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EXPLORING THE NUTRITIONAL VALUE OF FEEDSTUFFS IN TWO FOOD-FOREST CASE STUDIES IN THE NETHERLANDS

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Abstract

Food-forest systems are generally thought to be able to make better use of available nutrients, maintain or even increase soil organic carbon balance while preserving a valuable landscape. In the Netherlands, the contribution of livestock and/or farm animals to such systems is poorly understood. For two food-forest farms with pigs and poultry, respectively, the nutritional value of feedstuff was assessed using the Weende and Kjeldahl-analyses, and the number of bacterial colonies was assessed using agar plates. Comparison was made to grass. N-contents in the feedstuffs of the food-forest systems were low in comparison to intensively managed grassland, which had a N-content of 2.8%, but comparable to that of extensively managed grassland. Total number of colonies did not differ significantly between the plates. It was concluded that the addition of manure may have influenced both the nitrogen content of the aboveground feedstock as well as belowground carbon and nitrogen mineralisation process.

Keywords: food-forest; livestock; poultry; nutritional value; sequestration

Introduction

Food-forest systems are generally thought to be able to make better use of available nutrients, maintain or even increase soil organic carbon balance while preserving a valuable landscape (Shepard 2013). However, not much is known about the perspectives for food-forests with livestock or animals in temperate regions. In the Netherlands, food-forest systems are gaining attention as examples of nature-inclusive agriculture and/or circular economy. At present, a network of pioneering enterprises exist, with mixed farming systems based on woodland, shrubs, and in certain cases also livestock.

Within this network, two farms pioneer with food-forest systems and pigs and poultry, respectively. At the first farm, Tamworth pigs are raised in a woodland with oak trees with grass underneath. This pig species is well-suited for forest grazing and the meat is well known for its superior taste. At times additional feed is given to the pigs, e.g. apple pulp. This farm has recently acquired a plot with nettle - thistle bush, and aims to convert this plot into a grazed food-forest. Major research question at this farm concerns the nutritional values of the vegetation. The second farm includes several small agroforestry plots, e.g. elderberry - grass confinements, with and without the presence of chickens. Both farms are situated on sandy soils in the north and south of the Netherlands respectively. An exploration was made of the nutritional quality of feedstuffs at these food-forest farms. Our main objective was to assess differences between feedstuffs from food-forest systems without and without livestock/animals. Our hypothesis was that, as the presence of pigs and poultry would lead to addition of manure in the food-forest system, the corresponding feedstuff would be of higher nutritional quality. In addition to the main objective, the possible impact of pig and poultry manure on soil bacterial communities was explored.

Materials and methods

Samples were taken in plots of three food-forest systems: oak - grass - pig, elderberry – grass - poultry, and nettle - thistle, in autumn 2017. For each system, samples were taken from vegetation and soil. Mixed samples from vegetation (e.g. leaves, twigs, acorns, and grass). These samples were analysed for nutritional value (Weende analysis) and nitrogen contents (Kjeldahl). For comparison, a grass sample from intensively managed grassland from elsewhere was also included. In each plot, mixed soil samples were taken in two layers (0 - 20 and 20 - 40 cm). For comparison, a soil sample (0 - 20 cm.) was also taken in extensive grassland at the same farm as the elderberry - grass food forest system. In the soil samples, bacterial numbers and diversity were assessed using various dilutions of soil in water, on plates with standard nutrient agar. This part of the analysis was done in duplo.

Results

The crude protein content in the vegetation ranged from 1.71 to 6.71 for the oak – grass - pig and elderberry – grass - poultry systems, respectively (Table 1). Values for the nettles - thistle system and the grass sample (extensively managed) were in between these extremes. The crude fat content of the nettle - thistle system was with only 0.10% about 15 times lower than that in the feedstuffs from the other three systems. However, the nettle - thistle system contained the highest amount of crude fiber (1.63%).

N-contents in the feedstuffs of all four systems were low in comparison to the reference material of the intensively managed grassland, which had a N-content of 2.8% but comparable to that of the extensively managed grassland. Surprisingly, the highest organic matter content in the vegetation was not found in the oak – grass – pig system, but in extensively managed grass (15.1%) (no data available for the elderberry – grass – poultry system). Assuming C% in all plant material is 45%, the C/N-ratio declined following the oak – grass – pig system, extensively managed grass, and nettle - thistle system (18, 11, and 5, respectively).

Table 1: Nutritional value of the feedstuffs in the food forests

Food-Forest System	Crude Protein	Crude Fat	Crude Fiber	Nitrogen	Organic Matter
	%				
Oak - Grass - Pig	1.71	1.45	0.33	0.27	11.1
Elderberry - Grass - Poultry	6.71	1.91	1.56	1.07	n.a.
Nettles - Thistles	3.15	0.10	1.63	0.50	5.3
Grassland (int.)				2.18	
Grassland (ext.)	3.72	1.83	0.95	0.60	15.1

n.a. = not available

Initially, all agar plates were overgrown with bacterial colonies until dilutions of 10^{-4} were used. Total number of colonies did not differ significantly between the plates. Only a few different soil bacterial colonies were found. In the topsoils, soil bacterial diversity was higher for the extensively managed grass and elderberry - no chicken plots then in the other plots (Figure 1). For the subsoil, the nettle - thistle plot showed higher bacterial diversity than the other plots.

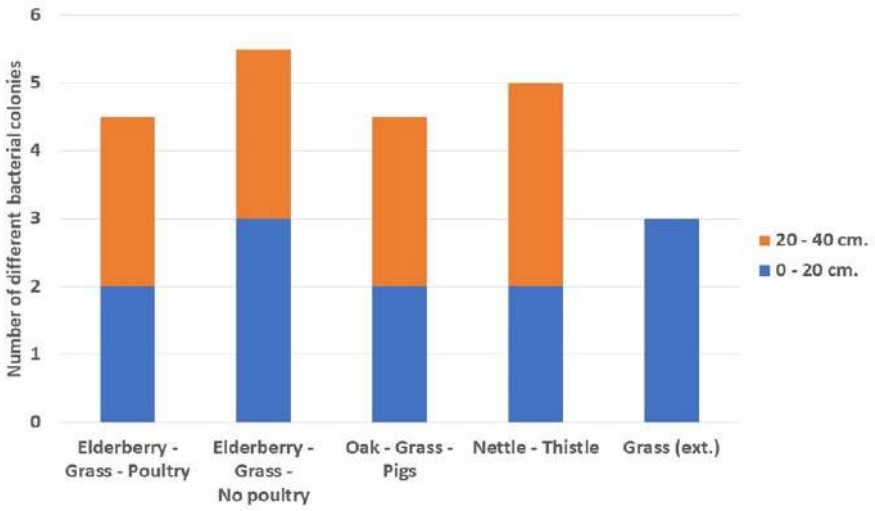

Figure 1: Differences in soil bacterial diversity in the food-forest plots.

Discussion

The oak - grass food forest with pigs provides the pigs with about half the crude protein and one-third crude fibre of what they would get in extensively managed grassland. The difference between the feedstuffs is for crude fat less prominent. The relatively low nutritional value of the oak - grass indicates a need for additional feeding. Dietary fibre is considered important for feed efficiency (Teagasc 2015) for which apple pulp may be a good source. Additional feedstuffs rich in protein may be useful for piglets and/or pregnant sows. In order to assess adequate pig diets, information needs to be collected on the relative proportion of the available sources of organic matter, as well as the daily intake by pigs.

Comparing the food-forest systems oak - grass and elderberry - grass with the extensively managed grassland at the same site, the elderberry - grass system showed the highest protein content. This suggests that the soil in the elderberry - grass system contained more nitrogen than the oak - grass system and the extensively managed grass plot. The presence of poultry manure in the elderberry - grass system could be a possible explanation for this. Considering the feedstuffs of the food-forest systems included, the elderberry - grass feedstuff appears to be of the best quality in terms of crude protein, fat and fibre. However, elderberry contains cyanogenic glycosides in bark, leaves, berries, roots and stems, from which hydrogen cyanide is released. This substance may be toxic to animals or at least affect palatability (Cope, Overview of cyanide poisoning).

The sequestration-mineralisation processes of plant material in soil are in part determined by the difference in C/N-ratio between the plant material and the soil. Materials with higher C/N-ratio than the soil may lead to immobilisation of nitrogen. If we assume a C/N-ratio of 10 in both our soils, decomposition of oak - grass material would require extra nitrogen. Pig manure could be a useful source in this respect, eventually sequestering more carbon in the soil. However, decomposition rates of oak depend on oak species (Jurkšienė et al 2017). Residues from elderberry - grass with its high N-content is expected to release nitrogen in soil. Also in the nettle - thistle bush nitrogen may become available from mineralisation if this bush would be added to the soil. Both nettle and elderberry are known for their high decomposition rate (Atkinson and Atkinson 2002). Conversion of the nettle - thistle bush into a food forest could be accompanied by adding low-N organic material to conserve the nitrogen in the topsoil. In order to assess the carbon sequestration potential of the oak - grass and elderberry - grass food forest, requires modelling of soil organic carbon using detailed information on the quality of the various inputs and their decomposition rates. The ability of an agro-ecological system to provide ecosystem services is regarded as a sign of ecological intensification (Tittonell 2014). However, in the case of carbon sequestration in a food-forest system, this service may be restricted by the natural ecological boundaries prevalent in such soils.