Organic World Congress 2020 | FRANCE

SEPTEMBER 21ST TO 27TH, 2020 IN RENNES
AT THE COUVENT DES JACOBINS • RENNES MÉTROPOLE CONFERENCE CENTRE
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OWC 2020 Paper Submission - Science Forum

Topic 3 - Transition towards organic and sustainable food systems

OWC2020-SCI-657

EFFECTS OF ALTERNATIVE FERTILISERS FROM FOOD AND HOUSEHOLD WASTE AND CLOVER BASED ON YIELD OF ORGANIC CABBAGE (BRASSICA OLERACEA CONVAR. CAPITATA VAR. ALBA L.)

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Preferred Presentation Method: Oral or poster presentation

Full Paper Publication: Yes

Abstract: Organic vegetable farms are highly specialized and therefore, the production is very dependent on external nutrient inputs by commercial fertilisers permitted in organic farming, often of conventional origin. Food and household waste and/or clover based fertilisers could replace and/or be additional alternatives to commonly used fertilisers and close rural-urban cycles. The effect of different alternative plant and waste based fertilizers were studied in a field trial using cabbage (*Brassica oleracea* convar. *capitata* var. *alba* L.) in Stuttgart, Southwest Germany. Total yield (head and residues), marketable head yield (> 1 kg) and non-marketable head yield (< 1 kg) were measured. All fertilisers increased the total biomass yield and marketable head yield of cabbage significantly, with horn grit (widely used commercial fertiliser in organic vegetable production) fertilisation showing the highest yields (Total yield: 88.6 Mg fresh matter (FM) ha^{-1}, Marketable head yield: 39.8 Mg FM ha^{-1}) of all treatments. Clover pellets, tofu whey, biogas digestate from organic household waste and clover based biogas digestate showed results comparable to farmyard manure and could be potential new fertilisers for organic vegetable production without compromising the yield.

Introduction: On-farm fertilisers (manure and legumes) are not able fulfil the nutrient needs of the crops and to replace high nutrient exports of harvested products (Möller & Schultheiß 2014). Therefore, intensive vegetable crop production in organic farming is based to a large extend on external nutrient inputs. Nutrient composition of farmyard manure as well as many of the commercial fertilisers does not fit the nutrient export in the harvested goods leading to nutrient imbalances. Furthermore, commercial fertilisers commonly used such as horn grit are either derived from intensive conventional animal husbandry or are imported from faraway countries. Hence, an increasing utilisation of alternative fertilisers, based on plant materials or regional food and household waste (On-farm and Off-farm) with optimised nutrient composition and availability could be an option to close the current nutrient gaps without yield losses.

The aim of the study was to investigate the effects of alternative fertilisers on total cabbage biomass production and head yield. Therefore, fertilisers based on residues of organic food production (tofu whey), biogas digestates from household

waste and mixed farming systems as well as clover based fertilisers (pellets, silage) were compared to the most commonly used fertiliser in organic farming, horn grit and farm yard manure.

Material and methods: In 2019, field experiment was carried out at the experimental station for organic farming of the University of Hohenheim, Kleinhohenheim (48° 74' N, 9°19' E and 435 a.s.l.) in Southwest Germany from April to July. Similar trials have been done on two other sites with similar fertiliser variants. The average annual temperature is 8.8 °C and average precipitation is approximately 700 mm. During the cultivation period of cabbage, the average temperature was 16.1 °C and the precipitation amounted to 236 mm. The soil type of the experimental site is a Haplic Luvisol. The trial was a one- factorial row-column design with alternative N-fertilizers (Control I (C-I: no fertilizer), control II (C-II: horn grit), silage (spring application), clover pellets, tofu whey, farmyard manure compost (autumn application), biogas digestate based on clover-pig slurry mix (BD-C) and biogas digestate based on bio-waste (BD-W). The crop used was white cabbage (*Brassica oleracea* convar. *capitata* var. *alba* L.) for direct consumption. Plot size was 4.5 x 8,5 m with six rows per plot, a row distance of 75 cm and an intra-row distance of 28 cm.

The N fertilization level of 159 kg N ha^{-1} was calculated based on the calculation of the determination of fertiliser requirement for vegetables for an expected yield level of 50 Mg ha^{-1} white cabbage (Düngebedarfsermittlung (DBE) Gemüse (from 03.09.18) and on the mineral nitrogen (N_{min}) content of 61.3 kg ha^{-1} in 0-60 cm depth measured three weeks before planting. Fertilizers were applied in autumn (farmyard manure), before planting (silage, clover pellets, horn grit, and the two different biogas digestates) and after planting (tofu whey) of the cabbage plants on 16th April 2019. Irrigation was applied after planting followed by an irrigation management according to the Geisenheim Irrigation Scheme. Intra row weeding was done two times during the cultivation period by a mechanical hoe at 16th May 2019 and 24th May 2019.

At harvest, plants of the two middle rows per plot were counted and total yield of aboveground biomass, the weight and number of heads (marketable (≥ 1 kg) and non-marketable (< 1 kg)) and residues were determined in the field. Samples were oven-dried until reaching constant weight at 105 °C for DM estimation and at 40 °C for analysis of C, N, S and macronutrients. Dried samples were ground and will be analysed.

Statistical analysis was done by using PROC MIXED (SAS version 9.2., SAS Insitute INC., Cary, NC, USA). Significant differences were presented using a letter display.

Results: Total yield of aboveground biomass and marketable head yield differed significantly among the treatments, while for non-marketable yield no significances were observed. Highest total yield was determined for C-II (88.6 Mg FM ha^{-1}), followed by biogas digestate (clover-pig slurry) (87.8 Mg FM ha^{-1}) and clover pellets (85.3 Mg FM ha^{-1}). The lowest yield was observed for the C-I treatment (65.8 Mg FM ha^{-1}) which differed significant from the other treatments. For marketable head yield C-II had the highest value with 39.8 Mg FM ha^{-1} and C-I had lowest value (17.4 Mg FM ha^{-1}). Within the alternative fertilisers, lowest total yield and marketable head yield were found for silage (78.3 Mg FM ha^{-1} and 27.9 Mg FM ha^{-1}). Non-marketable head yields showed to be highest for C-I (15.3 Mg FM ha^{-1}) and lowest for C-II (9.17 Mg FM ha^{-1}) and both biogas digestates (BD-C: 9.26 Mg FM ha^{-1}; BD-W: 9.32 Mg FM ha^{-1}).

*Figure 1: Effect of alternative fertilisers on cabbage yield (total, marketable and non-marketable) in 2019. Different letters indicate significant differences of treatments for P < 0.05; No letters indicate no differences of treatments. ANOVA: ***: P < 0.001; **: P < 0.01; *: P < 0.05; not significant (n.s.).*

Table 1. Total contents of N,NH_4^+-N and C:N ratio of organic fertilisers used in the experiment in 2019.

Fertilizer	Total N (% of dry matter (DM))	NH_4^+ -N(g kg^{-1} fresh matter (FM))	Total N (g kg^{-1} FM)	C:N ratio
Silage	2.64	2.18 - 2.3	11 - 12.7	15.3
Tofu whey	6.31	0.27	1.96	6.38
Clover pellets	3.31	30.9	30.9	12.9
Horn grit	14.7	17.2	138.4	3.07
Farmyard manure (autumn application)	3.38	0.69	6.3	10.6
Biogas digestate (clover grass-pig slurry mix)	3.17	5.31	6.5	11.4
Biogas digestate (bio-waste)	2.63	4.45	5.7	10.6

Discussion: The comparison of the effect of different fertilisers on white cabbage showed differences in marketable head yields and in total biomass production. Highest yields of marketable cabbage heads, total biomass and lowest amount of heads smaller than 1 kg have been produced by the fertilizer with the lowest C:N ratio of all tested fertilizers (C-II (horn grit): 3.07).Organic fertilizers with low C:N ratios are known to have a fast release of plant available nutrients as nitrogen (Müller & Von Fragstein Und Niemsdorff 2006). However, alternative fertilizers for organic vegetable production have shown to produce nearly the same yields as C-II, while having higher C:N ratios ranging between approximately 6 to 13. Highest C:N ratios and low amount of NH_4^+ of clover based silage resulted in lowest total and marketable head yields compared to the other clover based fertilizers. However, a late application of the silage shortly before planting could have led to a delayed mineralisation and resulted into a delayed N-release. Overall, our results are consistent with other trials, where plant based fertilizers with decreasing C:N ratios have led to higher N-availability and resulted in higher yields of cauliflower and kale (Nygaard Sorensen & Thorup-Kristensen 2011). Within the two biogas digestates, higher yields were found for BD-C compared to BD-BW, while also having higher total N and NH_4^+ concentrations. The results are supported by the results by Möller (Möller et al. 2009) where N- availability and direct N-release of biogas digestates increased with increasing N and NH_4^+ contents.

Based on the first results of our experiment, alternative fertilisers as clover pellets, tofu whey and biogas digestates based on bio-waste are able to achieve sufficient cabbage yields compared to the standard fertilisation with horn grit. However, nitrogen balances (N-uptake and –removal) will be investigated, as well as the carry-over effects on the following crops and will be compared to the two other experimental sites (Grötzingen and Schifferstadt). Overall, the results of this study should improve N-efficiency of alternative organic fertilizers and close the nutrients gaps without decreasing yield and quality.

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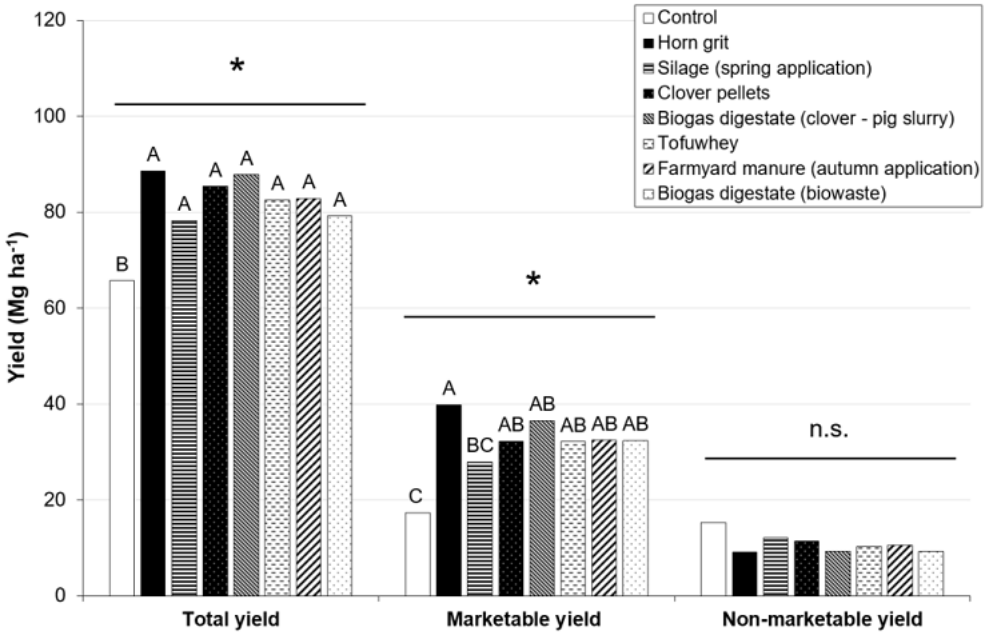
Image:



Disclosure of Interest: None Declared

Keywords: Biogas digestate, Nitrogen, Organic fertiliser, OrganicPlus, Plant-based fertilisers, Vegetable production