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DEVELOPMENT OF A TRAINING PROGRAM FOR ENHANCING THE USE OF ICT TOOLS IN THE IMPLEMENTATION OF PRECISION AGRICULTURE

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Training Package 4

Case 1 North Europe: Variable Rate Application of Nitrogen Fertilizer

Teacher guidelines

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1 Objective

The aim of Case 1 of Training Package 4 on Information and Communication Technologies (ICT) Devices is to present one of the most important Precision Agriculture (PA) technologies; Variable Rate Application (VRA) of nitrogen fertilizer. VRA of other products for crop growth regulation (such as seeding, spraying of fungicides, pesticides and herbicides, lime, growth regulation, etc.) are also relevant techniques in PA, so VRA of nitrogen fertilizer should be seen as only one example of VRA.

This activity will present the theory behind variable rate application of nitrogen fertilizer and the expected benefits. It will demonstrate software for creation of variable rate application maps. In the exercises students will work together to create and modify fertilizer application maps.

2 Guidelines

2.1 Practical information

- **Main target group:** Agricultural advisers, extension workers, farmers and other agricultural professionals who are interested in VRA and how to benefit from it
- **Expected duration:** 4 hours
- **Student preparations before the course:**
 - Bring a personal computer with internet access and a USB flash drive
 - If you want to work on specific fields: bring a fertilization plan for the fields.
 - If you have equipment for VRA: Find out which data format the equipment requires. Find out how fertilization application files are loaded into the tractor terminal
- **Homework after the course:**
 - Practice creating other VRA fertilization fields
 - Exchange practical experience with other participants: Did the software and the fertilization equipment work as expected? Was variable rate application an advantage? What can be improved next year?
- **Software:** There are various software products available for making VRA fertilization maps. The lecture and the exercise of this course mainly use the products CropManager and CropSat, but they can be exchanged for alternative software products that are better adapted to local conditions and language.

2.2 Suggested agenda

1. Welcome and presentation of participants (10 mins)
2. Brief presentation of the AgrICT e-training Platform, of the five training packages (TPs) of the platform, and of this case study as part of TP4 (ICT) (10 mins)
3. The program of today and alignment of expectations (10 mins)
4. Lecture: The theory behind of variable rate application of nitrogen fertilizer and the expected benefits (60 mins)
5. Presentation of the software for creation of variable rate application maps used in the exercises (15 mins)
6. Review of the instructions to the exercise and composition of groups (1-3 persons) for the exercise (15 mins)
7. Exercise (90 mins)
8. Questions, clarifications and conclusion (30 mins)

2.3 Learning goals

- Participants will be able to understand the principle of "three step development" of variable rate application maps
- Participants will understand the basic principle of redistribution of nitrogen within a field
- Participants will understand why redistribution of fertilizer will increase the yield and reduce nitrogen leaching
- Participants are able to produce variable rate fertilization maps by following the "three steps".

3 Exercise

3.1 Goal

To create a variable rate application map for a field and download the map on a file to a USB flashcard.

3.2 Instructions to the exercise

The VRA map is created by going through the following three steps: 1. Determine the average nitrogen requirement of the field, 2. Prepare an application map, 3. Make manual adjustments. The three steps are accomplished by following the 11 detailed steps below.

1. Select a field for which you want to make a VRA map for application of nitrogen fertilization. Depending on the time of year of the course and the crop

on the field it could be the first application of nitrogen to winter wheat or winter rape in the spring (if the course is conducted in January-February) or the third application in winter wheat.

2. Find the most suitable biomass map to use as a basis for VRA. The maps can be found in CropSAT or CropManager.
 - a. Winter wheat and winter rape, first application: Select the latest available map from the autumn. It is important to choose a map from a period when the crop is not yet affected by frost or snow.
 - b. Winter wheat, third application: Here, a map is selected taken as close to the application date as possible. In case it has been cloudy, 2-3 weeks old maps can be used. If the exercise is carried out during the off-season, you can use a map from a past year, and assume (for the exercise) that fertilization is for that year, e.g. on May 15.
3. Estimate the variation in the field and determine whether VRA is relevant. The variation can be estimated from a biomass map in CropSAT by observing the steps between levels of the five NDVI levels on the scale of the field (in the example to the right the steps between levels are around 0.04). Rule of thumb:
 - a. Steps below 0.02: Low variation -> VRA not relevant
 - b. Steps 0.02-0.04: Some variation -> VRA may be relevant
 - c. Steps above 0.04: Large variation -> VRA very relevant
4. Now the preparation of the application map starts with **step 1**. Find the desired field in the fertilization plan in the FMIS and find the planned nitrogen requirement. There are probably already planned dates and nitrogen levels for two or three applications. These must be reconsidered. In practice, this will probably often happen in close collaboration with the agricultural adviser in the FMIS. The following conditions may be included in the reconsideration:
 - a. Is the estimated yield level correct, based on the current conditions of the field?
 - b. Has the field's history been used in determining the nitrogen needs?
 - c. Is the mineralization of nitrogen during the growing season expected to be high or low?
 - d. Have the quantities of slurry, the nitrogen content and the utilization rate of the slurry been determined correctly?
 - e. Should the nitrogen fertilization be divided into two or three applications?
 - f. Is the crop stronger or weaker than usual and should this influence the application strategy?
 - g. Remember that after adjusting, the total nitrogen requirement of the fertilization plan must be accommodated by the farm's nitrogen quota.
5. When the fertilization plan has been updated, find the nitrogen

requirement for the application that you want to make a VRA map for. This is the average nitrogen demand that we want to meet. Now we can make a VRA map (**step 2**). Use the chosen biomass map to make an application map following the 'Robin Hood principle'. In CropSAT and CropManager you can choose automatic algorithms:

- a. CropManager will automatically find the amount of nitrogen for the relevant fertilizer supply in the fertilization plan and create the application map based on it.
 - b. CropSAT will suggest a nitrogen amount. For the first application in winter wheat or winter rape, the suggested amount depends on the NDVI of the area (high nitrogen amount for low NDVI). For a third application in winter wheat, a fixed amount of 40 kg N per ha is proposed. These suggested quantities can be adjusted to the actual required amounts from the fertilization plan.
6. Once the "raw" application map has been prepared, it is time for **step 3** where the map must be reviewed carefully and manually adjusted when necessary. Typically, the adjustments will consist of reducing the nitrogen rate in areas where growth conditions are not good enough to ensure a full response. Here, a high rate will be a waste of nitrogen and money, and this may result in nitrogen leaching. The following factors should be considered:
- a. Can full response be expected in headlands and along fences and such?
 - b. Are there wet areas where the crop growth is clearly affected by water? This might be low areas or areas with poor drainage.
 - c. Are there areas in the field where growth and yield are hampered by poor soil structure? For example areas of the field with heavy traffic of machines
 - d. Are there areas affected by winter-kill or severe manganese deficiency?
 - e. Are there areas where the yield is expected to be reduced by damages, such as slugs, snails, clubroot or poor germination?
 - f. Are there areas in the field where there are often cases of lodging? E.g. in low areas.
7. These areas can be drawn on the map and the immediately proposed nitrogen demand (which will typically be too high) is overwritten with a lower amount. Typically, one will settle for 0-40 kg N per ha in such areas.
8. After making the adjustments, you will typically find that the average nitrogen demand for the field is now lower than originally planned. It is now possible to decide whether the saved amounts of nitrogen in the adjusted areas should be distributed to the normal areas of the field or whether the fertilizer should be completely removed from the field.

- a. If the fertilizer is to be distributed to the other parts of the field so that the average nitrogen application fits with the planned quantity in the fertilization plan, in most programs it can be automatically adjusted, such that the quantity again fits the planned.
 - b. If the manure is to be removed from the field, you simply have to accept that the average nitrogen application is now lower than originally planned.
9. For some software programs, steps 2 and 3 may have to be switched, and other parameters and maps may have to be included rather than just NDVI. For example, yield maps of previous years and elevation maps can be valuable if they are available.
 10. When the total amount of nitrogen have been adjusted, the finished application map is ready to save to a file that can be stored on the USB flash card.

Repeat the exercise for other fields and crops if there is time.

4 Background information for the teacher

This is *not* a guide in how to apply a specific software for the planning of fertilization, but a guide into the considerations to be made, regardless of which software tool is used. It is possible to follow the guide using an alternative software tool. In that case, it is recommended to add information of how to use the particular tool, step by step. Likewise, the map can be made for various crops, but here winter wheat has been selected as an example.

We recommend that you go through the exercise instructions before the course and make adjustments in order to streamline the it to the context of the course (available time, applied software, skills and background of participants, etc.).

We also recommend that you conduct the exercise in groups of two participants, preferably such that at least one field for each participant will be created.