suitable growing medium of plants [14]. However, it was not known what benefits or other effects steam sterilization might produce in peat especially over a longer period of time.

Materials and methods

The experiments occupied a north-south 100 × 30 ft glasshouse. Each plot consisted of a trough 24 feet long × 32 inches wide lined with 500 gauge polythene. After the first year the sides were raised to increase the depth of substrate from 6 to 12 inches. Two crops were grown each year. Cultural details have already been reported [15].

The treatments were combined in a 3 (substrate) × 2 (steaming) random factorial design with 4 replications. There were 32 plants per plot. The substrates were sphagnum moss peat, fine calcareous sand, and a medium loam. Before each crop half the plots were sterilised by introducing steam through drainage tiles in the bottom of each trough. The temperature in each substrate was raised to 100°C.

Soil samples were taken in May 1968 and September 1969 and analysed for 'available' manganese using ammonium dihydrogen phosphate as extractant[2].

Leaf samples were taken in June 1968 and June 1969 and analysed for manganese only in 1968 and manganese and nitrogen in 1969 on dry matter[2]. Undisturbed core samples in cylinders (vol. = 800 cc) were taken in November 1969 after crop removal and pore size distribution was studied.

Results

The results (Table 1) show that yield is increased by steam-sterilizing peat, except in autumn 1968, and that the increase becomes more pronounced with time. The effect was greater in the summer crop than in autumn and was as high as 29 tons over unsteamed in the 3rd year. The effect of steaming on the yield of tomatoes grown in sand and in soil was broadly similar to that obtained in peat. The yield of the summer crop growing in sand rose sharply in 1969. A severe decrease in yield in the steamed treatment on soil in 1969 reduced the apparent effectiveness of steaming.

Table 2 shows that the manganese levels in the foliage rose as a result of steaming the substrate. Steaming led to a 6- to 9-fold increase in the case of plants growing in soil, while there was a 2- and 3-fold increase in peat and sand respectively. Soil analysis taken during the autumn crop showed similar trends. Analysis of the foliage also showed increase of nitrogen as a result of steaming. In view of the fact that the steamed plots had higher fruit yields and correspondingly bigger foliage, the effect of steaming on N-uptake was probably greater than is evident from the data on N-content.

There was hardly any effect on the total pore space in peat, sand and soil as a result of steaming (Table 3). Pores greater than 22 μ were significantly increased as a result of steaming peat and soil, but in the case of sand there was no effect.

Discussion

The results show that although fairly high yields are possible in unsteamed peat for 2 years a certain advantage may be gained by steaming peat even during this period. In the third year it is essential to steam peat and this

TABLE 1

Effect of steaming on yield * (tons per acre) of tomatoes

Substrate	1967		1968		1969	
	Spring	Autumn	Spring	Autumn	Spring	Autumn
Peat	54.1 (109.7)	28.3 (102.9)	53.9 (114.2)	26.5 (93.0)	48.1 (169.8)	38.7 (140.9)
Sand	39.3 (99.5)	29.8 (118.3)	34.1 (115.6)	23.6 (111.8)	51.4 (138.2)	23.0 (112.7)
Soil	29.6 (101.1)	28.4 (111.8)	46.7 (160.5)	28.1 (101.4)	36.3 (121.4)	22.6 (113.6)
F – test (steaming)	NS	**	***	NS	***	***
S.E.	0.8	0.7	1.0	1.4	1.5	1.2

* Figures in parenthesis give the yield of the steamed treatment as a percentage of the unsteamed treatment.

TABLE 2

Effect of steaming on manganese and nitrogen content

Substrate		Soil		Foliage		
		1968	1969	1968	1969	
		Mn*	Mn*	Mn**	Mn**	N†
Peat	Unsteamed	6	11	202	195	3.71
	Steamed	10	14	202	195	3.71
Sand	Unsteamed	3	42	112	105	4.15
	Steamed	6	45	390	280	4.68
Soil	Unsteamed	4	45	117	117	4.07
	Steamed	31	100	640	922	4.16
F – test (steaming)		***	***	***	***	N.S.
S.E.		1.56	2.11	29.2	49.5	0.12
F – test (substrate)		***	***	N.S.	***	N.S.
S.E.		1.91	2.58	35.7	60.6	0.15
F – test (substrate × steaming)		***	***	*	**	N.S.
S.E.		2.70	3.65	50.6	85.8	0.21

* ppm air dry soil ** ppm dry matter † % dry matter

TABLE 3

Effect of steaming on pore-size distribution

Substrate		Total pores (%)	Pores > 22μ (%)
Soil	Unsteamed	64.6	28.9
	Steamed	65.7	34.4
Sand	Unsteamed	58.6	41.5
	Unsteamed	56.5	40.0
Peat	Unsteamed	93.6	52.1
	Steamed	94.5	58.7
F – Test (steaming)		NS	**
S.E.		1.10	1.34

applied even for the short season autumn crop. The increase in yield in the third year in both steamed and unsteamed treatment in sand was due to the higher application of organic matter with consequent improvement in its physical and chemical properties. The advantage of steaming soil was self evident except during the first experiment when all substrates were free from pathogens. There was a marked response in the second year, but a decrease

in yield of the steamed treatment produced a lesser effect in the third year. This decrease was probably caused by manganese toxicity.

Steaming increases the availability of manganese. This increase of availability occurs not only in the case of native manganese as in the case of soil and sand, but also of the manganese sulphate added as fertilizer [12]. This increase of availability of fertilizer manganese is not only due to the reducing and heating action of steam, but also due to chelating properties of easily decomposable organic matter as a result of steaming [10]. The peat and sand 'available' manganese levels and the foliage levels although increasing do not approach levels which would be considered toxic. However, in the case of soil these readings approach the critical threshold values [16]. The foliage levels recorded in steamed soil in 1969 (920) ppm were much higher than those recorded in 1968 (640 ppm) and indicate a cumulative effect of successive steaming on manganese availability.

The increase in the nitrogen content of the foliage noted on all substrates is due to the liberation of mineral nitrogen as a result of steaming [13 7]. Mineralisation can lead to an increase of nitrogen in the foliage [6], and lead to a higher nitrogen uptake [9]. The present data do not permit a differentiation of various substrates on the basis of nitrogen content of the foliage.

The physical analysis data shown that steaming had a favourable effect on the permeability of peat and soil and consequently on drainage, but had no effect on sand. An improvement in drainage and aeration in the case of heavy soils as a result of steaming has been recorded by Baker and Roistacher [1]. These results are however, in contradiction to those reported by Herzog [5], who found a deleterious effect on soil structure as a result of steaming. She worked on heavy soils with low humus content, while in this case the soil was loamy with a high humus content. In the present experiment the water holding capacity of the soil and peat has been reduced by steaming and this agrees with the results of Pickering [11] and Malownay and Newton [8]. The fear that the structure of the peat may breakdown as a result of successive steaming has been shown to be groundless over three years. On the other hand the advantage resulting from increased aeration or the disadvantage of lower water holding capacity would not be significant since the physical conditions in the substrates were near optimum.

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