Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2019, 9(1), 19-24

ORIGINAL ARTICLE

Enrichment of field crops biodiversity in conditions of climate changing

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Received: 26.12.2018. Accepted: 28.01.2019

Gradual introduction into the culture of new species requires introduction of appropriate technologies of their cultivation, with taking into account varietal characteristics, species adaptation to the conditions of cultivation, analysis of yield and quality formation characteristics, taking into account content of biologically valuable components, depending on technological factors and environmental factors. The dynamics of the weather changes in the Right-bank Forest-steppe of Ukraine during the period is analyzed 2004-2017. The analysis of weather conditions showed a tendency the air temperature increasing and decrease of rainfall amount during period of spring crops vegetation compare with the average annual data. Weather conditions had their own peculiarities, sometimes they were extreme, which adversely affected on growth, development and productivity of plants was noted a tendency of increasing amount of active and effective temperatures during the growing season, what necessitates expansion of field crops biodiversity, especially spring crops. Identified cultures: lentil (*Lens culinaris*), chick-pea (*Cicer arietinum*), chufa (*Camelina sativa*); triticale (Triticale); millet (*Panicum miliaceum*); sorghum (*Sorghum bicolor*); white mustard (*Sinapis alba*); brown mustard (*Brassica juncea*); coriander (*Coriandrum sativum*) that, due to biological and technological characteristics, are suitable for introduction into production. Installation of the elements of adaptive technologies for the cultivation of scarce field crops. Developed elements of adaptive cultivating technology for species, introducted into the field culture, contribute to reducing the influence of uncontrolled factors on productivity formation, the role of species increasing, sustainable development of formed agrocenoses, improving the quality of raw materials and food safety. Analysis of weather conditions and the correspondence of biological characteristics of rare cultures in Ukraine have allowed distinguish cultures that have high production efficiency.
Keywords: Less common crops; weather conditions; adaptive technology; yield

Introduction

Main subject of the research is: crops biodiversity enriching in artificially created human biocenoses, based on analysis of weather changes in the Right-bank Forest-steppe of Ukraine, and identification of crops that, by their biological and technological characteristics are suitable for introduction into production. The establishment of adaptive technologies elements for cultivation of rare field crops, which is a limiting in productivity formation. Products quality and directions of use (FAO, 2005).

Throughout the history of development, a human tries to adapt new species, to create varieties and hybrids, to develop technologies for their cultivation that are maximally adapted to cultivation conditions, adjust them to changing environmental conditions (Altieri, 2009; Lobell & Field, 2007; Lobell et al., 2006). But global changes in temperatures that continue to grow are also due to the environmental change-temperature rise, uneven precipitation, droughts, and so on (Daba et al., 2015; CNA, 2007; FAO, 2011; Fuhrer, 2003; French & Schultz, 1984; Mundial, 2012; Olesen & Bindi, 2002; Yeo, 1998). In this connection, the significant impact of various negative factors on yield and yield quality is predicted (Hatfield et al., 2011).

Before humanity there is a problem of rational use, preservation and enrichment of natural resources of the Earth (Beach et al., 2008); searching for crops that can be potentially adapted to conditions of cultivation and prevail over the known crops by ecological and biological properties (Sala et al., 2000); development of new sources of raw materials for the food industry, as well as useful components that can become a source of renewable energy sources, nutrition, medicines, crop production (Heller & Zavaleta, 2009; Lobell & Asner, 2003; Sendzikienė et al., 2012; Mundial, 2011). Ukraine has significant natural

resources of valuable plant species (Rakhmetov, 2017). The concept of crop production in Ukraine needs a radical revision, from the view point of providing population by biologically valuable food and raw materials for industry, and not only the gross production of individual export-attractive types of crop production (Rakhmetov et al., 2016).
Introduction to the culture of new species also requires introduction of adaptive cultivation technologies, with taking into account features of the species, variety, and hybrid, based on species adaptation to the conditions of cultivation, peculiarity of yield and quality formation (Rosenberg, 1992; Schwartz, 1992; Tilman et al., 2002). Industrial and valuable rare crops that are suitable for cultivation in Ukraine and have a significant prospect of distribution include: lentil (Lens culinaris), chickpea (Cicer arietinum) , chufa (Cyperus esculentus); millet (Panicum miliaceum); sorghum (Sorghum bicolor); white mustard (Sinapis alba); brown mustard (Brassica juncea); coriander (Coriandrum sativum), mid-oleic sunflower (Helianthus annus L.) (Makarevicienea et al., 2013; Shcherbakova, 2017).
One of the main factors that provides a human with a complete protein and stabilizes soil fertility are legumes, in symbiosis with root nodule bacteria, can absorb nitrogen from the air (Pilar & Hirsch, 2017; Tubiello, F., Soussana, J. & Howden, M. 2007). For leguminous crops of polyfunctional use, in addition to traditional soybeans and peas, belongs lentil and chickpea-legumes that ensure not only availability of valuable food raw materials but also play an important ecological role due to the symbiotic nitrogen fixation and accumulation of nitrogen in the soil (Taran et al., 2016).
Among the rare cultures, chufa (earth almond) Cyperus esculentus L. deserves special attention as an oilseed, starchy plant with high dietary and healing properties. Chufa is a tuber crop with a high content of carbohydrates, proteins, fats, trace elements, vitamins, enzymes, which causes its wide use not only as food raw material, but also as raw material for biofuel production (Makarevicienea et al., 2013).
In oilseed crops considerable attention deserves coriander, white and brown mustard-valuable ethereal-oil crops that are in high demand in the food, pharmaceutical, chemical industry and medicine (Mooney et al., 2009). In recent years, demand commodity for coriander seeds has grown significantly, which has become a product of export (Tilman et al., 2001).
Millet-valuable grain crops used for production of various food products, is a potential raw material for bioethanol production, solid fuels from by-products (Zaimenko et al., 2015).
The analysis of research year’s weather conditions was determined by coefficient of deviations materiality agrometeorological regime elements of the current year from the average perennial, calculated by the formula 1:

$$Kc = \frac{\left(Xi - \overline{X}\right)}{\sigma} \qquad (1)$$

where: Kc-coefficient of deviations severity,
Xi-elements of the current weather,
$\overline{X}$ -average multi-year indicator,
σ -mean square deviation.
The level of coefficient of deviations severity corresponds to the gradation: Kc = 0/1-conditions are close to ordinary, Kc =1 / 2-conditions significantly differ from the average perennials, Kc>2-conditions close to rare.

Materials and methods

Field research was carried out in the stationary crop rotation Plant Growing Department of the National University of Life and Environmental Sciences of Ukraine "Agronomic Research Station", v. Pshenychne, Vasylkivsky district of Kyiv region in the Right-bank Forest-Steppe of Ukraine, and the experiment with mid-oleic sunflower was also conducted in the Left-Bank Forest-Steppe and Steppe of Ukraine. In the zone of Forest-Steppe, experiments were laid on typical black soils, in the zone of Steppe on ordinary black soil.
In conducting field research with chikpea, lentil, coriander, chufa, linseed, white mustard and millet registration area was-25-35 m^2, total area-30-50 m^2, repetition of the experiment quadruple, with systematic placement of plots. Sunflower was sown by wide-row method with row spacing 70 cm; the registration area of the plot is 50 m^2, and the total area is 60-100 m^2.

Results and discussion

The analysis of weather conditions showed a tendency the air temperature increasing and decrease of rainfall amount during period of spring crops vegetation compare with the average annual data. Weather conditions had their own peculiarities, sometimes they were extreme, which adversely affected on growth, development and productivity of plants. Was noted a tendency of increasing amount of active and effective temperatures during the growing season, what necessitates expansion of field crops biodiversity, especially spring crops (Table 1).

Table 1. The coefficient of deviations severity (Kc) of precipitation and average monthly temperatures from the average perennial.

Parameter	**Year**	**Month**				
		IV	**V**	**VI**	**VII**	**VIII**
Temperature, °C	2004	0.01	- 1.01	-2.71	0.72	0.8
	2005	0.12	0.71	-3.32	2.02	1.5
	2006	0.52	0.09	0.42	0.05	0.61

	2007	0.34	1.31	1.32	1.24	2.23
	2008	0.32	0.7	0.43	0.05	1.11
	2009	0.42	-0.72	0.51	1.14	0.93
	2010	1.92	2.63	10.6	2.31	0.13
	2011	0.14	2.12	9.13	0.42	0.25
	2012	3.11	2.03	11	0.92	2.03
	2013	2.12	2.11	1.42	1.23	1.21
	2014	0.55	1.33	- 0.14	0.49	0.62
	2015	0.48	1.28	0.25	0.61	2.51
	2016	0.72	1.16	0.39	0.86	0.5
	2017	0.38	0.71	0.24	-0.62	1.31
Precipitation, mm	2004	-0.61	-0.32	-2.13	-1.14	-1.01
	2005	1.13	0.12	-0.71	-2.62	-0.95
	2006	-2.81	-4.01	5.32	-2.75	-4.93
	2007	-5.81	1.22	-1.03	-7.14	-1.41
	2008	1.03	-5.02	-4.61	-6.92	-4.43
	2009	- 4.66	- 2.85	- 1.72	0.44	- 1.73
	2010	- 0.42	-0.43	1.34	2.3	- 1.62
	2011	- 0.49	- 0.20	1.47	- 0.11	- 2.21
	2012	- 2.03	1.44	- 0.27	1.51	- 0.41
	2013	0.51	0.21	- 1.42	- 0.8	- 0.22
	2014	- 0.51	4.74	- 1.04	4.12	- 0.65
	2015	-1.11	- 0.89	- 3.31	- 0.48	- 2.01
	2016	0.51	2.23	- 0.89	- 0.67	- 0.65
	2017	-1.01	- 0.71	-1.42	-1.1	-0.7

Introduction to the culture of new species also requires introduction of adaptive cultivation technologies, with taking into account features of the species, variety, and hybrid, based on species adaptation to the conditions of cultivation, peculiarity of yield and quality formation. Industrial and valuable rare crops that are suitable for cultivation in Ukraine and have a significant prospect of distribution include: lentil (*Lens culinaris*), chickpea (*Cicer arietinum*), chufa (*Cyperus esculentus*); millet (*Panicum miliaceum*); sorghum (*Sorghum bicolor*); white mustard (*Sinapis alba*); brown mustard (*Brassica juncea*); coriander (*Coriandrum sativum*), linseed (*Linum usitatissimum L.*), mid-oleic sunflower (*Helianthus annus L.*). During 2008-2017 we conducted a series of experiments to achieve the goal (Table 2).
Lentil (*Lens culinaris* Medik)-Lentil (*Lens culinaris* Medik) is a leguminous crop, which by protein content inferior to soybean and fodder beans, it plants fix nitrogen, which is important in the context of ecological production and energy shortages. In field experiments, we explored that efficiency of lentil production depends on a number of factors, whose share in yield formation is: weather-31.7%; fertilizer-24.1%; seed inoculation-18.3%; variety-15.6%. The yield of lentil significantly depends on length of the growing season, which depends on the sum of effective temperatures and precipitation: 2008 year-92-109; 2009 year-105-123; 2010 year-94-111 days. Fertilizers and seed inoculation cause to extending vegetation for 2-6 days. The yield of varieties Linza and Krasnograds'ka 39, growed on background N30P60K60 was 2.19 and 2.01 t ha; Luganchanka and Svetlytsya-1.89 and 1.76 with yields in control 1.32; 1.27; 1.14 and 1.11 t ha respectively. With pre-sowing seed inoculation yields increase by 3.1-10.7% depending on fertilizer doses. Lentil actively fixes nitrogen-the mass of active noodels on the plants roots of varieties in the flowering phase is: Linza-67.2; Luganchanka-64.4; Svetlytsya-39.3; Krasnograds'ka 39-36.1 mg/plant for growing on background $N_{30}P_{60}K_{60}$. The active symbiotic potential increases proportionally to the mass of active noodels.

Table 2. Efficiency of cultivation of the less common types of field crops.

Crop		**Years of fild research**	**Yield range, t ha**	**Content protein, %**	**Content oil, %**
Lentil	*Lens culinaris* Medik	2008-2010 2016-2017	1.24-3.11	23.8-31.1	1.33-1.95
Chickpeas	*Cicer arietinum* L.	2010- 2017	1.97-4.50	22.2-28.9	4.05--5.12
Chufa sadge	*Cyperus esculentus L*	2005-2011 2015-2017	4.82-7.64	n/d	24.4-27.4
Coriander	*Coriandrum sativum*	2013-2017	0.92-2.37	n/d	17.2-25.7
Sunflower	*Helianthus annus* L.	2014-2017 S[1]	1.16-3.07	14.1-18.2	32.8-43.1

high-oleic		2016-2018 F[2]	2.10 -3.68		
Oil flax	*Linum usitatissimum* L.	2010-2013 2016-2017	1.59 -2.88	22.1-24.2	42.1-49.2
Millet	*Panicum miliaceum* L.	2014-2017	1.91-4.27	10.2-14.1	3.3-3.9
Indian mustard	*Brassica juncea* L.	2005- 2011 2015-2017	1.68-2.70	22.2- 29.4	32.5- 37.5

S-zone of the steppe; F-forest-stepp zone; 3 n/d-not determined.

Introduction of chickpea modern varieties Pam'yat', Triumph, Budjak, Odisey, optimization of nutrition system, pre-planting seed treatment, and system of protection allows to obtain competitive growth of culture in the Right-Bank Forest-Steppe with a yield from1.97 to 4.50 t ha; content of protein in the seeds-22.2- 28.9% and 4.35-5.12% of fat. Considerable attention in research was paid to the development of an optimal system of varieties nutrition. Variety Odisey was the most productive-formed 4.0-4.5 t ha of grain with main fertilizing $P_{60}K_{60}$ and extra feeding N30 kg/ha a.s., with seed inoculation.

The aim of research with chufa Cyperus esculentus L was to establish optimal fertilizing doses in accordance with biological characteristics of chufa variety Novinka. The scheme of experiment provided the following doses of fertilizing: $P_{140}K_{220}$ (control); $N_{140}P_{140}K_{220}$; $N_{180}P_{140}K_{220}$; $N_{220}P_{140}K_{220}$; $N_{260}P_{140}K_{220}$. Phosphorus and potassium fertilizers are introduced under the basic tillage, nitrogen-fractionally: ¾ under the main soil cultivation, ¼ under pre-sowing cultivation. The regulation of mineral nutrition causes an increase in productivity: on background $P_{140}K_{220}$-2.11; $N_{140}P_{140}K_{220}$-5.24; $N_{220}P_{140}K_{220}$-6.65; $N_{260}P_{140}K_{220}$-6.79 t ha. It was established, that chufa oil is similar to the olive by composition of fatty acids.

The limiting factor for growing white mustard Smuglyanka is time of sowing and seeding rates. Field experiment is multifactorial: factor A-time of sowing: first-with soil temperature at a depth 10 cm 4-5 °C (III decade of March-the first decade of April) (control); second-with soil temperature-6-7 °C (I-II decade of April), third (III)-with soil temperature-8-9 °C (II-III decade of April); factor B-sowing rates: 1.5; 2.0; 2.5 (control) million similar seeds per 1 hectare.

On average over the years, the most productive sowings of white mustard were with second time of sowing and sowing rate 2.0 million pieces/ha-2.70 tons/ha. With sowing rate lowering as well with it increase, the yield was decreased. In first and third sowing periods was yield decreasing compare to the second period, but regularities of it dependence from sowing rates was remained. The lowest yield -1.68 t ha was obtained with sowing rate 1.5 million similar seed/ha and third sowing period, during which the high average daily temperatures during period of flowering-seeds formation and lack of moisture negatively effect on white mustard yield.

Coriander (*Coriandrum sativum*) Coriander coriander (*Coriandrum sativum*) is grown to produce seeds and vegetative mass. Traditionally, coriander grown in the Mediterranean countries, and its cultivation and processing in Ukraine is at the level of introduction for cultivation in the southern regions. In Ukraine and in the world practice, the modern development of food, cosmetic and medical industries depends to large extent on the availability of essential oils raw materials, which is only satisfied with 30% now. The yield of coriander is 0.92-2.37 t ha. The highest yield of coriander varieties Oksanit and Nectar is formed with sowing rate 2.5 million pcs./ha on background $N_{90}P_{40}K_{80}$ and $N_{135}P_{60}K_{120}$-1.96-2.37 t ha. The highest yield of variety Caribe was formed by sowing 3.0 million seeds/ha on background $N_{135}P_{60}K_{120}$-2.06 t ha. The share of the 'Fertilizer' factor in the coriander seed production is 12.0%; 'Sowing rate'-56.0%; 'Variety'-5.1% and 'Weather conditions'-18.8%. The average yield of coriander for growing without fertilizer was 1.47 t ha, and with variable sowing rates-from 1.5 to 3.0 million seed per hectare, the yield increase was 0.19-0.41 t ha.

The application of N90P40K80 and $N_{135}P_{60}K_{120}$ provides an increase in the essential oils collection-22.1-26.7 kg/ha and content of essential oil in the seeds to 1.89-2.29%, which exceeds control by 1.3-3.5 kg /ha and 0.07-0.15%. Collection of fatty oils per 1 hectare with cultivation on background of various fertilizer standards changes at the range 311.3-338.9 kg/ha, 292.6-319.4 and 278.2-303.9 kg/ha, for varieties Oksanit, Nectar and Caribe respectively.

For linseed cultivating, there are many factors that limit yields-row spacing, sowing rates. In order to establish reaction of varieties to these factors, during the 2016-2018 years, we conducting research in a field multivariate experiment: factor A-varieties: Iceberg, Liryna; factor B-sowing rates-4, 6, 8 and 10 million similar seed per hectare; factor C-the width between rows-12.5, 25 and 37.5 cm. We have established a varietal reaction to the study factors. In variety Liryna yield increased with densify: with width between rows 12.5 cm from 1.20 t ha for rate 4 million /ha to 1.94 t ha for rate 10 million/ha. At width between rows changing this variety reacted poorly. Variety Iceberg, by contrast, has shown a good reaction to increasing spacing between rows and yields reducing with sowings densify. So the highest yields of this variety were with wide 37.5 cm:1.60 t ha for sowing rate 4 million seeds per hectare; 1.54 t ha for 6 million /ha; 1.51 t ha for 8 million /ha and 10 million/ha on average for 2016-2017.

In the contrasting conditions of the southern Steppe and the northern part of the Left- Bank Forest-Steppe of Ukraine, studies were carried out on the identification of hybrids of mid-oleic sunflower (*Helianthus annus* L.) of various regional selections for establishment of stable and plastic hybrids for conditions of insufficient and unstable moisture provision. Hybrids differed considerably from one another in response to a lack or excess of moisture, low or high temperatures, a predisposition to disease and other factors. During 2014-2017, 29 hybrids of sunflower were explored under the same conditions, with an assessment of their yield, stability and plasticity of hybrids. The presented samples included hybrids of both domestic and foreign selection and one of the main objectives of the study was to establish a level of adaptability. The range of variations in yields, in terms of hybrids and years of research, was 0.81-3.07 t ha, and on average, in terms of hybrids, 1.55-2.45 t ha. The highest yields on average in the years of research have formed hybrids: PR64F66-2.45; EC Bella-2,35 t ha; another 11 hybrids formed yields above 2.00 t ha, but below the indicated hybrids; 15 hybrids formed yields in the range from1.50 to 1.99 t ha, and one hybrid formed yield below 1.50 t ha. The lowest productivity, as the average for years of research and in absolute yields, was formed by hybrids; Forward-1.15 t ha, with a range of changes from 0.81 to 1.46 t ha; Yason 1.55 t ha, with a range of changes from 1.36 to 1.80 t ha.

In Ukraine, currently, the low prevalence of groats crops, and in particular millet (*Panicum miliaceum*) with hight demand for a quality grain. During 2014-2017, field studies have been carried out on the technological features of growing three millet varieties for organic production. The duration of millet vegetation in conditions of the Right Bank Forest-Steppe of Ukraine is 90-106 days and is determined by variety, system of protection against weeds, weather conditions and plant nutrition. This length of vegetation allows grow millet in all zones of Ukraine. With extra-feeding vegetative plants by Gumisol Plus, vegetation is lengthened for 3-6 days, which contributes to the bigger formation of generative organs. productivity of millet varieties with row spacings mulching increases by 39.5-44.2%; mulching by worked-out mycelium -17.0-19.1%; mulching by sawdust-13.7-16.1% and 21.7-24.1% for mechanical protection, compare with technology without protection from weeds-2.14-2.51 tons/ha. in millet cultivation with row spacings mulching by film and seed treatment by preparation Hetomik, yield of grain on average is 3.38 t ha; 3.34 and 3.45 t ha, and for chemical protection system-3.51 t ha; 3.54 and 3.63 tons per hectare, respectively, for varieties Zapovitne, Myronivske 51 and Omriyane. With using Gumisol Plus, the yield increase is 0.12-1.03 t ha or 4.2-40.2%, depending on variety and combination of preparation application, and reach 4.01 t ha for its combined use. According to technologies of millet organic grain production, the share of factor ‘protection system from weeds’ in the yield formation is the determining-54.2%. Yields of millet varieties on 22.4% are determined by factor ‘weather conditions’; 10.1%-by factor seed ‘treatment’; 7%-by factor ‘variety’. Millet grain quality is determined by genetic characteristics of variety with a slight change depending on cultivation technology. Protein content in the grain of variety Zapovitne is 8.7-10.5%; Myronivske 51-9.4-11.2; Omriyane-11.0-12.5%, depending on protection system, pre-sowing seed treatment, nutrition; starch content- 53.4-55.3%; 50.2-53.2 and 47.1-49.8% respectively to the variety; fat content-3.4-3.9%; cellulose-6.0-6.7%. The graininess is an important technological feature: 14.6-15.4% in variety Zapovitne; 16.5-17.6-Myronivske 51; 13.6-14.7%-Omriyane. Weed protection systems had an integrated impact on the grain quality class, which resulted to development of a non-herbicide cultivation technology for the food grain production.

Conclusions

Analysis of weather conditions and the correspondence of biological characteristics of rare cultures in Ukraine have allowed distinguish cultures that have high production efficiency. Developed elements of adaptive cultivating technology for species, introducted into the field culture, contribute to reducing the influence of uncontrolled factors on productivity formation, the role of species increasing, sustainable development of formed agrocenoses, improving the quality of raw materials and food safety.

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Citation: Kalenska, S., Yeremenko, O., Novictska, N., Yunyk, A., Honchar, L., Cherniy, V., Stolayrchuk, T., Kalenskyi, V., Scherbakova, O., Rigenko, A. (2019). Enrichment of field crops biodiversity in conditions of climate changing. Ukrainian Journal of Ecology, 9(1), 19-24.