Date: 16 June 2015

1. Basic information

Number and name of the activity	**5.1.Drought management by agricultural practices and measures increasing soil water holding capacity**
Activity leader *(name, organization, email)*	Pavol Bielek (SK)
Duration of the activity	2013-2015
Participating partners *(name, organization, email)*	Research Institute for Soil and Water Conservation, Praha (J.Hladík) Institute of Agricultural and Forest Environment, Poznaň (A.Kedziora) Slovak University of Agriculture, Nitra (P.Bielek) University of Ljubljana, Ljubljana (R.Mihelič)
Chairman of the CWP	Elena Fatulová (SK)

2. Contribution to Challenges

Your activity belongs to:

- *Operational mode (next year drought, ongoing multiple-year drought)*
- *Strategic mode (future drought, prepared for global change)*

Please explain (max 500 characters).

Activity is focused on delivering experimental results for strategic policy decisions and planning with the purpose to increase water saving in the soil by use of specific agricultural practices as adaptation measures against drought, floods and threats from possible climate change. Results are available for implementation into the legal and policy documents and for practical use at national and EU levels (strategic mode).

What is your activity addressing?

- *Which of the seven steps described in the Guidelines for Drought Management Plans (act. 2.1)*
- *monitoring, forecasting / prediction, impacts, vulnerability, measures, management, risk management*

Shortly describe main challenges which you have addressed with your Activity on International, regional (especially CEE), national level? How has your Activity contributed to these challenges? (Max 1000 characters)

Results of Activity 5.1 describe concrete methods and procedures for increasing soil water holding capacity. Proposed methods are: subsoiling, organic matter application into the soil, conservation tillage (to the depth of 10 cm), ecological farming (preferring organic fertilizers), composting tillage, no-till farming and another no radical partial measures increasing water infiltration into the soil profile and improving water regimes of the countries.

All proposed technologies are immediately applicable but several activities need to be performed before any large scale implementation. Therefore it is necessary: to include soil water saving technologies in Drought Management Plans as one of the protecting measures against drought ; to prepare a practical handbook concerning application of soil water saving technologies at both CEE and national levels; to consider soil water saving technologies in the EU water and agricultural policies; to create incentives and procedures on how to implement those policies into real practice (e.g. technical supports, subsidies, extension services, control, evaluation of implementation, feedbacks).

3. Contribution to Objectives (max 1000 characters)

Were the Activity objectives achieved (see Activity list)? Describe how you have achieved these in quantitative and qualitative terms. Are there any, which were not achieved?

All Activity 5.1 objectives have been fulfilled according to the Activity list. All four countries (Czech Republic, Poland, Slovakia and Slovenia) carried out both theoretical and practical (field) studies. Results are summarized in 4 national milestone reports (according to the Agreement).

Eight different soil and ecological conditions in participating countries, 5 principal methods and several technological modifications focusing on increasing soil water holding capacity have been set up and observed. The methods studied

included conventional farming, subsoiling, organic fertilizers use, no-tillage farming and composting farming. All different field experiments on increasing of soil water holding capacity have been set up and studied by relevant approaches and methods (in the field and in laboratory too).
Results can be implemented into the practical farming systems on large areas where it is needed. Summary of all 5 different methods is included in the Compendium of good practices (Act.7.1).

4. Description of the implementation process and methodologies applied *(max 1000 characters)*

Describe and explain what actions have been taken to address the challenge(s) mentioned in point 2
What were the key implementation issues?

- *describe all phases of implementation*
- *actions taken, instruments used*
- *information and methodologies applied*
- *etc.*

Did you encounter problems during the implementation phase? If so, how were they overcome? What problems could not be solved?

Two implementation approaches can be distinguished:

1. to publish all technical and technological instructions for practical activities;
2. to adopt supporting policy measures in agriculture and water management practices.

(1) First, it is necessary to start some **effective information activities** (newspapers, journals, presentations, discussions in TV and radio, etc.) and **publish all detailed expert descriptions of recommended methods and procedures for increase of the soil water holding capacity**. For example in Slovakia we published an article under title *"We need the changes in principles of soil tillage" (Bielek,P., newspaper Rolnícke noviny, 13.11.2013, 46/2013 SK)* where positive arguments for implementation of water saving farming technologies in agriculture were presented. In 2014 the book *"Compendium to practically oriented soil science" (P.Bielek, SUA Nitra, 244 pp.)* was published, containing separate chapter focusing on soil water holding increase technologies. On 11.6.2014 a one day expert meeting was held in Prague – Pruhonice (Czech Republic). The meeting *"Water in the country"* focused on water management practice in agriculture where water saving technologies were discussed and recommended. The meeting was organized by Research Institute for Soil and Water Conservation - national coordinator of Activity 5.1. Practical experiences have been received from field experiments in 8 different soil-ecological conditions of 4 countries, verifying of 5 farming systems (conventional, subsoiling, no-till farming, organic farming, composting tillage) all by using of 18 field plots

For the future it is necessary to provide recommendations, for example: identification of fields appropriate for implementations, the needs and types of machines, recommended time of application, appropriate plants and farming systems used, frequency of application, economy and ecology of implementation, review of available instruction documents and advisory services, advantages and disadvantageous for farmers, availability of financial supports.

The main knowledge base resulting from Activity 5.1. can be summarized an background for technical and technological instructions of implementations: subsoiling and mainly cross-subsoiling are effective measures for soil water holding capacity increase; composting tillage is beneficial for soil quality improvement and for water holding capacity increase of the soil; no-tillage farming is increasing soil water holding capacity due to the increase of pedofauna activities (more mesopores in soil); organic matter application into the soil is also improving water infiltration and water holding capacity of soil. All measures have had also significant positive effect on crop yields.

(2) As a second step it is necessary to incorporate proposed procedures for increase of the soil water holding capacity into the existing legal and policy documents as measures recommended for agriculture and water management practices. Moreover it is necessary to propose and adopt policy support systems for practical implementations of these measures (recommendations, subsidies, advisory services, evaluations and control). Also EU policy documents (mainly CAP-Common Agricultural Policy) should adopt those measures as recommended for application in the EU member states. Both EU and national Water Management Plans have to be completed by the water management practices proposed. At t least subsoiling, composting tillage and no-tillage farming should be incorporated into the key political, legal, and practical documents relevant to water management problems. Besides of water saving effects also lowering flooding threats should be emphasised in all legal and policy documents as arguments for implementation and support.

There are some barriers concerning adoption of the proposed measures by farmers, such as higher expenditures in the beginning of the implementation (machine costs), conservative behaviour of some farmers and their lack of trust in the new farming systems, usually caused by the absence of advisory and supporting services for farmers. Those problems can be overcome by collecting and presenting new arguments for implementations, by more effective advisory activities, by financial support and by stronger pressure of water sector on extensions of those technologies as water management procedures in the country.

5. Outputs *(max 3000 characters)*

What are the main outputs of your activity? Please shortly describe each of them (main purpose, etc.)

Main output of Activity 5.1 is an "analysis and proposals of preventive measures as a tool for drought management in agriculture practices and technologies".
Several practical proposals for the increase of soil water holding capacity can be summarized as follows:

Subsoiling of soil profile; This technology is recommended for farmers as a new principle of soil cultivation by subsoiler machines (available in the market) instead of traditional ploughing of soil. Subsoiling is technology for deeper soil cultivation (at least 60 cm) while traditional ploughing goes into the soil in depth of 20-25 cm only. This deeper technology allows for better conditions of water infiltration into the soil profile and for higher water holding of rain fall water in the field. Simultaneously it is reducing the threats of floods, decreasing agricultural drought and increasing yields of agricultural crops. Based on the results of field experiment carried out within the framework of this project we can conclude: soil profile resistance against water infiltration (penetrometric study to the depth of 100 cm) was significantly lowered in the subsoiled soil (to the depth of 60 cm at least) but mainly in case of the cross-subsoiled alternative; following one year after application of subsoiling this effect have decreased; significantly higher water infiltration in subsoiled and mainly cross-subsoiled soils have been observed (determined by methods of soil saturated hydraulic conductivity); higher yields of cultivated crops (at least 10 %) have been achieved after subsoiling of soil (more from cross-subsoiled plots);*(repetition about those cross-subsoiled technology!)*
More positive effects of subsoiling can be expected in compacted soils. In several countries of Europe (e.g. Slovakia, Czech Republic) have detailed geographical information (GIS) systems about compacted soils. These GIS systems allow for better implementation of this technology into the agricultural practice.

Conservation tillage (10 cm deep cultivation) increases water holding capacity, water infiltration into the soil profile, increases aggregate stability and create more space of soil bio-pores by roots and earthworms mainly in heavy clay soils. This all improves conditions for water infiltration and for the increase of soil water holding capacity.

Composting tillage (by Vario-disk shallowly incorporated plant residues into the well-ventilated layer of soil) is positive in term of general soil improvement, including improved infiltration and water holding capacity in light as well in heavy soils. Plant residues bring also higher resistance of soil against water evaporation from soil cover.

Organic matter application (both manure and green manure application by ploughing) is also supporting higher water infiltration and its holding in the soil. It is due to soil structure and soil profile quality improvement.

No-till farming is increasing density of macro-fauna in upper layer of soil as well as epigeic (living in soil surface) macro-fauna. This is key argument for soil properties improvement including water infiltration and increase of water holding capacity.

Generally, infiltration and water holding capacity in soils are increasing in the following order: conventional farming, no-till farming, conservation and composting farming, subsoiling. But important and/or limiting are conditions where technologies are used, such as soil, climate, cultivated crop, and socio-economy.

Moreover it is necessary to take into consideration several positive effects of verified technologies on other aspects than water regime improvements in the soil, such as higher crop yields, soil protection against erosion, soil parameters protection, lower water evaporation from soil, improvements of soil profile/architecture parameters, etc.. These aspects are also motivating farmers to adopt the proposed soil cultivation technologies. Important is to accept all those technologies as water saving and against drought measures in comprehensive water management plans and strategies.

Remark: see more detailed information in the annexed national reports.

6. Added value *(max 1000 characters)*

What is the "added value »generated by your Activity? What new (science, practical experience, guidelines or others) was developed by IDMP CEE and how your work is related to earlier knowledge (research) and experiences in the past?

Project (5.1. Activity) have been focused on not enough known effects from the already existing farming technologies (subsoiling, mulching, no-tillage farming) which have not been used enough because of traditions in practices and lack of motivation by farmers. This project was focusing on specific effects of those technologies, mainly on soil water holding capacity increase, higher water saving in soil, and prevention against drought and floods in the country. Results of this project could be used as motivation for testing those farming systems in favour of better water regimes in soil profile. For example subsoiling, composting tillage, conservation and no-tillage farming significantly improved conditions for higher water penetration into the soil profile and for higher water content in soil. It also leads to improvement of water regimes in the country and to decrease negative threats from drought and floods. Results of this project can enlarge use of those technologies with positive effect on agriculture and water regimes in the country as well.

7. Lessons learnt and transferability *(max 2000 characters)*

This section considers how your experience can be used elsewhere.
What are the most important lessons from this Activity that might be useful for other countries and policy level in the preparation / implementation of Drought Management Plans?

Results and recommendations of this project are usable as motivation for the whole territory of Europe. Recommended technologies are effective in the following conditions: compacted soils, heavy soil by profiles, no sandy and other light soils, soils deeper than 30 cm, no drained soils, in rainfed areas, in areas suffering from drought, and in areas with regular heavy rain and floods. As good starting point of implementations are available soil survey data and relevant soil information systems including the already mentioned soil and country parameters. Also good agricultural and water management policies must be adopted including the subsidiary support systems for recommended farming technologies. Better implementation can be achieved when proposed measures will be incorporated into the Water and Drought Management Plans. Final reports of this project (national and common reports) can be everywhere used as theoretical and practical background for implementation of the proposed procedures.

8. Proposals for follow-up *(max 2000 characters)*

In case resources become available in what aspects would you like to continue your activity? Some concrete proposals for follow-up projects?

(1)At first some continuation of the existing field experiments is needed. It can bring information about optimum of temporal repeats of applications. This information can increase economy of measures use.

(2) Also creating computerized systems for the use of proposed technologies in real large scale areas and different ecological conditions (regions, state, and country) would be a fruitful extension of the project implementation.

(3) Handbook on soil water holding capacity increase by different approaches must be prepared and published as well. It is a critical fundamental work what is necessary to be done in the nearest future.

(4) Proposals (arguments) for policy regulations concerning the increase of soil water holding capacity on EU and national levels must be proposed. Some qualified proposals of principles for appropriate subsidiary systems must be also comprised in this document.

9. Annexes

Milestone reports, tables, other data, etc.

- Joint report *"on recommendations for increasing of soil water holding capacity by different agricultural methods"*
- National final reports (Czech Republic, Poland, Slovakia, Slovenia)