Case Report
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Do mineral fertilisers have a deleterious effect on soil fertility? – case report

Abstract

In the present case study, the aim is to show an example of the effect on residual fertility parameters (particularly with regard to the re-sprouting of plants after the harvesting of the aerial part), taken from a pot experiment, where modalities without fertilization, with mineral fertilization, with organic fertilization and with mixed fertilization were contrasted. Within this context it is possible to conclude the following: Mineral fertilization, alone, leads to a drastic inhibition of plant re-sprouting, that even in mixed fertilization situations (mineral + organic) it is considerable; in terms of residual microbiological activity, this phenomenon seems to be better correlated with reduced dehydrogenase activity than with β-Glucosidase activity.

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Introduction

The resilience of soil fertility, to enable food security for an exponentially growing world population, is among the serious and justified concerns of mankind today.[1] With the optimistic prospects of the "green revolution" having been dashed – by ignoring the harmful consequences of mineral fertilizers on residual soil fertility, when overused or misused, and the prospects of the "Malthusian trap" continuing in much of the developing world - there has been an increased focus on organic fertilizers as a possible mitigation of the environmental footprint and greenhouse effect resulting from agricultural activity. In this sense, and given the controversy of myths regarding organic or mineral fertilization,[2] new technologies have been developed to improve organic fertilizers, in order to set them free from the burden of their environmental footprint and to reduce or eliminate the need for mineral fertilizers. Despite progress already achieved through increased research and experimental development in this area,[3] triggered in particular by the need to promote the innocuous disposal of organic waste that is being produced in overwhelming proportion, justified doubts remain about the possibility of total replacement of mineral fertilizers without affecting agricultural productivity levels compatible with the scale to be expected for long term global needs. In the present case study, without doctrinal prejudices on the use of chemical fertilizers, but with a view to a scale of production compatible with the current and prospective global needs of agricultural production, the aim is to show an illustration of the effect on plant regrowth after the aerial part has been harvested, taken from a pot experiment,[4] where modalities without fertilization, with mineral fertilization, with organic fertilization and with mixed fertilization were contrasted.

The background

The present case study is based on a pot experiment with lettuce (*Lactuca sativa* L. var. Crispa) in Haplic Fluvisol (ISSS-ISRIC-FAO, 2006) mixed with perlite, in a proportion of 4:1 respectively, and fertilized with a biodigested by the larvae of the black soldier fly (BSFL) - opportunely reported.[4] The mineral fertilizer used was Foskasuper®, considering 100% of the expected N requirement. Entomocompost was produced by Entogreen® and resulted from the black soldier fly larvae (BSFL) digestion of agro-industrial by-products (from potato and onion), without any stabilizers or preservatives added, and in accordance with the Portuguese legislation.[6] The treatments, with five replications, were as follows: **T0**, control without fertilization; **TM**, mineral (100% N); **T50**, organic (50% N); **T100**, organic (100% N); **T150**, organic (150% N); and **Tmix**, mixed (100% N - 33.3% mineral N plus 66.6% organic N). The results assessed for the aerial biomass fresh weight and dry weight production per pot did not reveal any statistical significance between TM (162.5 g) and Tmix (144.5 g), which differed by a statistically significant margin from the remaining treatments (21.2 g). The vegetative aspect verified for the different treatments, immediately before the harvesting of the aerial part, was that shown in Figure 1.

Figure 1 Appearance of the experiment immediately prior to harvesting the aerial part.

From left to right: **T0, TM**, **T50**, **T100**, **T150** and **Tmix**

The case

After harvesting the aerial part of the plants, to evaluate their production and chemical composition, the experimental display was not changed in its positional arrangement, and after seven days without irrigation the aspect of the test was as shown in Figure 2.

Figure 2 Aspect of the experiment seven days, without irrigation, after the harvesting of the aerial part of the plants.

From left to right: **T0, TM**, **T50**, **T100**, **T150** and **Tmix**

Discussion

The results, previously evaluated for production,[4] had revealed no significance between TM and Tmix, as well as for the other treatments among themselves, the results between these two groups being significantly different, which was already to be expected from what can be seen in Figure 1. This endorses the thesis that, as far as biomass production is concerned, and in the experimental situation in question, organic fertilization alone does not compete with exclusively mineral fertilization, as far as immediate soil fertility for the crop in question is concerned, unless adequately supplemented with the latter. Even in this last situation, although the productions in TM and Tmix did not allowed us to reject the null hypothesis that they are equal, the results shown, when comparing the two figures, were not particularly convincing; thus, in underestimating the statistical evidence, one of the most plausible conclusions would be that the 33% contribution of mineral fertilization was not enough. This proportion of mineral fertilizer is far from that suggested by Timsina[2] which can be around 75%. However, it should be noted, that in the reference trial we were dealing with a short-lived crop and the mineralization of nutrients from the organic fertilizer is a slow process. With regard to the pH (H_2O) of the soil after harvest, as shown in the reference study,[4] the beneficial effect of the crop in raising the pH was significant, except for the treatment with exclusively mineral fertilization, which however did not differ from the initial soil value. With regard to the residual OM content after harvest, the positive difference was significant for the T100, T150 and Tmix treatments (23 g kg^{-1}), in relation to T0 and TM (18 g kg^{-1}). Note, however, that if we compare the residual OM contents recorded for T50 and Tmix, whose initial contents were little divergent (respectively 50% and 66%), we can infer that the effect of the mineral fertilizer in the mixture with the organic fertilizer, was positive (possibly synergetic) with respect to the conservation of OM. With regard to microbial activity, based on the dehydrogenase activity, further considerations merit the following comments:

I. The treatment with exclusively mineral fertilization (TM) proved, on average (1.30 µg TFF/g/h), to be the treatment least propitious to soil dehydrogenase activity, although by differences for the T0, T50 and Tmix treatments not statistically significant - this is in line with the drastic effect of mineral fertilization on plant re-sprouting seen for TM, and also evident for Tmix (2.96 µg TFF/g/h), as depicted in Figure 2;

II. On the other hand, treatments T100 (3.15 µg TFF/g/h) and T150 (5.18 µg TFF/g/h) showed, in a statistically significant way, to be the most favorable to the increase of the dehydrogenase activity - notwithstanding the fact of no statistical difference from each other, the effect was, on average, remarkably higher for the higher contents of organic N of T150 - which is also evidenced in Figure 2;

III. When comparing T50 (2.88 µg TFF/g/h) with Tmix (with respectively 50% and 66% organic N), although the result refers to treatments with similar endowments of organic fertilizers, a deleterious effect of mineral fertilizers on dehydrogenase activity is not perceptible, however the effect on plant re-sprouting is quite evident in Figure 2.

With regard to β-Glucosidase activity, we think it is relevant to point out the following facts:

I. Contrary to what was suggested for dehydrogenase activity, the treatment with exclusively mineral fertilization did not show a detrimental behavior for soil β-glucosidase activity - it seems therefore that the negative effect on plant re-sprouting seen for Tm and Tmix could not be justified here;

II. As with dehydrogenase activity, organic fertilization promotes a marked improvement in β-Glucosidase activity, and mineral fertilization does not negatively interfere with the improvement provided by organic fertilization;

III. β-Glucosidase activity was significantly higher for treatments T100, T150 and Tmix (86.44 µg PNG/g/h) in relation to TM (61.95 µg PNG/g/h) and T0 (54.79 µg PNG/g/h).

These results were in accordance with the fact, already well known,[6,7] of the enhancement of the microbial activity with the application of organic fertilizers. However, they do not justify the notorious effect of the mineral fertilizer on the re-sprouting of plants, as can be seen when comparing, in Figure 2, TM with T0 or Tmix.

Conclusion

In the context of the specific constraints that inform the present case study - as above reported - the information on the comparison of exclusively mineral fertilization with exclusively organic fertilization, mixed fertilization (mineral + organic) and the control without fertilization, with regard to the residual fertility of the soil seven days after harvesting, the following conclusions are considered relevant:

I. Mineral fertilization alone leads to a drastic inhibition of plant re-sprouting, that even in mixed fertilization situations (mineral + organic) it is considerable;

II. Residual organic matter seems to be better correlated with dehydrogenase activity than with β-Glucosidase activity;

III. The potential of organic fertilizer, in the immediate fertilization of crops, can only be seen to be positive when used in a mixed fertilization system, in a proportion greater than that adopted in the experimental trial that informed the present case study.

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None.

Conflicts of interest

The author declares there is no conflict of interest.

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