ENDURE

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Summary

This review is concerned with new technologies critical to effective implementation of Decision Support Systems and Farm Management Systems. Effective implementation is here defined as the situation where DSS and FMS are used directly by a substantial contingency of farmers in planning and executing crop protection.

Information collected by sub-activity IA2.4 (Delivery DI2.3) has revealed that a large number of DSS have been developed and made available in Europe. An increasing number of DSS are available online with automatically updated auxiliary data (e.g. weather, crop stages, pests and disease progression). The direct use by farmers is low, but the indirect impact through advisers is considered high.

Farm Management Systems are not well documented in the literature and evidence is based on circumstantial information from providers and users. FMS are primarily constructed by bookkeeping principles and they are well suited to store data on fields, operations and materials, and FMS are indispensable in the administration of EU subsidies.

The new technologies of importance for this review are the development of pervasive computing in sprayers, the availability of high precision geographical positioning systems, and the penetration of wireless and mobile communication in rural areas. Innovative technologies in sprayers are the subject for sub-activity RA2.2 (Delivery DR2.5). For this review, the relevant aspect is the ability of these sprayers to operate automatically on basis of geo-referenced data containing specifications for the choice of pesticide and dose for a given polygon. Geographical positioning, for the time being GPS and in the future Galileo, is the technology being used to find out when the sprayer is within a polygon present in the geo-referenced data definitions. Finally, wireless or mobile communication technology is the means to establish communication between the sprayer under operation in the field and external sources, for example a Farm Management System.

The review provides evidence for the applicability of integrated systems making use of the technologies described above regarding late application of variable rate nitrogen (see Appendix 9.1 for an example of operational use in France), and in variable rate spraying of barley (see Appendix 9.2 for a prototype being developed in Finland).

The current trend in many European countries toward large farms, big machines and employees with less skill is actually contributing to a reduction in precision of agriculture, Durable crop protection strategies with a high reduction in negative effects on the environment will undoubtedly require a high degree of adoption to local circumstances, i.e. ah high precision. This review suggests that variable pesticide and dose selection in sprayers, global positioning and wireless/mobile communication are critical technologies for effective implementation of Decision Support Systems and Farm Management Systems.

The vision is an integrated system, where the farmer takes decisions on crop protection for his fields with advices from a DSS and store these decisions in a FMS. At operation, decisions are automatically transferred to computers on the tractor and on the sprayer. The farmer's skills are utilised to make good decisions, his time is not wasted handling of information, and the sprayer operator's skills are restricted to using the machinery correctly.

Propriety software solutions and data standards may be a hindrance for an effective implementation of the DSS, FMS and the new technologies, and development of open standards and open software should be a subject for further investigations in ENDURE.

1. Introduction

The purpose of this review is to identify new technologies, which are critical to effective implementation of DSS and FMS. What is then meant by "effective implementation of DSS and FMS"? In this report effective implementation will mean that Decision Support Systems and Farm Management Systems are used directly by a substantial contingency of farmers in planning and executing crop protection.

The main reason for wishing this effective implementation is that the use of DSS is required to translate detailed crop protection strategies into context-aware rules being applicable in today's farming practice, while FMS is the tool required for this actually to happen.

From the farmer's point of view, durable crop protection strategies are not the goal of primary interest. Farmers care about costs, benefits and risk control of crop protection, and labour demands are important in terms of hours as well as qualifications required to implement and use new technologies. Therefore, in pursuit of the purpose, this review will concentrate on technologies, which offers possibilities to make advices from DSS be applied in practical crop protection with low demands for labour hours and qualifications.

The vision is an integrated system, where the farmer manager can take decisions on crop protection for his real fields (possibly group of fields or zones in fields) with advices from a DSS and store these decisions in a FMS. At operation, the decisions are automatically transferred to computers on the tractor and on the sprayer, which take care of applying the prescribed pesticide in the prescribed dosage at the right place. The farm manager's skills are utilised to make good decisions, his time is not wasted by transfer of data and information, and demands for the sprayer operator's skills are restricted to using the machinery correctly.

The review is written on the basis of this vision, and the description of technologies is restricted to what is required for evaluating an implementation of the vision. Conclusions on technologies should therefore not be interpreted as complete evaluations of the technology in question.

2. State-of-art of DSS and FMS

2.1. Decision Support Systems

Decision Support Systems for crop protection is the subject for sub-activity IA2.4, which hosted a workshop in Flakkebjerg, Denmark, 17-19 March 2008. This workshop revealed a wealth of DSS for crop protection in Europe with ongoing activities in almost any country. A detailed report on the results of the workshop is to be found in delivery DI2.3.

For the purpose of this report, the following observations from the workshop are relevant:

- The direct use of DSS for crop protection by farmers is low. This is in line with international experiences of disappointing uptakes of DSS in agriculture in general (McCown, 2002).
- The indirect use via agricultural advisers is high. This is also in line with findings in the literature (Thysen, 2007).
- The DSS are predominantly "information island" type of systems, in the sense that they do not share input data with Farm Management Systems and that the output cannot be exported for direct use in other systems, e.g. a FMS. In other respects, the

"information island" characteristic is not true, as the DSS in most cases use problem relevant input data and provides output online.

The conclusion of these observations is that DSS for crop protection currently are targeted towards directly or indirectly improve the decision making capabilities of farm managers, leaving further actions to be taken to effectuate the decisions to the manager.

2.2. Farm Management Systems

Farm Management Systems in crop production are supporting the management of the actual fields and crops of a farm. The heart of a FMS is a database containing information on field identifications and locations, soil characteristics, crops with data on specie and variety, and records of all field operations with required data. The FMS has facilities to enter data and to produce reports for various purposes, including statements on pesticide use to relevant authorities.

Farm Management Systems are present all over Europe and are provided by agricultural advisory organisations, extension services as well as private software houses. Information about the capabilities of the systems, the number of users and the users' satisfaction with the systems are generally not available in the literature; considerations on systems architecture and systems modelling can be found in Pesonen et al. (2008). The following observations are therefore mostly based on private communication with users, developers and providers:

- Farm Management Systems have the technical facilities needed for delivering sufficient data for automated control of sprayers.
- Farmers are generally not seeing the use of a FMS as an opportunity for improving farm management, but rather as an extra cost and nuisance related to documentation required by environmental authorities, subsidy awarding authorities and retailers.
- Labour reductions in crop growing documentation by automated field recordings may be a strong incentive for farmers to invest in new technologies (Keicher & Schwarz, 2008).

In conclusion, FMS have the technological basis for automated control of sprayers, but further research and development is required. Coupling with facilities appealing to farmers should be pursued.

3. New technologies

3.1. Computer controlled sprayers

All major sprayer manufacturers are marketing computer controlled sprayers and the computerized control functions are continuously developed and sophisticated. There are sprayers on the market, which can carry several chemical compounds separately from the water tank with abilities to mix compounds and change dosages under operation. Sprayers with very wide booms are divided in sections, which can be controlled and function independently of each other.

Sprayer manufacturers will normally use propriety software and control boxes, which are claimed to be user-friendly, but in reality they are quite demanding to use manually. However, the sprayer control boxes can also function on basis of input data from a co-called Task Controller in combination with a GPS unit, which can modify spraying instructions on basis of an input file containing geo-specific spraying decisions (Stoll, 2003).

The technical and operational issues of modern sprayers are dealt with in details in Delivery DR2.5 (Intermediate report on Exploitation of innovative technologies). For the purpose of this review, it is sufficient to conclude that there are sprayers on the market, which can operate in an automated crop protection scheme as envisaged in the introduction. Further evaluation of the communication with the computerized sprayer will be in section 3.3.

3.2. Global positioning

The Global Positioning System (GPS) is the only fully functional Global Navigation Satellite System. The GPS uses a constellation of at least 24 (32 by March 2008) Medium Earth Orbit satellites that transmit precise microwave signals, that enable GPS receivers to determine their location, speed, direction, and time. GPS was developed by the United States Department of Defense. GPS has become a widely used aid to navigation worldwide, and a useful tool for map-making, land surveying, commerce, scientific uses, and Precision Agriculture. The upcoming European Galileo positioning system is designed to provide very high precision for civilian use.

Hardware and software for positioning by GPS are commercially available with varying degrees of precision closely connected to the prize. Sufficient precision for auto guidance of agricultural vehicles can be achieved at relative low costs (Desbourdes, 2007).

3.3. Wireless and mobile communication

Electronic communication and the development of the Internet are the technological foundation of the digital revolution experienced in most business sectors. Agriculture has in many respects lacked behind, because of the inappropriateness of cabled communication for use in most agricultural operations. Wireless communication is now changing this situation. Standard wireless access points based on the WIFI protocol can range up to 1 km, depending on the environment and is a possible solution for a wireless network for a farm and its vicinity. The newer WIMAX protocol can range many kilometres and is an attractive technology for Internet providers who wishes to cover sparsely populated areas; wireless Internet aimed at rural areas will automatically serve clients installed in agricultural machines.

For the moment, data transfer over the mobile phone networks is a plausible solution for communication in automated crop protection. Although the transmission rate (at least in a standard mobile network) is much lower than in the above mentioned wireless technologies, the bandwidth is sufficient for the rather small amounts of data required in automated crop protection. A real world proof of the applicability of mobile networks for this type of functions is the fact that track and tracing systems in the transport business area are working very well by mobile communication.

In conclusion, communication with computerized sprayers during operation in the field is possible with proven technologies and further, rapid developments in wireless communication can be expected to bring further improvements along.

3.4. Integration of technologies

Having established evidence for the technical feasibility of automated crop protection, it is time to look at how solutions are being designed and implemented in practise. We are looking at a system as depicted in Fig. 1, with an information flow from aggregate DSS/FMS sending spraying decisions to a Task Controller with GPS, which in turn sends spraying instructions to the computerized sprayer; through an information flow the opposite way completed spraying operations are stored in the FMS.

Figure 1 Principle of technology integration

The Task Controller is in some case an integrated part of the computerized sprayer (e.g. in Hardi sprayers), and in other cases separate units with the Task Controller being capable of controlling a range of machines (e.g. in John Deere tractors and machinery). Smaller sprayer manufacturers are likely to adapt their sprayer computer to a Task Controller from an independent supplier (AutoFarm and Raven Industries have agreed a joint venture on a combined auto guidance and Task Controller computer). This is a classical situation with some dominant players in market place trying to retain control by closed propriety systems, while other players are advocating open systems in order to keep up with new technologies without damaging development costs.

The market for Farm Management Systems is far more diverse with several systems in each country in Europe. Some of these are provided by commercial software houses, some are semi-commercial systems provided by farmer organisations, and some are provided by public extensions services. Decision Support Systems are mostly developed and operated by public organisations, only a few commercial companies are providing decision support to farmers, and they do not offer a true Farm Management System.

3.4.1. Integrated technology for variable rate nitrogen application

Integration of technologies has been implemented regarding variable rate nitrogen application according to observations during the growing season (Desbourdes, 2008). A late application of nitrogen is analyzed with the regard to the homogeneity over the field and if sufficient variation in homogeneity is found, a variable rate application is advised. This can be effectuated as a manual rate application or an automatic rate application based on data files distributed to computers in the tractor and the nitrogen spreader. The possibility of automatic application depends on type of machinery being used; data files must be tailored to the brand of spreader.

The possibilities and potentials of variable rate nitrogen application in France is outlined in details in Appendix 9.1

3.4.2. Integrated technology for variable pesticide application

Integration of technologies for pesticide application has been part of research project on user-centric mobile information management in automated plant production (Pesonen et al., 2008). This study included interviews with farmers in Finland and Sweden practising Precision Farming and an important observation was that data and information handling is a major constraint for implementation of Precision Agriculture in practise. The study also included elaborate modelling of information systems adapted to the non-linearity of decision making.

The integration of technologies was implemented as a prototype for the case of precision spraying in malting barley. The outline of this prototype is shown in Appendix 9.2 as an illustration of advanced use of modern technologies.

4. Precision agriculture

Precision Agriculture (PA) was introduced in the early 1990'ties as a respond to new technological innovations, in particular yield maps constructed from records of cereal yields with high spatial resolution, based on a combination of inline yield measuring, Global Positioning System (GPS) and Geographical Information Systems (GIS). The hypothesis was that a spatial variation in yield reflects an underlying spatial variation in soil characteristics, which can be exploited in a more precise management of inputs to crop growing. In plant protection, the similar concept is to spray precisely according to weeds, pests and diseases variations over a given field (Zande & Aachten, 2005). In spite of more than 15 years of research and development, precision agriculture is by no means widely used in practical farming; commonly stated reasons for this low rate of adoption are difficulties in gathering the required data on within-field variations, difficulties in handling the spatial information, and low returns when all costs of applying precision agriculture are included (McBratney et al., 2005). The environment protection argument remains appealing, however, and is the strongest motivation for continued R&D in the area (Bongiovanni & Lowenberg-DeBoer, 2004).

The definition of precision agriculture is evolving as technology changes. A generic definition, recently put forward in the literature, could be ''that kind of agriculture that increases the number of (correct) decisions per unit area of land per unit time with associated net benefits'' (McBratney et al., 2005). This moves the focus a little away from simply spatial resolution to one involving the fineness of decisions in both space and time. This more generic definition does not imply a particular technology or set of technologies, the decisions can be made by electronic sensors, GPS, GIS, VRT etc., but they can also be made by humans.

By this generic definition, "precision" is relative, and not absolute. The trends in many European countries toward larger farms, employees with less skills and bigger machines (sprayer booms approaching 100 m) contribute to a reduction in precision: Uniform treatments that are known to provide a reasonable result and not requiring skilled operators are applied to fields of same crop as fast as possible. A return to individual evaluations for each field will be more precise than common practise, and may thus be considered Precision Agriculture.

The point is that the concepts of Precision Agriculture are in danger of being discarded because of a bad reputation concerning practical relevance. The possibility of applying PA concepts to increase precision by individual field consideration may thereby be missed. After all, the technology is just a matter of operating on basis of geo-referenced data, and the technology does not care whether the data describes fields or parts of fields. Farmers are usually quite familiar with their fields and may often assign specific treatments to each field. They just need tools to store field-based decisions and to have these decisions effectuated automatically.

5. Discussion

This review is concerned with new technologies critical to effective implementation of Decision Support Systems and Farm Management Systems. Effective implementation is here defined as the situation where DSS and FMS are used directly by a substantial contingency of farmers in planning and executing crop protection. The relevance of the review in the context of ENDURE is to evaluate the perspectives of applying new technologies to enhance the uptake of durable crop protection strategies in practice.

The development and use of Decision Support Systems for crop protection is the subject of sub-activity IA2.4. The information collected by IA2.4 has revealed that a large number of DSS have been developed and made available in Europe. An increasing number of DSS are available online with automatically updated auxiliary data (e.g. weather, crop stages, pests

and disease progression). The direct use by farmers is low, but the indirect impact through advisers is considered high.

Farm Management Systems are not well documented in the literature and evidence is based on circumstantial information from providers and users. FMS are primarily constructed by bookkeeping principles and they are well suited to store data on fields, operations and materials. Much effort is allocated to ease data entrance, for example by online systems and mobile access. FMS are indispensable in the administration of EU subsidies. It is unsure to which degree farmers use FMS actively in the management of daily operations. Farm Management Systems contains the data needed for storing decisions on crop protection in each of a farmer's fields.

The new technologies of importance for this review are, firstly, the development of pervasive computing in sprayers, secondly, the availability of high precision geographical positioning systems, and thirdly, the penetration of wireless and mobile communication in rural areas. Innovative technologies in sprayers are the subject for sub-activity RA2.2, which is evaluating the technological performance of advanced sprayers in details. For this review, the relevant aspect is the ability of these sprayers to operate automatically on basis of geo-referenced data containing specifications for the choice of pesticide and dosage for a given area. Geographical positioning, for the time being GPS and in the future Galileo, is the technology being used to find out when the sprayer is within an polygon present in the geo-referenced data definitions. Finally, wireless or mobile communication technology is the means to establish communication between the sprayer under operation in the field and external sources, for example a Farm Management System.

The review provides evidence for the applicability of integrated systems making use of the technologies described above regarding late application of variable rate nitrogen (see Appendix 9.1 for an example of operational use in France), and in variable rate spraying of barley (see Appendix 9.2 for a prototype being developed in Finland).

The two examples are both marketed or published under a label of Precision Agriculture, which is characterized by taking account of within field variation in the application of fertilizers and pesticides. Most of the research and development concerning the use of innovative technologies in crop protection seems to be motivated by the concepts of Precision Farming. It is well known that the adaptation of Precision Farming is hampered by difficulties in establishing reliable data describing within field variation in fertilization or crop protection needs. The technologies are, however, indeed relevant for farming normally not considered Precision Agriculture.

The current trend in many European countries toward large farms, big machines and employees with less skill is actually contributing to a reduction in precision: Farmers prefer a crop protection strategy, which is a standard treatment known to provide reasonable results and not requiring skilled operators, and farmers want to apply this to all fields of the same crop as fast as possible. A return to individual evaluations for each field will therefore increase precision in the operation phase of crop protection. Durable crop protection strategies with a high reduction in negative effects on the environment will undoubtedly require a high degree of adoption to local circumstances, i.e. ah high precision, and the technologies investigated for Precision Agriculture are thus very relevant.

The review suggests that variable pesticide and dose selection in sprayers, global positioning and wireless/mobile communication are critical technologies for effective implementation of Decision Support Systems and Farm Management Systems.

The vision is an integrated system, where the farmer manager can take decisions on crop protection for his real fields (possibly group of fields or zones in fields) with advices from a

DSS and store these decisions in a FMS. At operation, the decisions are automatically transferred to computers on the tractor and on the sprayer, which take care of applying the prescribed pesticide in the prescribed dosage at the right place. The farm manager's skills are utilised to make good decisions, his time is not wasted by transfer of data and information, and demands for the sprayer operator's skills are restricted to using the machinery correctly.

Propriety software solutions and data standards may be a hindrance for an effective implementation of the DSS, FMS and the new technologies, and development of open standards and open software should be a subject for further investigations in ENDURE.

6. Conclusions

The conclusions of this review are:

- Decision Support Systems and Farm Management Systems are available and hold the required capabilities
- The relevant new technologies are
    - Sprayers with variable pesticide and dose selection by pervasive computing
    - Geographical positioning
    - Wireless and mobile communication
- Integration of technologies developed and applied in Precision Agriculture have proved applicability and feasibility
- The vision is DSS used in decision making based on durable crop protection strategies, FMS used to store decisions on individual fields or part of fields, and the new technologies used for automatic implementation of the decisions
- Open standards and open software should be a subject for further investigations in ENDURE.

7. References

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8. Appendicies

8.1. Variable rate nitrogen application

8.1.1.1. Manual mode

The farmer adjusts the rates according to visual reference points in the field or a recommendation map. As it is displayed on a pocket PC screen or a machinery or equipment manufacturer's box linked to a GPS, the farmer can see his tractor moving in the field. He/she adjusts the rate on the spreader box. The inaccuracies of this system are due to variations in rates: ± 5 or 10% variation from the reference rate depending on the spreader. The rate applied is therefore approximate. The greatest source of error may come from forgetting to adjust the rate at some point.

8.1.1.2. Automatic mode

Using a GPS, the tractor locates itself on the recommendation map. The rate corresponding to its location is sent by the recommendation map management box (RDS, John Deere, Satplan box, etc.) to the spreader box, which opens or closes the hatches according to the rate that should be applied. There may be some compatibility issues between those two boxes. The reading of the recommendation map being automatic, the risk of mistakes is limited, except when there are problems on the recommendation map itself. This solution also has the advantage of making it possible, with most equipment, to check on the application map the rates that were actually applied in the field.
We have two possibilities to modulate nitrogen rate, which affected the cost of precision farming:

1- The spreader box is not capable to manage the GPS and the recommendation map. We need to use another box (fig1).
2- The spreader is capable to manage the GPS and recommendation map. It is possible with two constructors: Sulky and Evrard. The others are not capable to use the recommendation map directly. (fig2)

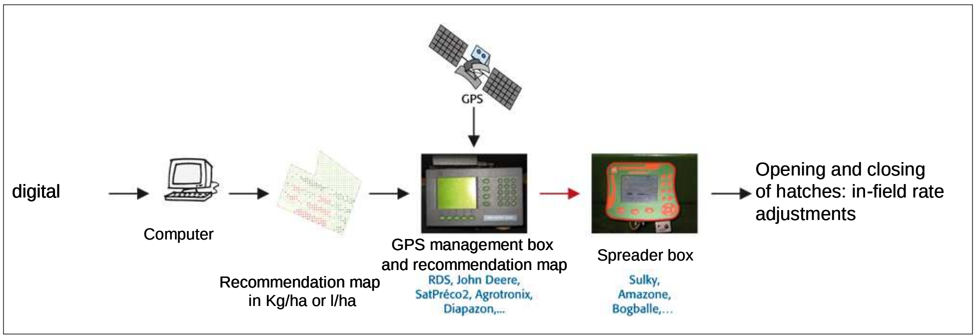


Fig 1

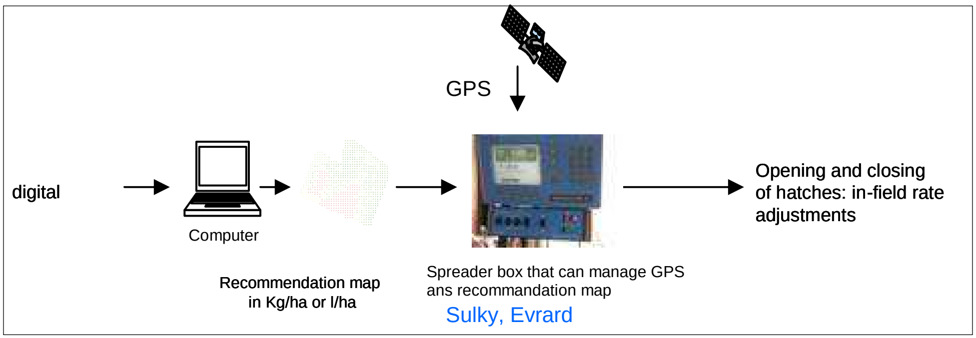


Fig 2

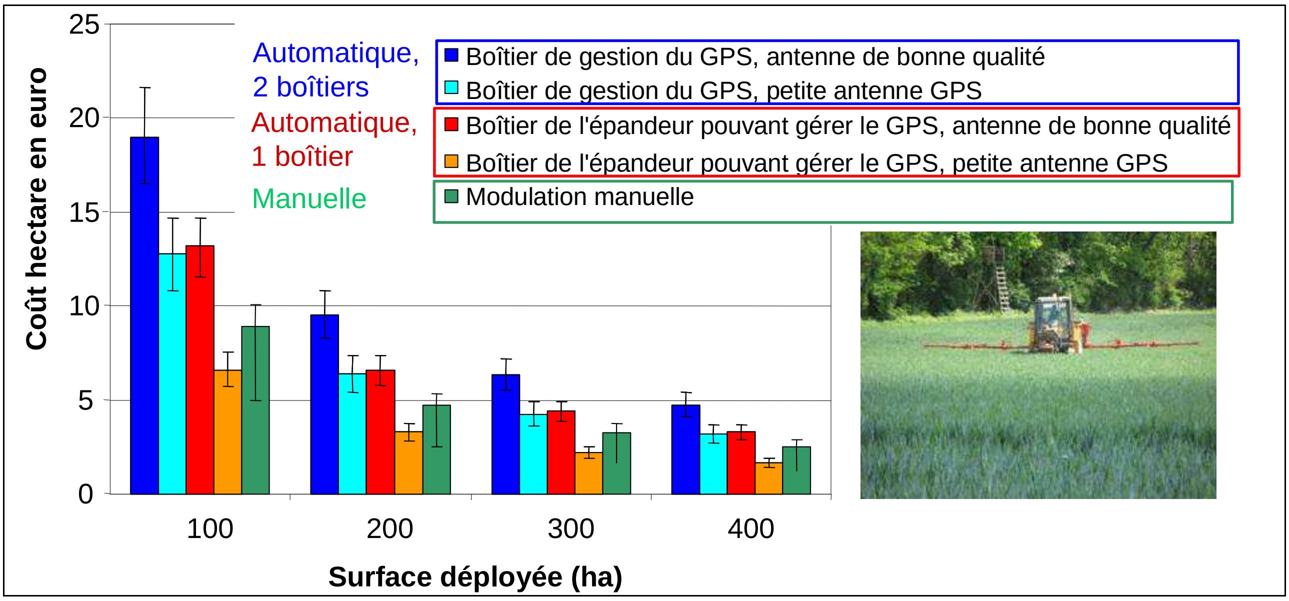
Sulky and Evrard uses RDS box. Therefore, the recommendation map has to be in RDS size. There are two software products in France: Agrimap software of the Isagri society, price 1700 euros; BGRID software of the SARL Barbereau, price 400 euros.

The others spreader constructors (John Deere, Amazone, Bogballe, etc.) need to be driven by another box (constructor box like John Deere or pocket PC). In this case, the recommendation map needs to be accustomed to the rqquirements of this box. The main software is Agrimap from Isagri.

8.1.1.3. Average Cost of precision farming

The cost is calculated for 5 years with the following materials:

- A GPS: a good GPS (Trimble, Raven or John Deere) for guidance option or a little GPS (Holux, Garmin, Magelan…).
- A software
- A box to manage recommendation map and GPS
- Taxes financial: 4 % of the costs
- Maintenance : 2% of the costs



In bleu: Automatic application. The farmer needs two boxes in his tractor, the spreader box and the box to manage recommendation map and GPS. We use two options: with or without guidance option.

In red: Automatic application. The farmer has a Sulky or an Evrard spreader. It drives the GPS and recommendation map. We use two options: with or without guidance option.
In green: Manual application.

Conclusions:

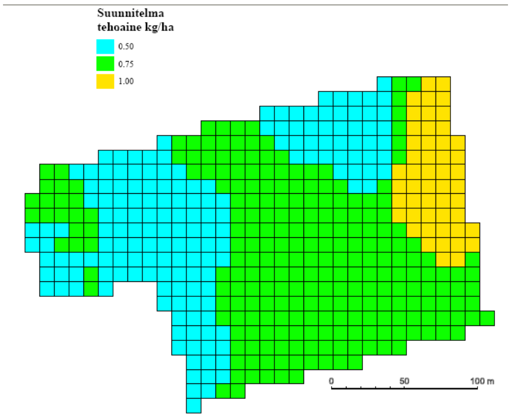
- Automatic application can be cheaper than the manual application.
- With a price of wheat of 24€/q, the specific equipment of precision farming if less than 1q/ha.
- If the spreader box is capable to manage the recommendation map and the GPS, the cost is about 300 euros for a single GPS and 400 euros for the BGRID software.

8.2. Precision spraying

The scenario of precision spraying task utilising the novel InfoXT system concept (Pesonen et al., 2008)

Picture 1.

- The summer has begun and the growths in farmer’s fields look good.
- However, according to the forecast and observations of advising service there is a need to protect growths against diseases.
- The advising service gives a disease alarm to the farmer.
- The alerted farmer is now aware of the risk and decides to carry out field inspections in his own fields.
- Farmer uses with GPS and digital camera equipped PDA-phone to make field notes.
- He sends the results and selected pictures to Farm database straight from the field by his PDA-phone.



	Recom/ha		Fluid amount,l		Mixture rate		Planning 2007
Herbisides	min	max	min	max	min	max	
Hankkijan Trio, l	1.5	2.5	200	400	0.0075	0.00625	(Kirjava, Uutela 2,0 l/ha)
Starane 180, l	0.4	2	200	300	0.002	0.00667	(Hovi 0,4 l/ha)
Express 50 T Classic, tap	1	3	200	300	0.005	0.01	(Hovi 2 tabl.)
Ariane S, l	1.75	3	150	400	0.01167	0.0075	
Fungiside							
Amistar Duo, l	0.5	0.8	100	300	0.005	0.00267	
Acanto Prima, kg	0.75	1.25	100	300	0.0075	0.00417	(1 kg/ha)
Zenit 575 EC	0.5	0.75	200	300	0.0025	0.0025	
Pestiside							
Karate 2,5 WG	0.15	0.8	200	400	0.00075	0.002	
Growth retardant							
Moddus M	0.1	0.7	200	300	0.0005	0.00233	(Kirjava 0,1 l/ha)
Cerone	0.3	1.5	200	300	0.0015	0.005	

Picture 2.

- After evaluating the situation in the fields he chooses – with advising services assistance - the most suitable chemical from his storage to be used in spraying.
- He asks the advising service to make a spraying plan to the fields.
- The advising service gets the biomass maps and other field specific information from the Farm database.
- The advising service produces a spraying task which contains following information: field ID, area, relative application map, chemicals, default application rate (mean rate, min and max rates), expected spraying date, expected wind, expected canopy humidity. It is also determined in the TASK file, which information and in which accuracy will be documented during the work.

Picture 3.

- When the plan is ready and the task is stored to the Farm database, the service informs the farmer by SMS to his phone. The service sends the content of the plan and the visualised application map to the farmer by e-mail, so that he can give feedback to the plan if necessary.
- Now, the farmer is ready for action.

Picture 4.

- The farmer decides that now is the best moment for spraying and climes up to his tractor-sprayer combination.
- He retrieves the planned task and information about available nozzles from the Farm database to the Task Controller (TC).

- TC initializes the task, retrieves weather data from the weather service and sends the information to Sprayer ECU (Electronic Controller Unit).

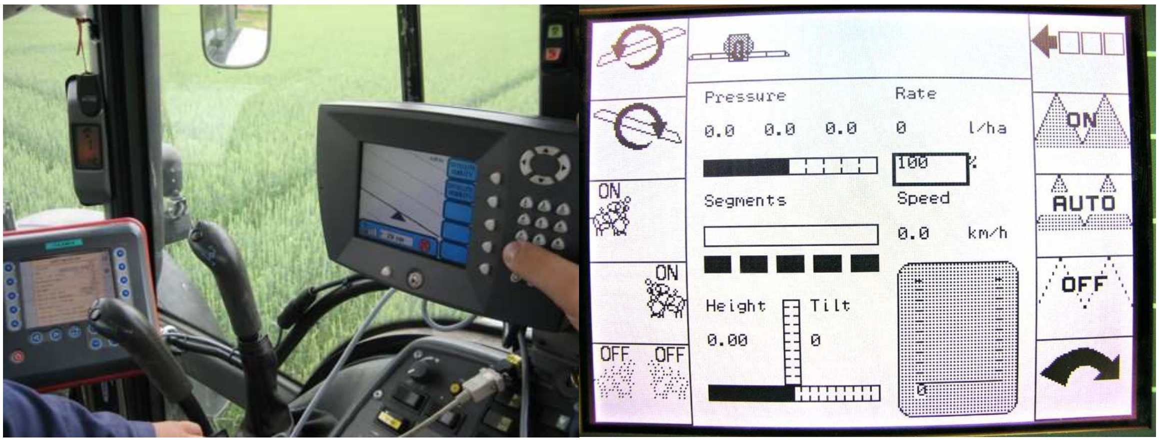
Picture 5.

- The Sprayer ECU uploads the sprayer specific view to Virtual Terminal (VT) of the system.
- VT acts as a user interface.
- Expert system of the Sprayer ECU determines, on the base of the latest information, the optimal combination of parameters for the spraying session.
- The system tells via VT to the driver which nozzle type to use, and the ”recipe” for the tank filling.
- When the preparations are ready the execution of the task can begin.

Picture 6.

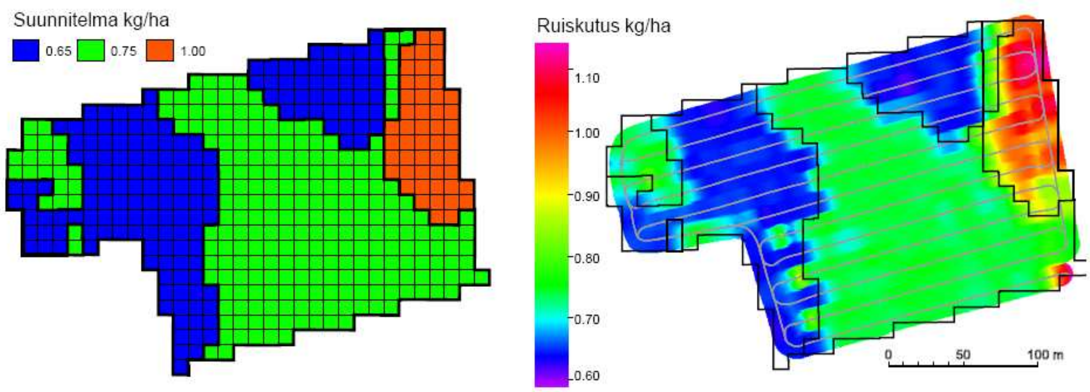
- When the actual task realization starts the TC gives commands to Sprayer’s controllers site specifically for Variable Rate Application (VRA).

- If ISOBUS version Class 3 is in use, the Sprayer ECU gives commands to TractorECU to control the driving speed automatically to adjust the application rate (with constant chemical mixture).



Picture 7.

- The TractorECU and its auto steering system take care of driving lines in the field and show them to the driver via VT.
- Sprayer has automated user assisting functions, like headland automation, remaining area that can be treated with present tank filling etc.
- The state of the system is shown and updated to the VT during the work, so that the driver is always aware of the situation. He has opportunity to take over the control when ever he wants to.
- The driver can make notes during the work session and save them to TC.



Picture 8.

- In the end of the work session TC prepares document file of the realized task as it is determined in the TASK file.
- The file is uploaded straight from the field to the Farm database, where it is available for later use.

The scenario ends