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Influxence of agroecological and factors upon formation of productivity of winter wheat in South-East Steppe technological

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The purpose. To determine influence of ingredients of abiotic environment, deposits and temperatures of air upon formation of conditions of humidification of predecessors of winter wheat, sizes of total evapotranspiration and productivity of basic cereal crop on various soil fertilities. **Methods.** Field experiment, descriptive-generalized, calculation and statistical analysis. **Results.** Ranges of moisture provision of predecessors of winter wheat (bare fallow and corn for silage) are determined, and features of differentiation of conditions of humidification during vegetation of basic cereal crop are specified. **Conclusions.** Significance and influence of agroecological and technological factors upon moisture accumulation ability of predecessors, sizes of total evapotranspiration and productivity of winter wheat on different soil fertilities of mineral fertilizers are proved.

Key words: *winter wheat, predecessors, productivity, climatic changes, moisture provision , pay-back of fertilizers.*

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Winter wheat is the main grain crop in the steppe zone, and in particular in its southeastern region, where it has a leading place in terms of yield and gross collections of food grain. The noted soil and ecological region is characterized by a certain climatic moistening resource, which is conditioned by both geographic-latitudinal changes and weather-climatic warming, whose activation intensified with the beginning of this century [1–3].

One of the decisive factors for obtaining high yields of winter wheat is the level of moisture content of precursors by soil moisture as the time of sowing to obtain timely plant stacks, and for their further growth and development during the autumn period, which guarantees successful winter crops, high efficiency of mineral fertilizers and remedies plants and the formation of high-yield agrocenoses [4–7].

In modern technologies of growing of field crops priority is given, first of all, to the use of fertilizers, which in agrophytocenosis determine and correct the production processes of plants. The effectiveness of doses and timing of nitrogen fertilizer application under winter grain crops is determined by many factors: varietal response to weather conditions, plant development, the presence of easily digestible forms of nutrients in the soil, as well as the programmable yield [8–10].

The purpose of the research – to determine the influence of abiotic factors on the peculiarities of soil moisture formation of the predecessors of winter - black steam and corn on silage and the size of the total water consumption of crops when forming the crop of this crop on different agrofones of mineral fertilizers.

Materials and methods of research. Field experiments were conducted at Rozovka experimental station the SI Institute of grain crops of NAAS for fourteen years, represented by two seven-year plans: 2001/02–2007/08 v.y. – IS (first seventh year) and 2008/09–2014/15 v.y. – IIS (second seventh year). Soil cover of experimental areas – black earth, ordinary medium-humus with a content of humus of 3,5–3,9%, mobile forms of phosphorus – 11,2–13,7 mg, exchangeable potassium – 9,0–12,5 mg per 100 g of absolute dry the soil (according to Chirikov). Ecological-agro-chemical estimation of soil is 65 points, resourcefulness is 2,3 t/ha of grain units. Two predecessors of winter wheat: black pairs were studied, after which almost every year favorable conditions were created for sufficient soil moisture and the most complete implementation of the potential of plant productivity, and corn for silage, after which the soil moisture content in most cases was determined by the amount of precipitation, as at the time of wintering of wintering, as well as in the autumn-winter and spring-summer periods.

The technology of winter wheat cultivation, besides the questions put to study, was commonplace for the steppe zone. From the mineral fertilizers used nitro-amofosku, ammophos and ammonium nitrate. The nutrients were fed to sowing in pre-sowing cultivation and in crop fertilization according to the scheme: after black steam – option 1. Without fertilizers (control) option 2. N_{30} at the end of planting phase, option 3. $N_{15}P_{30}K_{15}$ to sowing, option 4. $N_{15}P_{30}K_{15}$ to sowing + N_{30} at the end of the planting phase, option 5. $N_{30}P_{60}K_{30}$ to sowing, option 6. $N_{30}P_{60}K_{30}$ to sow + N30 at the end of the planting phase; after maize on silage - option 1. Without fertilizers (control), option 2. N_{30} in early spring, option 3. $N_{30}P_{30}K_{15}$ to sowing, option 4. $N_{30}P_{30}K_{15}$ to sow + N_{30} in early spring, option 5. $N_{60}P_{60}K_{30}$ to sowing, option 6. $N_{60}P_{60}K_{30}$ to sow + N_{30} in early spring. Annually five varieties of winter wheat were planted, characterized by the best adaptability to the soil-climatic conditions of the region and technological measures, and characterized by high signs of resistance to unfavorable agro-ecological conditions, high yields and quality of grain.

For a comprehensive assessment of the humidity conditions, along with the direct definition of soil moisture in winter wheat crops, the priority climate criterion for assessing the water supply resources is also used – the hydrothermal coefficient of Selyaninov (HTC), which represents the ratio between the amount of precipitation in the period with the average daily air temperature above 10 °C and the sum temperatures for this period, multiplied by 10 (conditional coefficient). Estimation of humidification conditions of winter wheat were conducted monthly and in particular periods of its vegetation according to the HTC grading scale: to 0,49 – very dry (v.d.); 0,50–0,57 – dry (d.); 0,57–0,64 – moderately dry (m.d.); 0,64–0,73 – arid (a.); 0,74–0,80 – moderately arid (m.a.); 0,81–0,90 – insufficiently moistened (i.m.); 0,91–1,00 – moderately moistened (m.m.); 1,00–1,10 – moistened (m.); 1,10–1,20 – over moistened (o.m.); 1,20–1,30 – well moistened (w.m.); 1,30–1,40 – sufficiently moistened (s.m.); 1,50–1,60 – very humid (v.h.); 1,60–1,75 – moderately wet (m.w.); 1,75–1,90 – wet (w.); 1,90–2,20 – heavy wet (h.w.); 2,20–2,70 – very wet (v.w.); 2,70–3,60 – super wet (s.w.) [11–14].

Research results. In the conditions of insufficient and unstable moisture to ensure the full growth and development of winter wheat plants in the autumn period, the decisive value belongs to the proper reserves of available (productive) soil moisture during the time of sowing, which in experiments conducted after a black pair was observed annually, in particular, in the upper crop layer the soil (table 1). At the same time, after the non-precursor predecessor (corn on silage), such moisture stores in the IS accumulated three times, in the IIS – for five years out of seven. It has been experimentally established that in the steam field, the reserves of available moisture in a 1,5-meter layer of soil during the sowing of the IS accumulated within 120–165 mm, in the IIS – from 115 mm to 190 mm. After the corn on silage, these indicators in the specified seven-year periods were changed, respectively, within 10–132 and 8–95 mm. During the vegetation of wintering, the replenishment of soil moisture reserves due to atmospheric precipitation changed annually. Thus, in IS, their inflow fluctuated within the limits of 263–527 mm, and in the IIS – from 252 to 511 mm. The total moisture content of the IS in the areas after the black pair was 483 mm on average, after corn on silage – 400 mm, which was less than in IIS of 30 and 12 mm, respectively.

1. Wetness of agrocenoses of winter wheat, yield and efficiency water consumption depending on predecessors, 2001/02–2014/15 v.y.

Vegetation year	Reserves of available moisture in the soil layer, mm						Precipitation for September–June, mm	Total evapotranspiration from a layer of soil 0–150 cm		Grain yield, t/ha		Coefficient evapotranspiration mm/t of grain	
	for sowing time				for the time of full ripeness of the grain								
	0–10 cm		0–150 cm		0–150 cm								
	1*	2**	1	2	1	2		1	2	1	2	1	2
I seven-year period													
2001/02	8	3	137	36	7	9	321	451	348	6,38	4,71	70,7	73,9
2002/03	10	4	165	23	0	0	263	428	286	0,48	0,30	891,7	953,3
2003/04	9	3	120	32	40	0	527	607	559	4,63	2,17	131,1	257,6
2004/05	7	2	160	132	0	0	301	461	433	3,72	3,36	122,9	128,9
2005/06	6	2	125	10	36	0	391	480	401	3,82	2,02	125,6	198,5
2006/07	9	3	135	18	19	0	273	389	291	4,76	3,43	81,7	84,5
2007/08	10	4	140	49	10	4	434	564	479	8,02	6,40	70,3	74,8
On average, 2001/02–2007/08 years													
	8	3	146	43	16	2	359	483	400	4,54	3,20	106,4	124,9
II seven-year period													
2008/09	11	8	190	27	9	0	374	555	401	7,26	4,21	76,4	95,2
2009/10	12	9	153	13	17	0	324	460	337	5,74	3,97	80,1	84,8
2010/11	10	8	130	40	33	2	461	558	499	6,58	4,38	84,6	113,9
2011/12	7	3	115	13	30	6	379	464	386	4,49	3,01	103,3	128,2
2012/13	6	2	165	8	5	0	252	412	260	6,11	3,75	67,4	69,3
2013/14	11	7	150	25	12	8	403	541	420	8,04	6,26	67,3	67,1
2014/15	12	8	147	95	53	27	511	605	579	5,65	3,86	107,1	150,0
On average, 2008/09–2014/15 years													
	10	6	150	32	23	6	386	513	412	6,27	4,20	81,8	98,0

Note. 1*– black pairs, 2**– corn for silage.

For all time studies and observations on areas of black steam, from harvesting the predecessor to sowing wintering, in a half-meter layer of soil on average accumulated 146–150 mm of productive moisture. Before sowing winter wheat after corn on silage, the amount of moisture available to plants in the corresponding soil horizon was 32 to 43 mm.

The agro-ecological conditions of the autumn-winter period, the characteristics of wintering, as well as the spring and summer vegetation, were integratively determined by the conditions of the growth and development of plants, the formation of their productivity and yield of agrocenoses of winter wheat in seven years. By black steam, the highest grain yield of winter wheat during the IS was observed in 2008, 2002, 2007 and 2004, and the most effective soil moisture and precipitation were used in 2007/08, 2001/02 and 2006/07. At the same time, the yield was 8,02; 6,38 and 4,76 t/ha with coefficients of evapotranspiration: 70,3; 70,7 and 81,7 mm/t of grain.

After corn for silage, the largest grain harvest was 6,40 t/ha (2008), 4,71 t/ha (2002) and 3,43 t/ha (2007) with the corresponding moisture consumption of 74,8; 73,9 and 84,5 mm/t of grain. In the IIS on black steam the maximum yield of winter wheat was 8,04 (2014); 7,26 (2009); 6,58 (2011) and 6,11 t/ha (2013) with evapotranspation coefficients of 67,3; 76,4; 6,58 and 67,4 mm/t of grain, respectively. When placing winter wheat after corn on silage, the largest harvest of grain was obtained in 2014 – 6,26 t/ha; 2011 – 4,38 t/ha; 2009 – 4,21 t/ha and in 2010 – 3,97 t/ha with the corresponding coefficients of evapotranspation: 67,1; 113,9; 95,2 and 84,8 mm/t of grain.

In the regional conditions of the zone of inadequate humidification, the differentiation of agro-ecological components in winter wheat production through the hydrothermal coefficient gives an opportunity to more thoroughly evaluate the peculiarities of the growth and development of plants in its agrocenoses. Thus, in tables 2 and 3 the annual hydrothermal conditions of pre-planting, autumn and spring-summer periods as well as in the most important phases of growth and development of plants of this culture and its level of yield, depending on predecessors on different backgrounds of mineral fertilizers.

2. HTC (numerator), conditions of humidification (denominator) and yield of winter wheat Depending on predecessors and fertilizer backgrounds, 2001/02–2007/08 v.y.

Month, fertilizer background	Vegetation years							Medium
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	
Sowing period								
VIII	0,364 v.d.	0,354 v.d.	1,006 m.	3,550 s.w.	0,141 v.d.	0,233 v.d.	0,510 d.	0,880 i.m.
Autumn period								
IX	0,783 m.a.	1,865 w.	0,011 v.d.	0,712 a.	0,438 v.d.	0,263 v.d.	1,510 v.h.	0,797 m.a.
IX–XI	0,613 m.d.	1,554 v.h.	0,084 v.d.	0,598 m.d.	0,350 v.d.	0,812 i.m.	1,170 o.m.	0,740 m.a.
Spring-summer period								
IV–V	1,308 v.h.	0,069 v.d.	0,766 m.a.	0,434 v.d.	0,802 m.a.	0,165 v.d.	2,023 h.w.	0,795 m.a.
V	1,486 s.m.	0,069 v.d.	1,046 m.	0,308 v.d.	0,710 a.	0,165 v.d.	0,704 a.	0,641 a.
VI	0,580 m.d.	0,636 m.d.	2,232 v.w.	0,409 v.d.	1,451 s.m.	0,425 v.d.	0,846 i.m.	0,940 m.m.
IV–VI	0,986 m.m.	0,340 v.d.	1,410 s.m.	0,424 v.d.	1,048 m.	0,304 v.d.	1,473 s.m.	0,855 i.m.
During the growing season								
IX–XI IV–VI	0,868 i.m.	0,760 m.a.	0,970 m.m.	0,476 v.d.	0,786 m.a.	0,377 v.d.	1,370 s.m.	0,801 m.a.
Black-steam yield, t/ha								

No fertilizer	5,86	0,22	4,35	3,32	3,42	4,31	7,63	4,16
Also + N_{30}	6,13	0,27	4,60	3,55	3,64	4,64	7,92	4,39
$N_{15}P_{30}K_{15}$	6,36	0,43	4,48	3,45	3,73	4,70	7,90	4,44
Also + N_{30}	6,61	0,53	4,75	3,69	3,94	4,96	8,09	4,65
$N_{30}P_{60}K_{30}$	6,56	0,66	4,65	4,10	3,99	4,88	8,20	4,72
Also + N_{30}	6,79	0,77	4,94	4,23	4,20	5,08	8,37	4,91
On average, in terms of fertilizer backgrounds								
	6,49	0,53	4,68	3,80	3,90	4,85	8,10	4,62
Crop yield after silage, t/ha								
No fertilizer	4,19	0,13	1,94	2,64	1,37	2,74	5,54	2,65
Also + N_{30}	4,47	0,17	2,22	2,94	1,79	3,17	6,04	2,97
$N_{30}P_{30}K_{15}$	4,62	0,23	2,02	3,37	1,89	3,43	6,23	3,11
Also + N_{30}	4,84	0,35	2,32	3,62	2,20	3,77	6,64	3,39
$N_{60}P_{60}K_{30}$	4,96	0,35	2,14	3,70	2,28	3,63	6,87	3,42
Also + N_{30}	5,17	0,54	2,39	3,86	2,58	3,87	7,06	3,64
On average, in terms of fertilizer backgrounds								
	4,81	0,33	2,22	3,50	2,15	3,57	6,57	3,31

Optimal hydrothermal conditions of moisture precipitate period were observed in 2003, 2004 and 2012. In autumn periods, in particular in September, good soil moisture provision was provided in 2002, 2007–2010 and 2013–2014, that is, for two years in the IS and for five years in IIS. In the spring-summer period, the vegetation of the best hydrothermal conditions in the IS was noted in 2004 and 2006–2008, and in the IIS in 2009, 2011, 2012, 2014, and 2015. In general, during the vegetation period, the HTC in the IS was 0,801 and generally characterized conditions of growing winter wheat as moderately arid, and in the IIS the value of this indicator increased to 1,035, which corresponded to moistened conditions, in which much better the needs of plants for the realization of their productive potential were provided.

After placement after a black pair, the winter wheat yield on non-fertilized control was 4,16 t/ha in the IS and 5,89 t/ha in the IIS, which was increased by 1,73 t/ha. At the same time, in seven years the increase in crop in the average fertilizer background was practically equivalent and amounted to 0,46 and 0,45 t/ha respectively.

After maize on silage in the IS, the average yield of winter wheat in the control without fertilizers was 2,65 t/ha, and in the IIS increased by 0,46 t/ha. On average, in the background of mineral fertilizers in the IS, the increase in yield to unhealthy background was 0,66 t/ha, in IIS – increased by 1,32 t/ha.

3. HTC (numerator), conditions of humidification (denominator) and yield of winter wheat Depending on predecessors and fertilizer backgrounds, 2008/09–2014/15 v.y.

Month, fertilizer background	Vegetation years							Середнє
	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	
Sowing period								
VIII	0,370 v.d.	0,042 v.d.	0,000 v.d.	0,109 v.d.	1,234 w.m.	0,207 v.d.	0,232 v.d.	0,313 v.d.
Autumn period								
IX	1,435 s.m.	1,174 o.m.	1,221 w.m.	0,643 a.	0,124 v.d.	1,900 w.	2,616 v.w.	1,302 s.m.
IX–XI	1,234 w.m.	1,082 m.	1,221 w.m.	0,576 m.d.	0,188 v.d.	1,845 w.	2,348 v.w.	1,260 w.m.
Spring-summer period								

IV–V	1,395 s.m.	1,000 m.m.	0,669 a.	1,098 m.	0,466 v.d.	1,562 v.h.	0,462 v.d.	0,950 m.m.
V	1,685 m.w.	1,116 o.m.	0,605 m.d.	1,508 v.h.	0,584 m.d.	1,698 m.w.	0,540 d.	1,105 o.m.
VI	0,726 a.	0,584 m.d.	0,468 v.d.	0,899 i.m.	0,698 a.	1,344 s.m.	1,997 h.w.	0,959 i.m.
IV–VI	1,029 m.	0,784 m.a.	1,063 m.	1,015 m.	0,566 d.	1,471 v.h.	1,247 w.m.	1,172 o.m.
During the growing season								
IX–XI IV–VI	1,102 o.m.	0,894 i.m.	1,113 o.m.	0,890 i.m.	0,516 d.	1,571 v.h.	1,604 m.w.	1,035 m.
Black-steam yield, t/ha								
No fertilizer	6,71	5,28	6,19	4,27	5,72	7,76	5,30	5,89
Also + N_{30}	7,10	5,61	6,63	4,59	6,01	8,15	5,61	6,24
$N_{30}P_{30}K_{15}$	7,26	5,63	6,35	4,59	5,99	7,85	5,51	6,17
Also + N_{30}	7,52	5,92	6,72	4,79	6,27	8,18	5,81	6,46
$N_{60}P_{60}K_{30}$	7,37	5,89	6,61	4,24	6,20	7,95	5,69	6,28
Also + N_{30}	7,58	6,13	6,97	4,45	6,46	8,37	6,00	6,57
On average, in terms of fertilizer backgrounds								
	7,37	5,84	6,66	4,53	6,19	8,10	5,72	6,34
Crop yield after silage, t/ha								
No fertilizer	3,15	2,83	3,19	2,30	2,83	4,79	2,69	3,11
Also + N_{30}	3,65	3,57	3,94	2,74	3,41	5,32	3,25	3,70
$N_{30}P_{30}K_{15}$	3,90	3,68	4,18	2,75	3,45	6,45	3,79	4,03
Also + N_{30}	4,36	4,34	4,81	3,10	3,90	6,93	4,25	4,53
$N_{60}P_{60}K_{30}$	4,75	4,36	4,77	3,47	4,26	6,85	4,33	4,68
Also + N_{30}	5,44	5,04	5,40	3,72	4,66	7,19	4,86	5,19
On average, in terms of fertilizer backgrounds								
	4,42	4,20	4,62	3,16	3,91	6,55	4,10	4,43

Significant improvement of hydrothermal components in winter wheat cultivation in IIS in comparison with the IS also caused an increase in the efficiency of both anhydrous mineral fertilizers and nitrogen during the cultivation of crops in different phases of development of plants (table 4). For example, on black steam in the IS compared with the control variant, the yield increase of winter wheat when introduced into the $N_{15}P_{30}K_{15}$ sowing was 0,28 t/ha. When doubling the doses of the main fertilizer ($N_{30}P_{60}K_{30}$) additional grain harvest increased to 0,56 t/ha with a payback of 1 kg a.s. fertilizers 4,7 kg of grain.

4. Comparative analysis of wheat yields of winter dependent from predecessors and fertilizer backgrounds, 2001/02–2014/15 v.y.

The background of fertilizers	I seven-year period (2001/02–2007/08 v.y.)					II seven-year period (2008/09–2014/15 v.y.)				
	crop capa-city, t/ha	including the increase in fertilizers, t/ha		with a payback of fertilizers, kg of grain per 1 kg of a.s.		crop capa-city, t/ha	including the increase in fertilizers, t/ha		with a payback of fertilizers, kg of grain per 1 kg of a.s.	
		back-ground	N_{30}	back-ground	N_{30}		back-ground	N_{30}	back-ground	N_{30}
The predecessor is black pairs										
No fertilizer (control)	4,16	-	-	-	-	5,89	-	-	-	-

N_{30} at the end of the planting phase	4,39	-	0,23	-	7,7	6,24	-	0,35	-	11,7
$N_{15}P_{30}K_{15}$	4,44	0,28	-	4,7	-	6,17	0,28	-	4,7	-
$N_{15}P_{30}K_{15}$ + N_{30} at the end of the planting phase	4,65	-	0,21	-	7,0	6,46	-	0,29	-	9,7
$N_{30}P_{60}K_{30}$	4,72	0,56	-	4,7	-	6,28	0,39	-	3,2	-
$N_{30}P_{60}K_{30}$ + N_{30} at the end of the planting phase	4,91	-	0,19	-	6,3	6,57	-	0,29	-	9,7
The predecessor is a corn for silage										
No fertilizer (control)	2,65	-	-	-	-	3,11	-	-	-	-
N_{30} in the early spring	2,97	-	0,32	-	10,7	3,70	-	0,59	-	19,7
$N_{30}P_{30}K_{15}$	3,11	0,46		6,1	-	4,03	0,92	-	12,3	-
$N_{30}P_{30}K_{15}$ + N_{30} in the early spring	3,39	-	0,28	-	9,3	4,53	-	0,50	-	16,7
$N_{60}P_{60}K_{30}$	3,42	0,77	-	5,1	-	4,68	1,57	-	10,5	-
$N_{60}P_{60}K_{30}$ + N_{30} in the early spring	3,64	-	0,22	-	7,3	5,19	-	0,51	-	17,0

From the fertilization of winter wheat crops with winter nitrogen (N_{30}) at the end of the planting phase at various fertilizer phases, the yield increase with a slight increase in the dose of anthropogenic fertilizers slightly decreased, namely from 0,23 to 0,19 t/ha. Also, the recoupment of nitrogen fertilization decreased with a rise in the dose of background fertilizers from 7,7 to 6,3 kg of grain per 1 kg of active substance of fertilizers. In the IIS due to the best flow of hydrothermal conditions in the autumn and spring-summer periods there was an increase in the efficiency of nitrogen feeding in a dose of N_{30}, which provided an additional increase in the winter wheat yield on different feeding backgrounds ($N_{15}P_{30}K_{15}$ and $N_{30}P_{60}K_{30}$) to 0,29 t/ha with a payback of 1 kg a.s. fertilizers 9,7 kg of grain.

When placement of winter wheat after corn for silage and growing on different backgrounds of mineral nutrition – $N_{30}P_{30}K_{15}$ and $N_{60}P_{60}K_{30}$ – its yield in the IS compared with the background without fertilizers increased respectively by 0,46 and 0,77 t/ha with a payback of 6,1 and 5,1 kg of grain per 1 kg a.s. fertilizers. The increase in the winter wheat yield to control of the early spring feed (N_{30}) was 0,32 t/ha on the unabated background, at 0,25 t/ha $N_{30}P_{30}K_{15}$ and 0,22 t/ha of $N_{60}P_{60}K_{30}$. In IIS, when applying pre-sucrose fertilizer, a significant increase in winter wheat yield was observed, which was compared with the control in accordance with the indicated feed backgrounds of 0,92 and 1,57 t/ha with payback of the nitrogen fertilization of the crops (N_{30}): 19,7 (background – without fertilizers); 16,7 (background – $N_{30}P_{30}K_{15}$) and 17,0 (background – $N_{60}P_{60}K_{30}$) kg of grain per 1 kg a.s. fertilizers.

Conclusions

The conducted researches and observations allow to state that in the conditions of the southeastern steppe during 2001/02–2014/15 v.y. there were sufficiently significant changes in weather and climatic conditions, which in general had a positive effect on the ontogenetic processes of plant development in the cultivation of winter wheat. Thus, during the period of vegetation of the main grain crop, the observation (precipitation) of precipitation in the IS (2001/02–2007/08 v.y.) was 359, in IIS (2008/09–2014/15 v.y.) – 386 mm.. By black pair, the total evapotransportation of winter wheat agrocenoses was 389–607 mm in IS, 412–605 mm in IIS, and on average, for vegetation, it was 483 and 513 mm, respectively. After corn for silage, the corresponding indicators in the IS were 286–559 and 400 mm and 260–579 and 412 mm in IIS. In general, during the vegetation period, the HTC for Selyanynov in IS was 0,801, in IIS 1,035.

The average annual yield of winter wheat in a black steam on various backgrounds of mineral fertilizers in the IS amounted to 4,62 tons per hectare, and in IIS it increased to 6,34 t/ha. Efficiency of anthropogenic full mineral fertilizer in IIS has increased with respect to IS at introduction of $N_{15}P_{30}K_{15}$ and $N_{30}P_{60}K_{30}$ accordingly in 1,39 and 1,33 times. At the same time, the total increase in the winter wheat yield when compared to seven seven-year periods was 1,72 t/ha, that is, yields during 2008/09–2014/15 v.y. increased by 37%.

After corn on silage, when mineral fertilizers were introduced into sowing and fertilization, the yield of winter wheat in the IS and IIS was on average 3,31 and 4,43 t/ha respectively, that is, the increase in grain yield in IIS compared with the IS was 1,12 t/ha, or 1,34 times more.

In the experiments conducted, the highest yield of winter wheat was formed in the IIS and in the black pairs it was provided with a background of fertilizer $N_{30}P_{60}K_{30}$ + N_{30} at the end of the planting phase, which amounted to 6,56 t/ha, with the return of background fertilizer and nitrogen fertilization, respectively, 3,2 and 9,7 kg of grain per 1 kg of active substance of of fertilizers. After maize on the silage, it was best to introduce $N_{60}R_{60}K_{30}$ + N_{30} in the early spring, providing a maximum yield of 5,19 t/ha, and the return on the background fertilizer and early spring nitrogen fertilization (N_{30}) at the rate of 10,5 and 17,0 kg of grain per 1 kg a.s. fertilizers respectively.

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