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AGROCHEMICAL RECEPTIONS OF ACCLIMATIZATION OF CROPS TO EXTREME WEATHER-CLIMATIC CONDITIONS

The purpose. To determine and research efficiency of agrochemical receptions of acclimatization of plants to extreme weather-climatic fluctuations in conditions of Left-bank Forest-Steppe. **Methods.** Researches were carried out by long stationary and field experiments. **Results.** Agrochemical receptions aimed at decrease of vulnerability of the system soil–plant to extreme weather environment during vegetation are offered. **Conclusions.** The high performance of targeted control over plant nutrition by development of integrated system of fertilizing crops is proved.

Key words: acclimatization of crops, extreme weather-climatic conditions, plant nutrition, application of fertilizers.

Introduction. One of the greatest challenges faced by the world community is the climate change which related to greenhouse gas concentrations in the atmosphere and desertification [13, 20]. Due to the expected increase of air temperature of Northern hemisphere food security of Ukraine and other countries will largely depend on how effectively adapting agriculture to agro-climatic conditions for growing crops in the nearest future. This is the reason of forming a strategy of agriculture adaptation, because hydrothermal conditions during the growing season directly determine the quantity and quality of agricultural products and, consequently, the current situation on the food market.

Nowadays in the European Union (EU) has developed a wide range of adaptive measures: technological, political, experimental sciences, etc. [11-12, 18]. Among acting EU projects with government support, are: «Policy Incentives for Climate Change Mitigation Agricultural Techniques», «Adaptation and Mitigation Strategies: supporting European climate policy» (ADAM), «Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis»

(PESETA). Within the framework of the projects developed the recommendations of regional measures adaptation, methodology for assessing potential economic consequences of climate change, created forecast map of the changes yield, etc. [13]. Main directions of adaptation of agriculture to extreme changes in weather conditions are mainly aimed at reducing greenhouse gas emissions, selection of rotation to achieve the most efficient use of available moisture, changing the sowing time, selection of crop varieties [10]. National Strategies for adaptation of agriculture to climate change are prepared or under development in Finland, Spain, France, Britain and other EU countries [13].

As known, climate fluctuations have a positive side, in particular, the increase of CO_2 in the air accelerated processes of plants photosynthesis which positively affect to the production of biomass and efficiency of water use by plants [1]. The experimental research of R. Norton et al [4], the increase in wheat harvest by increasing the concentration of CO_2 in the air from 385 ppm to 550 ppm is about 0.5-0.9 t/ha as in the dry and in a normal year for moisture. However, other results of scientific modeling predict that in field conditions such changes will be quite low [14, 17]. As a rule, extreme weather phenomena make only negative impact on agricultural production [13, 15]. Loss of crop yield from adverse weather conditions in certain years can reach for 45-50%, and the combination of several extreme events (such as in 2003, 2007-2009 - freezing, the loss from ice cover, drought) - 70% or more. Counteract such anomalies not easy, but possibly one of the most realistic ways is agrochemical measures that allow you to control the growth of plants, their nutrition and water supply through such instruments as the spatial location of fertilizers, their form, frequency and method of fertilizing, the combination of growth stimulants and micronutrients. In this context, the main purpose of the work was to determine and research the efficacy of agrochemical measures of plant adaptation to extreme weather and climatic fluctuations in the conditions of left-bank forest-steppe Ukraine, where due to increased continental climate effects of spring-summer droughts are the most noticeable.

Materials and methods of research. Studies were conducted by the Agrochemistry Department NSC "ISSAR" in the conditions of long term and temporary field experiments. Long field experiment is located in the ISSAR Experimental Field "Grakivske" (in Kharkiv region). This experiment was founded in 1969 in chernozem typical with the following characteristics: pH_{KCl} – 5,3, humus content – 5,4%, mobile phosphorus and potassium by Chirikov - 57 mg/kg and 114 mg/kg, respectively. Various agrochemical backgrounds were created through the use of fertilizers in reserve (aftereffect from 1983) and systematically.

Temporary field experiments were carried out on chernozem typical heavy loam (Kharkiv, Chuguev and Balakleyskiy districts in the Kharkiv region), on chernozem podzolic heavy loam (Kharkiv district Kharkiv region) and medium loam (Lokhvitskii district, Poltava region).

Results. Summarized data the network geographical experiments showed that the effectiveness of fertilizers is closely dependent on weather and climate conditions, the decreases in dry years at 25-30% compared with an increase under favorable weather conditions and closely depends on the cultivated soil [5]. On the other hand, purposeful management of the plant nutrition is one of the most effective and at the same time flexible strengthening methods of plant adaptation to adverse weather conditions, promoting the rational use of water in the growing season. Productivity of water consumption in a shortage moisture of increases under the influence of fertilizers in 2-2,4 times, while for optimal humidification mode - only 1,4-1,6 times [2]. The general pattern is that while fertilizers contribute to an increase total spending soil moisture through transpiration due to the formation of a larger crop, but per unit production the moisture spending decreased.

Optimization of plant nutrition increases the osmotic pressure of the cell sap and the degree of hydration of colloids, increases the amount of colloid-bound water in the leaves and intensity of assimilation flexible substances [3, 16]. The effect of increasing the resistance of agricultural crops to adverse conditions of moisture content is also determined by structural changes organoids cells and dysfunction of water absorption in conditions of phosphate starvation and vice versa the higher their activity by sufficient ensuring plant phosphorus. The accumulated in soil residual phosphates from fertilizers by its properties different from natural forms inherent in this soil: they are more active, remain in more available for plant compounds and thus may be the hallmark of his cultivated [6].

Our results indicate that in chernozem with a high content of residual phosphates significantly improved conditions of water consumption from soil to create yield (table 1).

1. Effect of fertilizers on crop yield and water consumption by crops in chernozem typical with different levels of phosphorus supply

The content of available phosphorus, mg P_2O_5 per 100 g soil	Variants of experiment	The yield, t/ha	Stocks of productive moisture in soil layer of 160 cm, m^3/ha		Using water, m^3		
			the beginning of the growing season	the harvest yeild	through transpiration	per 1 kg main products	per 1 ton of dry matter
Corn for silage							
4-5	Control	34,0	1050	550	2280	0,67	2,87
	NPK	34,4	1000	460	2330	0,52	2,24
14-16	Control	36,9	1140	510	2410	0,65	2,32
	NPK	41,2	890	460	2200	0,53	2,29
Sugar Beets							
4-5	Control	21,4	1040	210	3160	1,48	3,88
	NPK	38,9	1250	130	3750	0,96	3,07
14-16	Control	33,4	980	180	3130	0,94	2,91
	NPK	40,9	1300	130	3510	0,89	2,66
Note. Rainfall during the growing season corn - 1780 m^3/ha; sugar beet - 2340 m^3/ha							

The use of water for 1 ton of dry matter for growing corn for silage and sugar beet reduced for 20-25% on the soil which content a lot of phosphorus compared to the low supply of soil phosphorus. During fertilization, the difference is greatly reduced, but still significant.

Results research on agrochemical backgrounds with different content of mobile forms of potassium (table 2) demonstrate that the yield of sugar beet depends on the content of potassium in the soil, which is applied with fertilizers and weather conditions (rainfall per year and growing season). In dry years, when rainfall during the growing season average for three years did not exceed 215 mm, sugar beet harvest increased significantly with increasing the reserve in the soil potassium of fertilizer: on the control - from 22,3 t/ha with a little potassium content to 26,9 t/ha with a high potassium content, in a variant $N_{180}P_{180}$ - from 33,3 t/ha to 35,7 t/ha, respectively. Additionally applied (on the background N180P180) potassium fertilizers in doses of K90 and K180 provide the maximum crop growth (respectively 34 and 26 kg/ha) on natural background with low potassium content in the soil. In agrochemical backgrounds with high potassium content in soil and high application of potassium fertilizer does not provide crop growth [7].

2. Effect of fertilizers on the sugar beet yield in chernozem typical with different content of mobile potassium depending on soil moisture conditions

Rainfall, mm *		Variants of experiment	Yields of sugar beet by various mobile potassium content in the soil, t/ha							
for April-August	in a year		85-87 mg/kg		92-96 mg/kg		96-117 mg/kg		107-139 mg/kg	
			1	2	1	2	1	2	1	2
215 (167-243)	517 (340-727)	Control	22,3	-	21,4	-	24,6	-	26,9	-
		$N_{180}P_{180}$	33,3	-	33,0	-	34,8	-	35,7	-
		$N_{180}P_{180} + K_{90}$	36,7	3,4	33,9	0,9	37,3	2,5	36,0	0,3
		$N_{180}P_{180} + K_{180}$	35,9	2,6	35,4	2,4	34,9	0,1	36,1	0,4
350 (313-389)	657 (564-711)	Control	33,4	-	31,6	-	34,5	-	34,2	-
		$N_{180}P_{180}$	40,1	-	42,4	-	43,5	-	44,1	-
		$N_{180}P_{180} + K_{90}$	38,9	-	39,5	-1,9	44,0	0,5	44,8	0,7
		$N_{180}P_{180} + K_{180}$	42,2	2,1	44,0	1,6	43,7	0,2	43,5	-0,6

Note: * The average data for three years, in brackets - the limits fluctuations;
Count 1 - sugar beet crop, quintal per ha;
Count 2 - growth the harvest from potassium fertilizers to background $N_{180}P_{180}$.

In the years with heightened and high amount rainfall (average number for the April-August 350 mm) the sugar beets much weaker responsive to changes potash background of chernozem typical: without fertilizer only on heightened and high background is observed a slight increase in yield compared with low potassium content in the soil. More significantly and logically (almost proportionally) increase yield on variant $N_{180}P_{180}$ with increasing residual reserves of potassium in the row from natural to high agrochemical background.

In periods of long and hard spring-summer drought sharply reduced fertilizing efficiency, and the reaction of plants may even be negative, because any fertilizer increased concentration of salts in the soil solution. That is why this fertilizer should be applied in advance, as the nourishment because to correct deficiencies in stressful conditions very difficult. In the conditions low humidification in spring the effectiveness of nitrogen fertilization of winter wheat largely depends on the agrochemical background. In particular, at the beginning of the growing season in 2015, reserves of productive moisture in 100 cm soil layer were assessed as insufficient, at the end of the growing season - very low (table 3). Spring fertilizing by ammonium nitrate on the agrochemical background without fertilizers had the lowest effect, the increase in yield was only 6,4% of the control. In contrast, the agrochemical background with application a high dose of phosphate fertilizers in stock increased crop, it is reached 64,3%.

3. Efficiency spring nitrogen fertilizing of winter wheat in different agrochemical backgrounds under adverse conditions moisture software

Variants of experiment		The reserves of productive moisture in 100 cm soil layer, mm		The reserves of mineral nitrogen in 100 cm soil layer, kg/ha		Winter wheat yield, t/ha
agrochemical background	nitrogen fertilizing, kg/ha	the beginning of the growing season	the end of the growing season	the beginning of the growing season	the end of the growing season	
Control (without fertilizers)	0	102	23	115	32	2,80
	60	-	14	-	76	2,98
P_{1800}	0	94	49	200	49	3,51
	60	-	5	-	73	4,60
$N_{1800}P_{1800}K_{1800}$	0	116	33	167	34	3,50
	60	-	15	-	63	3,72

One of agrochemical ways to increase crop resistance to drought is purposeful differentiation topsoil for the nutrient. During the local fertilization and the formation of a dense network of roots in the area of their placement the created conditions, allowing use even unproductive precipitation and increase supply the nutrients. As shown V.K. Trapeznikov with colleagues [8], in conditions of soil drought and weak development or even absence of secondary roots can perform their function highly-saline roots that intensively formed in the area of localization. According to A.I. Fateev, localization of fertilizers gives effect to all zonal soils of left-bank forest-steppe - in chernozem typical, podzolic and dark gray podzolized soils, and is best suited to - the cultures with the fibrous root system [9]. Long-term studies indicate that the total loss of soil moisture at creating per unit yield of winter wheat grain during a fertilization in row reduced by 15%, barley - 30% and millet - by 24%, and the yield of grain increased by 0,4-0,5 t / ha.

Alongside with this, the spatial distribution the row of fertilizer a single solution cannot be. Too shallow making fertilizer stimulates shallow of placing root system plants that will have negative consequences in the case of dry conditions, especially in the first half of the growing season. As an example, we can cite the situation with spring fertilizing of winter wheat when the duration and spatial distribution of nitrogen can be controlled only by its form (nitrate, ammonium or amide). Nitrate nitrogen in the soil moves well and more or less evenly is distributed in the root layer. In contrast, much of ammonium ion is absorbed by soil absorbing complex in five centimeter area of the granule fertilizers and enriched of nitrogen topsoil which is often dries up faster than in the spring. In this regard, for the late timing of fertilizing should use fertilizers that have some kind of nitrate form of nitrogen. According to earlier fertilizing the effectiveness of different forms of nitrogen fertilizer is aligned (table 4).

4. Effect of pretornal fertilizing by various forms nitrogen fertilizer on the yield of winter wheat on chernozem typical in conditions of Kharkiv region

Timing of fertilizing	Forms and doses of nitrogen for fertilizing	The yield, t/ha	The growth of yield, kg/ha
1 decade of March	Control (without fertilizer)	4,91	-
	Fertilizing by ammonium nitrate N_{60}	5,54	0,63
	Fertilizing by ammonium sulfate N_{60}	5,68	0,77
3 decade of March	Control (without fertilizer)	4,08	–
	Fertilizing by ammonium nitrate N_{60}	6,10	2,02
	Fertilizing by ammonium sulfate N_{60}	5,64	1,56

In turn, the deep location of ribbons also has its advantages and disadvantages. This is well illustrated by the research results of comparative effectiveness ammonium nitrate and liquid anhydrous ammonia on the chernozem podzolic on the experimental field of "Rise Maksymko" (Lokhvitskiy district, Poltava region.), which were carried out together with S.V. Galushka and A.V. Revtye [19] (table 5). The larger growth the harvest from application of anhydrous ammonia, which was observed in 2012-2013 (with 86-97 mm of rain in April-June), primarily due to the effective use of nitrogen fertilizers from localization zone at a depth of 18 cm, which stimulates increased proliferation (branching) roots plants and, consequently, increases the rate of absorption of fertilizers. Fertilizer, applied in ribbons to a depth that is three times lower than the depth of the seed placement, roots culture "intercepts" faster, because it contains moisture that persists longer than in the surface layer of soil. In conditions with a very favorable soil moisture during the growing season in 2014 (193 mm of rain in April-June) a deep nitrogen application, conversely, reduced the payback fertilization.

5. The yield of crop in rotation link during the use of different forms of nitrogen fertilizers in a dose of N100 on the chernozem podzolic medium loam

Forms of nitrogen fertilizers	Yields of crops in rotation link t/ha					
	Maize (2012)		Winter wheat (2013)		Sunflower (2014)	
	crop yield	growth yield	crop yield	growth yield	crop yield	growth yield
Anhydrous ammonia	4,9-8,4	not defined	5,3	0,9	3,8	0,5
Ammonium nitrate	4,6-5,2	not defined	4,9	0,5	4,6	1,3

The results of observations by efficiency foliar fertilizing spring barley - a culture that in a short growing season requires an early formation of agrochemical background confirm the hypothesis of differential reactions the different types of fertilizers on weather conditions. Accurate diagnosis of deficiency of any macro or microelements for normal growth and development of plants during periods of extreme weather conditions and the correction and optimization of mineral fertilizers may increase the adaptive capacity of “soil-plant” system. In connection with this adjustment nutrition in tillering stage and phase of exit in the tube was carried purposefully by identifying plants in need of macro and microelements by the method of functional diagnostics (table 6).

However, very dry weather conditions during growing season in 2012 (63 mm of rain in April-July) were so stressful for plants, that on not fertilized plants background did not respond to foliar fertilizing neither growth yield, nor grain quality, nor intensity of photosynthesis.

In contrast to this, under conditions of very good moisture ensuring in 2014 (272 mm of rain in April-July) growth yield from foliar fertilizing by complex macro- and micronutrients is ranged from 0,35 t / ha to 0,80 t/ha.

6. Influence of foliar fertilizing based on functional diagnostics on yields of grain of spring barley on chernozem podzolic hard loam

Variants of experiment	Yield of grains barley, t/ha		
	not fertilized background	on the background $N_{30}P_{30}K_{30}$	on the background $N_{60}P_{60}K_{60}$
2012			
Without fertilization	3,00	3,10	3,30
Fertilizing in the tillering stage	2,90	3,10	3,30
Fertilizing in the tillering stage and in the phase of exit in the tube	2,90	3,00	3,20
2014			
Without fertilization	2,00	3,45	4,05
Fertilizing in the tillering stage	2,60	3,55	4,35
Fertilizing in the tillering stage and in the phase of exit in the tube	2,80	3,70	4,40

Comparison of different agro-chemical measures of control nutrition of malting barley on chernozem typical hard loam showed that favorable for moisture ensuring years (in the study area they were in 2008, 2011 and 2014) not only mineral fertilizers but also other kinds of fertilizers (bacterial, micronutrients) provide high growth yield, and integrated fertilizer system provides nearly 60% growth yield. In particular, under these conditions the efficiency of complex biological product mikrohumin approaching to the impact of mineral fertilizers (table 7).

7. Comparative effectiveness of the various components of the integrated system of fertilization of spring barley in years with different moisture ensuring for the period of 2008-2014

Variants of experiment	Yields of spring barley in years with different amount of precipitation in April-June, t/ha	
	droughty (68-102 mm)	favorable (195-265 mm)
Control, without fertilizer	1,29	2,76
$N_{18}P_{60}K_{60}$	1,79	3,66
NPK, 2 foliar fertilizing	1,50	3,34
Seed processing by biological preparations	1,47	3,51
Humate, 2 foliar fertilizing	1,55	(incomplete data)
Integrated fertilization ($N_{18}P_{60}K_{60}$ + biological preparations +micronutrients + humates)	2,09	4,39
HIP_{095}	0,62	

In contrast to this, in drought years (2009-2010 and 2012) growth yields from microbial preparation was an average of 0.18 t/ha, which is much lower than the statistically significant level. Was also a great effect from foliar fertilizing; the increase in yield was obtained mainly on the mineral fertilizers background, and on not fertilized soil, sometimes (like in 2010) was observed even lower yields.

Thus, investigations show that agrochemical measures are an important factor in strengthening of plant adaptation to adverse weather conditions during the period of growing season. Through the creation of a high phosphorus-potassium background, the choice of optimal forms of fertilizers and the method of their application, the combination with other types of fertilizers and growth stimulants we can significantly improve the stability of the yields of major crops at different hydrothermal conditions of years.

Conclusions.

On chernozem of the Left Bank Forest Steppe Ukraine creating high background of residual phosphate significantly improves soil moisture use for the creation products and the efficiency of nitrogen fertilizers. In return, the efficiency of nitrogen-phosphorus fertilizer depends on the increase in reserves of residual potassium in the soil, which is particularly manifested in the dry years.

Effective agrochemical methods of strengthening the plant adaptation to adverse weather conditions is the regulation of plant nutrition by choosing forms of nitrogen in accordance with the terms of fertilization and conditions of moisture ensuring, spatial distribution of tapes fertilizers.

The effectiveness of foliar fertilization of spring barley sharply reduced during periods of long and hard spring-summer droughts. The use of an integrated system of fertilization helps to stabilize yields, and in years with favorable conditions provides the highest growth yield.

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