Extended Abstract
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Paper Title	Assessing the value of organic fertilisers

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Abstract	***200 words max***

Fertiliser prices have risen worldwide since the end of 2021. In this context, the value of organic fertilisers has also changed from the farmers' perspective. With the increased demand for organic fertilisers, there is currently an open question about their value. This question must be addressed individually for each farm. To achieve this, a linear optimisation model is applied. The model can be adapted to farm conditions and provides mineral and organic fertilisers as plant nutrition variables. By parameterising the organic fertiliser prices, it is possible to identify the price level at which an organic fertiliser becomes competitive within the farm. This substitution value marks the maximum price a buyer could pay for a particular fertiliser. This method is repeated in the study in different farm scenarios. Based on the fertiliser market situation in September 2022, substitution values between 10 and -8 € m^{-3} could be determined for a digestate (with: NPK=5-2-5 kg m^{-3}). This study provides the basis for a decision support system that farmers can use to determine the value of organic fertilisers. As a positive implication, it can be expected that organic fertilisers will be used where they contribute best to value creation.

Keywords	Substitution value; organic fertiliser; fertiliser price; optimization; linear programming;
JEL Code	Q120 Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets; D400 Market Structure, Pricing, and Design: General

Introduction *100 – 250 words*

Organic fertilisers contribute significantly to the nutrient supply of crops. As natural compound fertilisers, they are able to substitute mineral fertilisers. However, from the farmers' point of view, the use of organic fertilisers has disadvantages compared to mineral fertilisers, e.g. due to increased transport and application costs or a lower nitrogen utilisation efficiency. In addition, restrictions under fertiliser legislation mean that farms with a large amount of organic fertiliser have to pass on considerable quantities to other farms. As a result, organic fertilisers have often been valued below their actual nutrient value and in some cases have even been subject to " transfer costs".

Due to the effects of the energy crisis and the war in Ukraine, fertiliser prices have multiplied. In addition, the availability of fertiliser is also not guaranteed in all cases. This situation had a significant impact on the demand for organic fertilisers in the

2022 season. This now raises the question of a reassessment of the value of organic fertilisers for many farms. Here, numerous farm-specific aspects have to be considered that have an influence on the substitution value of organic fertilisers.

Methodology	***100 – 250 words***

Marginal costs and marginal benefits determine the maximum price that a buyer of organic fertiliser could pay. Marginal costs arise, for example, if the application of organic fertiliser leads to higher costs than the previous application of fertiliser. Marginal benefits arise, for example, if the use of organic fertiliser can reduce previous fertiliser expenditures. Marginal costs and marginal benefits also vary within the farm: for example, the first unit of organic fertiliser applied, can be used more efficiently than the last unit before reaching a potential saturation limit. In order to be able to represent these relationships individually for each farm, a linear optimisation model is used. This model represents the receiving farm and includes the purchase of mineral and organic fertilisers as variables. Mineral fertilisers are included in the model at market prices and the price assumptions for organic fertilisers are parameterised. In this way, the farm-specific substitution value of organic fertilisers is determined.

Results	***100 – 250 words***

The results show that the substitution value of a digestate (with: N_t=5 kg m^{-3}; P_2O_5=kg m^{-3}; K_2O=5 kg m^{-3}) can be up to 18 € m^{-3} in September 2022 (including transport and application). The price level of CAN, which was 870 € t^{-1} at that time, serves as a reference. It should also be noted that the substitution value of organic fertilisers can be subject to enormous fluctuations from an on-farm perspective.

Factors with very large, to large influence: Nutrient content in organic fertiliser; Phosphorus and potash content of the soils; Phosphorus and potash removal in crop rotation; Price situation on the market for mineral fertiliser

Factors with medium influence: Transport and application costs; If applicable, storage costs for temporary storage; Timing of organic fertiliser uptake (e.g. unfavourable in autumn or winter)

Factors with low influence: The achievable N efficiency (especially if high N efficiencies are gained through expensive application technology).

Considering these influencing factors, different scenarios were formed and the substitution values of the exemplary digestate were determined for these scenarios. The range of results was between 10 and -8 € m^{-3}, in case of self-collection at the digestate storage.

Discussion and Conclusion	***100 – 250 words***

Since the nutrient composition of organic fertilisers is often not homogeneous, a value determination can only be sufficiently accurate if the nutrient composition is

permanently monitored. NIRS technology, which allows the measurement of nutrients in real time, is particularly suitable for this purpose. Only when this important condition is fulfilled, it is meaningful to derive substitution values for organic fertilisers. The method described currently does not consider micro nutrients, which can cause positive yield effects depending on the situation and thus increase the value of organic fertilisers. However, the method also leaves out possible negative yield effects, which can be caused, for example, by the use of heavy machinery.

This study provides the basis for a decision support system that farmers can use to determine the value of organic fertilisers. As a positive implication, it can be expected that organic fertilisers will be used where they contribute best to value creation. This is likely to defuse regional hotspots of organic fertilisation, which meets numerous social demands in connection with organic fertilisation.