Pot Experiment for Comparison of the Suitability of Fungal Biomass and Castor Meal for Nitrogen Fertilization of Tomatoes in Organic Farming

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Table of Contents

List of Figures

List of Tables

Summary of the Results of the Pot Experiment for Comparison of the Suitability of Fungal Biomass and Castor Meal for Nitrogen Fertilization of Tomatoes in Organic Farming

In organic farming, the high nitrogen requirement of a tomato culture should be met by organic fertilizers. The purpose of this paper is to examine the fungal biomass fertilizer Agrobiosol produced in Austria and the vegetable fertilizer Castor Meal imported from developing countries with regard to their effect on yield, mineral nitrogen content in the soil, and formation of root dry matter.

Pot experiment station (photo: Rührer, 2003)

In 2003, the Institute of Organic Farming of the University of Natural Resources and Applied Sciences, Vienna, conducted a pot experiment regarding these questions.

Fertilization was carried out as combined basal/top dressing. 50 kgN_{verf}/ha[1] of farmyard manure compost and commercial fertilizer (Agrobiosol or Castor) amounting to 157 N_{verf}/ha were admixed to the top 10 cm of the pot to simulate the incorporation of fertilizers performed in the field. Apart from the nitrogen content, the availability of the nitrogen contained was also taken into consideration for the calculation of the fertilizer rate.

<u>Mineral nitrogen content of the soil</u>

The variant *Compost /Agrobiosol* treated with fungal biomass fertilizer showed a more rapid nitrogen mineralization than the two other variants.

<u>Root dry matter</u>

The growth of root dry matter was promoted in the variant *Compost/Agrobiosol*. The more rapid nitrogen mineralization, the greater nitrogen supply or specific properties of the fertilizer of this variant may have promoted root growth.

<u>Yield</u>

After 12 weeks of cultivation, the crop yield of the variant *Compost/Agrobiosol* was significantly heavier than that of the *Compost* variant. The heavier yield as compared to the variant *Compost/Castor* cannot be verified.

In combination with compost as basal dressing, Castor Meal as well as the fungal biomass fertilizer Agrobiosol can be used for nitrogen supply of tomatoes. The more rapid nitrogen mineralization from the fertilizer Agrobiosol than from Castor Meal can be regarded as verified. The differences in yield and root dry matter that are clear, but statistically insignificant, indicate an advantage of the fungal biomass fertilizer Agro-biosol as compared to the Castor Meal fertilizer in the tomato culture.

[1] N_{verf} = nitrogen that is available to plants

I. Problem Definition and Targets

Nitrogen fertilizers used for organic farming have to meet the following requirements:

- Registration in accordance with the guidelines for the respective type of cultivation.
- Availability of nitrogen adapted to the vegetation period and growth stages of the respective type of culture.

Extract from the production guidelines for organic-biological farming in Austria (ERNTE für das Leben, 2003):

Purchase of organic fertilizers of conventional origin for special cultures (horticulture[2], fruit, wine, hop):

- Not more than 170 kg of nitrogen from animal fertilizers may be applied per hectare. This limit may be exceeded when purchasing organic fertilizers (not of animal origin). The use of residual potato juice is prohibited. The guidelines regarding water rights always have to be observed.

In addition to farm fertilizers and soil improvers, the following products may be used:

- The following products or by-products of animal origin: hair meal, wool, Walk (boiled wool) hair, hair and bristles, as well as horn shavings; milk products (written approval of the control authority required.)
- The following products and by-products of vegetal origin for fertilization (e.g., filter cake of oil crops, cacao shells, malt roots etc.)

The present paper examines the commercial fertilizers Agrobiosol (fermented fungal biomass, Biochemie comp.) and Castor Meal with regard to their effect on yield, mineral nitrogen content in the soil, and formation of root dry matter.

Agrobiosol is a by-product of the manufacture of antibiotics by means of fermentation with *Penicillium chrysogenum* over a period of several days. The dried fungal biomass is pelleted without supplementing mineral nutrients.

Castor Meal is generally subject to conventional growing conditions. It has to be transported to Europe from developing countries of the tropical zone. As the beans of *Rizinus communis L.* are classified as highly toxic and castor beans also contain potential allergens, inhaling powdered beans or contact with skin may frequently lead to allergic diseases (Poison Center Bonn, 2002).

A tomato culture *(Lycopersicon lycopersicum)*, which has to be supplied with nitrogen over a period of about 25 weeks (BMLFUW, 2001) and is harvested several

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[2]this includes: protected cultures, field vegetable growing, officinal and spice plants except threshable spices

times, makes heavy demands on the availability of nitrogen of the fertilizers used at different times.

The purpose of this paper is to compare the application of Agrobiosol as fertilizer in a pot culture of tomatoes with fertilization using Castor Meal. Both fertilizers were used as top dressing in addition to farmyard manure compost as basal dressing. The fertilizers were admixed to the top 10 cm of the pot volume to simulate the superficial incorporation of fertilizers performed in the field (Fig. 3).

The following working hypotheses were deduced from the relevant literature and from previous trials (Rührer et al., 2001):

i. Mineralization of nitrogen from Agrobiosol is faster than from Castor Meal.
ii. Fertilization with Agrobiosol promotes the root growth of tomato plants. More root dry matter is found in these variants than in the variants without Agrobiosol addition.

II. Materials and Methods

1. Trial Design

5 replicates per variant with one plant per pot were established for testing the selected variants. The plant material consisted of tomato seedlings of the variety *Mercedes*.

The plant pots had a volume of 8 l (Tab. 1). Farmyard manure compost and the organic top dressings were admixed to the substrate 7 days before setting the tomato plants (Tab. 2).

Fig.1: Experimental plant of the variant *Compost/Agrobiosol*, May 28, 03 (photo: Rührer, 2003)

The experimental period was 12 weeks. The temperature in the pot experiment station corresponded to the outside temperature at the time of the trial (Fig. 2). The experimental plants were protected from rain.

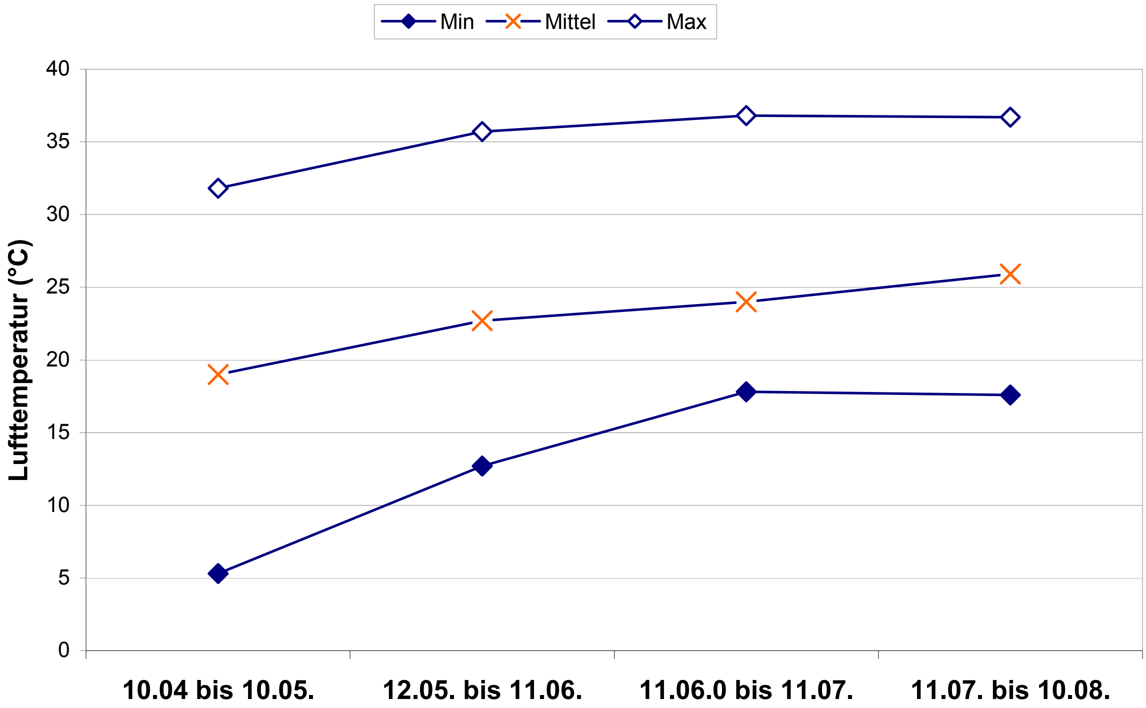


Fig. 2: Maximum, mean, and minimum air temperatures (°C) during the experimental period

Sifted arable soil, which can be characterized as silty loam, was selected as the substrate (Tab.1).

Tab. 1: Description of the substrate

Parameter	Method	Result	Evaluation[1)]
pH	in $CaCl_2$	7.5	-
Carbonate content	calculated as $CaCO_3$	20.6 %	-
Humus content	dry combustion	3.3 %	C (mean)
Nitrogen, total	CNS-automatic system	0.19 %	-
Sand/ silt/ clay	soil type triangle	21/58/21%	uL
Nutrients available to the plants			
Phosphorus	in CAL-extract	84 mg/ 1000g	C (sufficient)
Potassium	in CAL-extract	113 mg/ 1000g	C (sufficient)
Water-soluble components			
Electric conductivity	electrochemical	199 µS/cm	-

[1)]From BMLF (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management), 1996

[2)]CAL=calcium-acetate-lactate method

Tab. 2: Trial variants

Variant	Composition	Nitrogen supply
Compost	Soil + Compost (control)	Soil: results of analysis (Tab. 1)+ Compost: 50 kg N_{verf}/ha
Compost/ Agrobiosol	Soil + Compost + Agrobiosol	Soil: same as above + Compost: 50 kg N_{verf}/ha + Agrobiosol: 157 kg N_{verf}/ha
Compost/ Castor	Soil + Compost + Castor Meal	Soil: same as above + Compost: 50 kg N_{verf}/ha + Castor: 157 kg N_{verf}/ha

N_{verf} = nitrogen that is available to plants

2. Sampling und Analyses

Yield [g/plant] ripe fruits were harvested from every plant as required and weighed
Dry matter of roots [g/kg] after 12 weeks of cultivating the tomato plants. Method: the entire root ball is predried (1 week), then the roots are washed, dried at 60 °C and weighed.
Mineral nitrogen content [kgN_{min}/ha] (5 replicates, time periods listed in Tab. 3) Method of analysis: samples are extracted with 0.0125 M $CaCl_2$ solution in the overhead shaker. Then the concentrations of NO_3^- and NH_4^+ in the extract are determined photometrically (ÖNORM (Austrian Standard) L 1091, 1988: 2)

Tab. 3: Schedule

Treatment/assessment			***Time***			
	Where	***How***	***04/2003***	***05/2003***	***06/2003***	***07/2003***
Basal dressing	substrate	*manual*	*10.04.03*	-	-	-
Top dressing	substrate	*manual*	*10.04.03*	-	-	-
Planting	tomatoes	*manual*	*17.04.03*	-	-	-
Potassium fertilization	substrate	*manual*	*28.04.03*	-	-	-
Trial conclusion	-	*manual*	-	-	-	*17.07.03*
Sampling/analyses			***Time***			
	Where	***How***	***04/2002***	***05/2002***	***06/2002***	***07/2002***
N_t	compost	-	*01.04.03*	-	-	-
N_t	Castor Meal	-	*04.04.03*	-	-	-
N_{min}	substrate	-	*23./28.04.*	*12.05.03*	*12.06.03*	*17.07.03*
H_2O	soil	-	*23./28.04.*	*12.05.03*	*12.06.03*	*17.07.03*
Root dry matter	roots	-	-	-	-	*17.07.03*
Yield (contin.)	tomatoes	*per plant*	-	-	*25.06.03*	*17.07.03*

3. Fertilizers, Fertilizer Rates

- Compost as basal dressing: farmyard manure compost Csardahof/Pama (analytical results: Tab. 4)
- Agrobiosol (fermented fungal biomass, Biochemie comp.) and Castor Meal as nitrogen fertilizers (analytical results: Tab. 4)

Tab. 4: Characteristics of the selected fertilizers

Fertilizer	**Nitrogen content** %	**Carbon content** %	**C/N**	**N availability** (assumed) %	**Potassium content** %
Compost	0.75	8.47	11.3	30[1)]	0.78
Agrobiosol	6.4	43.5[2)]	6.8	64[3)]	0.8
Castor Meal	6.1	47.6	7.8	60[3)]	1.5

[1)] Sächsische LA f. Landwirtschaft (Saxony State Institute of Agriculture), 2001; [2)]analysis of a batch of 2001; [3)]deduced from C/N

- The nitrogen content and availability, as well as the subsequent delivery from the soil have been taken into account for the calculation of the fertilizer rates (Tab. 5)

Tab. 5: Calculation chart of nitrogen fertilizer rates

Variant	Compost/Agrobiosol Compost/Castor kg N_{verf}/ha	Compost (control) kg N_{verf}/ha
1. Basal dressing[1)]	50	50
2. Top dressing[2)]	157	0
3. N_{min} supply[3)]	65	65
4. Delivery from the soil buffer[4)]	176	176
5. Crop residue	0	0
Available nitrogen rate[5)]	448	291
Requirement of the tomato culture[6)]	448	448

[1)] Farmyard manure compost rate: approx. 24.5 t/ha; [2)]Organic, commercial vegetable fertilizer; [3)]N_{min} supply = mineralized nitrogen, available in the soil; [4)]Delivery from the soil supply of ~ 8 kg of nitrogen per week from May to mid September (20 weeks) and ~ 4 kg of nitrogen per week from mid September to mid October (4 weeks); [5)]Total from 1. to 5.; [6)]According on the yield, ~ 448 kg N/ha are withdrawn by plant parts above ground (foliage, fruit) (Laber, 2001)

N_{verf} = nitrogen that is available to plants

- Potassium was supplemented according to the K requirement of the crop and the K content of the added nitrogen fertilizers in the form of Patentkali (potassium, magnesium, sulphur) (Tab. 6)

Tab. 6: Calculation chart of complementary fertilization of potassium

Variant	Compost/Agrobiosol kg K_2O/ha	Compost/Castor kg K_2O/ha	Compost (control) kg K_2O/ha
1. Basal dressing	173	173	173
2. Top dressing	31	73	-
Total K_2O	204	246	173
Requirement of the tomato culture [1)]	485	485	485
Addition of K_2O	281	239	312

[1)]For an assumed yield of 2 kg of tomatoes per pot ~ 5 kg/m² in 12 weeks of cultivation

The fertilizers (basal dressing, nitrogen and potassium fertilizers) were admixed to the top layer of the pot 7 days before setting the tomato plants to prevent growth inhibition caused by Agrobiosol. This simulates the incorporation of fertilizers into the top soil layer performed in the field.

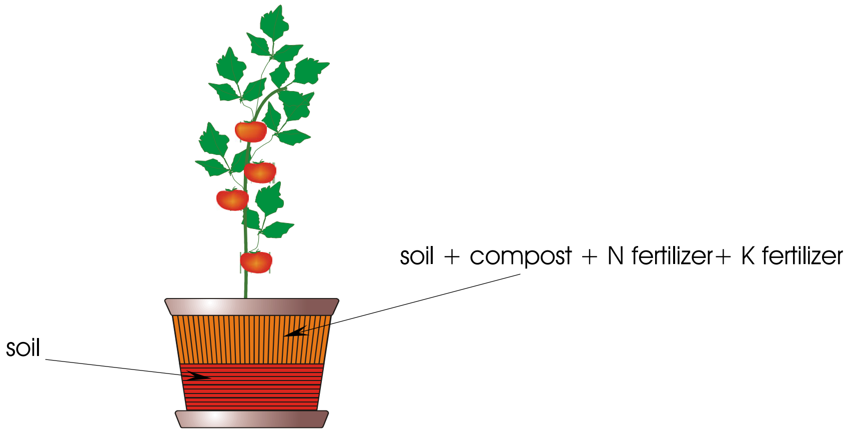
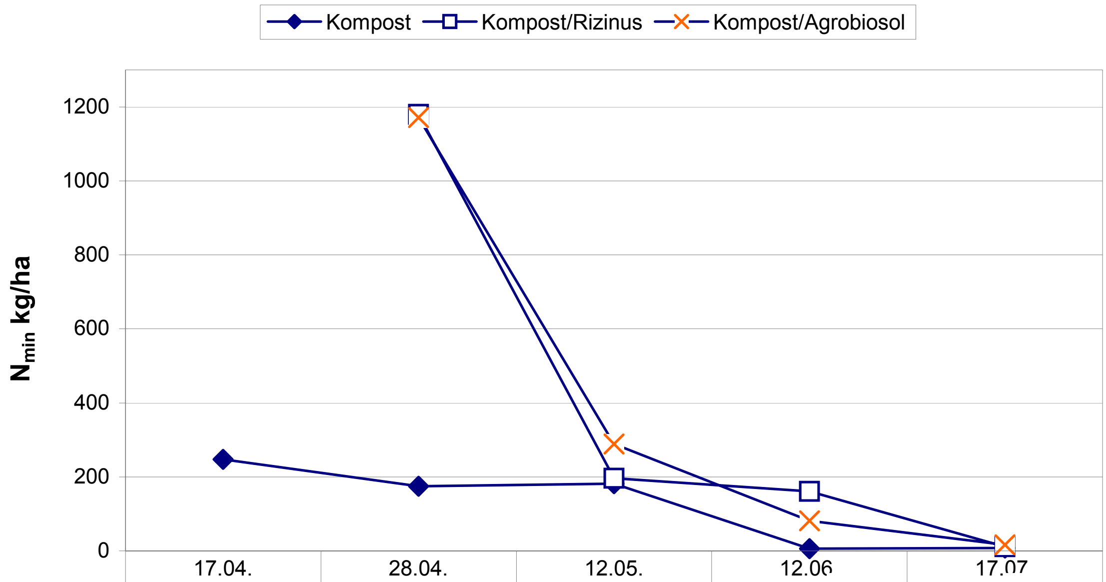


Fig. 3: Pot filling pattern

III. Results and Discussion

1. Mineral Nitrogen Content in the Soil

The high mineral nitrogen values in the variants *Compost/Castor* and *Compost/Agrobiosol* on April 28 (18 days after admixture of the fertilizers) can be attributed to an exceptionally high NH_4^+ formation. The reasons for this presumably were temporary, anaerobic substrate conditions.



	17.04.	28.04.	12.05.	12.06	17.07
Kompost	248	175 [a]	181 [a]	6 [a]	8 [a]
Kompost/Rizinus	keine Daten[1)]	1180 [b]	196 [a]	161 [c]	11 [a]
Kompost/Agrobiosol	keine Daten[1)]	1171 [b]	289 [b]	81 [b]	16 [a]

Fig. 4: Mineral nitrogen content (kg/ha) in the substrate at 5 dates, mean values with the same letter do not differ significantly (Tukey test, μ<0.05); [1)]Data missing due to a manipulation error

On the dates Apr. 28, May 12, and June 12, the mineral nitrogen content of the substrate of the variant *Compost/Agrobiosol* was significantly higher than in the *Compost* variant. On May 12, the mineral nitrogen content of the variant *Compost/Agrobiosol* was significantly higher than the content of the variant *Compost/Castor*. These results indicate a more rapid nitrogen mineralization from fungal biomass than from Castor Meal.

An increased plant uptake can be assumed as the mineral nitrogen content of the variant *Compost/Agrobiosol* was significantly below that of the variant *Compost/Castor* on June 12. This is caused by clearly increased root growth (Fig. 5) in the variant with fungal biomass fertilizer.

2. Root Dry Matter

The root dry matter in the variant *Compost/Agrobiosol* was significantly greater than in the *Compost* variant. The difference in root mass from the variant *Compost/Castor* was clear, but statistically insignificant. In the variant *Compost/Castor, as well as* in the variant *Compost/Agrobiosol, the higher nitrogen application seems to have had a positive effect on the root growth*, this effect being more pronounced in the variant *Compost/Agrobiosol* due to specific substance properties of the fertilizer (Fig. 5).

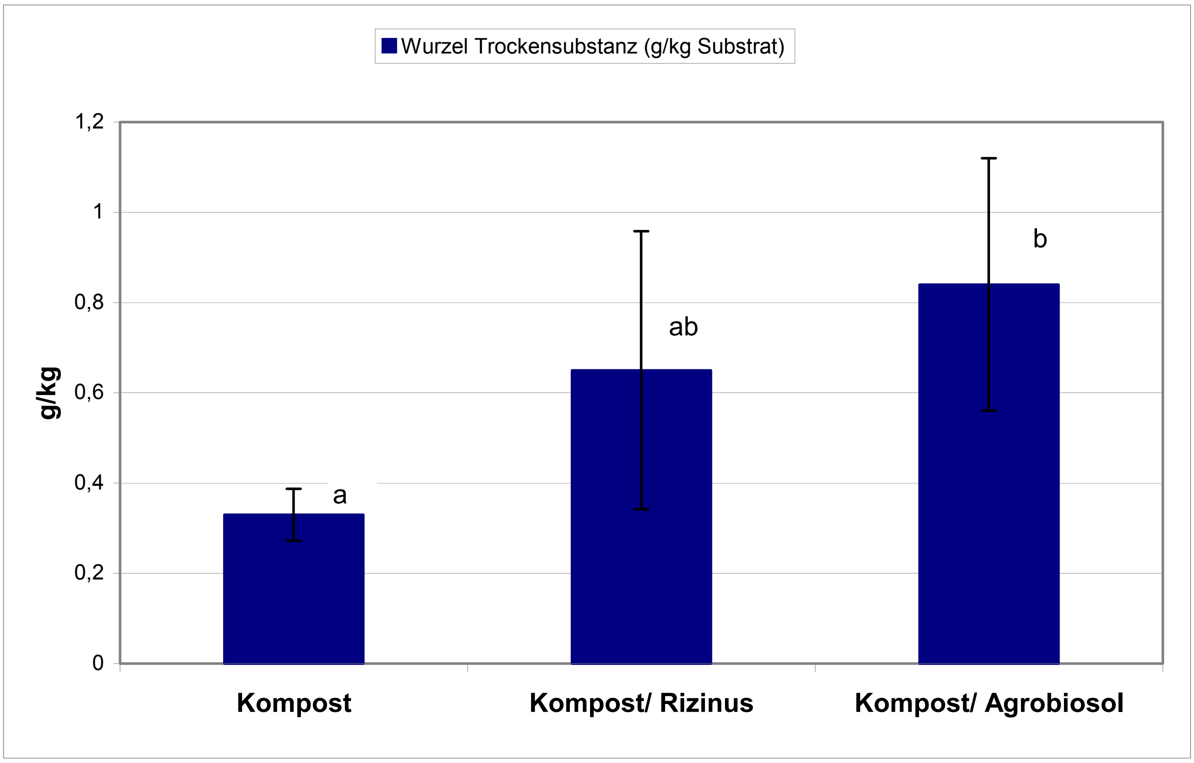


Fig. 5: Root dry matter (g/kg of substrate) depending on the tested variants; mean values with the same letter do not differ significantly (Tukey test, μ<0.05)

3. Yield

The yield of the cultivated tomato plants was determined until mid July, i.e., up to the 12th crop week, and can therefore not be compared to crop yields on farms, where the plants are cultivated up to 25 weeks. The yields are meaningful in relation to the quantities (g/plant). As expected, the *Compost* variant produced the lightest crop yield (428 g/plant). A significantly heavier crop (604 g/plant) was determined In the variant *Compost/Agrobiosol*. The yield of the variant *Compost/Castor* is average with regard to the former two variants and without significant differences to the other variants (515 g/plant). The heavy crop of the variant *Compost/Agrobiosol* can be attributed to the more rapid N mineralization of the fungal biomass fertilizer (Fig. 4), as well as to a presumably better uptake due to a better root penetration (Fig. 5).

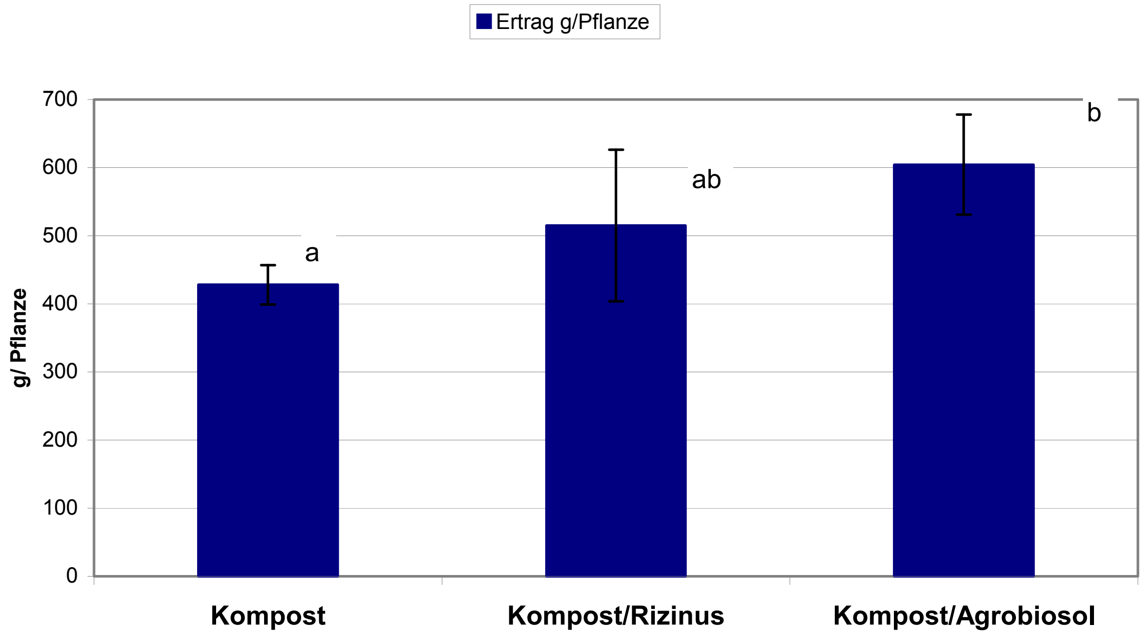


Fig 6: Yield in g/plant; mean values with the same letter do not differ significantly (Tukey test, μ<0.05)

IV. Conclusion

Based on the results of this one-year pot experiment, the following conclusions can be drawn with regard to the suitability of the examined nitrogen fertilizers:
In combination with Compost as basal dressing, Castor Meal as well as the fungal biomass fertilizer Agrobiosol can be used for nitrogen supply of tomatoes. The more rapid nitrogen mineralization from the fertilizer Agrobiosol than from Castor Meal is regarded as verified. The clear, but statistically insignificant differences in yield and root dry matter indicate an advantage of the fungal biomass fertilizer Agrobiosol as compared to the Castor Meal fertilizer in the tomato culture.

V. Literature

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