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THE EFFECTIVENESS OF THE APPLICATION OF SPECIALIZED TECHNIQUES OF FOREST PLANTING TECHNOLOGIES ACCORDING TO THE SYSTEM OF GENOMIC TECHNOLOGIES EXPRESSED IN THE FORM OF IN-VITRO WITH THE USE OF HUMIC ACIDS EXTRACTED FROM COAL FOR THE CONVERSION OF HEAVY SALINE SOILS SUITABLE FOR THE CULTIVATION OF CONIFEROUS AND DECIDUOUS CROPS.: BETA PROTOCOL

Abstract: *Currently, more than 9,000 hectares of hybrid aspen forest plantations have been created in Northern Europe, most of which are planted with microclonally propagated planting material [2]. The industrial introduction of this technology was preceded by research work carried out in forest research centers [2-4]. In the CIS countries, forest biotechnology has not been widely used in production. Currently, a number of research works are being carried out aimed at studying the features of the introduction of this technology into forestry practice. In Russia, the greatest attention is paid to aspen and aspen-poplar hybrids of local origin. The growth and development of plants obtained from tissue culture in natural conditions is most actively studied. So, in 2001-2006, the staff of the St. Petersburg Scientific Research Institute of Forestry created a number of experimental sites where six aspen clones are tested.*

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Introduction

Comparison of two methods of reproduction of mother strawberry plants (by mulch film and rooting rosettes in place) showed that the reproduction coefficient depends on the origin of the mother plant and the method of cultivation (Table 2). Plants F0 in vitro, obtained directly in tissue culture, by the reproduction coefficient significantly exceeded control plants obtained by the traditional method — 205 and 112 accordingly. The aftereffect of in vitro cultivation was also preserved in F1 plants in vitro, which were rooted rosettes of the first order of F0 plants. This is due to the fact that the first dead leaves of the mother plant develop from buds laid in vitro. The increased reproduction coefficient in strawberry plants after in vitro culture depended on the genotype (Table 3). At the end of June, the number of rosettes in the Zarya variety propagated in vitro exceeded the indicator of control plants by 2.1 times. Redgontlit — 3.2 times, Zenga-Zengana — 5.4 times. Over time, the advantage of micro-propagated plants has increased even more: at the end of August, the Zenga-Zengana variety exceeded the control by 5.7 times, and Redgontlit — by 6.8 times.

Picture 1.

Similar The assessment of somaclonal variability was also carried out on forest crops. About 5 thousand plants of common ash in vitro were acclimatized in the greenhouse and showed no phenotypic abnormalities. Since in vitro and greenhouse observations alone are not enough to detect somaclonal variability, more than a thousand ash plants were planted in the field for laying forest plantations. Evaluation after two seasons also found no signs of somaclonal changes. Our results are quite consistent with the data of other researchers who, in field trials, did not observe deviations in plants obtained by micropropagation or regeneration. Particular attention should be paid to the clonal micro-reproduction of chimeric plants. We propagated in vitro lilac plants of the Sensation variety with two-colored flowers, which were then planted for growing in the field. After 5 years, they bloomed and it turned out that out of two thousand plants, about 10% have white flowers, and five plants had both white and flowers with normal color. It is known that this popular variety, which has purple-red flowers with a silver-white border, is a periclinal chimera — it was obtained in 1938 as a mutation of the Hugo de Vries variety with reddish-purple flowers. Data on the behavior of chimeric genotypes in in vitro culture are contradictory. On the one hand, chimeras can be separated by various methods in vitro. For example, banana chimeras (mixoploids) were separated using three micro-multiplication systems. Adventive regeneration has been successfully used to separate two chimeric pear varieties into genetic components: Louise Bonne Panachee with variegated leaves and fruits and Red Hardy with red fruits. On the other hand, Rosati found that micro-propagated plants of the thornless chimeric Loganberry variety remain genetically stable after 3 years of growing in the field. Finally, micro-reproduction of chimeras may even have an advantage over traditional reproduction. The chimeric violet Pinwheel Flowering with bicolored flowers, when propagated by leaves, retained this feature only in 30% of plants (70% were unicolored), and its reproduction by in vitro method provided 96% of plants with bicolored flowers. Our results show that in vitro reproduction leads to splitting of the flower color trait in the chimeric lilac variety Sensation, but the frequency of such splitting is relatively low. In our work, we also evaluated somaclonal changes in transgenic plants.

Picture 2.

After the transformation of the pear by the genome of the plant defensin, 70 transgenic lines of the Burakovka variety were obtained [13]. Clonal micro-multiplication of the obtained lines revealed that some of them have a number of differences: a thickened stem, larger leaves, necrosis of the apical bud. Cytological analysis showed that these lines are tetraploids. Out of 70 lines, only 9 turned out to be tetraploids (12.9%), and one line was a chimera: cells from two shoot meristems turned out to be tetraploid (68 chromosomes), and from one — diploid (34 chromosomes). Other researchers also showed a change in the ploidy of the pear after transformation, and, apparently, the influence of the genotype was present: during the transformation of the Passe Crassane variety, 12% [15] and 15% [16] tetraploids were detected, and during the transformation of the Conference variety - only 0-4% [17]. Polyploid genotypes are a valuable source material for further breeding and one of the methods of obtaining them can be considered transformation and/or regeneration. There may be several reasons for the change in ploidy during in vitro cultivation. One of them is the presence of polyploid cells in the initial explan-te. For example, it was found that the tissue of cotyledons of carnation contained about 60% of tetraploid cells [22]. In this regard, the use of explants of non-seed origin, for example, leaves, is preferable, since the level of ploidy of cells in them is more stable. We used leaves from plants in vitro to transform pears. However, it is known that juvenile organs, such as cotyledons, usually have a higher regeneration rate and are often used for the regeneration and transformation of plants, especially woody species. On the other hand, the use of such explants can lead to an increase in the level of somaclonal changes. However, despite the role of the source material, most polyploids and aneuploids arise during cultivation. Flow cytometry has shown that 14% of papaya plants obtained through somatic embryogenesis from callus have altered ploidy [5]. It is known that the probability of deviations increases if the callus stage is present during in vitro cultivation. For example, changes in the level of ploidy were lower in the stem explants of asparagus than in the callus obtained from these explants [19]. Meanwhile, most transgenic plants, including pear transformants in our experiment, are obtained precisely through the callus, which is formed from transformed cells that survive on a selective medium. In addition, the regeneration of transgenic plants is characterized by the use of high concentrations of growth regulators, in particular, cytokinins. To regenerate pear shoots after transformation, we used a medium with the addition of 3 mg/l of TDZ. This concentration is ten times higher than those that are usually used for the proliferation of plant shoots in vitro. The role of the concentration of growth regulators in the induction of somaclonal changes has been repeatedly noted by researchers. The addition of 6-BAP and NUC and an increase in their concentration led to a twofold increase in the proportion of tetraploid and octoploid cells in the pea callus, as well as to the appearance of triploid and aneuploid cells, which had not been observed before [9]. An increase in the concentration of BAP and 2,4-D from 10 to 20 microns induced the appearance of up to 10% of dwarfs among regenerants from strawberry callus [21]. Also, prolonged exposure of explants and callus to nutrient media can increase the frequency of deviations, which has been confirmed by a number of studies. For example, plants from 8-week-old strawberry callus did not show any morphological changes, whereas plants regenerated from 16- and 24-week-old callus showed deformation (6-13%) and yellowing of leaves (21-29%) [21]. In our experiments, pear transformants regenerated starting from the first passage after transformation, but polyploid ones appeared only from the sixth passage, i.e. after several months of culturing the callus, which could contribute to a change in ploidy. All these factors combined could lead to the appearance of polyploid transgenic pear lines. The level of ploidy was also determined in transgenic plants of the bp3f1 birch genotype obtained after transformation by the glutamine synthatase gene. The original genotype is a mixoploid with a predominance of tetraploid cells with 56 chromosomes (72.8%) and also contains 15.2% triploid (42 chromosomes) and 6.0% diploid (28 chromosomes) and aneuploid cells. In the process of regeneration, cells with different chromosome sets were separated and analysis of 6 transgenic lines showed that three of them were dominated by tetraploid cells (100.0, 93.3 and 86.7%), two — triploid (85.7 and 82.1%) and one - diploid (66.7%). Thus, we were able to obtain transgenic birch plants with different chromosome sets, which can later be used for breeding purposes. The separation of cells by ploidy during regeneration from the initial chimeric explants has already been observed earlier [22]. However, in these studies, the proportion of polyploid regenerants was significantly lower than the proportion of polyploid cells in the initial explants, and the authors attribute this to the increased ability of diploid cells to regenerate compared to tetraploid cells. In our work, the average number of polyploid cells in the transformants was 81.3%, which does not differ significantly from 88% in the original genotype. From this it can be concluded that diploid and polyploid birch cells have approximately equal potential for regeneration. Microclonal reproduction of plants is one of the methods of biotechnology. In fact, it is vegetative reproduction (cloning), however, it differs in that its methodology is based on the use of tissue culture approaches. The result of this is a significant acceleration of the planting material production process, improvement of its quality, as well as in some cases improvement. In forest biotechnology, the technologies developed for fast-growing and economically valuable tree species have received the greatest development [1]. In order to expand the practical use of the method of microclonal reproduction in the forestry of Belarus, the study of the experience obtained in similar soil and climatic conditions of neighboring states is of the greatest interest. Microclonal reproduction of forest tree species is widely used on an industrial scale in Scandinavia and the Baltic countries. There, a technology for the production of hybrid aspen planting material (P. tremula x P. tremuloides Michx.) has been developed. The choice of the object is due to a number of reasons, the main of which is its high productivity and winter hardiness. Currently, more than 9,000 hectares of hybrid aspen forest plantations have been created in Northern Europe, most of which are planted with microclonally propagated planting material [2]. The industrial introduction of this technology was preceded by research work carried out in forest research centers [2-4]. In the CIS countries, forest biotechnology has not been widely used in production. Currently, a number of research works are being carried out aimed at studying the features of the introduction of this technology into forestry practice. In Russia, the greatest attention is paid to aspen and aspen-poplar hybrids of local origin. The growth and development of plants obtained from tissue culture in natural conditions is most actively studied. So, in 2001-2006, the staff of the St. Petersburg Scientific Research Institute of Forestry created a number of experimental sites where six aspen clones are tested. It is shown that the increase in the height of triploid aspen plants in crops by the age of eight is 2 times higher than the control for this indicator. Similar results were obtained at experimental sites in the Republic of Tatarstan [5, 6]. Similar applied tasks require their solution in Belarus. The study of the growth parameters of plants obtained under aseptic conditions makes it possible to assess the genetic potential and productivity of each clone, determine the impact of the technology used on the development of seedlings, and study the economic aspects of the introduction of scientific developments. Thus, the purpose of this study was to study the features of growth and development of microclonally propagated plants of selectively selected clones of tree species in natural conditions. The main part. The objects of the study were woody plants aged 2-3 years, growing in experimental forest crops. They belonged to 21 clone forms: clones bp3f1 and bp1b of fluffy birch (Betula pubs-censs Ehrh.); clones bb31, 171b and bb9a1 of hanging birch (Betulapendula Roth.); clones 54-84/8 and 66-150/10 hybrids of hanging birch and fluffy birch; clone ROR 4 of the Canadian poplar (Populus canadensis auct.); clone GlA of the hairy poplar (Populus trichocarpa Torrey et A. Gray ex Hooker); clones M22, M26, Psv3, Psv5, Psv6, Gl8 and Petrovsky of complex poplar hybrids; clone Chinese poplar Chinese (Populus simonii Carriere f. fastigiata); clone Korean Korean poplar (Populus koreana Rehder); clones 215, Pt and V22 aspen

(Populus tremula L.). Planting material for the creation of experimental crops was obtained through microclonal reproduction. The process of obtaining seedlings from micro-plants included two main stages: adaptation to ex vitro conditions and rearing in closed ground conditions (greenhouses). Regenerants were adapted ex vitro for 1-2 months. Then the seedlings were grown in closed ground conditions with a closed root system (pot volume - 1.0-1.5 liters) on a peat-sand substrate with the addition of complex fertilizers during one growing season. Using the obtained planting material, an experimental object was created - experimental forest crops. The work was carried out on the lands that have come out of agricultural use. The experimental facility was created in the Makeyevsky forestry of the Gomel Forestry (block 214, section 1). Laying was carried out in two batches: in spring (April) (planting material was grown in 2012 and preserved until spring 2013 in a forest nursery) and in autumn (October) (seedlings were grown in the year of laying) 2013. Tillage consisted of cutting furrows. The area of the object is 5 hectares. The planting scheme is 3 ^ 3 m, representatives of various clones are planted in rows without mixing. During the monitoring of the state of forest crops during the growing season of 2013, it was found that in May the plants developed normally, the survival rate was at a level close to 100%. However, already at the end of August, a significant part (up to 30% or more) of the planted plants died, many showed signs of inhibition of growth. During soil excavations, extensive damage to the root system was found due to the presence of root-gnawing pests in the soil. This, on the one hand, led to a noticeable decrease in survival, on the other hand, suitable conditions are being created at this experimental facility to determine the resistance of plants of various clones to this unfavorable factor. The results of the examination of the condition and survival of planted plants. As follows from the data in Table 1, the growth of microclonally propagated plants varies markedly from variant to variant, the survival rate varies greatly from clone to clone. In addition, in most cases there is a large variation of individual morphometric parameters. All of the above indicates the presence of an unfavorable factor acting with different strengths and randomly even on plants of the same clone. In the case of this experimental object, plants of two birch clones (bp3f1 and bb9a1) were planted both in spring and autumn. During autumn planting, the level of metabolic processes and the regenerative ability of plants are noticeably reduced, and they are more susceptible to adverse conditions. The reverse situation occurs when creating crops in the spring. Such arguments are confirmed by the ratio of survival rates of plants planted at different times (about 70 and 40% when planted in April and October, respectively). Thus, the most favorable time for the laying of forest crops with microclonal birch planting material is the period before budding. Previously, the shortage of wood was due to the fact that the main percentage of it was exported. Now the processing capacity is almost 100% loaded. However, their main concentration falls on the European part of Russia, where a significant part of the forest has already been put under the axe. In the Urals, where the main timber reserves are located, the timber processing industry, with the exception of individual regions, is still rather poorly developed. As a result, processing companies incur serious costs for the transportation of raw materials, which are constantly increasing due to the growth of railway tariffs. In addition, the development of forest resources is constrained by the need for large investments in the construction of logging roads. Until recent years, timber harvesting was tied to roads that had already been built, and by now these reserves of "available" forests are close to depletion. The actual reserves of wood, the harvesting of which seems economically feasible, may not be so great. The indicated problem can be solved in both extensive and intensive ways. In the first case, we are talking about the development of new regions of forest reserves by increasing investment in the creation of forest-industrial complexes. Or the transition of existing enterprises to the development of advanced technologies for the cultivation of industrial forests, which allow to obtain "ready-to-use" wood at the site of deforestation in a much shorter time compared to traditional cultivation. Currently , the following innovative technologies for growing trees can be distinguished: cultivation of genetically modified breeds, "closed root system" technology and grafting method. Despite the absolute difference in the applied technological processes, all of them are aimed at obtaining high-quality wood material in the shortest possible time compared to traditional schemes. The cultivation of GM trees While biotechnology may be severely restricted or even banned in the food industry, its position is becoming strong in the non-food sector, including in the forestry industry. The first genetically modified tree was obtained in 1987. To date, experiments on the use of genetically modified trees in forestry have been conducted in 35 countries. In total, over the past decade, about 2,700 experimental studies have been conducted related to the introduction of various biotechnologies into forestry. Approximately 70% of these experiments are carried out in the developed countries of the world: the USA, Canada and France. The volume of global investments totals hundreds of millions of dollars. Biotechnological experiments were carried out on 140 species (biological genera) of trees, but 60% accounted for 6 of them — pine, eucalyptus, spruce, poplar, oak and acacia. Approximately 19% of biotechnological experiments in forestry account for experiments related to genetic modification. Field tests are conducted only in 16 countries. In total, there are 270 plots in the world where genetically modified trees are grown, most of which are in the United States.

In North America and Europe, research is largely controlled by the government and scientific communities, while in Latin America, Africa and Southeast Asia, research has been left to the private sector. All this has already led to a sharp increase in the number of commercial plantations in recent years, and it continues to grow. According to forecasts, the development of commercial GM plantations will begin in Indonesia, Chile and possibly Brazil. However, at the moment only one tree is allowed to grow – papaya. Features of the technology. The main efforts of scientists are aimed at identifying key genetic modifications that affect the formation of the most valuable properties of wood for industry, which will increase productivity and reduce the cost of production. These include: growth rates (this will reduce the age and turnover of felling trees);

resistance to pesticides and diseases to reduce losses; resistance to herbicides to increase yield;

salt resistance (will allow trees to grow on soils salted during irrigation of tree plantations);

chemical compositions of wood fibers, especially lignin (will reduce the price and simplify the technology of paper production);

sensitivity to the length of daylight (will increase the number of regions suitable for growing such trees); ozone and stress resistance.

However, the regulated benefits of genetic modification of trees should be considered, first of all, taking into account their environmental safety. According to experts, the main threat of GM trees is their adaptability. There is a high probability of displacement of natural forests. At the same time, transgenic rocks cannot perform their functions: water conservation, maintain biodiversity, serve as a source of food, wood and medicinal plants for local residents. In addition, tree pollen spreads over hundreds of kilometers, and no one will ever be able to exclude the possibility of genetic contamination of natural forests not only of the same breed as neighboring GM samples, but also of related species.

In response, scientists declare the sterility of genetically modified breeds, which, in turn, can lead to even more serious consequences. As you know, tree seeds are an important food source for insects and birds. If GM trees do not have them, then such forests will become a "green desert" that has nothing to do with full-fledged forest ecosystems. The main driving factor in the development of genetic engineering in the forest industry is commercial interest. One of the main tasks facing scientists is to obtain homogeneous products. Natural forest as a raw material is very heterogeneous, and the heterogeneity of the product reduces its commercial value. From an industrial point of view, gene plantations have an undeniable advantage, since they involve obtaining a large amount of homogeneous wood. The potential benefits for multinational companies from the use of genetic engineering technologies in the forest industry are enormous: the estimated value of the annual global timber harvest already exceeds $ 400 billion. However, the beginning of the use of genetically modified trees for industrial purposes has been announced so far only by China, which is acutely experiencing a shortage of wood materials. In order to meet the growing demand for wood, China intends to increase the cultivation of GM trees. The most common tree in the country is poplar. So far, the plantations of transgenic poplars occupy only 200 hectares. Analysts of the UN Food and Agriculture Organization doubt the economic feasibility of using biotechnologies in forestry, since the cost of forest products on the world market is much less than the cost of food. Experts are convinced that the plantations of genetically modified trees will remain relatively limited in area. In Russia, the law prohibits the cultivation of genetically modified crops. However, in 2002, the Center for Environmental Education and Information (Yekaterinburg), Ural State University named after A.M. Gorky (Department of Plant Physiology), the public organization "Association of the Green Movement" (Nizhny Tagil) together with the Laboratory of Industrial Botany of the University of Freiburg (Germany) decided to conduct research on the cultivation of modified poplars as part of an experiment on phyto-purification of soils from heavy metals. The main task of the scientists was to study the possibility of recultivation of man-made lands using plants with increased resistance to heavy metals. Transgenic poplars, which are a natural hybrid of poplar and aspen, were used as the subject of the study, in which additional genes from the DNA of the same poplar responsible for the synthesis of compounds containing sulfur were introduced. Thus, the plant's properties were enhanced to absorb sulfides, sulfites, sulfates and other sulfur compounds from the environment and convert them into a fixed, insoluble form. A total of 188 trees were planted in the vicinity of Nizhny Tagil. They were created at the Institute of Tree Physiology in Germany. It is known that the practical part of the experiment has been completed, and the theoretical part continues to the present. The technology of growing trees using planting material with a closed root system was first proposed by the Finns about 40 years ago. Its essence is to use seedlings or seedlings growing in special container pots (cassettes) as planting material. When transplanting to a permanent place, such seedlings are removed from containers and planted with a lump of earth, so that their root system is not damaged at all and the seedlings are much easier to transfer. There are several different technologies for growing seedlings or seedlings with a closed root system. In the world, the most common technology for growing annual seedlings, mainly conifers (pine, spruce), in small containers in special greenhouses, where the necessary microclimate, timely watering and fertilizing are provided (despite the small volume of each container, the earth in it does not dry out and the supply of necessary nutrients is not depleted). "One of the priorities in the region is the development of biotechnologies, and the biotechnological approach is applicable to various sectors of the economy, including such an urgent one as the forest complex," Alexey Kozhevnikov said. -In 2017, 10.5 million rubles were allocated from the regional budget for the reforestation of plots cut down by small and medium-sized businesses, and compared with 2016, reforestation works are clearly ahead of schedule. But financial support is only a part of investments in this direction. The creation of plantations of fast–growing forests, the cultivation of which requires much less time, the support of such projects is the best solution to meet the growing global demand for wood and the promotion of a "green" approach to the use of forest resources in the region." In 2014, a group of scientists from the Institute of Bioorganic Chemistry of the Russian Academy of Sciences (Moscow) carried out work on the breeding of fast-growing aspen and birch lines. In 2015, the question arose about the need to create an experimental landfill for growing plants. Vologda enterprise LLC "Tolshmenskoye" became interested in this topic and offered its plot of land for testing. Thus, in 2016, a plantation of fast-growing birch and aspen forest crops was created near Totma. The introduction of a new technology of "Multi-purpose forest reproduction" using plants with improved hereditary properties makes it possible to solve both the problem of reforestation and the problem of deep processing of wood. Bred clones grow 30% faster than normal ones. Due to the rapid growth of trees, they have higher quality, and therefore more expensive wood. The new approach allows you to harvest 2 "harvests" of wood from one area in a shorter time. This opens up opportunities for the creation of new investment projects in the Vologda region. It is the Vologda enterprise that will become the owner of the exclusive right to use several of the most effective clones. Tolshmenskoye LLC will be able to sell seedlings of fast-growing plants, including to other regions. The regional government supports representatives of small and medium-sized businesses who are introducing innovative biotechnologies and directing their activities to preserve and protect the environment. The company will be included in the biotechnological cluster of the region in order to receive all the support measures available today. "Innovative biotechnologies, which are used in the cultivation of breeding plantations, allow not only to maintain balance in ecosystems, but also to create a platform for future investment projects. But I would like to note once again that, first of all, when engaged in breeding, it is necessary to see in forestry indicators not the euro with the dollar, but the reforestation and ecological effect. Considering that 2017 has been declared the Year of Ecology by the President, we are developing and supporting projects in this direction at all levels of government," Alexey Kozhevnikov summed up. The Institute of Bioorganic Chemistry of the Russian Academy of Sciences has created fast-growing birch and aspen lines using cell selection technology. Thanks to the interaction with the Department of Forestry of the Vologda State Agricultural Academy and Tolshmenskoye LLC, a plantation for growing seedlings of these trees was created near Totma (245 km from Vologda) (the rights to these lines now belong to Vologda Tolshmenskoye LLC). This technology (approach to reforestation) can be broadcast to other regions (in 2017, the innovative technology of "Multi-purpose forest reproduction" was patented) The abbreviation GMO is on the ear of many. But most of the biotechnologies that are currently used in forestry are vegetative reproduction and genetic markers. However, according tosome experts, GMOs will probably soon playa major role in forestry. The essence of GMOs is that foreign genesare introduced into the genome of a plant, as a result, its phenotype changes. So,for example, it is possible to increase the level of strength of the tree structure, resistance to adverse natural environmental factors, etc. The ease of gene transformation depends on the types of trees: conifers,for example, they are more difficult to transform than deciduous trees.In most cases, biotechnology in forestry is used to expand agricultural innovations: for example,the resistance of tree species to herbicides. The benefits of biotechnology for the environment are also unconditional: GMO wood replaces wood from natural forests, it is much cheaper. Trees undergo genetic transformation, in particular, in orderto populate unsuitable places for growth (saline soils, arid conditions, etc.). Cold-resistant tree species are being developed. With the help of GMO trees, logging innatural forests can be significantly reduced.One of the benefits of biotechnology in forestry is the cultivation of plantation wood in order to reduce the commercial harvesting of natural forests.Plantation forests for the production of wood began to be grown in the XIX century . in Europe and in the middle of the XX century in North America. Over the past 40 years, industrial plantation forests have become the main supplier of business timber, largely due to higher productivity, as well as due to the high cost of wood obtained from logging of natural forests The risks of using biotechnology will be in the genetic exchange between transgenic and wild trees, which is very undesirable. Transgenic technology turned out to be controversial when it related to agriculture, and part of the controversy is now flowing to forestry. GMOs in agriculture are being persistently introduced by the most powerful multinational corporations into the food market of the world. But the warnings of many scientists, who experimentally (on animals) prove, are equally insistent. the high level of danger of GMO consumption in food for both humans and animals. Many countries have abandoned the cultivation of GMO vegetables, berries and other products.

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