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Multiple premises for research-integrated blended education via mapping genetic resources

Abstract: Since the last century a special emphasis has been made on the species and crop diversity and their conservation, especially after several N.I. Vavilov's research expeditions. Institutional pre-requisites may have been seen from the pattern of the Belorussian collection which has been integrated recently to AEGIS initiative affiliated in turn with ECPGR (European Cooperative Programme for Plant Genetic Resources). The initiative comprises 650 institutions from 43 European countries engaged in promoting specific gene banks. Each institution is targeted to preserve and breed activities on a domestic valuable crop. National repositories summon up to adapting valuable crops to changing environment, production and consumer needs. On the other hand, the current trends lead to merged interdisciplinary MSc and PhD educational programs in mapping genetic resources domestically and internationally. Besides, current educational purposes of Bologna-linked universities worldwide demand to obtain and immediately imply highly competitive knowledge, consistent with growing trends of relevant accreditation, life-long learning, internationalization, further excellence of women in research and management, extending business-education partnerships, digital skills, support to innovative environment, proper employment of graduates and other factors. The above mentioned premises can be supported by modern GIS-technologies and versatile aerospace information, which supply more and more precise and reliable data on the state of agro-landscapes.

Key words: research-integrated blended education, mapping genetic resources.

Introduction

Current education needs impose new teaching formats via its modernization, and particularly massive online education, hands-on education, blended education, and therefore multisubject-"addicted" didactics. Historical, institutional and educational backgrounds put forward such a multidisciplinary educational program as mapping of genetic resources. Such program would facilitate subsequent multidisciplinary research including geoinformatics, genetics, plant breeding, agricultural science, bioinformatics, land and production management, digital management, space photography, mapping, computer modeling, IT technologies, employment analysis, charity policy, transnational student communications, and etc.

We propose the following question: Why such facet-like boundary programs should be developed regionally as across the continents? In the present paper we aimed to reveal the versatile backgrounds of such programs. Why such facet-like, boundary programmes should be developed regionally as across the continents? There may be versatile backgrounds we would like to concentrate at in current paper.

Historic pre-requisites

Plant genetic resources in general have been always under the scope of advanced science since the works of Linnaeus and Darwin. During the several research expeditions of N.I. Vavilov (who's 130-th anniversary has been celebrated as international forum in the institute named after him in November, 2017) special emphasis was made on plant diversity and conservation. Initially Vavilov focused on crop's fungal diseases [1] and subsequently the Research Institute of Experimental Agronomy have been established following the series of 1924-1929 expeditions encompassing Afghanistan, Africa, China, Japan, Korea, Mediterraneans, and Taiwan [2]. In 1856, the monk of an Augustinian Monastery, Gregor Johann

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Mendel, conducted experiments to study the transmission of hereditary traits on peas. As a result of the research, he made a series of biological discoveries, which he described in "Experiments on plant hybrids" in 1865. In his work, he noted that hereditary traits are not whole, as it was previously thought, but are transmitted by separate factors. Factors are found in cells in pairs and transmitted to the offspring through gametes. Now these factors are known as the genes [3]. In 1909, the Danish botanist Wilhelm Ludwig Johansen introduced the term "gene", and the American geneticist Thomas Ghent Morgan substantiated the chromosome theory of heredity in 2011 [4].

Investigation methods of plant evolution include hybridization and chromosome conjugation analysis in meiosis in hybrids (unrelated chromosomes do not conjugate) [5; 6]. An important method is the artificial re-synthesis of existing species by hybridization and the subsequent duplication of the chromosome number [7]. Significant role in the evolution of plants, including different crops (wheat, oats, cotton, potatoes, fruits, etc.) belongs to the effect of alloploidy [8]. Since the discovery of the action of the alkaloid colchicine, which appeared to prevent from the disjunction of paired chromosomes to the different poles of the cell, autopolyploidy is widely used to obtain new, valuable forms [9]. Completing methods of distant hybridization by cytogenetic studies, the researchers clarified the role of individual chromosomes (and their loci) in the inheritance of traits to further develop techniques that allow chromosome insertions of wild plants towards generation of valuable traits (e.g., resistance to rust) in cultivated plants [10]. Contribution of the nucleus and cytoplasm in the trait inheritance and development is investigated by applying a remote hybridization and analyzing the nature of the male cytoplasmic sterility used for obtaining heterozygotic forms. In plant genetics, apomixis and the phenomenon of self-incompatibility, i.e., the inability of plants to self-fertilize, as well as the genetic characteristics of self- and cross-pollen, vegetatively and apomictically reproduced forms are widely studied [11]. Modern plant genetics is increasingly saturated by ideas and methods of molecular biology (DNA hybridization, DNA-RNA hybridization, isozyme assays, etc.). Methods of population genetics and biometrics are used in plant genetics to distinguish genotypic and paratypic elements within general phenotypical diversity of traits in order to enhance the efficacy of conventional or molecular breeding [12]. All these methods are used to improve the economically valuable properties of crops: yield, resistance to unfavorable environmental conditions and diseases, a number of biochemical and technological features of the plant (or its seeds, fruits and rhizome), developmental features (wintering, early maturation, etc.).

Institutional pre-conditions

Ex-Soviet republics possessed a united collection of genetic resources based on the assemblage of a Vavilov Institute's of Plant Industry. It contains over 330 000 specimens of different crops. These accessions are being maintained to be further developed by 33 national supporting points. Since 2000 Belorussia is being engaged in collecting own crop stock by shaping the national genetic bank. This work financed by the Belorussian government and coordinated by the Research Arable Farming Institute in Zhodino. At present the collection enlists almost 50 000 specimens out of cereals (51%), leguminous (20%), fodder (12%), oilseed (8%), technical (2%), and vegetable crops (1%) [13]. The Belorussian collection has integrated recently into AEGIS initiative which is affiliated with European Cooperative Programme for Plant Genetic Resources (ECPGR). Altogether, 650 institutions from 43 European countries have elaborated a range of specific genebanks. Each genebanks is aimed to provide the conservation and breeding activities of a crop important for local agriculture (www.ecpgr.cgiar.org/aegis/). The Memorandum of Understanding of AEGIS came into force in July 2009. Total number of European collection of resources has reached 33 234. Among the national repositories the Plant Gene Resources of Canada (http://pgrc3.agr.gc.ca/) may be pointed as aimed to solve specific problems of Canadian agriculture and crop science. Its main task is to adapt valuable crops to changing environments, production facilities and consumer needs. This repository has transformed domestic breeding to become more flexible and consistent in meeting regular climate as antropogenic challenges [14].

One of these challenges is air pollution. Various negative chops and changes in the Earth's atmosphere are being registered mainly due to fluctuations in the contents of minor components of atmospheric air. There are two main sources of atmospheric pollution, natural and anthropogenic. A natural source is volcanoes, dust storms, weathering (erosion), wildfires, the decay of plant and animal residues [15]. Anthropogenic grounds of air pollution include facilities of the fuel and energy complex, transportation, a range of engineering enterprises [16]. By the year 1990 25.5 billion tons of carbon oxides, 190 million tons of sulfur oxides, 65 million tons of nitrogen oxides, 1.4 million tons of chlorofluorocarbons (freon gas compounds), organic lead compounds, hydrocarbons, including carcinogenic (causing cancer) have been emitted to the air [17]. In addition to aerial concomitants, a large amount of solid particles pollutes the atmosphere, which is dusted and sooted. One of the greatest danger on the environment is the contamination by heavy metals [18]. Lead, cadmium, mercury, copper, nickel, zinc, chromium, and vanadium have become virtually permanent ingredients of the air of industrial centres. Particularly acute is the problem of air pollution by lead.

Global pollution of atmospheric air [19] affects the state of natural ecosystems, especially the green cover of our planet. One of the most visible indicators of the state of the biosphere are the forests and their well-being. Acid rains caused predominantly by sulfur dioxide and nitrogen oxides, evoke devastating damages of forest biocenoses. It is established that coniferous tree populations suffer from acid rains more than deciduous forests. Adaptation is one of the most important mechanisms supposed to increase the stability of biosystems including plants under changing conditions of a habitat. The better the living thing is adjusted to an environmental or inner factor, the more resistant it is to ongoing alterations [20].

The genotypically determined ability of the organism to modulate metabolism within certain limits depending on the action of the external environment is called the norm of reaction [21]. It is controlled by the genotype and is characteristic of all living organisms. Most of the modifications taking place within the norm of the reaction have an adaptive value. They correspond to changes in the habitat and provide better survival of plants under fluctuations in the condition of the environment. In this connection, such modifications have an evolutionary significance. The term "*reaction norm*" was introduced by W.L. Johansen in 1909 [22].

Educational trends

In a recent article [23] tendencies of Bologna-linked education were surveyed worldwide, and it has been emphasized that ongoing process of obtaining and immediate implying of highly competitive knowledge is not plausible without new prospects of education through the relevant accreditation, life-long learning, internationalization, excellence of women in research, business-education partnerships, distribution of digital skills, maintenance of innovation-tuned environment, decent employability of graduates and some other factors. So current education should get involved new ways of teaching via its modernization, and namely inducing massive online education, hands-on (i.e. experimental) education, blended (i.e. hybrid-form) education, and then multisubject-targeted didactics.

Thus, three forementioned backgrounds are giving a nudge to develop such multidisciplinary directions as mapping of genetic resources. On one hand, judging by abbreviated history of this specialty given above, it has already existed in more or less tangible form. The second conclusion is that it has already defined an institutional "shell" as a network of national and transnational gene banks and repositories. Finally, due to process of educational internationalization there are European and overseas heaps of research teams remaining out of the scope of this paper. However, there are no any transnational multidisciplinary programs of master or moreover doctoral education on this account.

GIS-based solutions for mapping genetic resources

The main task of research and educational institutions is the creation of maps as figurative-symbolic models reflecting the reality; where the solution depends on the use of standard and specific GIS technologies including new mapping techniques based on remote sensing. Geographic mapping is critical not only as automated reproduction of the cartography image, but also in terms of designing automated map implication thus automating the overall map studies. Graphic output devices allow to automate the process of map designing and utilization [24]. Cartographic images on the screen provide a number of advantages that are not possible in frame of conventional mapping: the ability to quickly build up different versions, transform coordinate systems, simulate 3-D images and dynamic videos, etc. This is a new tool for modeling the reality. In addition, an interactive way to combine various principles of processing, editing and proofing, manual generalization, taking into account the relationships of phenomena and objects, may assist in rising the effectiveness of using the experience and knowledge of the map designer [25].

The set of objective natural and social phenomena are indicated in a map, from a cartographic point of view, may be divided into five groups, depending on the nature of spatial allocation:

i, point localization (e.g. monitoring posts, businesses and cities on small-scale maps) for which the target is their exact locations and qualitative or quantitative characteristics;

ii, line localization (e.g. roads, pipelines, borders), display objects – locations, and their qualitative and quantitative characteristics;

iii, area localization, i.e. present on some parts of the mapping territory and absent on others (enterprises, cities and their parts on large-scale maps, specially protected natural areas) for which the distribution areas and qualitative or quantitative characteristics serve as the object of the map display;

iv, continuous propagation (atmosphere and its characteristics, rocks and their properties) for which the display object is not a fact, but the spatial variability of the qualitative or quantitative characteristics;

v, scattered distribution, individual display of which is impossible (biological species, crops of agricultural crops), the object of the show is the territory and the density of distribution.

Graphic means on ecological maps are the same as on maps of other subjects: extra-scale (iconic, alphabetic and digital), linear, area. They differ in shape, size, orientation, color, color saturation, and internal structure of the image [26]. The relationships of spatial allocation types of the cartographic phenomena, the nature of information and the applied graphic means supply with the methods of cartographic imaging. Ecological mapping implies the same methods of cartographic imaging as in other thematic areas. In this case the specificity is only in the content features of the cartographic phenomena [27-29]. Geoinformation technologies assume the application of the program-technical means of processing, transfer and analysis of the information while planning the agroforestry landscapes [30; 31].

Our resources allow us to analyze the agro-landscapes across the steppe, dryland and semi-desert zones. Application of GIS-technologies and aerospace information charts, and pictures for monitoring of the state of agro-landscapes provide their relevance and credibility. Use of GIS-technologies for monitoring, mapping and modeling of the agro-landscapes of the North-West Caspian region proved its high effectiveness. The total surveyed area exceeded 4.4 million hectares [30; 32-33]. This approach is being implemented in modern geoinformation research on long-term potential of Northern croplands in Kazakhstan [33].

Conclusions

In the previous chapters we introduced the importance of plant genetic resources, the role of higher education, and as a connection between them the GIS and remote sensing was also introduced, as a new and modern technology in both research and higher education. Why this approach should be implied as a pilot international educational program on mapping of genetic resources? What advantages are being seen in our opinion?

1. There will be a specific opportunity to issue and maintain double degree of European-Central Asian universities to be designed to combine general and molecular genetics with crop resources mapping and related investigations;

2. Experts with dual M.Sc. diploma in Genetics and Cartography will provide necessary “hookups” to modern agriculture, management of arable lands, biodiversity and trends in mutagenesis or monitoring over umpteen cases of environmental deteriorations;

3. Future graduates of that program would be able to run urban space management claiming to relieve life of cities, regions and districts;

4. Such knowledge-based education will certainly influence on quicker resolution of boundary and international conflicts via getting new knowledge and solving problems in multidisciplinary knowledge-based and interactively computed modes;

5. The program will enhance transnational alignment (lining) of educational and human resources: less developed universities could quickly grow to the level of those much better promoted, whereas stronger universities will be supplied with new young talents and teachers resources;

6. The program will lead to humanization of current science and technology: its multidisciplinary and challenging nature would broaden thinking dimensions of all the participants including teachers, researchers and students, to let them raise erudition, accelerate creativity, ability to build up teams and finding new options for worldwide employment, training and charity fairs;

7. Finally, such program will evoke multidisciplinary researches in the fields of geoinformatics, genetics, plant breeding, agricultural science, bioinformatics, land and production management, digital management, space photography, mapping, computer modeling, IT technologies, employment analysis, charity policy, transnational student communications, and etc.

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