In: Agricultural Research Updates. Volume 9
Editors: Prathamesh Gorawala and Srushti Mandhatri
ISBN: 978-1-63482-358-6

Chapter 2

SIGNIFICANCE OF SEED AND ROOT CROP PROPERTIES IN ORGANIC FARMING

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ABSTRACT

The need to breed crop varieties suitable for organic farming, that is to say a new type of plant suitable for this type of agriculture exist,in this type of agriculture and at research activities, still outweighs varieties bred for conventional crop production; i.e., for a high level of fertilization with the application of complex of protective substances (pesticides). High quality seeds and roots are desirable, however they need improved or up-to-date features which are suitable for a lower level of agrotechnical treatments.

The quality of the root and seeds is very important, but in the case of the root system it is not only a question of the size of the root system, it is also a question of the root system activity and the maximum development available in optimal time during crop growth. It is necessary to pay attention to individual crops and their phylogeny and ontogeny.

Influence of the root traits for the seed’s growth and development is very significant and this relationship exists also in reverse. It has been noted that a 1% change of the root system size corresponded to a 2% change of the grain yield. Similarly, the possibility of breeding for greater vitality of seeds was also noted.

The overall results at the root system, also suggest, that mycorrhizal colonization could improve the osmotic adjustment response of most plants, enhance its defence system against pests and diseases, and alleviate oxidative damage of cell viability.

More than 90 - 95% of organic production is based on the utilisation of crop varieties that were bred for the conventional high-input sector. Most of the contemporary varieties lack important traits required under organic and low-input production conditions.

The results showed that the seeds and embryos of different provenance have almost the same dimensions but have different physiological characteristics, chemical

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composition and enzyme activity, seed vigour, content of seed dry matter and water and size of embryonic roots.

The efficiency of water utilization in time of germination is one of the basic factors influencing successful germination and the field emergence rate. There exists a large variability in the water-use efficiency of seeds from different species and cultivars. This is very important for the future growth and development of crops for plant breeding. It is already possible to identify selection for resistance to environmental stress conditions at the seed germination stage. The quality of the embryonic root is important for the subsequent growth of the roots.

INTRODUCTION

Organic agriculture: Organic farming is a form of agriculture that relies on techniques such as crop rotation, green manure, compost, and biological pest control. Organic farming uses fertilizers and pesticides if they are considered natural but it excludes the use of various other constantly utilised conventional methods for reasons including sustainability, openness, independence, health and safety.

Ecological farming: Ecological farming is not the same as organic farming but it is a very similar process, however there are many similarities and they are not necessarily incompatible. Ecological farming includes all methods, including but not limited to organic methods, which regenerate the ecosystem and ensures healthy farming and healthy food for today and tomorrow by protecting soil, water and climate, promoting biodiversity, and does not contaminate the environment with chemical inputs or genetic engineering etc.

THE SIGNIFICANCE OF SEED AND ROOT PROPERTIES GROWS IN ORGANIC AND IN ECOLOGICAL AGRICULTURE DUE TO THE LOWER LEVEL OF AGROTECHNICAL INPUTS

Basic ideas of organic farming: Organic agriculture is a response to a growing awareness that the health of the land is linked to the health and future of the people [1]. Organic farming requires adherence to certain rules: prevention of soil erosion, water infiltration and retention and carbon in the form of humus. Organic farming is important in creating globally sustainable land management systems, and maintaining biodiversity in food production and farming and also achieving a productive food system that is sustainable . However long-term water management by ecological farming methods can also increase water availability for the locality [2]. There have been some suggestions and ideas that this type of farming is suitable for old varieties of seeds and plants. These ideas are from time to the time erroneous, because even among contemporary cultivated varieties it appears that some have a similar efficient nutrient uptake, health status and quality of production as in organic growing systems.

This type of farming system differs fundamentally in soil fertility, weed, pest and disease management, and makes higher demands on product quality and yield stability than conventional farming. The desired variety traits include adaptation to organic soil fertility management, implying low(er) and organic inputs, a better root system, better seed vigour and ability to interact with beneficial soil micro-organisms, ability to suppress weeds, crop and seed health, good product quality and a high yield stability [5].

Traits such as adaptation to organic soil fertility management require selection under organic soil conditions for optimal results. The organic crop ideotypes may benefit not only organic farming systems, but also the conventional systems in the future, if it is required to have more ‘plastic’ cultivars. To achieve this, organic farming relies on a number of principles and practices to minimize our impact on the environment, working the earth as naturally as possible.

Constant practices of organic farming; crop rotation, the foundation of efficient use of land resources, strict limits on the use of pesticides, synthetic fertilizers, antibiotics, additives, and the use of farm resources, e.g. manure as fertilizer or produced locally for livestock feed [6].

Currently ecological agriculture is limited by the lack of varieties adapted to organic conditions, hence the need for breeding exists [7] The limited area of organic agriculture will possibly be an impediment in the future for economic interest and also for development and for establishing specific breeding programmes for organic farming systems [8].

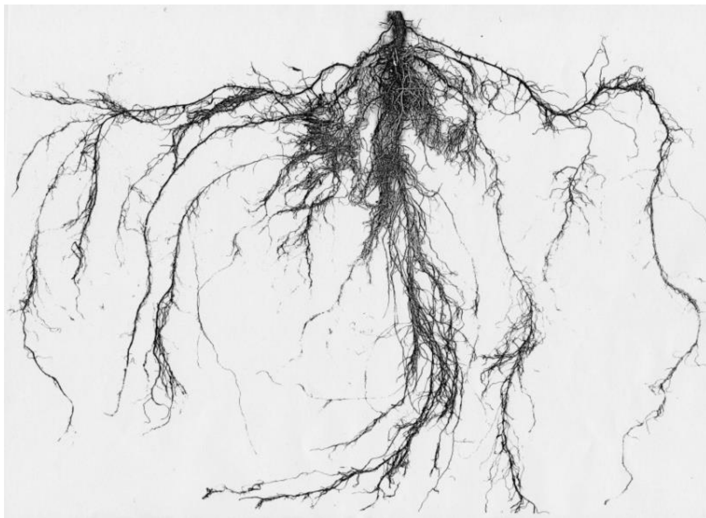
The choice of crops and varieties within the rotation and use of appropriate husbandry practices are critical to these success of the system and it is very important to determine strategies for the control of key pests and diseases. Pest problem is high in agricultural and horticultural farms where several hectares of a single crop species may be grown.

Levels of soil borne pathogens and root disease are generally (probably) lower in most crops in comparison with conventional agriculture. Resistant species and varieties, basic cultural controls and utilisation of a variety mixtures are useful aids to foliar disease control [9].

SEED IMPORTANCE IN ORGANIC CROP FARMING

When compared with conventional agriculture, seed germination takes place in relatively ‘worse conditions’ in the low input system and therefore seeds of cultivars of high quality, vitality, efficiency of water-use and with resistance to soil stresses during germination, must be used.

If we can imagine ‘Seed History’, they have developed over a long period of approximately 300 million years of phylogeny. Seed history consists of four main steps: the development of morphological structures, anatomy of seeds; the development of dormancy and the evolution of seed size. The roots, have from the paleontological view, their first predecessors in rhizoids: unicellular ‘fibres’. So far, the oldest fossils of these plant organs: real roots, came from the period 396 million years ago. That is to say roots are older than the seeds [10, 11, 12, 13]. The quality of the seeds is under the influence of the multitude of genes that are active during seed development and during seed germination, a large part of these genes plays a role in the response of the seed during germination to the environmental stresses. Analysis of these genes will be beneficial to the plant breeders or for seed technologists [14]. The relationship between the roots and the relationship between the roots and the traits of the seeds and sprouting seeds is very important from the physiological and practical point of view. Seed quality is affected by the location of the seed on the mother plant, by environmental conditions and by storage conditions. To date, known results confirm the importance of the seed characteristics for crop production. The deteriorating quality of soil in recent years, the increasing variability of weather and long periods of drought directly support the need to intensify activities in this research. In the suboptimal conditions, the poor seed quality results in reduced root growth and also in a low yield level [15]. The following figures are the roots of crops (older soybean cultivar Imari) from the good quality seeds (Figure 1) and those from seeds with bad provenance (Figure 2)



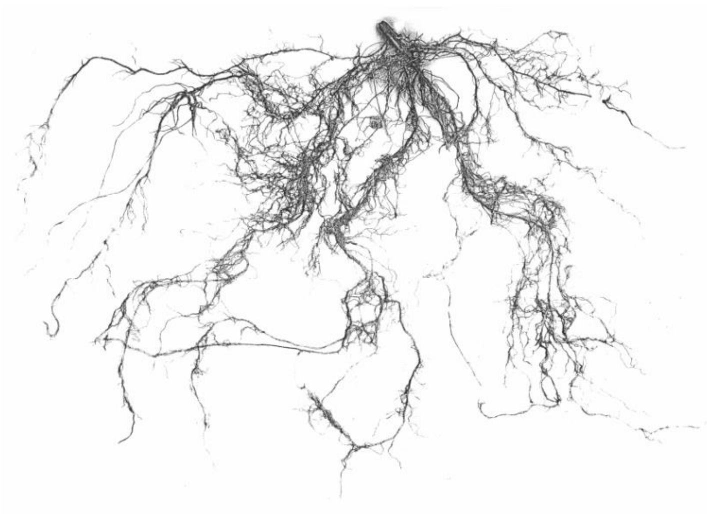


Figure 1. Soybean root system of juvenile plant before the nodules formation, provenance of seeds-good soil quality.

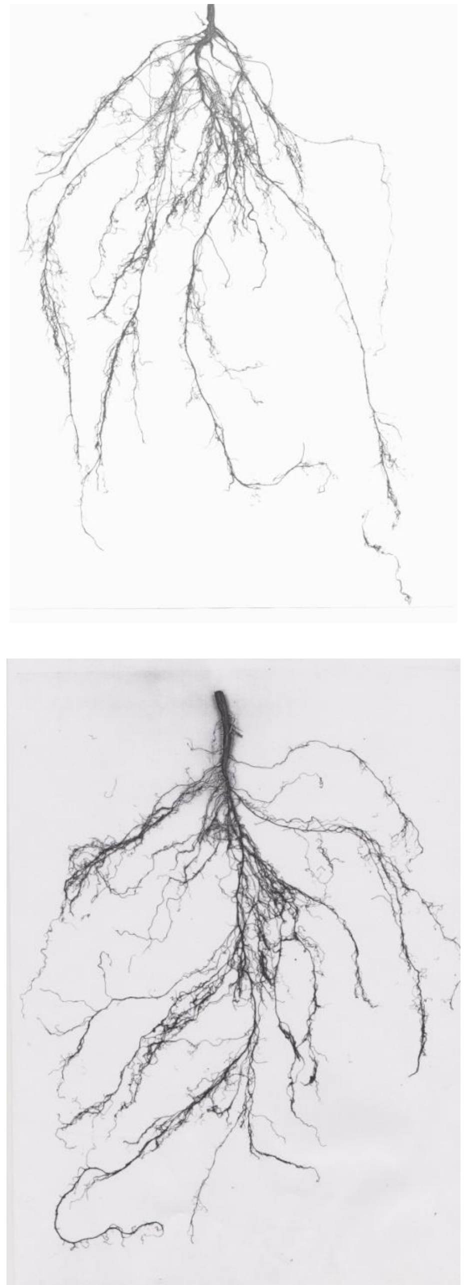


Figure 2. Soybean root system of juvenile plant before the nodules formation , provenance seeds–bad soil quality.

Seed germination is a complex physiological process and besides the basic requirement for water, oxygen, temperature, the seed may also be sensitive to other environmental factors (light, abiotic and biotic stress, nitrates etc.). Effects of stress and degraded environmental conditions slows down the germination process, this is not advantageous for organic agriculture, where slow growth of seedlings can be damaging to the subsequent growth of vegetation i.e., far more than in conventional agriculture.

Genetic variation in plant seed tolerance to the stresses during sprouting is a very important factor. Stress tolerance during germination can lead to successful agricultural work, it is well known that seed quality is possibly one of the most efficient agrotechnical measures.

It is commonly known that the good seed quality can increase yields by up to 5 to 10 per cent.

Water uptake (after 4 h imbibition) as a function at the moment of its onset shows rhythms with a period length of approximately 6h. The period length is not affected by an increase in temperature of 10°C, suggesting that the oscillation is endogenous in character. Furthermore, heat-killed seeds show no oscillations in water uptake, indicating that the rhythm originates from the live seeds [16].

Changes in seed germination during the year exist in some species. Obtained results [20],

[21] confirmed a statistically significant relationship between the speed of seed germination and the intensity of geomagnetic activity during a year period [17, 18].

The analysis of seed and root traits is still neglected. Most physiological experiments do not take into account the fact that "half" of the metabolic processes in plants take place in the roots. Plant integrity in plant research, breeding and production is 'unknown' for many scientists thanks to their narrow and rigid specialization [19].

When seed samples of the spring wheat were aged, they showed delayed field emergence and slower seedling growth. Experiments carried out over a wide range of population densities supported this proposition.

They also showed that, if direct effects of poor vigour seed on yield through reduced establishment are avoided by adjusting sowing rates so that the recommended rates of the establishment are achieved, then there will probably be little or no effect of seed vigour in the final yield, providing normal germination in the laboratory test is 85% or more, and sowing in the spring is not delayed.

However, if these conditions are not met, then significant yield reductions can be expected which could not be overcome by increasing the sowing rate."

Long-term seed storage conditions influence the following seedling growth and the deterioration speed of the seed stored for a long time is affected by environmental conditions in which the seed was grown.

From the practical point of view it is connected with question of the preservation of important genetic resources. Seeds from adverse environmental conditions rapidly lose germination energy and longevity. Deterioration, storage conditions, bad conditions during seed development, affect yield in the subsequent generation by the following ways: suboptimal population of plants per unit area, slower growth of plants, poorer performance of surviving plants and in winter crops is a further reduced percentage of the surviving plants. This is especially important in organic agriculture, where the emphasis on seed quality is higher than in conventional agriculture

The vigour of the seeds is not only the result of the weight and chemical composition of endosperm, starch, damaged starch, proteins, lipids etc., but there is also a large influence of enzyme activities, embryo vigour and many other characters [20, 21, 22].

The irrigation during the vegetation period in conventional agriculture shows a positive influence on the seed weight and in the next generation on the root system, i.e., from the practical view, better water-use for seeds utilised in organic agriculture is desirable, especially in organic agriculture because absence of irrigation exists [23].

In conventional agriculture no yield advantages can be associated with high vigour seeds when environmental and soil conditions are available. If conditions are unsuitable, it is important to use seeds of good quality and with high vigour in organic & ecological agriculture. i.e., in organic or similarly ecological agriculture high advantages can be associated with high vigour and quality of seeds.

ROOT IMPORTANCE IN ORGANIC FARMING

A Similar problem exists in seed-utilisation as in organic agriculture when growth and root development takes place in relatively "worse conditions"and therefore the root system must have the optimum structure, depth of penetration, efficient nutrient uptake and their transport, increased resistance to soil stress, good growth energy and optimal ratio to above-ground biomass.

In terms of the general view in organic farming, the characteristic competitiveness against weeds and pests, nutrient uptake, nutrient use efficiency and tolerance to diseases are more important when choosing a root variety than in traditional farming.

Basic requirements are connected by different ways with root system traits:

Good water-use efficiency in low water level of the soil, nutrient use efficiency (particularly of nitrogen and phosphorus is desirable), their transport, root length, surface and also depth of penetration.

From a practical view, the following characteristics are important:

Early maturity: As a mechanism for avoidance of particular stresses; abiotic and biotic stress tolerance especially at the root system (i.e., drought, salinity, etc.)

Selection for competitiveness against weeds: Early ground cover: even if the number of plants is less than 160 per m2, varieties with good tillering ability can give good results.

Growth habit: Planophile growth habit (angle > 45°) has a clear advantage for weed suppression over an erectophile type of plant (plantophile type - bigger leaf angle).

Plant height: Most important for erectophile plant type. Tillering ability: more important in a cool moderate climate. Rapid early growth of the root and shoot system.

Time advance in root growth before the growth of aboveground part of crops is desirable.

It is well known that the disease pressure in organic crop production is in most cases lower than in conventional agricultural systems. Organic farmers not only look for genetic resistances, they also want to reduce the risk by selecting for additional morphological traits and look for a more robust plant architecture not conductive to disease development

Plant breeding: Breeding methods are not shown in this work. It is a separate issue requiring a separate chapter. For organic breeding programmes there is an interest in maintaining variation within varieties to allow for a buffered response to variation in the local environment. Special attention must be focused on the root system traits [25].

In organic farming is also required by the appropriate crop rotation, suitable effective soil preparation and crop cultivation by suitable agrotechnic technique.

Organic agriculture cannot, and does not have to, be suitable to all the crops, but nevertheless the share of organically bred varieties should increase. [26], cultivars for organic agriculture must have better nutrient (especially nitrogen) uptake without their application.

It is commonly known that the roots are the most sensitive part of the crop plant. An important factor in the nutrient availability is also the root morphology and physiology [27].

In the case of environmental conditions the following influence of environmental factors on the root system exists:

Drought changes depth of root penetration.

Low pH has an influence on the length of roots.

The influence of salinity depends on the type of salinity.

High temperature influences number of root branches.

Low nutrient level is connected with the increase of the root system length, decrease of root volume and the number of branches, a combination of abiotic stresses has a large influence on the decrease of every trait, but not in every type of environmental conditions. These types of changes can have influence on the transport of water and metabolites in plants and also on the shoot, and especially on seed growth and development. On the other hand the influence of the seed traits on root growth and development is also negligible as previously mentioned. The seed traits and traits of sprouting plants affect filial generation root morphology at the beginning of the vegetation period: especially length, surface, depth of root penetration and also root weight, and later the number of root tips, number of root hairs, number of lateral roots and the density of roots. Good roots influence the further course of growth. The start of the vegetation period has a significant influence on the following growth. The developmental and growth stage, in which stress appears, is very important for all the vegetation period [28, 29].

It is Therefore Necessary in Organic Farming to Use Genotypes which Have the Stability of Specified Properties Across Various Environments

To date, results, by one of the largest symposiums in Japan concerning the root physiology and ecology, confirmed ecological manifestations of the roots in different conditions. On the basis of the results of this symposium it is required to analyse the following at the root system:

Anatomy and morphology of the roots, tropism and nutational movement of the roots, growth physiology and environmental stress, functional ecology of the root systems, root soil interaction, rhizosphere and soil microbiology, agricultural and horticultural sciences, forest ecology and management, methods of investigation, plant nutrition, physiology, biotechnology, genetics, microbiology in rhizosphere, forestry science, ecology and horticultural sciences [30].

Quality and physiological activity of the roots is a necessary condition for growth and optimal shoot development and subsequent development of the seeds for good quality in the majority of the field crops. This relation is also valid vice versa: the seed quality has a positive influence on the root growth and development.

Darwin expressed that 'Roots are the brains of plants' [31], i.e., roots can be taken as a similar body like the "brain of plant". Currently, it is well known that for the transmission of signals (changes in potential) between root and above-ground plant parts plasmodesmata is needed and there seems to be an important role for auxin molecule (IAA) and other phytohormones. The importance of the seeds and roots are still neglected in the plant production, but in organic agriculture this will be very important

It is also necessary to distinguish between two types of root system; monocotyledonous root system and dicotyledonous root system. In the first case, the 'monocot' root system, is known as fibrous roots because of the massive group of small roots in the top 10 to 20 centimetres of the soil. A dicotyledonous root system grows vertically and has a system of subordinate branches

Influence of soil types on the crop root system is relatively high. There exists an important influence on the root traits of both the soil temperature and its nutrient content.

It is very important for organic and ecological agriculture that stabile root growth and the development of utilised cultivars is desirable across the different soil types.

It is well known that the nutrient concentration has influence on the volume, number and dry matter of the roots. Substantial effect has also been observed for different types of root environment during cultivation. That is to say the cultivars for the ecological and organic agriculture must have root system stability across the different soil conditions [32]. Old cultivars are more tolerant to drought and high temperature stresses. They show deeper penetration of the root system in the soil [33]. There has been very interesting results from the research on special the protein ACR4. Therefore, it is particulary relevant for this issue to directly quote (reproduced) from an original citation [34].

VIB researchers at *Ghent University* have discovered the substance that governs the formation of root offshoots in plants, and how it works. Root offshoots are vitally important for plants and for farmers. Plants draw the necessary nutrients from the soil through their roots. Because they do this best with a well-branched root system, plants must form offshoots of their roots at the right moment. The VIB researchers describe how this process is controlled in the prominent professional journal Science. A key player in this process is a protein called ACR4. Depending on the signals that it receives from its environment, this protein triggers the formation of a root offshoot. Now that we know the control mechanism, we can begin to stimulate plant roots to form more, or fewer, offshoots. This can lead to a more ecological agriculture and to the production of better crops at the same time.

An efficient network. So, a well-coordinated, controlled formation of root offshoots is crucial to a plant. But, until now, how a plant determines when and where an offshoot should be formed was unknown. *Asymmetric cell division.* The presence of stem cells is very important in the development of plants and animals. Stem cells are cells that can transform themselves into various types of cells. In animals, tissues and organs are formed before birth; but in fully-grown plants, stem cells continue to play a major role in the formation of new organs or tissues, such as root of shoots.These stem cells are found inside the root, and several of them will induce the formation of an offshoot. These 'root-founder' cells undergo an asymmetric cell division. In contrast to the usual cell division, which gives rise to two identical cells, asymmetric cell division produces two different cells: a stem cell that is identical to the original cell, and a cell that is ready to become a specialized cell – in this case, a secondary root cell. *The decisive signal.* They found out which genes are active in these cells and compared them with the genes that are crucial to normal cell division. In this way, the researchers identified a specific set of genes that control asymmetric cell division and send the signal for the formation of offshoots.

ACR4: control over asymmetric division. The ACR4 gene contains the DNA code for a receptor, a protein that is often located on the exterior of a cell to pick up signals from the outside and transmit them to the controlling mechanisms within the cell. ACR4 plays a key role in the creation of offshoots. Because the protein has a receptor function, triggering the formation of offshoots depends on its reaction to signals from the environment. *Desired or undesired.*This new knowledge enables us to promote, or retard, the formation of offshoots, both activities are useful in a large number of applications.

Promoting an extensive root system helps plants absorb nutrients more readily, and thus they need less fertilizer. Such plants can also grow more easily in dry or infertile soils. Furthermore, plants with a well-developed root system are more firmly anchored in the soil and can be used to counteract erosion.

On the other hand, slowing down secondary root formation can be advantageous in tuberous plants, like potatoes or sugar beets.

Root Shoot Ratio Importance

In the course of ontogenesis, each species creates a specific optimal ratio between above ground biomass and below ground portions of plants: the roots. The ratio of the mass of the roots and shoots is genetically fixed. During the phylogenesis of every species, and cultivars, the ratio has a stepwise development modified by environmental conditions. This is the result of the of physiological processes in the plant during the vegetation period. For every period of plant growth and development of an optimal root to shoot ratio exists. For organic agriculture a larger root system is desirable.

Conclusion

In this type of farming it is necessary to use seeds with good germination, great vitality, efficient nutrient utilization, with seedlings resistance to abiotic and biotic stresses, because the level of agro-inputs is lower in organic farming that in conventional agriculture.

Seed quality has an influence on the growth and the development of the roots and the relationship exists vice versa. The roots must be resistant to abiotic and biotic stresses with a good nutrient and water uptake in deteriorated conditions. A lower-modifying effect of external conditions and a low variability at the optimum root to shoot ratio is desirable.

The current range of varieties are usually bred for conditions of higher levels of fertilization and protection against diseases and pests.

Suitable varieties must be bred specifically for organic agriculture because the current varieties can only satisfy the requirements for partial organic farming. Problems such as heredity of described seed and root properties are not negligible.

From time to time it is proposed that organic agriculture should cultivate/combine old varieties with contemporary varieties, but this is a misconception and very much the opposite is true. There are traits associated with conventional and old varieties, which are unsuitable for organic production systems and certain traits required in organic farming systems are not present in recently developed “conventional” varieties.

Special problem is utilisation of the “organic seeds”. Are Organic Seeds Required for Organic Certification? What it is question….Certified organic seeds for crops and other organic agricultural uses has been a long-standing problem within the organic industry. Seed availability over organic vs. non-organic seed production systems both play a part. Organic seeds defined, means seeds that are untreated, or treated only with allowed substances found on the National Lists of Allowed and Prohibited Substances. This type of seeds s are seeds that are grown without the aid of synthetic fertilizers, chemicals, pesticides or herbicides.

ACKNOWLEDGMENTS

The work was supported by the Project No. MZe RO0414 of Ministry of Agriculture of the Czech Republic.

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