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Impacts of vermicast on commercially grown onion crop yield

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Abstract
In a time where food production is adequate, but distribution is poor, there is a need for increased food production. This, however, can clash with environmental health. This manuscript includes preliminary results for a pilot trial investigating the impacts of vermicast derived from industrial organic wastes on commercially grown onions. Vermicast had a significant impact on the fresh mass of 5-month-old onions, demonstrating that organic waste can be (diverted from landfill) and recycled to benefit food production.

Keywords
Vermicast, onion crop yield, commercial market garden

Introduction
Global food production is sufficient to meet the energy needs of the current and growing population (Fraser et al., 2016). Unfortunately, food production and distribution systems are inefficient, which has led to globally unequal distribution of food per capita (Mc Carthy et al., 2018). Putting the issue of distribution aside, it cannot be assumed that food production will remain sufficient for a growing population under the threat of climate change (Foley et al., 2011). Therefore, efforts to meet the food energy demands of a growing population should include (i) improving availability e.g. via efficient distribution and reduced waste, and (ii) increasing total food production and farm system resilience (Foley et al., 2011; Fraser et al., 2016). In addition, and quite importantly, environmental health needs to be an integral part of future food production. Climate change has already impacted food production (FAO, 2021) and preparations need to be made to meet the challenges these changes pose.

Cropping using conventional methods involves substantial quantities of fertiliser, results in losses of soil carbon, soil health and excess nutrients (Edmeades, 2003; Turmel et al., 2015). Vermicast (worm castings) is known for its value as a soil conditioner and plant growth stimulant (Blouin et al., 2019), but has only recently started to see large scale applications in agriculture in New Zealand. Literature regarding the environmental impact of large-scale vermicomposting and application to agricultural land is lacking.

A meta-analysis by Blouin et al. (2019) found significant improvement in commercial yield (26%), shoot (+78%), root (+27%) and total plant (13%) biomass when vermicast was applied. The study investigated subgroups such as dose of vermicast, combination with mineral fertiliser, plant functional groups, material vermicomposted and growing environment. In almost all cases, vermicast had a positive effect on plant production.

This study includes preliminary results from a pilot trial investigating the impact of vermicast on the yield of a commercially grown onion crop.

Hypothesis

Application of vermicast will significantly increase harvestable fresh plant biomass of commercially cultivated red onions.

Methods

The pilot trial was begun in October 2021, three months after the onion crop was sown. The vermicast applied to onion seedlings was derived from dissolved air flotation (DAF) sludge from a milk plant and pulp fibre from a pulp mill. It was hand-applied at rates of 0, 6.25, 12.5, 25, 37.5 and 50 t FM ha^{-1} to commercially grown red onions in Matamata (37°47'34.5"S 175°46'28.5"E). Generally, MyNoke's recommended vermicast application rates are 10 to 20 t FM/ha though this can be higher or lower depending on the crop, management and soil fertility. Each treatment was replicated four times and treatment location was randomised within a 6x4 randomised block design where each treatment was replicated in rows running perpendicular to the direction onion beds had been sown. The trial was ~1,000 m^2. Each plot was 42 m^2 (including a 1 m buffer around each side of each plot) and there were four individual onion beds within each plot. The onion beds were continuous throughout columns (Figure 1). Soil samples were taken before vermicast application and at the final harvest. The plots were subject to the same fertiliser and pest control (spray) regimes as the non-trial crop. In December, (2 months after vermicast application, at 5 months age) 0.44 m^2 areas (subplots) of each plot were harvested for total harvestable fresh matter measurements. At this stage, the onion plants were beginning to form bulbs. An analysis of variance was run on the December harvest data with soil pH as a covariate.

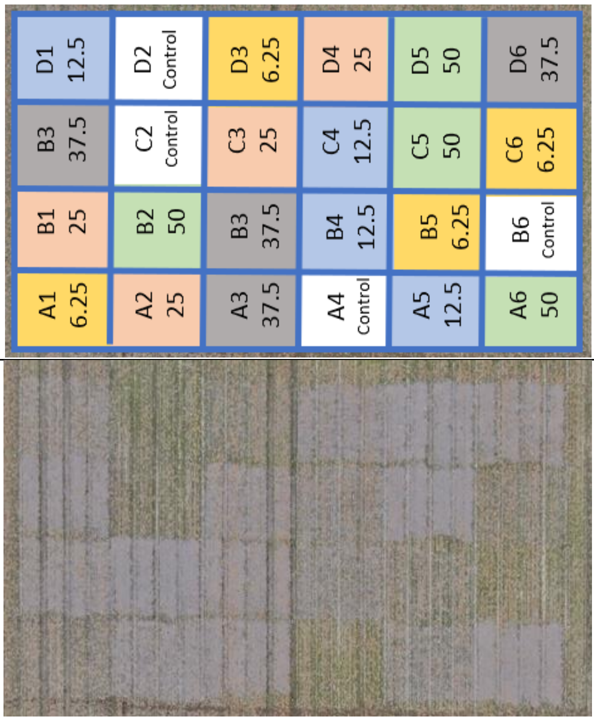

Figure 1: Onion trial layout. Top left are the treatments corresponding to plots visible as patches in the aerial image (Left). Image taken after vermicast application in October 2021. Top right shows orientation of columns (1-6) and rows (A-D).

Results and Discussion

The trial was located where soils were expected to be homogeneous. However, baseline soil samples taken at the beginning of the trial, but analysed after treatments had been applied showed that plots in Column 5 had notably lower soil fertility results for Olsen P, pH, Ca, CEC, Mg and K than Columns 1-4 and 6 (Figure 2). Results of sampling in December indicated notable underperformance in Column 5 compared to the remaining columns. Soil fertility (namely pH) may have been the main factor affecting the performance of this column although seed sowing depth may have also had an impact. In hindsight, the plots should have been oriented 90 deg to ensure that each treatment was represented in each column, rather than each row to mitigate the potential impact of seed sowing depth.

There appeared to be a slight increasing trend in onion plant fresh mass with increasing vermicast (Figure 3), though this trend was not statistically significant. However, when soil pH was included in an ANOVA as a covariate Figure 4, vermicast treatments of 25, 37.5 and 50 t FM/ha became statistically significant to the Control ($P<0.05$).
The number of onion plants per subplot was not significantly different between treatments (results not displayed).

Other trends that were noted were: (i) notable differences in performance between the four onion beds within plots which may have been due to uneven seed sowing depths and/or soil fertility. As soil samples were taken across beds within each plot, it was not possible to determine the cause of this within-plot variation, and (ii) less variation in the control onions compared to those treated with vermicast Figure 3.

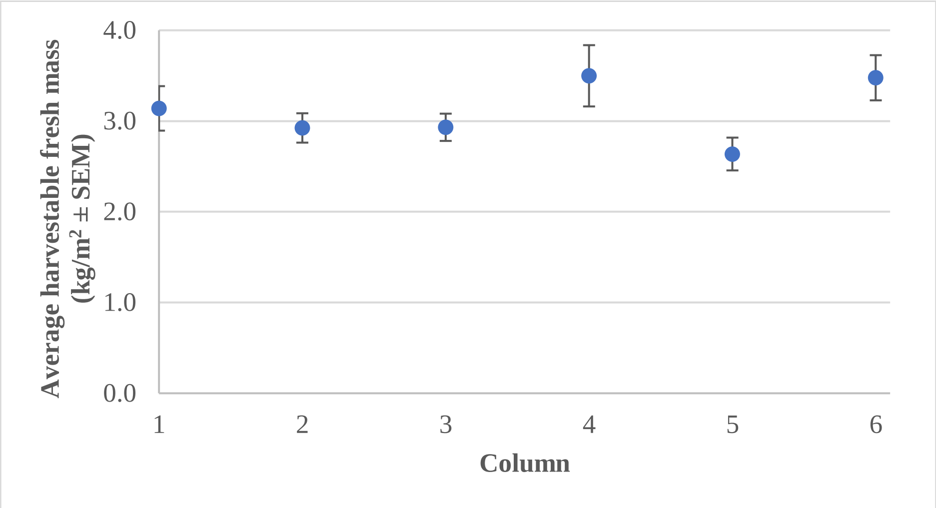

Figure 2: Effect of column on harvestable fresh onion mass. SEM = standard error of the mean.

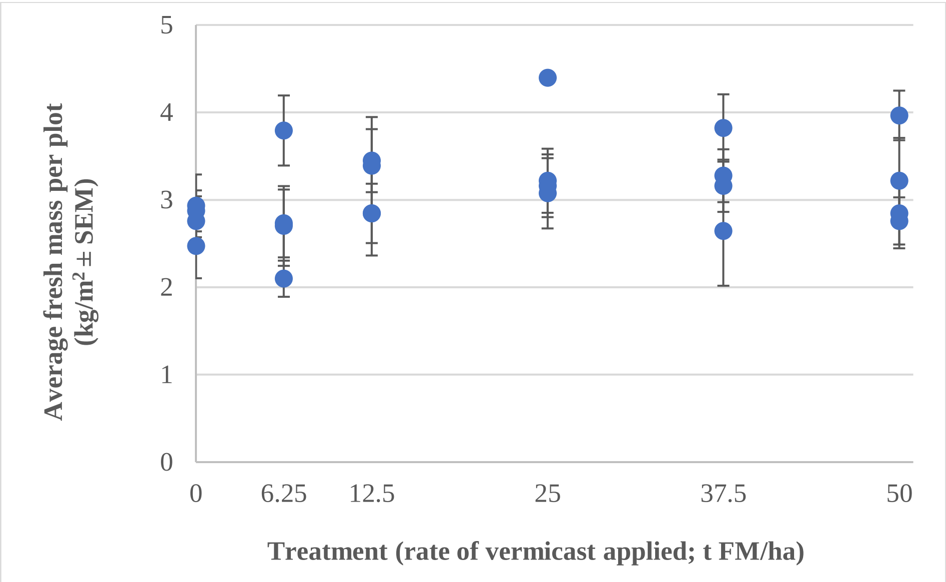

Figure 3:Average harvestable fresh onion mass per plot. SEM = standard error of the mean.

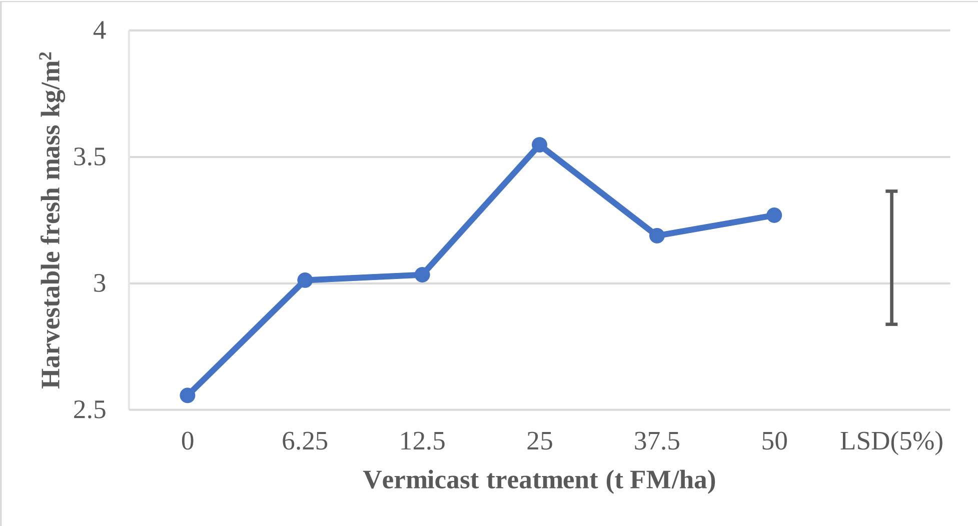

Figure 4: Modelled impact of vermicast on harvestable fresh onion mass. Means are from ANOVA run with soil pH as a covariant.

Conclusions

After accounting for differences in soil pH, vermicast applied at rates of 25, 37.5 and 50 t FM/ha significantly increased harvestable mass in 5-month-old onions over a period of 2 months. These results are an indication that vermicast impacts positively on fresh matter production in early/mid-development stage onion crops.

Future work

While increasing food production is necessary to feed the growing population, there is a definite need to modify agricultural production systems to be more sustainable and resilient (Foley et al., 2011; Fraser et al., 2016). In systems such as those designed on agroecological or circular economy principles, wastes are viewed as resources. Vermicomposting is an example of an agroecological principle where organic wastes are viewed as resources and nutrients are returned to productive soils. Modified agricultural systems would be different to conventional systems that tend to support linear nutrient transformation. Conventional farm systems are reliant on mining and manufacturing of chemical/mineral fertilisers. Phosphorous is a prime example of a nutrient that undergoes liner nutrient transformation in food production and consumption (mining → importing → application → food production → consumption → excreta → treatment → landfill) (Cordell et al., 2009).

The results and learnings from this pilot trial are being used to design a PhD project investigating the impacts of vermicast on commercially grown crops. Using circular economy and agroecological principles, local businesses, a poultry farm, a vermicomposting operation and a market garden will be integrated. The aims of this symbiotic system are to:

i. reduce reliance on external fertilisers inputs,
ii. benefit the environment,
iii. add value to organic wastes, and
iv. reduce the cost of food production.

Monitoring of vermicomposting windrows will investigate leachate, and gaseous (NH_3 and greenhouse gas) emissions from vermicomposting chicken litter with paper waste. Germination rates, yields and quality of crops grown with typical fertiliser regimes against vermicast and reduced fertiliser + vermicast treatments will be compared.

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