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PRECONDITIONS FOR IMPLEMENTATION OF CONSERVATION TECHNOLOGIES IN THE CULTIVATION OF INTENSIVE CROPS IN BULGARIA

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Abstract

At the beginning of 21st century, a number of economic sectors with an increasing relevance the question of increasing the productivity and quality of production, and this against the background of increasingly limited resources and rising prices. Farming is no exception from the general trend, given the fact that the sector has an important task to ensure adequate quality and quantity of food to feed the growing world population. It seems that the alternatives to increase productivity of the sector in terms of yield per unit area, and related general and individual productivity of the factors of production inputs and outputs of the system (biological productivity per unit of inputs, efficiency factor per unit of production, energy , nutrients, water, labor, land and capital) are already exhausted. This article aims to focus on new ways of agricultural production, which marked a growing popularity worldwide and prerequisites for implementation in Bulgaria.

Key words: Conservation, Agriculture, Sustainability, Climate change, Farming, Intensification, Productivity

INTRODUCTION

The new paradigm of "sustainable production intensification" as developed by the FAO (United Nations Food and Agriculture Organization) has discovered the need for a more productive and efficient agriculture, which is at the same time to conserve and enhance the natural resource base and the environment and to contribute to more efficient use of ecosystem services. The sustainable production intensification should not only reduce the impact of climate change on the production of plant products, but also reduce the influence of factors,which have a negative influence on the climate by reducing emissions and helping to capture and retain carbon in agricultural soils . Intensification should also preserve and enhance biodiversity in agricultural production system on the surface and subsoil and improve ecosystem services to improve productivity and healthy environment. Set of management practices on the soil-plant-water-landscape system, known as Conservation Agriculture (CA) which has the potential to achieve all these goals. Conservation agriculture reduces energy consumption and fuel for agricultural production and use of nitrogen fertilizer, thus reducing harmful emissions, increased biological activity in the soil and result in increased yields and productivity of the factors in the long term. Conservation agriculture can be used in conjunction with other techniques such as Integrated pest management, nutrient management and water balance of the soil, etc.. (FAO, 2011).

MATERIAL AND METHODS

For achieving the aim the following tasks have been solved:

- Clarified the essence, principles and objectives of Conservation agriculture;
- The distribution system in the world is presented;

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- Presented stages and prerequisites for the implementation of conservation technologies in the cultivation of intensive crops in Bulgaria.

The methods used are: analysis and synthesis, systemic and structural approach, induction and deduction.

The expected result is to bring arguments for implementing conservation practices in the cultivation of intensive crops, which would improve the economic performance of the sector and achieve objectives such as reducing the environmental footprint of agricultural production and achieve long-term sustainability.

RESULTS AND DISCUSSION

Looking at issues related to the conservation of natural resources and particularly those used for agricultural activities should clarify concepts related to the implementation of various systems for agricultural practices worldwide, to clarify the nature of conservation agriculture. In terminological respect initially as a description of a number of agricultural practices aimed at protecting natural resources are adopted by farmers "conservation tillage”. They aim to limit the harmful effects of intensive agriculture and reduce erosion by reducing machinery operation and maintenance of permanent vegetative cover on the soil. "Conservation tillage" is a term that combines practices such as zero or no-tillage, minimal tillage, direct seeding, ridge tillage and other specific practices relevant conservation objective. Usually, leaving at least 30% plant-protective cover on the soil after the seeding, is characterized as a lower limit for the determination of a kind technology as a conservation tillage, but the other purposes of the processing, such as saving time, fuel, maintenance of soil biodiversity, soil structure and moisture remain outside. This has led to confusion among the agricultural scientists and more importantly, the farming community. Added to the confusion, the term conservation agriculture has recently been introduced by the FAO (Food and Agriculture Organization website) and others and its goals defined by FAO as following:

“Conservation Agriculture maintains a permanent or semi-permanent organic soil cover. This can be a growing crop or dead mulch. Its function is to protect the soil physically from sun, rain and wind and to feed soil biota. The soil micro-organisms and soil fauna take over the tillage function and soil nutrient balancing. Mechanical tillage disturbs this process. Therefore, zero or minimum tillage and direct seeding are important elements of CA. A varied crop rotation is also important to avoid disease and pest problems.” (FAO)

According to this definition, Conservation Agriculture is a management approach to improve agroecosystem sustainability and productivity, increasing income and safety of food, while conserve and enhance the resource base and the environment. Conservation agriculture is characterized by three linked principles namely:

- Continuous no- or minimal mechanical soil disturbance (i.e., no-tillage and direct sowing or broadcasting of crop seeds, and direct placing of planting material in the soil; minimum soil disturbance from cultivation, harvest operation or farm traffic, in special cases limited strip tillage);
- Permanent organic soil cover, especially by crop residues, crops and cover crops;
- Diversification of crop species grown in sequence or associations through rotations or, in case of perennial crops, associations of plants, including a balanced mix of legume and non-legume crops

CA principles are universally possible applications to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface. Soil interventions such as mechanical tillage are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt the biological processes (FAO, 2011b). CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface. Soil interventions such as mechanical tillage are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes (FAO, 2011b).

CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rain feed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. The yield levels of CA systems are comparable with and even higher than those under conventional intensive tillage systems, which means that CA does not lead to yield penalties. At the same time, CA complies with the generally accepted ideas of sustainability. As a result of the increased system diversity and the stimulation of biological processes in the soil and above the surface as well as due to reduced erosion and leaching, the use of chemical fertilizer and pesticides, including herbicides, is reduced in the long term (Laurent et al., 2011).

It further helps to sequester carbon in soil at a rate ranging from about 0.2 to 1.0 t/ha/year depending on the agro-ecological location and management practices (Corsi et al., 2012). Labor requirements are generally reduced by about 50%, which allows farmers to save on time, fuel and machinery costs (Saturnino and Landers, 2002; Baker et al, 2007; Lindwall and Sonntag, 2011; Crabtree, 2010). Fuel savings in the order of around 65% are in general reported (Sorrenson and Montoya, 1984; 1991). Theoretical concepts resembling today's CA principles were elaborated by Edward Faulkner in his book "Ploughman's Folly" (Faulkner, 1945) and Masanobu Fukuoka with the "One Straw Revolution" (Fukuoka, 1975). But it was not until the 1960s for no-tillage to enter into farming practice in the USA. In the early 1970s no-tillage farming reached Brazil, where farmers together with scientists transformed the technology into the system which today is called CA.

The worldwide spread of CA in 2011 (about 125 M ha) is shown in **Table 1**, ranking the countries according to area adopted. CA in recent years has become a fast growing production system. While in 1973/74 the system was used only on 2.8 M ha worldwide, the area had grown to 6.2 M ha in 1983/84 and to 38 M ha in 1996/97. In 1999, worldwide adoption was 45 M ha, and by 2003 the area had grown to 72 M ha. In the last 11 years CA system has expanded at an average rate of around 7 M ha per year from 45 to 125 M ha showing the increased interest of farmers in this production system.

CA is not widely spread in Europe, excluding Russia **(Table 2):** no-till systems do not exceed 1% of the arable cropland. Only Africa has a smaller absolute area under CA than Europe. Since 1999 ECAF (European Conservation Agriculture Federation) has been promoting CA in Europe, and adoption is visible in Spain, Finland, France and UK, with some farmers at 'proof of concept' stage in Ireland, Portugal, Germany, Switzerland, and Italy. Especially in Spain, Portugal and Italy the growth of CA in perennial crops, such as fruit orchards, vineyards and olive plantations, has exceeded the adoption rate in annual crops.

In Bulgaria, the big farmers have aimed their production mainly to intensive crops. This is due to the fact that they are to a high degree can be mechanized, which implies the use of modern agricultural equipment. According to the Agricultural Report 2012 in Bulgaria in 2011, cultivated land increased by 2% compared to the previous year, occupy 3,227,237 ha or 63.4% of the utilized agricultural land. The increase was primarily due to increased area under wheat, maize, sunflower and industrial oilseeds. Despite some indications that farmers are beginning to pay attention to the tillage, partly applying certain operations (mulching, direct seeding etc.) which to some extent can be defined as conservation tillage, yet we cannot speak for Conservation agriculture in Bulgaria.

This is due to the fact, that short-term solutions and immediate benefits are always more attractive for farmers, and overall technical and economic advantages of the Conservation agriculture can be seen and felt only in the medium and long implementation period when the principles of the system (zero tillage, permanent soil cover and rotations) are established and applied consistently. In fact, if the these two production systems (conventional and conservation) are implemented on two plots of equal agro-environmental conditions and fertility, there is no big difference in productivity in the first year. However, after the cultivation of the same crop in the region a few years, the differences between the two systems will become increasingly visible.

Table 1. *Extent of adoption of Conservation Agriculture Worldwide (countries with >100 000 ha (FAO, 2011)*

Country	CA area (ha)
USA	26 500 000
Argentina	25 553 000
Brazil	25 502 000
Australia	17 000 000
Canada	13 418 000
Russia	4 500 000
China	3 100 000
Paraguay	2 400 000
Kazakhstan	1 600 000
Bolivia	706 000
Uruguay	655 100
Ukraine	600 000
South Africa	368 000
Venezuela	300 000
France	200 000
Zambia	200 000
Chile	180 000
New Zealand	162 000
Finland	160 000
Mozambique	152 000
United Kingdom	150 000
Zimbabwe	139 300
Colombia	127 000
Others	409 440
Total	124 794 840

Table 2. *CA adoption in some selected countries of Europe (FAO 2011c)*

Country	CA area (ha)
Finland	160 000
France	200 000
Germany	5 000
Hungary	8 000
Ireland	100
Italy	80 000
Netherlands	500
Portugal	32 000
Slovakia	10 000
Spain	650 000
Switzerland	16 300
United Kingdom	150 000
Total	1 311 900

CA requires a new way of thinking by all stakeholders. This "new thinking" in terms of CA already has sufficient technical and agronomic evidence that can positively affect farmers who planned adoption of the principles of CA. Very important is to demonstrate to farmers that agronomic and technical aspects are directly related to the management of economic and therefore, all technical and agronomic improvements obtained by applying the principles of IC should be measured in value in economic terms. Before analyzing farm management and economic aspects of CA should be clarified and divided the adoption process - adaptation of four theoretical stages. This theoretical division presented in **Figure 1**, facilitates the analysis of agricultural activities, and the impact of new technologies on the production process.

- **First stage -** Improved tillage techniques. During this first stage, it can not be expected to increase the agricultural production. Can be expected to decrease production costs, the amount of work, time to tillage operations, decrease the power used for tillage. It is possible that the increase of agrochemical agents for weed control, and the increase in costs for farmers to compensate for the low yields of this step compared with the conventional production method;
- **Second stage -** improvement of soil conditions and fertility. The reduction in labor costs, time and the required processing capacities (lower production costs). Increase yields and thus increase the net income of the farm;
- **Third stages -** Diversification of crops. Increase stability and increased yields. Increasing the net income of the farm and soil fertility;
- **Stage Four -** integrated production system operates stably. Stability of yields and productivity. Full technical and economic benefits of conservation agriculture can be assessed by the farmer.

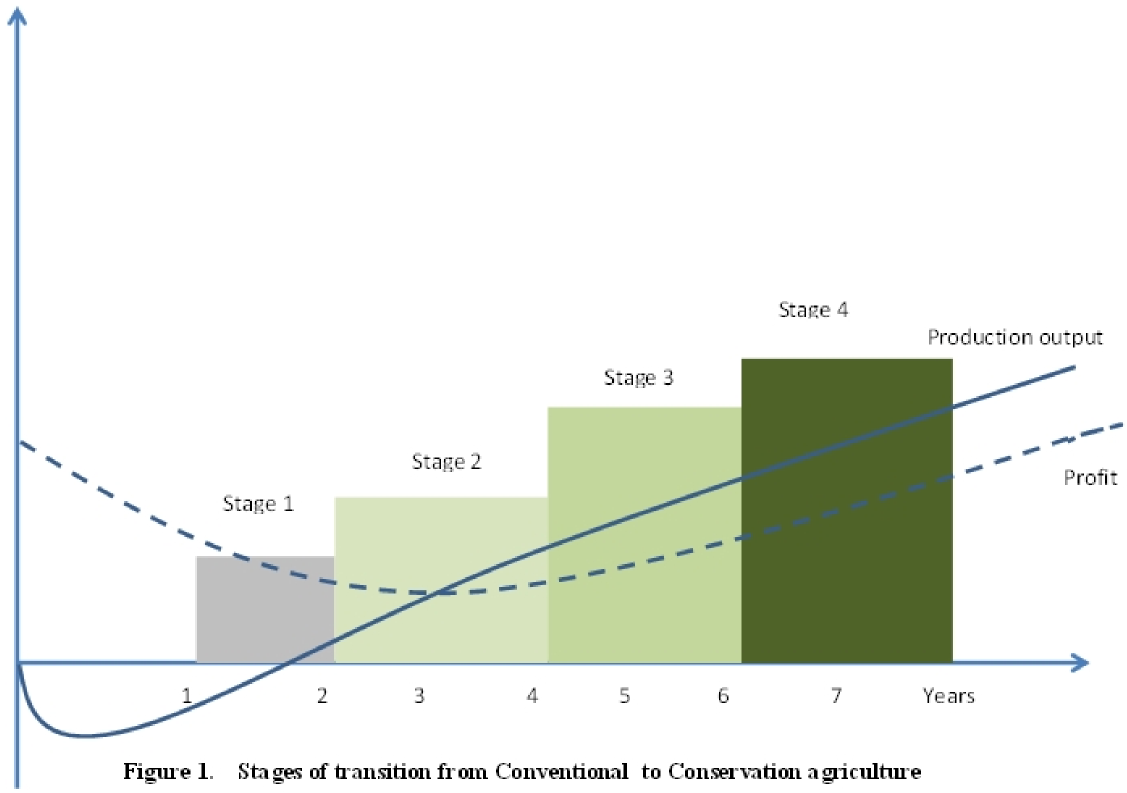

Figure 1. Stages of transition from Conventional to Conservation agriculture

Since opportunities to increase yields, reduce production costs and higher incomes are advantages that technological transition to CA to offer, they should be taken into account in the process of adoption and dissemination of technological innovations. The economic potential of conservation agriculture in terms of production costs, profit, production, soil conservation, etc. is very important. The practice of conservation agriculture may have an initial negative impact on the yield and increase the resources, which makes its implementation uncertain. We should not forget that the decision to transition - adaptation must be taken in an uncertain environment (depending on the variable nature and market factors). This needs to take into account the attitude of farmers towards risk and, in particular, their strategies for risk avoidance.

There are four general requirements for adopting the practices of CA: (FAO, 2004)
1. They must carry the farmer visible and immediate economic or other benefits.
2. Benefits should be significant enough to convince farmers to change current practices applied.
3. Farmer must be able to cover the cost of introducing the technology.
4. The introduction of the CA must be followed by adequate extension service for a long period of time.

In 2010 main part of the structure of farmland in Bulgaria covered with intensive crops including cereals, industrial seeds and forage crops. It's over 90 % of cultivated land. Thus opens great opportunities to take advantage of the CA to farmers, society and the landscape as follows:
To farmers:
- 50-70% lower fuel use for highly mechanized farmers;
- 20-50% lower fertilizer/pesticides;
- 50% reduction in machinery and use of smaller machines;
- C-sequestration of 0.20-0.7 or more t/ha per year, depending on the ecology and residue management;
- 50% labor saving for the small farmer

To the society:
CA offers public goods that include: less pollution, lower cost for water treatment, more-stable river flows with reduced flooding and

maintenance, and cleaner air and less siltation of dams.

At the landscape level:
CA offers the advantages of better ecosystem services including: provision of food and clean water, regulation of climate and pests/diseases, support of nutrient cycles, pollination, cultural recreation, enhancement of biodiversity, and erosion control.

At the global level:
The public goods are: improvements in groundwater resources, soil resources, biodiversity and mitigation of climate change

CONCLUSIONS

CA represents the core components of a new alternative paradigm for the 21st century and calls for a fundamental change in production system thinking. For the farmers, a mechanism to experiment, learn and adapt is a prerequisite. For policy-makers and institutional leaders, transformation of tillage systems to CA systems requires that they fully understand the large and longer-term economic, social and environmental benefits CA paradigm offers to the producers and the society at large. Today the main reasons for adoption of CA can be summarized as follows: (1) better farm economy (reduction of costs in machinery and fuel and time-saving in the operations that permit the development of other agricultural and non- agricultural complementary activities); (2) flexible technical possibilities for sowing, fertilizer application and weed control (allows for more timely operations); (3) yield increases and greater yield stability (as long term effect); (4) soil protection against water and wind erosion; (5) greater nutrient- efficiency; and (6) better water economy in dryland areas.

Analysis of international experience in the implementation of the CA suggests that there are no obstacles Bulgarian farmers to take advantage of a really sustainable product system.

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