Analysis of Influencing Factors on Infield-Logistics of different Farm Types in Germany

Michael Mederle*, Heinz Bernhardt

Technical University of Munich, Center of Life and Food Sciences, Agricultural Systems Engineering,
Am Staudengarten 2, D-85354 Freising, Germany
* Corresponding author; E-Mail: michael.mederle@tum.de

Abstract

Optimization of agricultural production processes will contribute to increasing efficiency in future agriculture. Knowledge of potential influences on infield-logistics is necessary to be able to navigate agricultural machinery in the fields effectively and process optimized. Preliminary studies in different German regions and Canada based on GPS-lane analysis show that decisions on specific infield patterns depend on unchangeable factors (e.g. field geometry, field access points) to a certain degree. Nevertheless regarding infield-logistics farm managers and staff members act farm specifically as well as depending on technology or situation and furthermore often intuitive.

The individual decision behavior of farmers is determined to be able to further specify "soft" influencing factors. The examination is based on expert interviews with the aid of aerial images of their arable land. Rural mixed farms with simple machinery are considered as well as large agricultural cooperatives which farm thousands of hectares using track guidance and other electronic assistance systems.

First results show that farm managers using guidance tracking or SectionControl increasingly attune their infield-logistics on direction giving obstacles such as power lines. Livestock farmers rather focus on the application of organic manure, where road conditions and possible field access points become important due to required supply logistics. Sugar beets make great demands on infield patterns because of relatively low bunker sizes compared to the mass to be transported as well as the positioning of the beet clamp.

Afterwards the obtained influences can be integrated into a navigation tool for optimizing infield logistics. Thus process efficiency can be further increased.

Keywords: Agricultural Logistics, Process Optimization, Onfield Navigation, Vehicle Guidance, Decision Criteria

1. Introduction

The logistics requirements in modern agriculture have been increasing enormously for some time. On the one hand this development is due to growing farms, of which farm-field-distances are rising continuously. On the other hand new branches such as the production of biogas require steadily growing transports of any kind [BE13].

An optimal utilization of all used machines is of high importance, particularly because of unpredictable weather influences. The more machines are interacting in complex process chains, the higher is the optimization potential of the logistics behind it [SHB14]. Some software solutions already help at planning and organizing of complicated agricultural processes. Entire process chains can be simulated, analyzed concerning efficiency and finally optimized theoretically. By now researches in this area rather deal with logistics on public and field roads till the edge of the field than in the field. This kind of navigation is pure line logistics where the field represents the defined target point.

Besides the navigation to the field also the navigation in the field is able to provide significant reserves of efficiency that should have to become available. This step would be a meaningful contribution for increasing efficiency which in future will be achieved not only by higher engine power or higher working widths but more and more by optimized techniques of agricultural processes.

Infield logistics especially gets into focus when several operating machines are working in one field. In this case an optimized coordination of all process participating equipment is of very high importance. By contrast to road logistics infield logistics is known as area logistics. Farmers can choose an endless number of possible lanes to work their fields but only a certain part of them is realistic and practicable.

During the last years a lot of optimization has been done concerning infield-logistics. The most important goals were reducing fuel consumption, reducing dead distances as well as maximizing process times in the fields. These optimizations do not take into account the reasons for certain farm-specific infield-strategies. There are influences why farmers do not work their fields as the optimization pretends. The aim of this research is to find these influences and to consider them when optimizing infield-logistics [MGB15].

Figure 1 shows a rectangular field with 3 different infield scenarios. The field is surrounded by neighbor fields north and south as well as field roads east and west. Scenario A serves as an example for cultivation so that neither supply- nor removal-logistics is needed. The field roads will not have any influences but the farmer will choose the longer north-south lane to reduce turning times while maximizing process times. Scenario B and C represent operations with supply-logistics, e. g. slurry application. Depending on tank volume and amount of application the farmer will accept the shorter

lane from west to east to use the direct entrance and exit to the field. The field roads now surely have influence on the infield-strategy and probably the farmer will do all the operations in west-east-direction [MHB14].

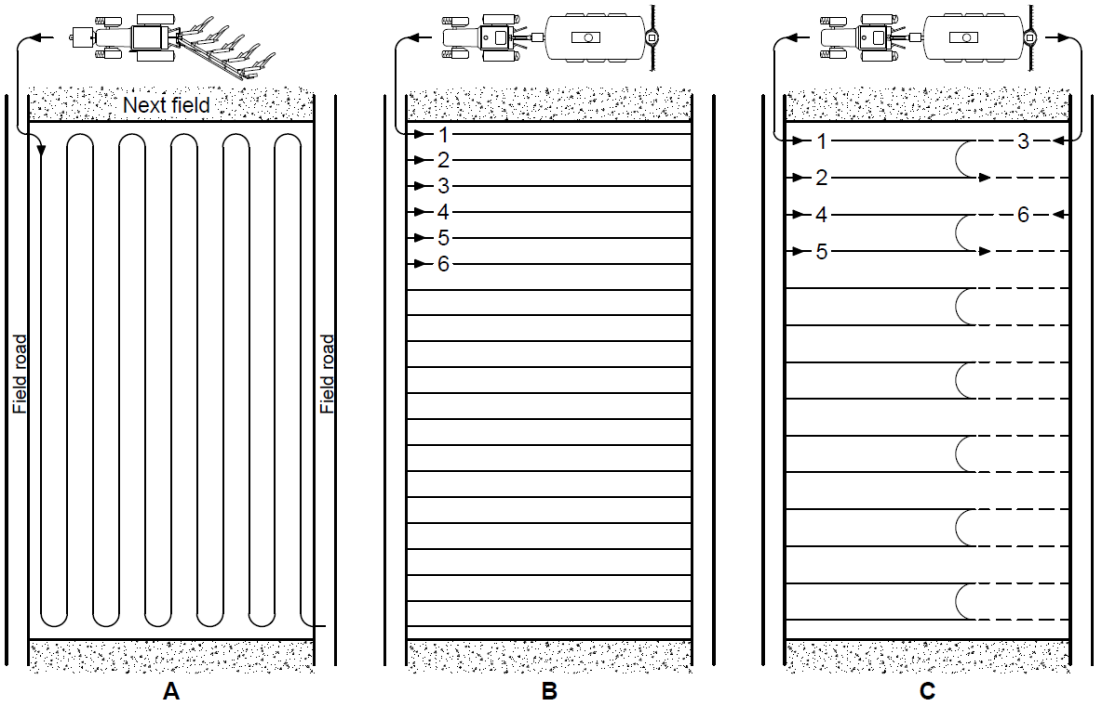

Figure 1: Different infield-strategies depending on various operations

The system due to which farmers work their fields is depending on several influencing factors that are hardly researched scientifically. The goal of this research is to identify reasons for certain infield strategies as well as to analyze and judge them.

2. Materials and Methods

Main part of the research is a survey of numerous farmers all over Germany which is conducted in the shape of an expert interview. The variety of German agriculture is very broad as there are different structures in the north and east of the country compared to the south. Arable farming in the north and east is rather large-scaled and farms are more and more often organized as agricultural companies whereas in the south family farms with mainly smaller sizes dominate the structure. It is intended to cover as many different types of farms as possible. Various types of farms are expected to have different preconditions concerning field shapes and sizes or machinery equipment and technologies used for cultivating their fields. All these factors are said to have influence on different infield scenarios.

Various preliminary studies based on GNSS lanes have predicted that influencing factors on infield strategies strongly depend on farm specific parameters. For this reason the structure of the survey is rather qualitative than quantitative in order not to lose valuable information. However, regarding the evaluation of the study it is important to be able to compare all the statements of the different farmers. Therefore all the conversations are carried out based on a certain interview guideline.

2.1. Guideline of the questionnaire

Every interview starts with general questions on the particular farm such as farm size, technical equipment or available manpower. Based on this information it is possible to range the survey participating farms.

Next part covers general questions on infield strategies. This section is intended to focus on reasons for certain infield patterns as well as to answer questions concerning specific field arrangements or area divisions. Examples might be as follows:

- Do you work your fields always the same way or is this depending on the cultivated crop?
- What parameters do you focus on when you consider on your infield logistics?
- Do you zone your fields in certain subdivisions or are you always trying to work biggest fields possible?

Third section of the guideline deals with issues concerning headland, patches and tramlines. The central question in this part is the particular way of headland designing as well as the question of working in special patches or not.

Further parts of the interview concern about operation steps as tillage, seeding, plant protection as fertilizing or

spraying as well as grain harvest. Livestock or biogas farmers are additionally asked about slurry or organic manure application affairs.

The last chapter is mainly foreseen for larger scaled grain farms where certain operation steps such as tillage or particularly grain harvest are done by more than one machine at the same time. Especially when working in such complexes the reasons for special infield strategies are extremely interesting and reasonable to analyse.

2.2. Already interviewed farmers

Table 1 shows 12 farmers of different parts in Germany with various agricultural preconditions that have already been interviewed in the first step of the study.

Table 1. Already interviewed farmers

Farm size	Total number	Livestock farming	Sugar beet cultivation	Use of GPS technology
< 100 ha	3	3	1	0
100-500 ha	6	0	5	4
> 500 ha	3	1	2	3
Total	**12**	**4**	**8**	**7**

The participating farms have been clustered in 3 different categories depending on their amount of arable land in hectare. The fact whether they do livestock farming is important to know because otherwise they cannot answer certain questions on organic manure application. Sugar beet cultivation is also an important criteria. Due to this crop farmers change their infield strategies more often than because of others.

3 of the participants farm less than 100 ha but all these 3 also do livestock farming. One of them cultivates sugar beets whereas no one uses GPS technology. Half of the already interviewed farmers belong to the second group of 100-500 ha arable land. Almost all of them grow sugar beets and two thirds use RTK assistance systems. 3 participants farm more than 500 ha. This range is from 640 to 1200 ha. All these 3 use RTK technology but only 2 cultivate sugar beets.

3. Results and Discussion

First results of the evaluation show that influences on infield logistics can be categorized in two different groups. There are so-called “hard” factors which are not or only hardly changeable such as field shapes, field sizes or field access points. Furthermore “soft” factors can be changed quite easily because they strongly depend on the organization and structure of the particular farm. Examples therefore are the equipment with manpower as well as the utilized machinery technique and electronic assistance systems.

3.1. Influence of Power Lanes when using electronic assistance systems

Especially the use of electronic assistance systems such as parallel guidance systems or SectionControl seems to change the habits of the farmers concerning the system of working their fields. 7 out of 12 already interviewed farmers use GPS technology and 4 of them indicated that power lanes influence their infield strategies. Figure 2 and 3 show this fact based on an example of an electric power lane crossing the field.

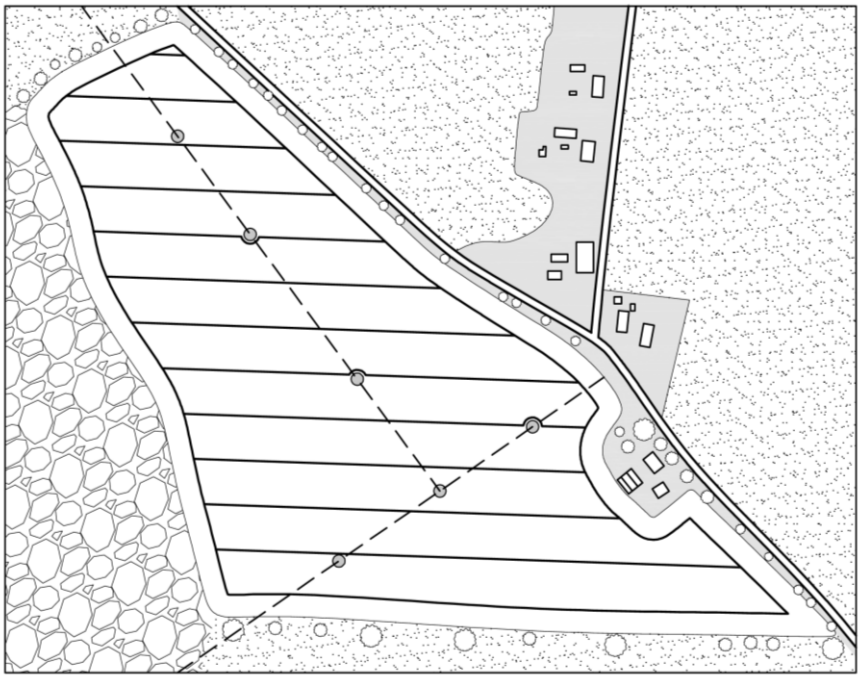

Figure 2: Way of working the field without using electronic assistance systems

In former times, when no electronic assistance as parallel guidance or section control was provided, the entire field has been worked just along the straightest edge. All tramlines were parallel. Wedges and angles were unavoidable and all caused by the natural shape of the field. One of the biggest disadvantage of this particular way to work this field appears at spraying, because the boom has to be flipped at every power pole which takes a lot of time.

Figure 3 shows exactly the same field after the implementation of electronical assistance.

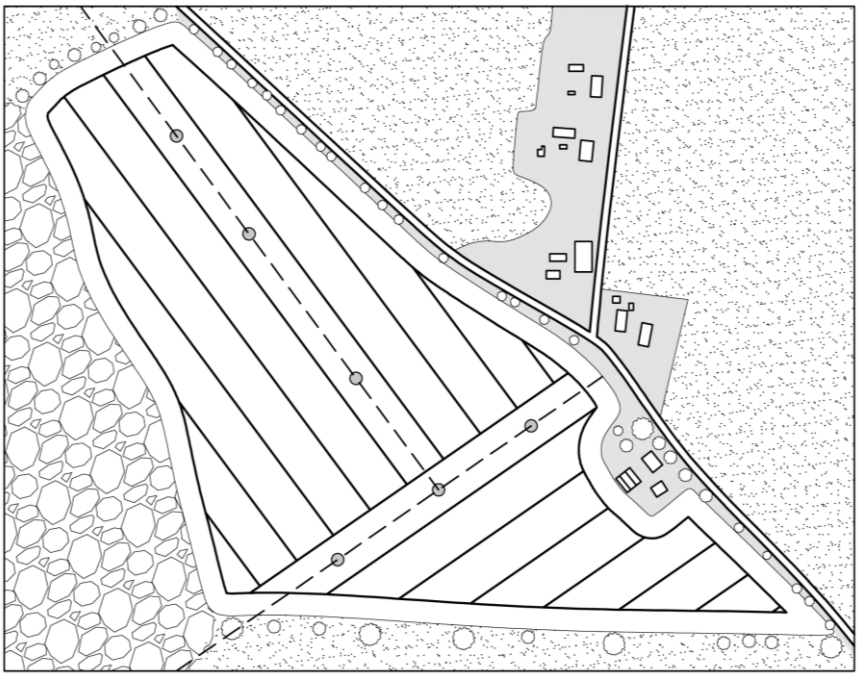

Figure 3: Way of working the field by means of using electronic assistance systems

Farmers are now able to attune their infield strategies to the power lanes, so they do not have to waste that much time for flipping the boom of the sprayer anymore. The fact that this scenario results in even more angles at the headland is negligible because of section control.

3.2. Influence of sugar beet cultivation

By now the survey shows that sugar beet is a crop with very high influence concerning infield logistics. On the one hand these influences are caused by high mass yields per hectare and on the other side by market regulation measures as supply quota. Additionally the positioning of the beet clamp requires some considerations because removal logistics is mainly carried out by trucks which are not able to use field roads of bad quality.

3.2.1.Influence of sugar beet cultivation on field arrangement

Figure 4 shows a typical case where farmers divide their fields when growing sugar beets.

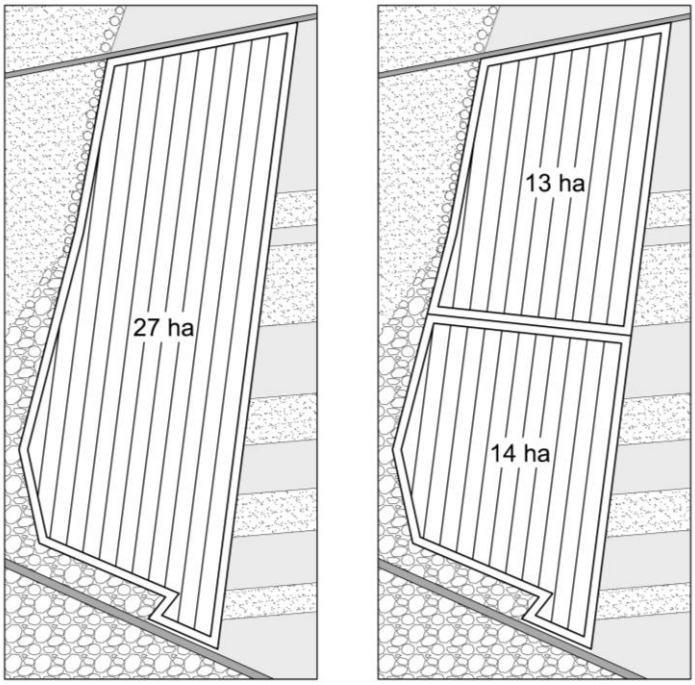

Figure 4: Field arrangement depending on sugar beet cultivation

One reason for this measure is the quantity of the supply quota. The farm is allowed to deliver not more than the amount of sugar beets which is equal to the estimated yield of 13 to 14 ha. Another reason for cutting the field across the longer side is the particular system of sugar beet harvesting. The farmer explicitly wants to work without multiphase logistic systems in the field because of soil protection. In this special case the farmer is willing to accept more time for turning and unloading while standing. Other farmers rather focus on process times of the expensive harvest machine at the expense of more vehicles in the field.

3.2.2.Influence of sugar beet cultivation on headland designing

Figure 5 shows the influence of sugar beet cultivation on the designing of the headland in particular cases.

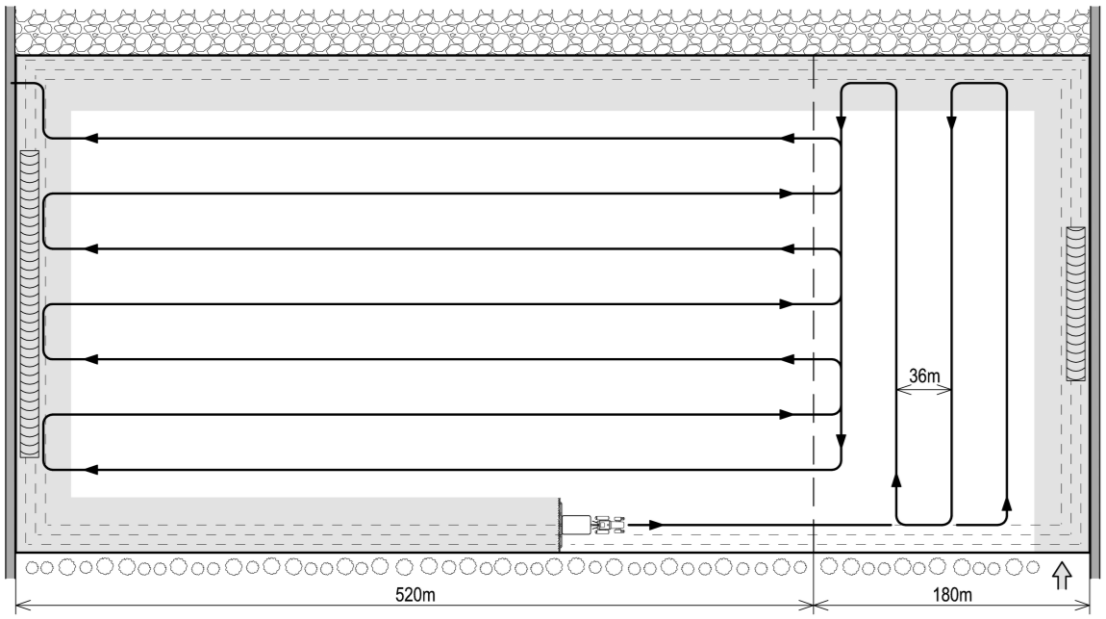

Figure 5: Influence of sugar beet cultivation on headland designing

The sugar beet harvester is not able to cover the whole distance from one edge of the field to the other and that's why the farmer decided to enlarge the headland on the east side of the field in order to reduce the distance of the main field.

4. Conclusions

Generally influencing factors on infield logistics can be categorized in "hard" and "soft" factors. Field shapes and the terrain of the fields are one of the biggest influences that are hardly changeable. More difficult to detect are influences that are caused by farm specific organizational reasons or by technical issues.

It is quite difficult to give binding statements in this early stage of the research but it is clearly to see that the utilization of electronical assistance systems such as GPS guidance or section control influence not only the managing people on the farm that make the general decisions but also the worker who carries out the work with the machines.

Furthermore because of the reasons mentioned above the cultivation of sugar beets plays a significant role when thinking about infield strategies. Depending on the common agricultural structure and farm specific organization these influences might differ from farm to farm.

In order to get a higher sample and results that are more detailed and more reliable it is planned to do further interviews.

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