Steffen Walther, Hohenheim

Site-specific Soil Tillage: Application and Potential

Site-specific management strategies in the context of Precision Farming are frequently associated with high expectations by the various stakeholders in and around agriculture. The attraction of this approach is based on the idea to adopt the management of each plot on a site with the aim to generate ideal growing conditions for the respective culture. However, the fact that in a complex system, as in agriculture, it is impossible to know and hence account for all variables is commonly neglected.

M.Sc. Steffen Walther is a member of the scientific staff at the Institute of Agricultural Engineering of Hohenheim University , Department Agricultural Engineering in Plant Production (Head: Prof. Dr. K. Köller), Garbenstrasse 9, 70599 Stuttgart; e-mail: *Steffen.Walther@uni-hohenheim.de*

Keywords

Tillage, site-specific application, depth variation

Literature

Literature references can be called up under LT 06SH12 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

The term "site-specific approach" describes a system where the variability of soil and plant parameters is used as a decision basis for the application of production inputs [1]. Site-specific approaches can be found in all areas of the agricultural production chain, from soil tillage and seeding over postdrilling cultivation and finally harvest. The site-specific or variable rate application (VRA) denotes the adjustment of the amount of cropping inputs within the respective process through appropriate technologies, the variable rate technology (VRT). Besides the well known site-specific approaches in seeding and postdrilling cultivations, e.g. plant protection and fertilization, site-specific soil tillage has recently attracted a higher degree of interest. In current (experimental) implementations, site-specific issues so far are mainly used to derive decisions on the tillage intensity (depth). These decisions can be generated from collected, newly created and/or already available spatial information, including soil maps, elevation models (DEM) and yield maps. Algorithms designed to meet the respective objective help to compute this information and derive recommendations that are displayed as application maps.

The point-of-view on and rating of site-specific approaches and consequently of all derived conclusions and options for action, as well as the expectations in general, are frequently quite distinct. This is mainly owed to the fact that the various stakeholders claim the main potential to meet their individual interests. The administrative sector (currently) focuses on documentation and traceability issues, and science on, besides technological advances, the system impact, costs, and/or potential environmental benefits. In agriculture, the field of interest is as diverse as there are the production systems and includes simplified production and more reliable yields as well as cost reduction and long-term benefits, e.g. melioration effects.

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An important interrelation in the direct, but also indirect sense of all approaches can be found in the common wish to gain efficiency. With the above mentioned process chain in mind, the potential through variable rate application can easily be assumed for each process: a reduction in the amount of fertilizer or herbicide, etc. The approach in soil

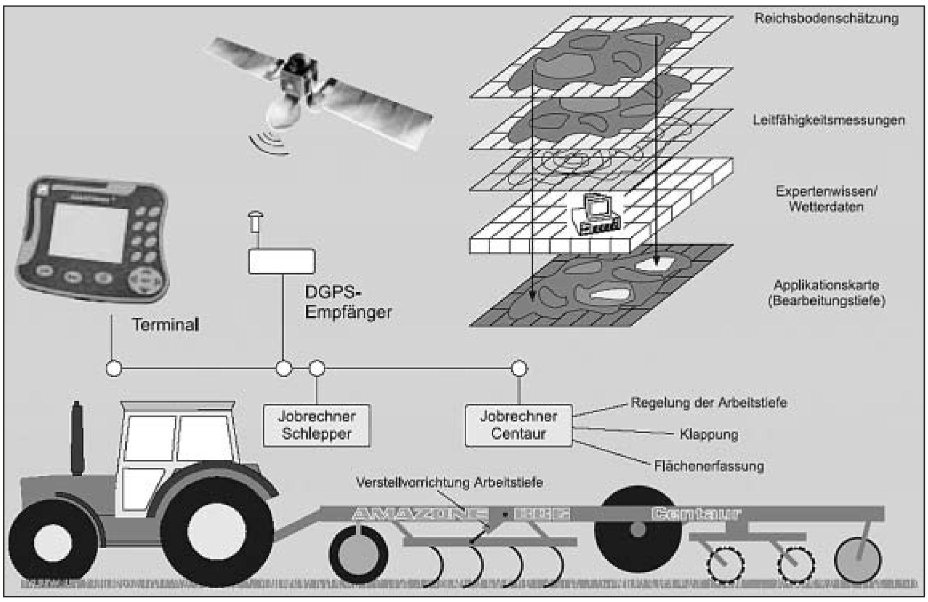

Fig. 1: System setup and components in draught based site-specific tillage [in 10]

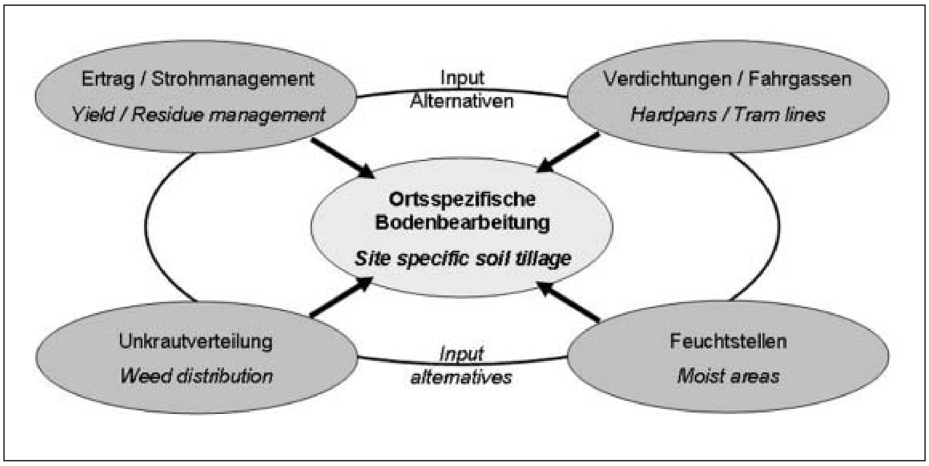

Fig. 2: Potential input data for application maps in tillage

tillage is, however, more complex. So far, the approaches to reduce input, no matter by what motivation, rely on conventional methods. Briefly it can be summarized as a reduction of tillage passes and the intensities going along with them, e.g. by omitting the plough (conservation tillage), further reduction and/or combination of passes, and no soil tillage at all (no-tillage seeding) [2].

An important parameter in soil tillage is the tillage intensity, or working-depth. Conventional soil tillage implements are commonly adjusted to a specific working-depth before tillage. Manual adjustments or changes in working-depth due to the draught-force control often are at the expense of working quality. Implements allowing variable working-depths in soil tillage have been shown as both, PTO-driven [3, 4] and purely passive (draught) [4, 10] systems. The variation of the working-depth commonly takes place through a hydraulic system at the implement itself. As in other VRA applications, a map- and a sensor approach are possible. A prerequisite for the map approach (*Fig. 1*) is a suitable navigation system, e.g. satellite navigation (GPS), and a predefined application map showing the respective site-specific working-depths. In contrast to this approach stands the also well known sensor approach [5]. Here, the necessary information is derived from appropriate sensors online while passing. Possible input parameters include soil texture [5], soil moisture [6], and soil coverage [7].

Following the map approach, it is obvious that suitable geo-referenced input parameters have to be readily available. The choice of parameters depends on the individual case, *Figure 2* lists a combination of possible data, that might either stand alone or be combined.

Soil tillage is commonly understood as an annually recurring process of tillage and seed-bed preparation. But also other, periodically necessary tillage operations might profit, e.g. if spatial information about hardpans is available [8, 11]. How far the different potential goals of variable soil tillage can diverge, is demonstrated in *Figure 3*. Each goal reflects on one hand the different ecological and economical premises at the respective location of origin, and on the other hand different philosophies about ideal management approaches.

Shallow tillage leads to a significant reduction in draught forces. As a result, fuel consumption is reduced. Further, at a limited scale, an increased working speed and hence an increased field capacity is possible [4]. The extent of savings, however, mainly depend on the share of „deep" and „shallow" operations on a site. In experiments conducted so far, site-specific soil tillage has proven to be yield-neutral [4].

Environmental protection is a comparable new approach in site-specific soil tillage. In first experiments, the potential for erosion reduction through variable soil tillage was evaluated [12]. Besides a direct effect on the sustainability of a site, positive effects might result from less substance translocation into adjacent streams and waters. An improved infiltration-rate and consequently reduced run-off also has a direct impact on watershed water levels and their ecology [13].

Some soils have a tendency to develop hardpans as a result of compaction if no regular (periodic) deep tillage is carried out. Precise knowledge about the dimension and location of such hardpans allows targeting them with appropriate means, and helps reducing the required time and energy to do so [8, 11]. The potential savings in time as a result of a higher field capacity is hereby of special interest, as such work is commonly carried out in addition to any conventional soil tillage and hence in peak times with a generally high work load.

A so far unsolved difficulty in the variation of tillage depth can be found in the choice of the share. Commonly used models are optimized for a certain working-depth, or depth-range, namely shallow (stubble) tillage or deeper (loosening) tillage. By diverging from this range of application, the gained benefits from the variable depth tillage might be reduced or reversed [9].

Conclusion

Site-specific soil tillage is an interesting alternative to conventional tillage for enterprises that do not want to, or cannot, forgo soil tillage. The potential to save operating inputs, gain time, and environmental aspects are general advantages. The possibility to include special, farm-specific problems, such as moist spots or hardpans is a further benefit. The technology is readily available on the market and most required data is either already present on-farm or can be created with little effort. The use of parts of the technology in more than one process, e.g. the GPS or data handling software will lead to economies-of-scale.

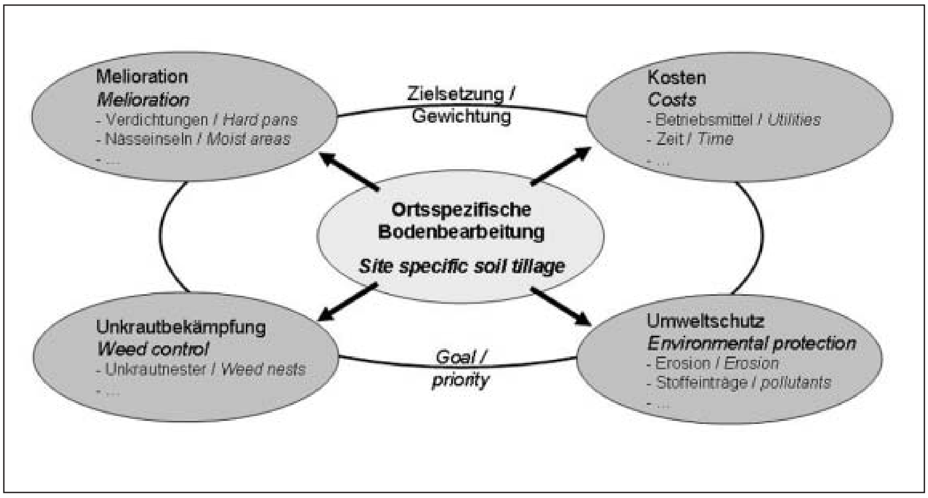

Fig. 3: Potential objectives of site-specific tillage