Opportunities and challenges of wastewater bio-based fertilizers application on vegetable crops

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Introduction

The high growth rate of world population and relative consumption demand is putting significant pressure on the food industry at different levels to multiply its production capacity. To meet this food demand, an increase of the already intensive agricultural practices is required, leading to a high land, water, energy, fertilisers and pesticides use. Therefore, the request for effective and high-performance fertilizers is expected to reach unprecedent levels. Wastewater streams are considered a promising resource to mitigate the soil nutrient imbalance and to recover nutrients for agriculture. Bio-based fertilizers from waste streams can provide nutrients and also protect crops from diseases (De Corato *et al* 2018). The European project "WalNUT" aims to close the waste water cycles for nutrient recovery. The aim of this study was to evaluate and compare different bio-based fertilizers, produced starting from waste water streams and brine, on development and health of vegetable crops in greenhouse and in open field conditions, outlining opportunities and challenges.

Material and methods

The following bio-based fertilizers were considered: a microalgae based fertilizer from industrial wastewater; ammonium sulphate and nitrate from municipal wastewater; fermented biochar from dairy wastewater (BIO-NPK-C); micronutrients from seawater desalination brine; ammonium nitrate from sewage sludge.

A first set of trials were carried out on potted plants in the Agroinnova's greenhouse, Largo Paolo Braccini 2, in Grugliasco (TO), Italy. The fertilizers were tested at three different dosages on tomato and lettuce cultivated in pots: low, corresponding to 85 kg*ha-1 N, 40 kg*ha^{-1} $P_2 0_5$, 100 kg*ha^{-1} K_2O; medium, 170 kg*ha^{-1} N, 80 kg*ha^{-1} $P_2 0_5$, 100 kg*ha^{-1} K_2O; high, 340 kg*ha^{-1} N, 160 kg*ha^{-1} $P_2 0_5$, 100kg/ha K_2O. One plant was transplanted in each 2 L pot and five pots were considered for each treatment. Five replications were considered for each treatment and each trial was repeated twice. The pots were disposed in randomized blocks. The fertilizers were applied and mixed to the growing media (peat) before transplanting. A second round of trials was carried by inoculating the growing media with plant pathogens (*Fusarium oxysporum*) before transplanting. Assessments were made on different parameters including chlorophyll content index, fresh biomass and disease severity for all the crops tested.

Experimental field trials were carried out in two farms in 2024. The bio-based fertilizers were applied at 10 kg*ha^{-1} of N, 10 kg*ha^{-1} of P_2O_5 and compared to untreated control and a control with mineral fertilizers. The plots were disposed in randomized blocks. The experimental field was about 1000 m^2 with 2.5 tomato plants or 14 lettuce plants for m^2 as planting density. Four replications were considered for each treatment. The fertilizers were applied in nursery at sowing (1% v/v) and before transplanting directly in the planting hole. Assessments were made on crop development, yields, chlorophyll content index, incidence and severity of plant diseases.

Results and discussion

Bio-based fertilizers showed an increase in plant height and biomass of potted plants compared to untreated control. However in some cases higher dosages reduced crop development. Positive effects were observed in the reduction of Fusarium wilt by bio-based fertilizers. In field trials, no significant differences were found between the bio-based fertilizers and the mineral fertilization control in terms of yields. However, the seedlings treated in nursery were significantly more vigorous and resulted in a significantly higher development index than the controls, confirming results observed in pot trials. A significant reduction of root diseases was also observed on plants treated with bio-based fertilizers and mineral fertilizers compared to untreated control (Table 1).

Table 1. Efficacy of bio-based fertilizers on tomato in field trial (Italy, 2024).

Thesis	Yields (t*ha^{-1})	Development index (1-4)	Chlorophyll content index	% diseased roots
Untreated control	99	2.8 b*	51 ab	22 b
Control (mineral fertilizers)	120	2.4 c	50 b	9 a
BIO-NPK-C (nursery)	118	3.1 ab	53 ab	10 a
BIO-NPK-C (nursery + field)	113	3.2 a	54 a	12 a

*Tukey post-hoc test (p-value < 0,05). Different letters correspond to statistically significant differences.

Conclusion

This study shows the potential application and challenges of bio-based fertilizers from wastewater streams. The tested bio-based fertilizers can substitute, at least partially, mineral fertilization both on potted plants and in soil. However, the mode of application and the dosages can have different effects on vegetable crops, and a higher supply of fertilizer does not always correspond to higher yields. In the future, new field experiments will be conducted and microbiome analysis by using 16S and 18S metabarcoding approaches will also be considered in order to understand potential impacts at soil and rhizosphere level of bio-based fertilizers.

References

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