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Commercial organic fertilizers with different nitrogen release kinetics for cultivation of pelargonium

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1. Introduction, Knowledge, Objectives

Besides of potted herbs the consumer's demand for organically produced ornamentals is increasing during the last few years. Thereby fertilization is the main concern of growers shifting from conventional to organic production (Burnett and Stack, 2009). Due to several problems as clogging of pipes and nozzles, fouling of greenhouse benches and reservoirs, odor nuisance or growth of pathogens harmful for both human and plants (Hanke and Geiger, 2014) liquid organic fertilizers are reluctantly used by growers. Indeed, then nutrients have to be applied completely to the growing media before potting by solid organic fertilizers. However, this pre-plant application bears a high risk in particular in case of nitrogen supply, because nitrogen applied by organic fertilizers need to be mineralized first. If mineralization runs too quick plants may suffer due to osmotic stress and in contrast if mineralization is too slow plant growth may be limited by a temporary lack of nitrogen (Seibold et al., 2015). Thus, to ensure an adequate nitrogen supply, growers need reliable information about the nitrogen release kinetics of their organic fertilizers. Regularly, N release kinetics are determined by incubation experiments under standardized lab conditions. The question however is: Can release kinetics simply be transferred from the lab to the greenhouse?

2. Material and Methods

In calendar week 11/2016 rooted cuttings of *Pelargonium x hortorum* 'Calliope® 'Dark Red' (Volmary, Münster/Germany) were potted (pot diameter 12 cm). Pots were filled with approximately 570 ml of an unfertilized commercial organic growing medium (Klasmann-Deilmann, Geeste/Germany) consisting of 50 % by volume of bog peat, 30 % by volume of coir pith and 20 % by volume green waste compost. Due to the use of compost neither liming nor addition of phosphorus, potassium, magnesium or trace elements was necessary. The eight commercial organic fertilizers were applied on basis of 800 mg total N/l, whereby inputs of other nutrients than nitrogen were not taken into consideration. N release kinetics were determined in an incubation experiment using the same growing medium and described accurately by the Gompertz growth function ($R^2 \geq 0.90$). For details to the incubation experiment and fitting of the Gompertz function refer to Koch et al. (2017).Table 1 lists the eight fertilizers and summarizes total height and time-course of N release deduced from the Gompertz function.

Tab. 1: N release kinetics of the eight commercial organic fertilizers (calculated with parameters T1, T2, T3 of Gompertz function given in Koch et al., 2017)

Fertilizer ($N+P_2O_5+K_2O$)	Cumulative N release until day 63 as percentage of applied total N	Days until 25 % of cumulative N was released	50 %	75 %	90 %
BA: Bioagenasol (6+3+2)	27	7	20	35	48
BV: BlütoVin Bio (10+3+5)	40	3	8	14	21
EP: Eco Plant 2 (6+3+4)	45	2	7	14	22
EX: Eco Xtra-1 (8+5+6)	49	8	17	27	39
HG: Horn grist (14+0+0)	45	3	7	13	20
PG: Phytogrieß (6+3+2)	42	5	11	19	27
SW: Sheep wool (10+0+5)	55	17	23	31	40
SO: Symbionta Organic (6+3+2)	47	1	8	19	30

Pots were placed in a greenhouse (block design with four replicates and nine plants per replicate) and irrigated separately on demand from above with tap water (electrical conductivity = 70 mS/m, acid buffer capacity = 6 mmol/l HCO_3^-). To avoid leaching at each irrigation event only 50 ml water were given. Pest management was done according to good professional practice in organic horticulture using beneficial insects.

Two, four, six and eight weeks after potting one pot per replicate was taken and the growing medium analyzed for pH, water soluble salts and CAT soluble N, P and K according to VDLUFA methods (VDLUFA, 2016). At the end of the experiment (calendar week 21/2016) shoot fresh and dry mass of the remaining five plants were measured and the optical impression (habitus and leave color) as well as root growth were rated. Furthermore, total N content of shoot biomass was measured by Dumas method (VDLUFA, 2016) and growing media were analyzed for parameters as described above. Subsequently, nitrogen uptake by plants was calculated from dry mass and total N content in plant tissue and compared to N release calculated from the results of the incubation experiment as well as CAT soluble N at start and end of the pot trial.

For fresh and dry mass, total N content and N uptake by plants an ANOVA (glm procedure) and in cases of significant differences a Tukey test ($p \leq 0.05$) was computed. Scores of optical rating were examined by Kruskal-Wallis and subsequent Nemenyi test ($p \leq 0.05$). All statistical calculations were carried out with Minitab v17 (Minitab Inc., State College/PA).

3. Results

In coincidence with the N release kinetics already two weeks after potting high amounts of 200 to 300 mg CAT soluble N per liter were found for most fertilizers. Only for Eco Xtra-1 (EX) and sheep wool (SW) amounts of CAT soluble N were rather low. At least for SW this was also found in the incubation experiment. As plant uptake until day 14 is supposed to be negligible CAT soluble N at this date can be considered as N release from the organic fertilizers. With exception for Bioagenasol (BA) and Exo Xtra-1 (EX) calculated N release was about 15 % higher than measured N values (figure 1). At the following dates (four, six and eight weeks after potting) a strong decline of soluble N occurred in all treatments and at the end of the trial nearly no mineral N (≤ 25 mg N/l) was analyzed. Hence, it can be concluded that already about three weeks after potting N uptake of plants was higher than N release from organic fertilizers. This is in line with the results of the incubation experiment where N release was mainly finished after 20 to 30 days.

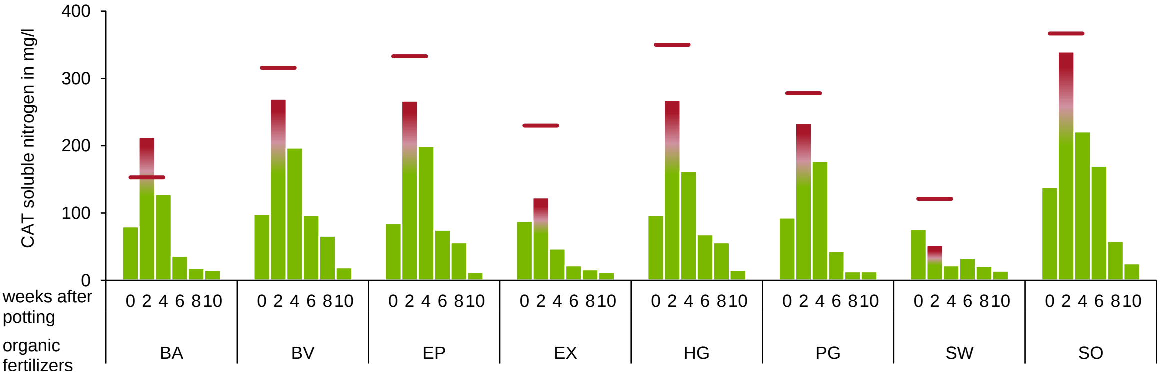

Fig. 1: CAT soluble nitrogen in the growing media during cultivation (mixed samples of replicates); horizontal red bars indicate N release calculated from Gompertz function two weeks after potting (for abbreviations of organic fertilizers see table 1)

Overall optical impression of plants and root balls did not differ significantly (data not shown). But plants in all treatments seemed to suffer from N deficiency as indicated by a light-green leaf color (figure 2).

Fig. 2: Pelargonium 'Calliope® 'Dark Red' plants at the end of the experiment (10 weeks after potting, for abbreviations of organic fertilizers see table 1)

N deficiency was confirmed by quite low N concentrations in plant tissue which were between 9 and 12 mg N per g dry mass (table 2). However, at least N content in plants fertilized with sheep wool (SW) was significantly higher than of those fertilized with Eco-Xtra 1 (EX). In contrast to N content, shoot biomass (fresh and dry mass were highly correlated, thus only results for fresh mass are shown) was lowest for sheep wool (table 2). Due to a relatively high N concentration of plant tissue and concurrently a high shoot biomass, the plants fertilized with Phytogrieß (PG) had the highest N uptake whereas plants fertilized with Eco Xtra-1 (EX) had the lowest. For all other treatments N uptake differs only in few cases significantly (table 2).

Tab. 2: N content in plant tissue, shoot fresh mass and N uptake calculated from N content and shoot dry mass) at the end of the experiment (treatments with same letters do not differ significantly; n = 4, Tukey test, p ≤ 0.05)

Fertilizer	N content of plant tissue mg N/g dry mass		fresh mass g/plant		N uptake mg N/plant	
BA: Bioagenasol	9.8	AB	112.4	CD	164	CD
BV: BlütoVin Bio	10.0	AB	123.3	BC	179	BCD
EP: Eco Plant 2	10.0	AB	145.5	A	202	ABC
EX: Eco Xtra-1	8.9	B	116.9	CD	156	D
HG: Horn grist	10.8	AB	138.6	A	211	AB
PG: Phytogrieß	10.5	AB	146.3	A	226	A
SW: Sheep wool	12.4	A	108.8	D	182	ABCD
SO: Symbionta Organic	11.1	AB	133.6	AB	205	ABC

In line with the incubation experiment where N release was between 30 and 55 % of added total N (table 1) also in the greenhouse trial for none of the eight tested fertilizers nitrogen efficiency was above 50 % of added total nitrogen. Figure 3 shows the quite good concordance between N release of organic fertilizers in the incubation experiment and N uptake of plants in the greenhouse trial for most fertilizers. In most cases 95 % confidence intervals overlap, whereas N release was slightly higher than N uptake. Only for sheep wool (SW) and especially for Eco Xtra-1 (EX) – which had the highest N release in the incubation experiment – N uptake was remarkably lower than N release.

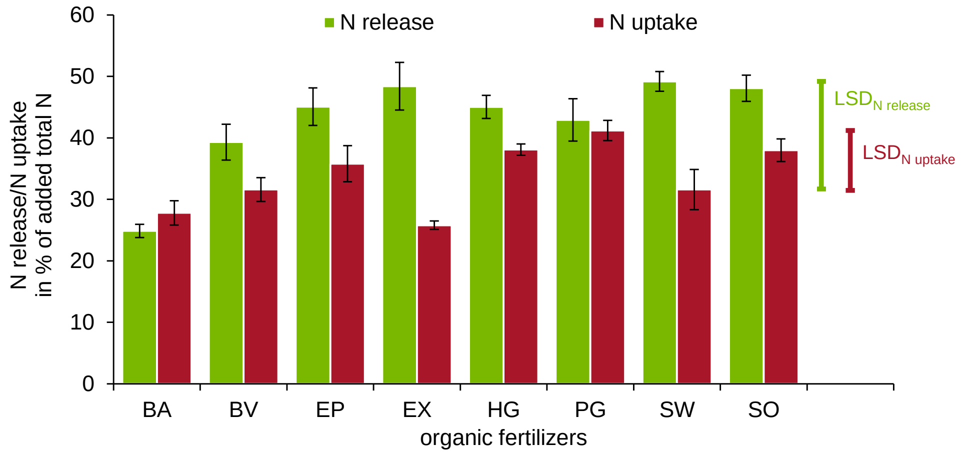

Fig. 3: N release in the incubation test (day 63) and N uptake of pelargonium plants (error bars indicate standard error; LSD indicate least significance difference for N release and N uptake, p ≤ 0.05, n = 4, for abbreviations of organic fertilizers see table 1)

4. Discussion

The coincidence of N release in the incubation experiment and N uptake of pelargonium indicates that conditions for microbial activity – in particular moisture, aeration and temperature – during plant cultivation are not far away from the optimum which is striven in incubation experiments. This is underpinned by results of Agehara and Warncke (2005). They show that moisture content (at least in a range suitable for plant growth) and thus aeriation has only a negligible effect on mineralization of organic fertilizers and temperature is only a retarding factor below 10 to 15 °C. Thus, in the common temperature range during cultivation of most ornamentals temperature seems to be less important for mineralization of organic fertilizers.

The current results are further confirmed by Koch et al. (2017) which did a comparable experiment using the same fertilizers. Similar results were also reported by Stadler et al. (2006) who used mineral soils and ryegrass for their experiments with fertilizers of plant origin. They found significant relationships between net N mineralization in short term incubation experiments and apparent N uptake of ryegrass for all four soils. As in the current experiment also in this study N uptake by plants was remarkably lower than expected for fertilizers with the highest N release. Indeed, the systematic higher N release than N uptake in the current study is partly contradictory to the results of Stadler et al. (2006) and completely contrary to results of Koch et al. (2017), who reported almost the same or even higher N uptake than N release. However, this is explainable, as N losses by leaching can be excluded in both of these studies, but not in the current research.

5. Conclusions

Time-course and height of N release from commercial organic fertilizers can be at least approximately deduced from incubation experiments done under standardized lab conditions. Thus, also under practical conditions growers have to appreciate that N fertilization has to be twice as high as the N demand of plants and that most of the nitrogen is released within the first few weeks. The quick N release directly after addition may limit complete pre-plant fertilizer application to few species with a relatively low N demand and a relatively high tolerance against high salinity.

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