Sheep wool as fertiliser for vegetables and flowers in organic farming

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Sheep Wool as Fertiliser for Vegetables and Flowers in Organic Farming

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Abstract

The availability of fertilisers for organic farming is often limited and not standardised. In Germany, high amounts of uncleaned sheep wool are available. Because of the high amount of nutrients - especially nitrogen -, sheep wool pellets could be used as multi-functional fertiliser in vegetable and flower cultivations. Four sheep wool pellet types with a total nitrogen content of 10 to 11% DM and different supplements (10% cellulose, 20% potato starch, 20% casein) have been tested in open and protected cultivation. Tomatoes (*Lycopersicon esculentum* L.) were cultivated in greenhouse using substrate culture with perlite, bark compost and sheep wool slabs, respectively, and sheep wool pellets as fertiliser. Kohlrabi (*Brassica oleracea* var. *gongylodes* L.) and iceberg lettuce (*Lactuca sativa* var. *capitata nidus* Jagg.) were cultivated in the field comparing the effect of mineral and organic fertilisers (sheep wool pellets, lupine and ricinus wholemeal). In flower pot cultivation, different amounts of pellets were investigated with poinsettia (*Euphorbia pulcherrima* Willd.). In most experiments, a stimulating effect of the pellets on growth and yield could be determined in comparison with mineral and other organic fertilisers. In cultivation of iceberg lettuce, the best results in all quantitative and qualitative parameters were obtained when using pellets as a fertiliser. In kohlrabi, however, the yield in the treatment with pellets was up to 50% lower than with mineral or other organic fertilisers. Best growth and highest yield for tomatoes were obtained using pine bark and perlite as substrate, both fertilised with sheep wool pellets. In poinsettia pot cultivation, the addition of 1, 2, 5, and 10 g pellets L^{-1} substrate resulted in a correlation between pellet concentration and plant development. Based on analyses of the nutrient content in plants it seems that sheep wool pellets can, for some plant cultures, successfully substitute mineral fertilisers.

INTRODUCTION

Organic farming has not only advantages for the environment, but also for improvement of nutritional value in vegetables (Worthington, 2001). The use of organic fertiliser is also recommended for environmentally friendly cultivation of other horticultural crops. However, the availability of fertilisers for organic farming is limited and its quality not standardised. Moreover, easily decomposable animal organic waste materials as horn- or blood powder are often not accepted in food production, due to health risks. Other animal based organic fertilisers, as poultry or farmyard manure, are more often used (Tüzel et al., 2004), but limited in availability in specialised vegetable farms and in greenhouses for cultivating vegetables and flowers. Therefore, in organic horticultural farms, organic fertilisers based on plant material, e.g., coarse meal of castor cake (ricinus wholemeal) and crushed seeds of lupine (lupine wholemeal), are used (Müller et al., 2006). The nitrogen content in these fertilisers is not high, ranging between 4 and 8%. Moreover, its efficiency in nutrient release for nitrogen, potassium, or phosphorus is often quite low (Nielsen and Thorup-Kristensen, 2004). Therefore, new sources for organic fertilisers are necessary.

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In Germany, high amounts of uncleaned sheep wool are available, currently used mainly as waste material. Sheep wool was already successfully tested as a substrate for cultivating cucumbers in greenhouse (Böhme et al., 2008). Its high amount of nutrients, especially nitrogen, suggests the possibility of its use as an organic fertiliser, in the form of pellets. Use of pelletised sheep wool was only reported by Bilderback and Lorscheider (2000). In their research, mixes with sheep wool pellets were tested in nursery containers and for *Petunia* pot plants.

The objective of our research was to develop sheep wool pellets as multi-functional fertiliser in open and protected vegetable cultivation as well as for cultivating ornamental pot plants. The development of this organic fertiliser was achieved in two steps. First, pellets with a good structure and an acceptable decomposition rate with different additional components and the technology for the production of pellets were developed (IfN, 2008). The best pellet types were then mixed in substrates or added to the soil in the open. First results are presented here.

MATERIALS AND METHODS

Sheep Wool Pellets Characteristics

Different combinations of sheep wool with other components (cellulose, starch, casein) were tested in order to find optimal physical and appropriate technological characteristics of the pellets (IfN, 2008). The dry matter (DM) and mineral content were different in the four investigated pellet compositions (Table 1). The pH ranged between 7.5-9 and the EC between 6.3-8.8 mS cm^{-1}. Both values were higher than recommended for horticultural crops, in particular for substrate culture and pot plants in the greenhouse. The appropriate values were reached through dilution and leaching before and during cultivation. After the cultivation of flowers and vegetables, the pellets were not completely decomposed and contained still 13% N of the initial amount. Analyses of imbibitions and water retention proved that the pellets take up more than 20 times their weight in water within 15 min (IfN, 2008). Because of their fibre structure, they have a large surface and can release the nutrients easily but slowly (IfN, 2008). The pellets can be stored for 2 years in cool and dry conditions without compromising quality. For the presented experiments, pure sheep wool pellets were used.

Vegetable Field Cultivation

Iceberg lettuce (*Lactuca sativa* var. *capitata nidus* Jagg. 'Elenas' RZ) was planted on 6 June 2009 with a density of 7.4 plants m^{-2} and was harvested on 12 September 2009. Before planting, the silty sand soil was fertilised with 46 g m^{-2} calcium ammonium nitrate (26% N), 120 g m^{-2}, sheep wool pellets (10.5% N), 200 g m^{-2} lupine wholemeal (crushed seeds of lupine, 6% N), and 240 g m^{-2} ricinus wholemeal (coarse meal of castor bean, 5% N), respectively.

Kohlrabi (*Brassica oleracea* var. *gongylodes* L. 'Eder' RZ) was planted on 6 June 2009 with a density of 7.4 plants m^{-2} and harvested on 5 September 2009. Before planting, the silty sand soil was fertilised with 65 g m^{-2} calcium ammonium nitrate (26% N), 170 g m^{-2} sheep wool pellets (10.5% N), 283 g m^{-2} lupine wholemeal (6% N), and 340 g m^{-2} ricinus wholemeal (5% N), respectively.

Tomato Greenhouse Cultivation

Tomatoes (*Lycopersicon esculentum* L. 'Alkasar' GR) were planted on 8 August 2008 at a plant density of 2.5 plants m^{-2} in a substrate culture with trickle irrigation. The plants of the four variants (two substrates, two different fertilisation levels, with 16 plants per variant) were cultivated in containers (8 L volume) filled with perlite (average dry density of 120 kg m^{-3}) or pine bark compost. The nutrient supply was calculated with the HYDROFER computer program (Böhme, 1993) in order to adjust the required amounts of fertilisers, salts and acids. Two variants were treated with 100 g sheep wool pellets per plant and irrigated with a reduced nutrient solution without any mineral nitrogen. The harvest started on 28 September 2008 and continued until 15 February 2009.

Poinsettia Pot Plant Cultivation

Poinsettia (*Euphorbia pulcherrima* Willd. 'Tosca') was planted on 31 August 2009, with 15 plants per variant, in pots with a peat-clay-substrate (Gramoflor). For fertilisation, sheep wool pellets (0, 1, 2, 5, and 10 g L^{-1} substrate) were mixed before planting with or without addition of the liquid mineral fertiliser 0.1% Wuxal super (8% N, 8% P_2O_5, and 6% K_2O) with 40 ml per pot, weekly. The final evaluation occurred on 5 December 2009. Height, number of bracts and weight of the whole plants were analysed.

RESULTS AND DISCUSSION

Vegetable Field Cultivation

In the field cultivation of iceberg lettuce, good results in all quantitative and qualitative parameters were obtained in the treatment with sheep wool pellets. The yield (Fig. 1) was up to 20% higher in comparison with the mineral fertilisation and with lupine wholemeal but with more than 30% significantly higher compared with ricinus wholemeal. Regarding the mineral content of the plants (Fig. 3) there were no significant differences between the various fertilisers.

In kohlrabi, the yield in the treatment with sheep wool pellets was up to 50% lower than with mineral fertiliser and with ricinus wholemeal but similar to the treatment with lupine wholemeal (Fig. 2). The nitrate content in the plants was the highest with mineral fertilisation and much lower with organic fertilisers, with lowest content in nitrate after fertilisation with lupine wholemeal (Fig. 4). For all the other minerals investigated the differences were not significant.

Tomato Greenhouse Cultivation

In this experiment in both substrates about 3 kg tomatoes per m^2 were harvested with standard nutrient solution (Fig. 5). In perlite substrate - due to the organic fertilisation by the sheep wool pellets - the total yield was increased by 20.6%, whereas a 35.4% increase was achieved with bark compost. Inden and Torres (2004) had already reported an increase in the yield on perlite substrate by adding organic material. Probably, there is a relationship between the slow nitrogen release from the sheep wool and the plant growth as well as the yield. Using sheep wool pellets, in the harvesting weeks 10-12 and 13-15, the fruit load was much higher than in the first weeks in comparison with the substrates without pellets (Fig. 5). The fruit quality parameters as mineral contents and the sugar/acid ratio were not affected by substrate or fertilisation (Table 2). The values were in the ranges indicated by Souci et al. (1991) and Liebster (1991). However, the nitrate content in tomato fruits achieved with the treatment with perlite and sheep wool pellets was 10% higher.

Poinsettia Pot Plant Cultivation

In poinsettia pot cultivation, in a standard peat substrate, the effect of pellets on plant growth was quantified. Adding 1, 2, 5, or 10 g pellets per L substrate resulted in increased plant height (Fig. 6). The highest plants were obtained with the application of 10 g L^{-1} substrate (with and without additional mineral fertiliser). Peat based substrate in combination with additional nitrogen affected the height of poinsettia (Frangi et al., 2004). The highest number of bracts was developed when treating with 5 g L^{-1} sheep wool plus mineral fertiliser (Fig. 7). At the end of this experiment the average fresh weight of plants with a sheep wool pellet application of 10 g L^{-1} was up to 65% higher than the treatment without sheep wool pellets (control).

CONCLUSIONS

Based on our results with different horticultural crops it can be concluded that sheep wool pellets can be used as an organic fertiliser and different combinations with mineral fertilisers are possible.

The effects are maybe dependent on the cultivation period and more pronounced in crops with longer cultivation periods because the nutrients are released slowly. In this regard an initial mineral fertilisation could be favourable, but more research is required to determine this effect. The application is possible in soil but also in other substrates common in protected cultivation. The encouraging results obtained with sheep wool pellets in both conditions could be due to an increase in nutrient availability by stimulation of microbial activity (IfN, 2008; Herfort et al., 2009).

Problems may arise due to the high initial pH and EC values, especially in salt sensitive plants. Therefore, more research is needed regarding quantity and frequency of pellet application for different soil and substrate types, as well for different crops.

Furthermore, experiments designed to improve the physical stability of sheep wool pellets for transport and application are needed.

It is still unclear whether the use of sheep wool pellets as organic fertiliser is in line with the European rules for fertilisers in organic farming and if no health risks are to be expected.

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Tables

Table 1. Dry matter and nutrient content of different sheep wool pellet compositions.

Sheep wool pellets composition	DM (%)	Org. matter (%)	Total carbon (%)	Total N (%)	Total P (%)	Total K (%)	Total Mg (%)
100% sheep wool	95.2	83.9	49.3	10.5	0.098	43.5	0.049
Pellets with cellulose	89.5	85.8	50.4	10.8	0.066	45.3	0.058
Pellets with potato starch	90.0	88.3	51.8	10.7	0.042	35.1	0.043
Pellets with casein	90.5	87.8	51.5	11.6	0.145	35.6	0.043

Table 2. Nutrient content of tomato fruits cultivated in perlite and bark compost affected by addition of 100 g sheep wool pellets per plant.

Content (mg/100 g FM)	Perlite + mineral fertilisation	Perlite + pellets	Bark + mineral fertilisation	Bark + pellets	Literature mean values[1]
NO_3^-	90.31	103.19	96.26	96.07	<500
P	18.73	20.28	19.21	18.31	25
K	242.75	236.71	257.57	244.81	295
Mg	9.66	9.84	11.06	9.70	20
Ca	6.08	5.47	5.20	5.48	14

[1] Liebster, 1991; Souci et al., 1991.

Figures

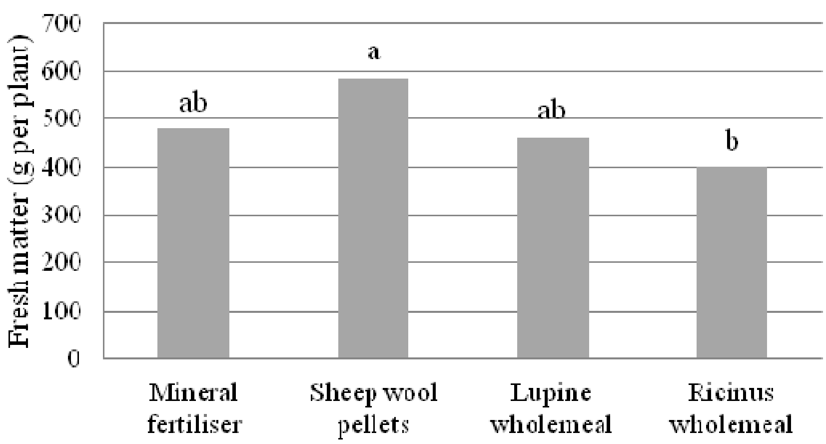

Fig. 1. Fresh matter of iceberg lettuce, as affected by mineral and organic fertiliser. Different letters indicate significant differences of the treatments (Tukey-test, P<0.05).

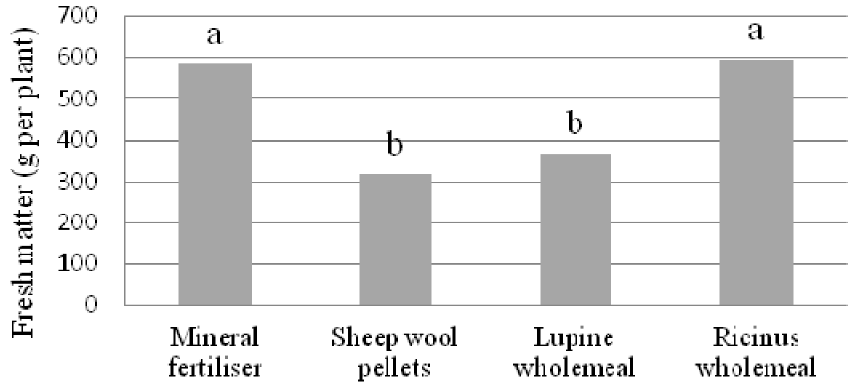

Fig. 2. Fresh weight of kohlrabi, as affected by mineral and organic fertilisers. Different letters indicate significant differences of the treatments (Tukey-test, P<0.05).

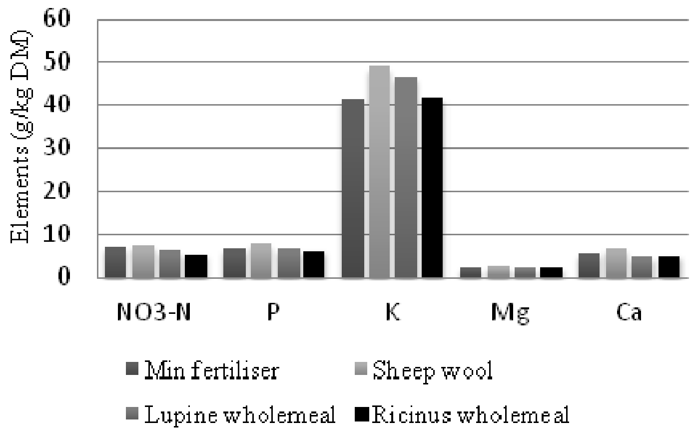

Fig. 3. Mineral contents of iceberg lettuce.

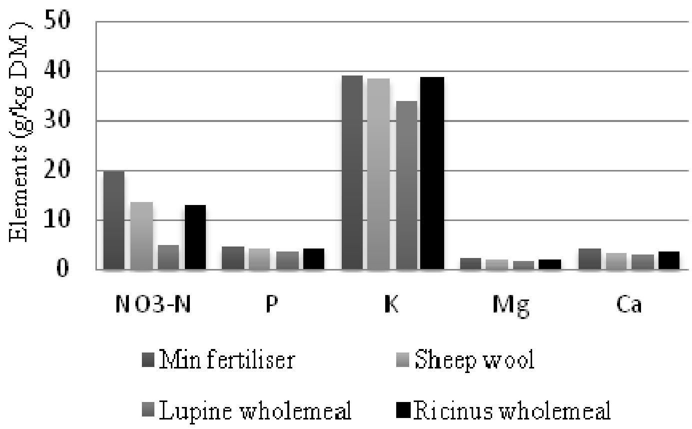

Fig. 4. Mineral contents of kohlrabi.

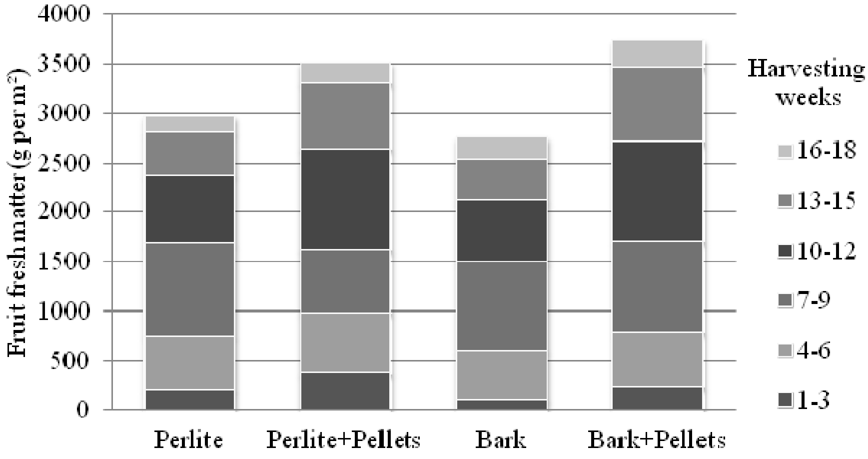

Fig. 5. Yield of tomatoes cultivated in greenhouse using perlite and pine bark with mineral or organic (sheep wool pellets) fertilisation. Differences are not significant ($p<0.05$).

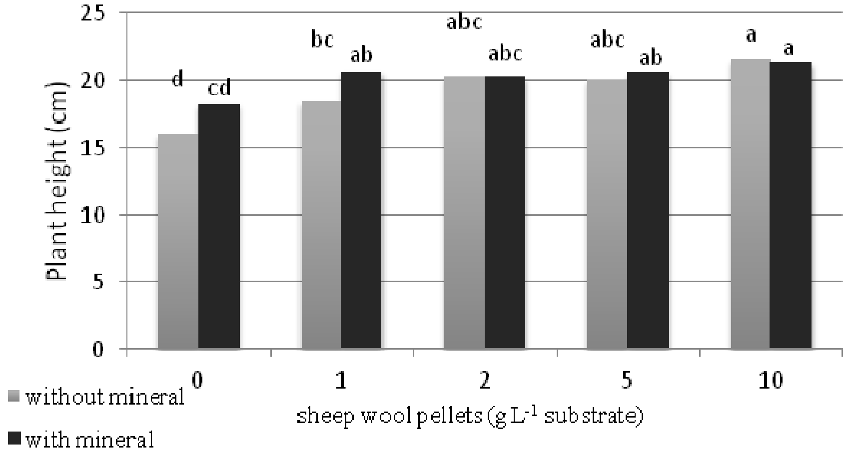

Fig. 6. Plant height of *Euphorbia pulcherrima* 'Tosca' as affected by the amount of sheep wool pellets. Different letters indicate significant differences between means (Tukey-test, $P<0.05$).

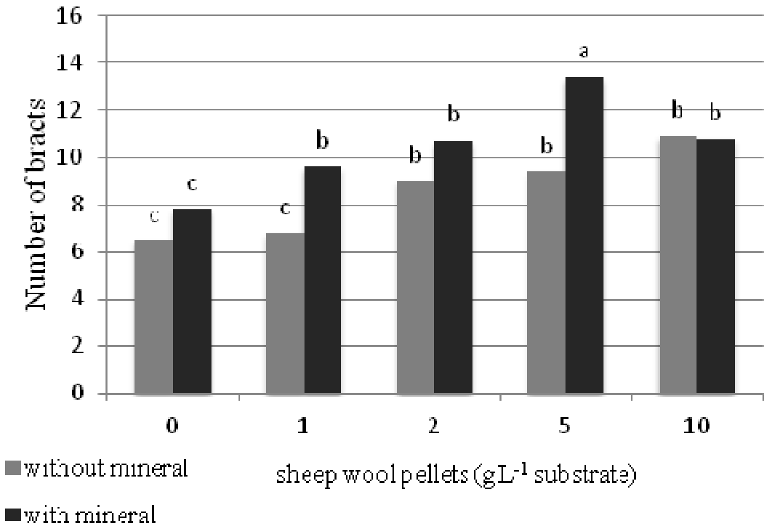

Fig. 7. Plant development of *Euphorbia pulcherrima* 'Tosca' regarding number of bracts. Different letters indicate significant differences between means (Tukey-test, $P<0.05$).