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# ПОПУЛЯЦИОННЫЙ АСПЕКТ В ОРГАНИЧЕСКОМ СЕЛЬСКОМ ХОЗЯЙСТВЕ

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## Реферат

Представленное исследование посвящено доказательству важности всестороннего изучения изменчивости признаков растений в пределах их популяций. Результаты исследования служат подтверждением основных генетических принципов развития растений; знание адаптивной роли структуры экоэлементов популяции, как показано в публикации, дает возможность предположения основной стратегии размножения растений.

Различные сорта пшеницы из различных географических и экологических местонахождений были исследованы в той же самой климатической зоне. Изменчивость фенотипического состава популяций была проанализирована с использованием эффекта различных сроков посева, температурных факторов, режима освещения. Проведенное исследование популяционной структуры культурных растений позволило выявить широкий спектр изменчивости различных признаков, что может быть использовано для улучшения сортовых качеств культурных растений.

С использованием методов популяционного анализа растений любое число вариантов сочетаний различных признаков может быть проанализировано, изолировано и впоследствии использовано для усовершенствования сортов.

**Ключевые слова**: популяционная структура, культурное растение, сорта, пшеница

# POPULATION ASPECT IN ORGANIC AGRICULTURE

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## Abstract

The presented research points to the significance of a comprehensive study of variability in plant varieties within their populations. That study would refer to the genetic principles of evolution. Knowledge of an adaptive role of the eco-element structure of a population, as presented in this paper, paves a new way to a promising basic strategy in plant breeding.

Different wheat varieties from various geographical and ecological locations were investigated in in the same climatic zone. An effect of different dates of seeding, temperature factors, light regime were used; the variability of phenotypic composition of populations was investigated.

From our investigation in the population structure of cultivated plants we are to conclude that such a population has quite big reserves of variability that can be widely used in plant breeding to improve existing varieties and develop new ones. Efficiency of intra population selection can be greatly improved under conditions of maximum disclosure of an apparent, or a probable, structure of latent reserves of the population variability. Using methods for population analysis, any number of varieties can be analyzed, isolated and subsequently used for the improvement of varieties.

**Key words**: population structure, cultivated plant, wheat, varieties

## Introduction

In this paper we start with historical and theoretical considerations to build a framework for the empirical results published in the second part.

Till the present time breeders' attention has been focused on an increase in plant productivity. This resulted in a paradox: yielding capacity of newly developed varieties grows while yield stability goes down and quality of produce does not always meet approved standards.

On the other hand, the role of the environment in manifestation of variety is well known. Usually plant breeders look for abiotic factors. The role of intra population relations is actually overlooked. Today a population approach is the most important in today's breeding of cross-pollinated and self-pollinated crops. Using population approaches in breeding will allow to raise sustainability and quality of yield, and to breed varieties that are tolerant to abiotic and biotic factors (Molchan, 1990; Temirbekova, 1994).

Already E. Sinskaya and her scholars (Sinskaya, 1939-1963) revealed that the varieties of cultivated plants consisted of a number of forms that differed in morphological and physiological characters. Variations met in populations were found to be in a dynamic equilibrium and to guarantee the stability of the populations' productivity in time. E. Sinskaya (Sinskaya, 1964) pointed out that the issue of populations' structures would have an impact on theory and practice of plant breeding strategies.

Variations in crops viz. their development is a starting point in plant breeding. This variability refers to diversity of individuals and groups of individuals in populations that differ to some degree in character and property. Variability is inherent to all organisms, which means that in nature no individuals are absolutely identical in all their characters and properties. The term "variability" is used to denote the ability of a living organism to be changed by endogenous and exogenous factors, which is to specify transformations occurred in the evolution process (Agaev, 1987). Here also other authors (Jablonka and Lamb, 2005) should be mentioned, who cretinously elaborated the concept of epigenetic factors (GRS, 2015), wherein the above mentioned variability is included.

According to N. Vavilov (Vavilov, 1957, 1962) the main role in increasing plant productivity and, for example, grain quality, is assigned to modification, i.e. non- hereditary form of variability. Vavilov explains this phenomenon by arguing that variability per se is genetically determined, and defined by the rate of response of a genotype to environmental conditions. Vavilov's estimation of the role of modification variability is in full agreement with his conclusion that "agricultural backgrounds for plant breeding ... as well as development conditions are of the foremost significance".

Here we argue that in plant breeding, considerable significance should be assigned to a comprehensive study of plant variability in their populations, referring to the epigenetic aspects of evolution (Jablonka and Lamb, 2005). Therein the notion of intra population reserves of variability, viz. their variability potential should be included.

Population botany regards all varieties - with pure lines included as lower taxonomy units of cultivated plants in their nature - as populations. Their relative homogeneity at any moment is short-term or illusory (Sinskaya 1961, 1979, 1991). Variety populations, irrespective of specificity, actually show common population regularities.

That is why investigations in population variability of varieties must, first of all, comply to the principles of phyto-population analysis. They disclose new layers of variability of cultivated plants that have not yet been utilized in the breeding process. In addition, knowledge of regularities of population variability of cultivated plants is an important prerequisite to develop a strategy to manage their ‘cultural’ evolution in landscape management and in plant breeding (Sinskaya 1939–1964).

Arguments for that approach are:

First: populations in general and phytopopulations in particular, are "accumulators of variability", because they contain and store considerable reserves of variability. They kind of “absorb” heterozygous mutations.

Second: populations are highly dynamic units of life, somehow the “generators of variability", wherein genetic processes of new formation and transformation of variability continuously occur.

Third: populations are substrates, or "laboratories" of a cultivated evolution processes, during which the initial breeding material, under a breeder's influence, turns into the products of breeding: the varieties.

Fourth: successful maintenance of cultivars’ yielding capacity potential and stability at a high level, and also regularly improving seed production, can be warranted using results of a population variability analysis.

Based on population studies as mentioned, ecoelements can be understood as genetically determined and adaptively significant units of the ecological structure of phytopopulations (Sinskaya, 1939; 1948; 1961; 1963; 1964; 1979, 2002; Jablonka, Lamb 1994; Jablonka 2004). Such ecoelements can be sources to form both new populations and new species. However, one should keep in mind that populations of some cultivars contain slightly expressed commencing eco-elements, or "incipient ecoelements". To reveal them it is necessary to use special disintegrating backgrounds, and to conduct comparative studies of incipient ecoelements as parts of variety populations. A. Gundaev (Gundaev, 1964) and V. Pustovoit (Pustovoit, 1966), two Russian plant breeders, achieved outstanding results by skillful detecting and using intra variety population variability in the process of selection of oil-bearing sunflower varieties (up to 60% of oil).

Adaptative plasticity of phytopopulations is increasing due to their eco-elemental structure, i.e. their adaptability to ever changing environmental conditions. Poly eco-element populations, with their intricate ecological and genetic structure, should be considered as the most ideal model of the adaptive varieties of the future. Such varieties can always withstand adverse biotic and abiotic conditions.

Knowledge of an adaptive role of the ecoelement structure of a population paves a new way to one of the promising basic strategies of plant breeding.

To develop the principles of population selection for organic agriculture, one should consider first of all the comment made by E. Sinskaya (Sinskaya, 1961): genetics of the population is not genetics of organisms and also variability of a population is not variability of an organism. That is why scientists have to use different methods in order to study and bring changes to an organism, or a population.

E. Sinskaya pointed to the necessity to develop new methods for a genetic analysis of a population and suggested disintegrating backgrounds to be used for this purpose.

## The Results and Discussion

According to the character of population variability we can subdivide ecosystem backgrounds into:

1. Stabilizing, or integrating systems, that provide maintenance of a given phenotypic structure of a population;
2. Leveling systems that can hide variability in a population;
3. Disintegrating systems where population variability can be manifested in the most complete and pronounced manner.

General picture of variability can be observed more easily against these three backgrounds. Using them makes the selection of separate ideotypes and their groups easier. For example, a provoking background serves well for the most vivid manifestation of certain plant the breeding process is aimed at.

4. The optimal background is not always the most polymorphous one. The optimal background can be also leveling. To choose the optimal background one should keep in mind the main purposes for growing a certain crop.

The idea of E. Sinskaya about the importance of disintegrating backgrounds has been further developed by M. Agaev (Agaev, 1987) who revealed "bursts" of variability even in pure line varieties. E. Jablonka and M. Lamb (Jablonka, Lamb, 2005) also elaborated vastly on this field of epigenetic knowledge.

Contrast conditions of crop growing (Sinskaya, 1963) exerted particularly strong influence on the increased phenotype polymorphism in a population. Namely, it is a specific feature of modern centers of intensive species formation; it promotes establishment of balanced genetic heterogeneity of variety populations and increase in their plasticity (Sinskaya, 1937). She classified the effect of climatic, soil and biotic factors according to their rate and direction of form building. It is very important to elaborate these relationships, as well to find their relevance for plant breeding, as well as for the rational distribution of breeding centers seen from an ecological point of view.

A native population retains its variability in a relative stability. Sudden hereditary variations can occur when biotypes are grown in conditions that differ from those where the rate of the biotype response has developed as a result of natural selection (Sinskaya, 1961). However, as variations in variety population, under unusual growing conditions, most frequently,occur within limits of this ‘natural’ rate, there is no evidence of variations in certain genotypes. These variations simply remain unseen. E. Sinskaya (Sinskaya,

1962) strongly opposed the idea that all new formations in mutagenesis experiments were referred to as resulting from mutations, since what was seen as a mutation phenomenon was actually the result latent variability 'coming out' (showing up). A phenomenon is typical for self-pollinated plant species.

The use of disintegrating backgrounds allowed to set possible mechanisms of micro evolutionary transformations of a population's variety structure. It turned out that under different growing conditions changes in the proportion of certain biotypes were found (Sozinov et al., 1985; Molchan, 1986, 1990). This means that a variety - as any balanced population - is an ecological and geographical notion (Sinskaya, 1948); an integral and dynamic system.

Variety study is very important for development of scientific bases of seed production. Without such studies we are permanently doomed to suffer losses in outstanding varieties - masterpieces of breeding work. And even today it is rather unclear whether a new variety that replaces an old one is superior to the latter in its initial worth, or that the superiority of a new variety is attributed to the deteriorating of qualities of an old variety during the seed production process (Sinskaya, 1963).

Conditions facilitating species' disintegration include:

1. Trials at various geographical and ecological locations in the same climatic zone.

In this context A. Gorsky (Gorsky, 1960) has conducted trials of many winter rye and wheat varieties in four geographical locations. Comparative analyses of varieties grown in two ecological nurseries located at a short distance from each other - in the foothill zone of the North-Western Caucasus (the Belaya River valley) and on the slope 300 meters higher, revealed the different phenotypic compositions of wheat and rye varieties.

B. Heyden (Heyden, 1995, 1997) presented trials with winter wheat (photo, Temirbekova). He showed that there were not any phenotypic differences in winter wheat variety 'Probus' during the 30 year period of its growing in Switzerland. But when this old Swiss variety was grown in Salem city and Bodensee city in Germany, interesting new biotypes had been singled out from the variety population. Thus, different soil conditions can be used as disintegrating backgrounds to study population composition.

Here results from Palamarchuk (1962) are of great interest. He studied the effect of different environmental factors on clover seed formation and plant vitality in hybrid populations. Heterosis was manifest only when hybrid seeds were sown in equal, or better growing conditions. When grown in peat bogs, the highest yield of hybrid clover was obtained from the seeds grown in the same peaty conditions.

When winter wheat variety ‘Diplomat’ was grown on Wiggenweiler, Rimpertsweiler and Lichtheg farms with different soil types, different phenotypic biotypes were obtained (Heyden, 1995; 1997).

2. Different dates of seeding

B.Heyden (1995; 1997) used different dates of seeding, deviating from the optimal date by two weeks or more, as disintegrating backgrounds for populations. He obtained interesting biotypes from varieties ‘Monopol’ and ‘Diplomat’ when deviations of the optimal sowing date were 2, 3, or 4, 5, 6 and 7 weeks.

**Exhibition in Dornach, 1998. New biotypes by Dr. B. Heyden**

R. Steiner (Steiner, 1924) in his agricultural course recommended later sowing dates to have better results in seed production of wheat. Late sowing of spring wheat resulted in the "burst" of variation in its population.

A. An effect of temperature factors on vernalization phase and disintegration of population into biotypes can be studied using a "stepped" approach to spring sowing -sowing begins from the emergence date every day, every other day, or every other two days.

V. Koryakina (Koryakina, 1961) studied the effect of variable temperature (day temperature was up to 20 C and night temperature was 0-1 C) on the young plants of red clover. This temperature regime enhanced and increased one time hay harvest and caused a number of morphologic changes of leaves and blossoms. Variable temperature resulted in enhanced development of clover and increased seed yield. It is no doubt that by using the same methods in trials one could distinguish different behavior of different groups of biotypes in variety populations;

B. Date of seeding in combination with presowing vernalization of different duration. E. Sinskaya and Vorobyeva (Sinskaya, Vorobyeva, 1964) revealed the effect of these factors in their experiments. They noted the exceptional richness of winter wheat variety populations in comparison with populations sown on the common date of winter seeding.

3. Effects of light regime on the variability of phenotypic composition of population.

The following variants were used (Sinskaya, 1964):

– a day length and a night length and "critical photoperiods"

– an effect of contrast photoperiods

– an effect of light quality

– light intensity

– an effect of a day length together with presowing vernalization and different temperatures.

It is essential to choose a disintegrating background in accordance with geographical origin of a variety (regional ecotype) and a certain trait under study.

<u>A.</u> This is an example of the combined effect of photoperiod and temperature factors. White acacia from Pamir region and Belorussia grown on a long day in St. Petersburg, Russia (10-13 hours) was damaged by frost by 100% (there was no selection for frost resistance, all plants died off), but when grown in Moscow it was damaged by 28%. Frost resistant forms have developed in the process of natural selection. Background in St. Petersburg with its 10-hours day length turned out to be the best disintegrating background. When populations of white acacia from Pamir region, Belorussia and Moscow were studied against this background with the aim to select the

most frost resistant biotypes, the number of frost damaged plants was 54%, 72% and 33% correspondingly. The most frost resistant biotypes survived in each population (Moshkov, 1940).

B. This is an example of the effect of different light quality on plants. For the southern varieties of peas and vetch the midday light was the most favorable, for the northern varieties - morning and evening light. The light regime of the previous year also had a certain effect on in generations and the composition of a population.

The alternation of contrast photoperiods in many cases has a great effect on phenotypic composition of populations and causes "bursts" of variability. An alternation of contrast photoperiods produces greater effect than alternation of two durable photoperiods. To achieve the maximum effect an alternation of contrast photoperiods must be used during the certain phase of organogenesis, in accordance with the phase of plant development. For example, different radiations (radiation genetics) cause hereditary changes in *Perilla* species. The effect of radiation also helps to reveal hidden variability in its populations. Probably it is better to treat plants at the phase when generative organs are set and formed, but not seeds.

A. Krjuchkov (Krjuchkov, 1962) performed a single selection of radish in a greenhouse using winter sowing date (Moscow region). He obtained forms of radish that could develop marketable roots when grown under conditions of limited light in combination with high air temperature. Selection process under conditions of winter sowing date resulted in development of radish forms adapted to conditions peculiar for that sowing date. He also managed to obtain radish forms that were resistant to early stem formation by selection of so called plus-forms in conditions of cold growing (frames of a hotbed were removed). Families of plus-forms differed from families of minus-forms (forms with larger tendency to early stem formation) in larger size of roots, less length and number of leaves.

Selection of radish plants in conditions of deep sowing enabled to obtain forms with round roots from the variety population. These forms almost didn't react to deep sowing. This new variety was free from biotypes that could change the shape of roots from round into oval, or elongated.

A. Krjuchkov's experiments devoted to growing radish against the background with dense planting versus normal rate of sowing are of great interest. Two-time selection process of radish under conditions of a very dense sowing resulted in radish forms that differed from an original variety ‘Saksa’ in early root formation, resistance to dense sowing, shape of leaves and root anatomy.

In China broad scale experiments with growing many crops under conditions of dense sowing and planting resulted in extremely high yields. Any deviations from the optimal rate of sowing can greatly affect selection process (Kryuchkov, 1962).

Influence of phytocenosis (the most complex background) on variability of population composition is not studied very well yet. Is phytocenosis always a leveling background that promotes "smoothing" and leveling of variability? In general, geneticists and plant breeders underestimate the significance of environmentally hidden variability and Possibility of its transformation into heredity category.

Tendencies in natural plant selection are determined by concrete environment. A plant breeder has to choose a proper background when he starts breeding. For example, growing conditions in the North are favorable for selection of late biotypes of timothy-grass of the Northern origin, but in the South - for early biotypes.

## Conclusions

Three main conclusions:

– First: a population of cultivated plants, per se including "identical" cultivars, has quite big reserves of variability that can be widely used in plant breeding to improve existing varieties and develop new ones.

– Second: efficiency of intra population selection can be greatly improved under conditions of maximum disclosure of an apparent, or a probable structure of latent reserves of the population variability Consequently, if we want to speed up a breeding process, it is necessary to develop and use disintegrating and provoking backgrounds and other methods for the population analysis and intra population selection.

– Third: with the help of the population analysis method any variety can be analyzed with the subsequent isolation and improvement of certain most promising elements.

This kind of work can accelerate and improve the efficiency of a breeding process.

These conclusions can be confirmed by the following example. Wheat varieties grown in the 60-70s in the former USSR were developed with the help of intra variety breeding method, i.e. on the basis of population variability reserves. ‘Bezostaya 1’, a renowned winter wheat variety is the result of an individual selection of ‘Bezostaya 4’ population (Luk'yanenko, 1969, 1973). Frost resistance variety ‘Albidun 114’ can serve a model of frost resistant variety; it was also selected in 'Albidum' 11 variety population.

Note that this approach is not efficient when a plant breeder works with pure lines.

On the other hand, it is rather important to know what can be achieved by repeated selection. The efficiency of selection of controlled by one, or a few genes is not high. Such pass quickly into homozygous state and can be revealed at early stages of breeding. Polygenic quantitative are quite different. Form-building process of such can go on for a long time. However, as E. Jablonka and M. Lamb (Jablonka, Lamb, 2005) point out, the number of properties based on few genes, is rather low; which makes the relevance of variety selection much bigger.

Most efficient inter variety selections have been carried out for quantitative Here I miss the point. For example, E.D. Nettevitch successfully used this method to develop baking qualities of spring wheat, 'Varenitsa' and 'Sandukhadze' (Temirbekova, 2014) used this method to improve the trait - 1000 grain weight in winter wheat.

Susceptibility of cereals to the enzyme-mycotic depletion in seeds (EMDS) is also a polygenic complex character. EMDS is a complex process resulting in yield decrease, deterioration of baking and sowing characteristics and seed infection with phyto-pathogenes (Temirbekova, 1994).

Results of our numerous studies of old and new winter wheat varieties have revealed that inter variety selection is promising and rather efficient for selection of ideotypes with higher EMDS resistance and other important economic characteristics. (Temirbekova, 1994, 2014).

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