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The influence of soil steaming on some properties of the soil and on the growth and heading of winter glasshouse lettuce II. The reaction of the crop

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Summary

The total growth of lettuce on steamed soil in a pot experiment was found to be improved due to an enhanced supply of nutrients. The plants had higher N and considerably higher Mn contents. Of the additional treatments leaching depressed yield and N uptake in plants on steamed soil, but caused an increased Mn content. The quantity of straw applied proved too small to influence growth and N uptake of the plants on steamed soil; however, it reduced the Mn content of the plants. Leaf-margin necrosis and bad heading were more serious in plants on steamed soil.

Introduction

The initial growth of plants on recently steamed soil may be hampered by toxic compounds, arising from organic matter during steaming. The plant roots are often found to be affected (Richter, 1896; Dietrich, 1903; Schulze, 1907; Koch and Lüken, 1907; Pickering, 1908; Russell and Golding, 1912; Russell and Petherbridge, 1913). Later on, when the adverse conditions have been overcome, the plants recover and often show an even unusually luxurious growth and high yields. This abundant growth is due to a rich supply with plant nutrients, owing to an accelerated decomposition of organic matter after steaming. Not all plants react in the same way on the conditions in the steamed soil. Grasses, and Gramineae in general, are found to be tolerant and to thrive even immediately after steaming (Schulze, 1907; Pickering, 1910; Robinson, 1944); moderately sensitive are buckwheat and peas according to Dietrich (1903) and Schulze (1907), and tomato, barley and maize according to Robinson (1944). As sensitive plants are regarded mustard (Dietrich, 1903; Schulze, 1907), and leguminous plants (Darbyshire and Russell, 1908), clover being mentioned by Robinson (1944) and *Trifolium subterraneum* by Rovira and Bowen (1966).

The development of winter lettuce on steamed soil is as a rule less satisfactory. After an initial good growth of the lettuce (planted with a pressed clod of soil-mix) a stagnation of the growth may occur and a correct heading may fail to develop, leading to the formation of a more or less hollow and relatively long head, which is generally only loosely or not at all closed on its top (called a 'tulip'). The formation of this 'tulip'-type in winter lettuce occurs also on not steamed soil, but is considerably promoted by steaming. This experiment was performed to compare some characteristics of lettuce plants grown in steamed and not steamed soil in order to get, in combination with the results of the chemical soil investigation, more information about the probable causes of bad heading in winter lettuce.

The materials and methods applied are described in Part I of this series.[1] There we reported already on chemical changes occurring in soil in relation to steaming and some additional treatments.

Results

In Fig. 1 are compared some data on the yield and the composition of lettuce plants grown on steamed and not steamed soil.

Fresh weight and dry weight of the plants reach the highest values in the plants grown on steamed soil. Leaching had a depressing effect by the removal of nutrients. The addition of straw reduced fresh and dry weight of the plants grown on the not steamed soil. The nitrogen percentage was higher in the plants on the steamed than

[1] *Neth. J. agric. Sci.* 17 (1969) 143–152.

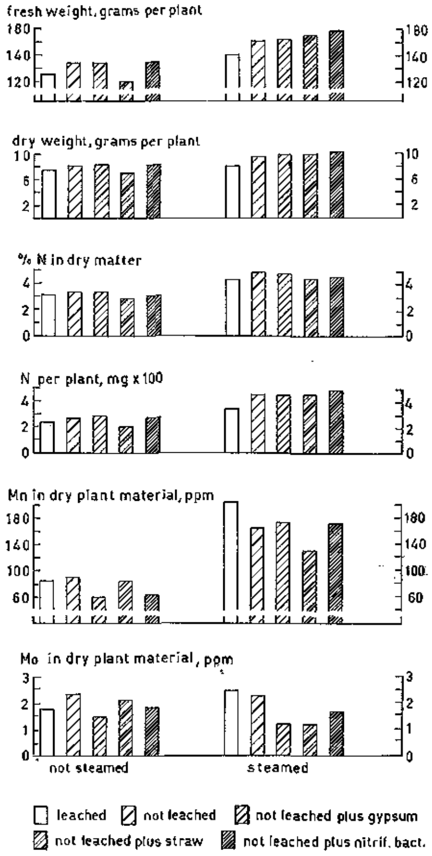

Fig. 1 Characteristics of lettuce plants grown on steamed and not steamed soil in relation to the different treatments

in those on the not steamed soil. The quantity of nitrogen per plant amounted in the plants grown in steamed and in not steamed soil to 340–480 and 200–280 mg N, respectively. This difference in nitrogen uptake is the result of liberation of ammonia during steaming and of a higher nitrogen mineralization in the steamed soil (see Part I, Fig. 1). Leaching had a depressing effect. The straw addition to the not steamed soil caused a nitrogen immobilization, leading to a decreased nitrogen uptake of 40–80 mg N per plant. In steamed soil the nitrogen immobilization did not influence plant growth and nitrogen uptake. Apparently the fixation of nitrogen by the straw was not enough to bring about a shortage in the NH_4-rich steamed soil. A larger gift of straw, leading to a higher C/N ratio (about 40), would have better compensated the nitrogen excess.

The manganese content of the plants grown on steamed soil was substantially higher than that of the plants grown on not steamed soil. Leaching caused a further increase of the Mn content, as it enhanced the availability of Mn in the soil (see Part I, Fig. 2). The addition of straw to steamed soil had a decreasing effect on the Mn content, reducing the available Mn in the soil. The Mn content of these plants, however, is still 40–50 ppm higher than that of the plants on the not steamed soil. The higher Mn content in plants grown on steamed soil was observed already by Darbyshire and Russell (1908) and was after that perceived repeatedly by other investigators, especially in connection with manganese toxicity.

The molybdenum content of the plants was 1–3 ppm and seemed not to be influenced by steaming in this experiment.

Besides the above-mentioned differences, the plants grown on steamed soil showed in comparison with those from fresh soil a darker green colour of the leaves, a more frequent occurrence of leaf margin necrosis and a more frequent bad heading. Fig. 2 presents data on 'tulip formation' and leaf margin necrosis. Both characteristics depress the marketing quality of the lettuce severely. Leaching of steamed soil seems to reduce the 'tulip formation'. This is caused, however, by a less luxurious development of these plants since nutrients are removed by leaching. Something similar can be observed when straw is added to unsteamed soil.

The leaf margin necrosis of the plants did not show differences under the influence of the additional treatments within the groups steamed or not steamed soil.

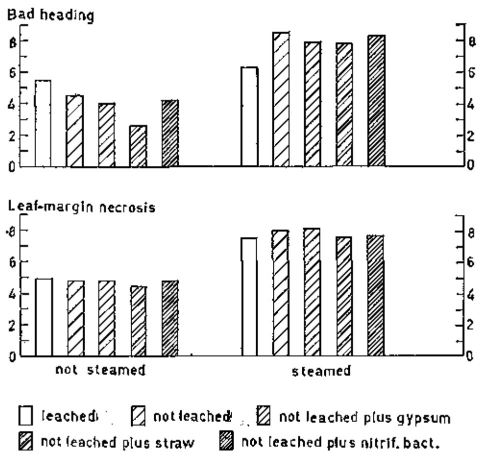

Fig. 2 Bad heading and leaf-margin necrosis measured according to a visual scale

Discussion

A higher yield of plants grown on steamed soil is regularly observed, when no severe toxicity occurs (Dietrich, 1903; Schulze, 1907; Koch and Lüken, 1907; Darbyshire and Russell, 1908; Pickering, 1910; Russell and Petherbridge, 1913; Herzog, 1939; Millikan, 1942; Davies and Owen, 1951; Strømme, 1955, 1962; Sonneveld, 1963; Howlett, 1964). This is not only due to an enhanced supply of nitrogen but also of other nutrients. Darbyshire and Russell (1908) observed a higher uptake of N, P and K. Millikan (1942) found higher amounts of P_2O_5, K_2O, Zn, Mn and N in wheat grown on steamed soil, but observed lower CaO and SiO_2 contents. Inoculation of steamed soil with an infusate of fresh soil depressed the contents of these nutrients in the plants, accelerating the competition of the rapidly developing microbe population.

The most striking changes in the properties of the soil after steaming are: (1) the augmentation of soluble salts and organic matter; (2) the enhancement of available nitrogen as NH_4-N and an extended nitrification lag; and (3) the increase of the available manganese content. Leaf margin necrosis is often ascribed to too high amounts of soluble salts in the soil. But although leaching diminished the total amounts of soluble salts in the soil (see Part I, Fig. 2), no favourable effect of leaching on the necrosis could be traced. The excess of NH_4-N in the soil after steaming may lead to a relative Ca shortage in the leaf and so cause the necrosis.

The growth stagnation, often observed in winter lettuce on steamed soil, may be caused by a temporary accumulation of nitrite in the soil (see also Part I).

Lettuce is very sensitive towards nitrite and the growth can be inhibited as long as nitrite is present (Paul and Polle, 1965).

It is a general grower's experience that in winters with bright freezing weather the heading is considerably better than in relatively dark and rainy winters. Consequently, it seems that unfavourable soil conditions together with low light intensities and short days promote the bad heading.

To further a better insight in the influence of the nitrogen form and of the manganese concentration on the growth and head formation in winter lettuce, greenhouse experiments are planned, using NH_4-N versus NO_3-N and enhanced versus normal manganese concentrations in sand cultures under normal and reduced light conditions.

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