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Ju-Kwang Yoon*, Walter Dirksmeyer

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Institute of Farm Economics, Thünen Institute, Bundesallee 63, 38116 Braunschweig, Germany; ju-kwang.yoon@thuenen.de, walter.dirksmeyer@thuenen.de

* Correspondence: ju-kwang.yoon@thuenen.de

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Ju-Kwang Yoon, Walter Dirksmeyer

Institute of Farm Economics, Thünen Institute, Germany

Abstract

Peat, as the primary substrate component, has dominated the horticultural industry for decades. However, the use of peat is challenged due to its negative environmental impacts. Consequently, the German government encourages the reduction of peat use and promotes peat alternatives. The potted herb industry is one of the horticultural business sectors that depends heavily on peat as substrate. While studies have investigated the physiological impacts of peat reduction in potted basil there is still a lack of economic analysis of the transition. This paper aims to fill the gap by analyzing the economics of peat reduction in the production of potted basil from the farmer's perspective. The data used in this study are from the ToPGa project, and a typical farm approach was employed to evaluate the status quo (65% peat content), peat-reduced (40%), and peat-free (0%) potted basil production systems. The economic analyses were conducted to assess the impacts of peat reduction on the production system and the economic feasibility of the change. The results show that the complete elimination of peat content in substrate leads to a significant increase in variable costs and a reduction in revenue, making it economically infeasible. However, with small adaptations in the current production system, a gradual peat reduction to 40% can be achieved with a minor reduction in gross margin.

1. Introduction

Peat has been the most widely used substrate component in the German hobby gardening and commercial horticultural industry in the last decades due to its favorable physical and chemical properties such as low density, good drainage, and absence of weed seeds and pathogens (Isaka et al. 2021). The substrate industry in Germany produced a total output of 12 million m³ substrate in the year 2021, with peat constituting 9.4 million m³ or 78% of the overall volume (IVG 2022). However, the use of peat has been challenged in recent years due to its negative environmental impacts such as the loss of carbon sequestration potential of peatland due to its depletion. This concern was reflected in the German government-initiated "German Climate Action Plan 2050 (German: Klimaschutzplan 2050)" and "Climate Action Program 2030 (German: Klimaschutzprogramm 2030)" where measures to reduce peat use and to promote the use of sustainable alternatives to peat based substrates are included (BMEL 2019).

The fresh herb market in Germany is a 200 million Euro p. a. industry that has shown increased demand in past years (AMI 2019). Moreover, with 60% of the market share, the potted herb is the most popular fresh herb product that heavily relies on peat as the main compound of the growing medium (AMI 2019). In 2019, the total estimated production of potted herbs was roughly around 140 million pots (Hinrichs 2019). The most distinct

advantage of potted herbs compared to fresh-cut herbs is the long shelf life with retained freshness.

Among potted herbs in Germany, basil (*Ocimum basilicum*) is the most important culinary herb which originates from Southern Asia (Bączek et al. 2019). Basil dominates 50% of the potted herb market in Germany, leading to approximately 70 million basil pots and an annual revenue of 46 million Euros per year (Frerichs et al. 2017). With regard to the use of peat, the standard substrates for potted basil usually contain an average of 70% peat (Koch 2022).

Several studies have assessed the potential impacts of reducing or eliminating peat use in potted basil production from an agronomic perspective (Koch 2022; Burdina and Priss 2016; Burnett et al. 2016; Degen and Koch 2003; Kunz et al. 2019; Salé et al. 2021; Souza et al. 2011). Despite the extensive agronomic research, a significant gap still exists in understanding the economic impact of peat reduction at the farm level, where the peat reduction scheme would have a direct influence. This paper aims at bridging this gap by constructing a status-quo and peat reduced model of typical production system for potted basil production and conducting economic analysis to assess the financial consequences of reducing peat in substrates in potted basil production systems from the farmer's level.

2. Data, Methods and Approach

The database used in this paper was established as a part of the ToPGa project, which is a collaborative research project funded by the German Federal Ministry of Food and Agriculture (BMEL) and managed by the Agency for Renewable Resources (FNR). The objective of ToPGa is to examine and evaluate the possibilities and effects of using peat-reduced substrates in the commercial horticulture sector.

The database established for this analysis is the typical production system, which follows a typical farm approach. A typical production system is a model that represents the prevalent production system of a crop in a specific region (Chibanda et al. 2020).

Figure 1: Steps of typical production system approach (Hirschler and Kretzschmann 2022).

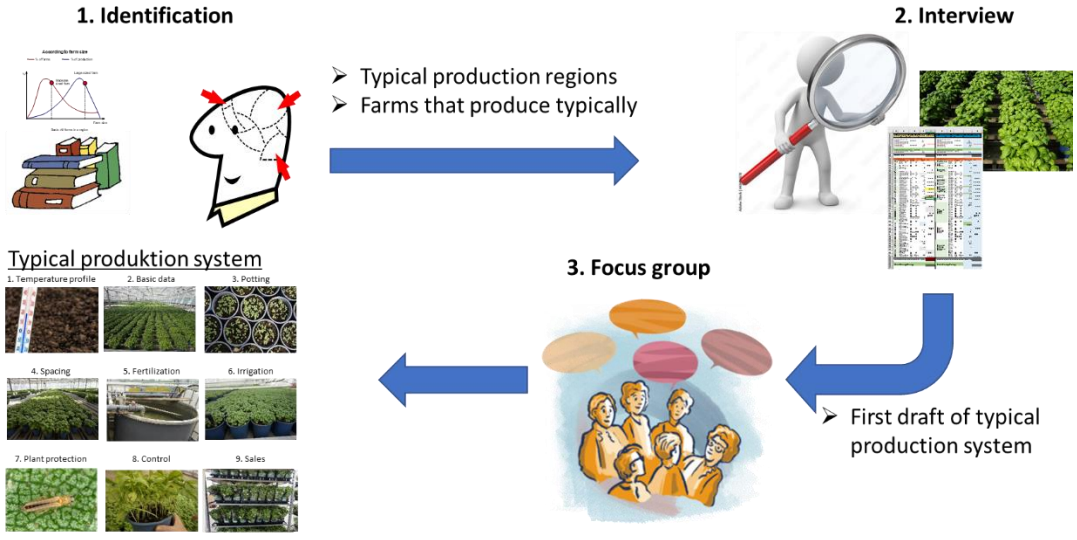


Figure 1 shows general steps of the typical production system approach. As the first step, a literature review and expert interviews were conducted to identify the prominent basil production system(s) and the main production region(s). From this process Papenburg region in Lower Saxony, where over 70% of the potted basil in Germany is produced, was selected as the typical region for potted basil production. Following the identification process, eight farms, recommended by the experts as typical farms for potted basil production in the region, were interviewed in August and September 2022 using questionnaires specifically formulated to elicit detailed information about the production system. These farms are not particularly small or big but average in size that use typical technology for potted basil production. The information gained include general farm information such as the farm size, average wage of permanent and temporary employees, the value of farmland as well as production system information such as materials and labor used for potting, irrigation, fertilization, plant protection, and harvest and finally sales information such as marketing channels, prices and quantities sold. Consequently, the data from the interviews was processed to develop a first draft model of the typical potted basil production systems. Such typical production systems depict the complete price quantity structure of production systems. To ensure that the model of the typical production system represents widely used basil cropping patterns, the draft was cross-checked and validated through a focus group in December 2022 with experts including researchers, consultants, and farm managers. The effects of peat reduction in the production system were also evaluated in the focus group by the experts. However, the knowledge was derived from limited experience with peat alternatives. Consequently, the assessment of peat reduction was speculative and based on specific peat-reduction and peat-free scenarios.

Based on the typical production system approach, it was revealed that the substrate of the status quo typical production system contains 65% peat. Furthermore, since there are significant differences in the production system of potted basil between the summer and winter seasons, the two distinct systems were separated, namely the summer set and the winter set.

Using the expert-validated typical production systems, various economic analyses were conducted to evaluate the effects of peat reduction on the production costs and profitability of the typical potted basil production system. Key variables were variable costs and gross margin as machinery and other investments are not affected by the shift in peat content of the growing media. Two scenarios with reduced peat content were evaluated in the economic analysis, namely the peat-reduced (40% peat content) and the peat-free (0%) scenarios.

3. Results and Discussion

Two typical production systems for potted basil production, namely summer set and winter set, were identified through the typical production system approach. Important differences between both systems are described in Table 1. The major difference between the production systems is the length of the cultivation period. Growing conditions are more favorable in summer, which enables potted basil to be ready for sale three weeks earlier than in winter. Further, the plant density can be higher in winter than in summer, as the growth rate is slower during the winter season. Although the plants in winter have a longer cultivation period, they require less water due to a lower transpiration rate. To compensate for the lack of sufficient light conditions in winter, artificial lighting and more than three times more heating energy has to be provided in the winter set compared to the summer set.

Table 1: Key information on typical summer set and winter set for potted basil production.

	Summer set	Winter set
Cultivation period (Weeks)	5	8
Number of sets (Weeks)	20 (CW 16 – CW 35)	32 (CW 36 – CW 15*)
Yield (Pl./Set)	53,000	37,500
Spacing (Pl./m²)	25	30
Water (m³/1,000 Pl.)	5.3	2.8
Fertilisation (l/1,000 Pl.)	13.3	13.3
Heating (kWh/1,000 Pl.)	1,355	4,290
Lighting duration (h/Day)	-	8

* following year

Figure 2 compares the operational costs between the summer set and winter set and for different peat content levels: status quo (65%), peat-reduced (40%), and peat-free (0%). In comparison to the status quo, it was observed that reducing the peat content down to 40% had only minor impacts on the production system. While most cost variables remain unchanged, only the substrate costs experienced a noticeable increase, which led to 25% rise in the potting costs (Figure 2). Overall, this resulted in a 5% increase in variable production costs in the summer set and a 3% increase in the winter set.

Contrary, the comparison between the status quo and peat-free scenario in summer set per 1,000 plants shows a 36% increase in potting costs (Figure 2), which is mainly due to increased substrate costs. Moreover, the experts in the focus group assumed that to date there is no optimal peat-free substrate for basil production available in the market. The experts argued that based on previous trials with peat-free substrates, the most noticeable impact of the utilization of a growing media with suboptimal properties is an extension of the cultivation period by one to two weeks in both the summer set and winter set due to the reduced growth rates. For this reason, the peat-free production system revealed slight cost increases in plant protection, fertigation, and irrigation, heating, and monitoring primarily caused by the prolonged cultivation period. Packaging costs remain stable. In total, the variable production costs in the summer set increased by 16%.

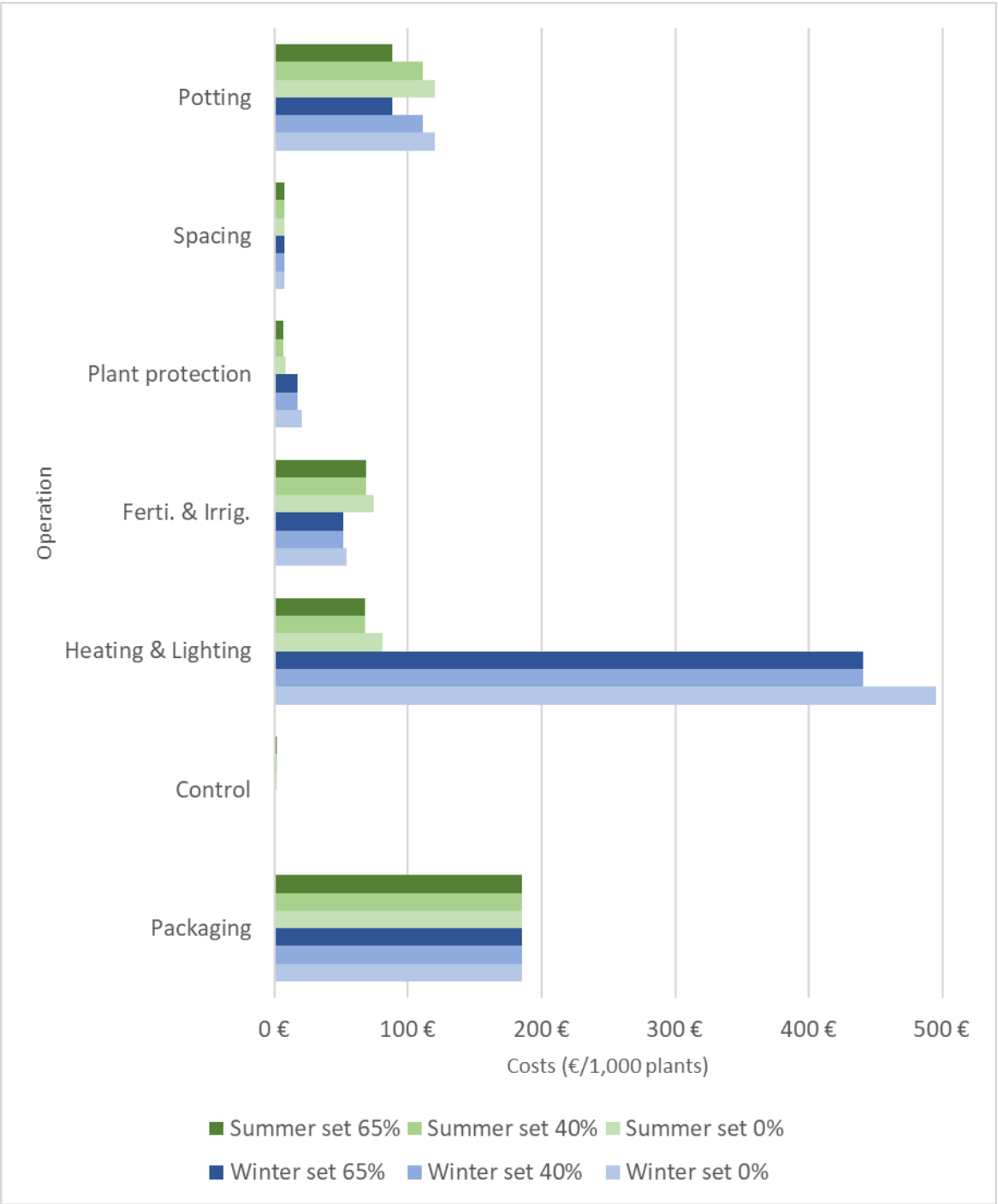
The impact of peat elimination in the winter set is similar to the summer set. Aside from packaging costs, which remain stable again, the one-week longer cultivation period causes a proportionally higher increase in variable costs. The overall variable costs increase from peat elimination in the winter set is 12%. However, the status-quo winter set already exhibits a negative gross margin due to 20% higher variable costs compared to the summer set. Consequently, the heightened variable costs in the peat-free production system would pose critical challenge to the financial health of the farm.

The economic analysis presented in Table 2 provides an overview of the major impacts of peat reduction in the potted basil production system in the status quo (65% peat content), peat-reduced (40%) and peat-free (0%) scenario for a one-year production cycle. In the peat-reduced scenario, a 25 percentage points reduction of peat content from the 65% in status quo was reached by substituting peat by the high-quality alternative coir. Consequently, the substitution led to higher substrate costs with no further changes to the production system due to the comparable characteristics of coir and peat. Hence, the

revenues in the peat-reduced scenario remained unchanged compared to the status quo, while the variable costs increased by 4% and the gross margin declined by 23% per year.

The peat-free production scenario demonstrated a more significant impact of peat reduction. The impact can be primarily attributed to the utilization of suboptimal growing media, which reduces the plant growth rate and consequently leads to a week longer cultivation period as described above. The analysis in one-year timeframe provides additional insights into the impact of utilizing suboptimal growing media in basil production.

Figure 2: Operating costs for summer set and winter set (per 1,000 plants) comparison between 65%, 40% and 0% peat content.



The prolonged growth period in the peat-free substrate has effects on the annual number of basil plant to be produced on a limited production area (Table 2). The reason for this is, that less sets or sets with a reduced number of plants can be produced. Assuming that the farm manager aims at producing basil set weekly, 37,342 instead of 40,385 plants can be potted per week leading to an 7.5% reduction in annual potted plants (Table 2). In addition, due to the change in substrate components, there is an increased exposure to diseases and pests and increased number of unmarketable products due to heterogeneous growth rate. Due to these factors, the failure rate might initially reach 100% and even with technological adaptations over time, it is anticipated to remain high. Therefore, the consensus reached in the focus group is that, in peat-free scenario, the failure rate will be set as double the status quo production system. The net effect of the longer cultivation period and the higher failure rate results in a 10% reduction in marketable basil pots and thus in revenue as well and in a 4% increase in variable costs at the same time. As a result, the gross margin decreases by 68%.

Table 2: Annual production comparison between 65%, 40% and 0% peat content.

	Status quo (65%)	Peat-reduced (40%)	Peat-free (0%)
Net area (m²)	8,000	8,000	8,000
Number of sets	52	52	52
Cultivation period (Week)	5 (Summer), 8 (Winter)	5 (Summer), 8 (Winter)	6 (Summer), 9 (Winter)
Production volume per week (Pl. / Week)	40,385	40,385	37,342
Annual production volume (Pl.)	2,264,116	2,264,116	2,084,761
Failure rate	2%	2%	4%
Revenue	1,597,560 €	1,597,560 €	1,440,987 €
Variable costs	1,308,139 €	1,359,082 €	1,347,810 €
Gross margin	**288,421 €**	**238,478 €**	**93,177 €**

4. Conclusions

The results of the economic analysis indicate that the production of peat-free potted basil is currently not economically viable using the existing technology. However, the economic analysis suggests that peat reduction down to a 40% peat content is attainable with only a slight reduction in gross margin. Contrary to this, peat-free production of basil is more challenging. Higher substrate costs, a prolonged cultivation period and an increased failure rate shrink the gross margin by 92%. However, it can be assumed that the peat-free substrate quality will be improved and adjusted towards the needs of basil in future. Further, advancements of substrate technologies and optimized sourcing of alternative growing media components may lead to a reduction in the price difference between the status quo substrate and the future peat-free growing media. Moreover, the production system will be gradually adjusted and optimized in response to the new substrate properties, based on the knowledge and experiences of the farm managers as well as insights from new research findings. These factors will contribute to the recovery of the decreased gross margin towards today's levels in the future for both peat-reduced and peat-free basil production. Therefore, further research into potential technological innovations for substrate manufacturing and production systems improvement is recommended to mitigate the impact of peat reduction in the production of potted basil.

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