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INFLUENCE OF SOWING TIME, SEEDING RATE AND FERTILIZATION ON SPRING WHEAT PRODUCTIVITY

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Наведено результати досліджень з вивчення впливу строків сівби, норм висіву та мінеральних добрив на особливості використання продуктивної вологи посівами, рівень водоспоживання рослин і формування елементів структури урожайності пшениці ярої в північному Степу України.

Ключові слова: *пшениця яра, строк сівби, норма висіву, мінеральне живлення, зерно, урожайність.*

The use of spring wheat in agricultural production, especially as insurance culture, creates real conditions for stabilization of high-quality food grains, rich in protein, gluten, vitamins, mi-nerals and other nutrients [1].

From the results of previous studies we know that spring wheat plants quite demanding as to water consumption and so to soil fertility, especially in the early stages of development. So they re-quire a significant amount of nutrients, particularly nitrogen, which significantly affects the growth and development, photosynthetic activity of leaf apparatus and the formation of grain productivity [2–4].

By conduction researches were supposed to set the optimum seeding rate of spring wheat at different sowing terms and norms of mineral nutrition in a Northern Steppe of Ukraine.

The study was conducted at the Erastivka Experimental Station of the Institute of Agriculture of Steppe zone of NAAS during 2011–2014, according to generally known methods [5, 6]. Soil of experimental field – ordinary chernozem, low-humic, loamy. The humus content in arable soil layer (0–30 cm) – 4,0–4,5 %, total nitrogen – 0,23–0,26 %, phosphorus – 0,11–0,16 %, potas-sium – 2,0–2,5 %, pH of water extract – 6,5–7,0.

Field experiments were laid in six-field crop rotation after predecessor winter wheat on a background of different rates of NPK: without fertilizers and $N_{40}P_{20}K_{20}$. Seeding rates of spring wheat were: 4; 5 and 6 million of seeds/ha. In experiments seeded spring wheat variety Spadschyna. Sowing of wheat started at physical maturity soil in two periods: first: March, 28 – April, 5, and the second – 5 days after: April, 3 – April, 10. Sowing method – ordinary with 15 cm sowing dis-tance.

Soil preparation, sowing, care of crops and harvesting were carried out according to the zo-nal recommendations. Variants in a field experiment designed systematically, with three replica-tions. Accounting plots area – 50 m^2.

Weather conditions during the investigation were different, which made it possible to fully assess its impact on grain productivity potential of spring small cereals. Thus, in 2011, during the growing season dropped 245,3 mm of rainfall, which is 25 mm more than the average long-term rate, the average temperature was 17,7 ºC, hydrothermic index (GTI) during the growing season was 1,33.

Extremely dry was 2012 (GTI = 0,61), which was characterized by higher temperatures (24,1 ºC, which is 9,1 ºC high than norm) and a deficit of rainfall (during the growing season dropped 172 mm of rainfall, 50 mm less the norm).

Weather conditions in 2013 and 2014 included both periods of drought and periods of abun-dant moisture (GTI = 0,77 and 1,31 respectively). The total depth of precipitation during the gro-wing season in 2013 amounted to 141,2 mm and average atmospheric temperature 17,6 ºC and in 2014 – 238,3 mm and 16,8 ºC, respectively.

The aim of investigation was to identify effective agro technological measures of increasing the grain productivity of spring wheat in Northern Steppe of Ukraine by choosing the best sowing time, seeding rate and mineral nutrition.

It is well known that the spring wheat is quite demanding culture to moisture conditions, es-
pecially in the early stages of growth. Therefore, in our research we studied the effect of factors (so-wing time, seeding rate) and moisturizing soil regime on productivity of sowings of spring wheat.

At the time of sowing the spring wheat (first term) productive moisture reserves in 0–10 cm layer were 18,8 mm; in the layer 10–30 cm – 52,2; in the layer 0–100 cm – 148,1 mm; at the second term of sowing – respectively 15,3; 49,4; and 135,1 mm (table 1).

1. Productive moisture reserves in spring wheat sowings at full grain ripeness, mm (means for 2011–2014)

Sowing time	Fertilization	Seeding rate, million of seeds/ha	Soil layer, cm				
			0–10	10–30	30–60	60–100	0–100
Moisture reserves at first sowing time			18,8	52,2	41,4	54,5	148,1
First sowing period (March, 28 – April, 5)	without fertilizers	4	4,3	7,9	3,0	6,7	17,6
		5	3,8	7,3	2,7	5,3	15,2
		6	3,1	6,4	1,7	4,3	12,4
	$N_{40}P_{20}K_{20}$	4	3,4	6,6	3,0	6,1	16,3
		5	3,0	6,1	2,1	5,1	14,0
		6	2,4	5,5	1,1	4,3	11,5
Moisture reserves at second sowing time			15,3	49,4	37,5	53,8	135,1
Second sowing period (April, 3 – April, 10)	without fertilizers	4	3,2	6,7	1,4	3,9	12,0
		5	2,9	5,6	1,2	3,4	10,1
		6	2,4	4,7	0,9	2,7	8,3
	$N_{40}P_{20}K_{20}$	4	2,6	5,2	2,5	3,3	11,0
		5	2,4	4,6	2,2	2,7	9,5
		6	2,0	4,1	1,8	2,2	8,1

During the growing season of spring wheat fell 95,6 mm of precipitation, which are differently influenced the growth and development of spring wheat plants depending on sowing time and seeding rate.

Analysis of productive moisture reserves in soil showed that at application of fertilizers with rate of $N_{40}P_{20}K_{20}$ in sowings of first sowing period at the same seeding rates, in the 0–100 cm layer, residual stocks of productive moisture decreased by 7,3–7,8 %, and in crops second sowing period – by 2,8–7,9 %, compared with the background without fertilizers.

Received initial parameters of productive moisture (481 m^3/ha) and rainfall during the growing season (956 m^3/ha) and residual reserves at the end of the growing season (81–176 m^3/ha) make it possible to determine the amount of water used by spring wheat crops during the period of yield formation and the ratio of total moisture expenditure to form the basic unit of harvest.

Thus, total water consumption of spring wheat crops variety Spadschyna sown at the first sowing period during the growing season was 2261–2322 m^3/ha, and the second period – 2186–2226 m^3/ha (table 2).

2. Use of moisture (from 0–100 cm soil layer) by spring wheat sowings depending on sowing time, fertilization and seeding rate (means for 2011–2014)

Sowing time	Fertilization	Seeding rate, million of seeds/ha	Total water consumption for growing season, m^3/ha	Coefficient of water consumption, m^3/t
First sowing period	Without fertilizers	4	2261	1627
		5	2285	1576
		6	2313	1880
	$N_{40}P_{20}K_{20}$	4	2275	1379
		5	2297	1359
		6	2322	1508
Second	Without	4	2186	1529

sowing period	fertilizers	5	2206	1554
		6	2224	1672
	$N_{40}P_{20}K_{20}$	4	2197	1348
		5	2212	1317
		6	2226	1357

Water consumption of plants per unit of basic output in crops of first sowing time was 1359–1880 m^3/t, and the second – 1317–1672 m^3/t. It should also be noted that the amount of water consumed for the forming a unit of output was increased with increasing seeding rate, and decre-ased with application of mineral fertilizers $N_{40}P_{20}K_{20}$.

Conducted biometric researches of plants showed that the growth of aboveground mass and secondary root formation during the growing season materially varied depending on sowing time and seeding rate.

The obtained data shows that both at the first and the second sowing period the best bio-metric indicators of spring wheat plants were when sown with rate of 4 million of grains/ha. Incre-asing the density of plants on area to 5 million of seeds/ha, reduced the plant height on a backgro-und without fertilizers for 2,6 cm and at plant density of 6 million – for 3,4 cm, and on the backg-round of $N_{40}P_{20}K_{20}$ respectively – 2,2 and 2,5 cm.

Studies have shown that the overcrowding of plants has negative impact on the formation of the root system (number of secondary roots at density 5 and 6 million on a background without fer-tilizers decreases respectively for 7,5–22,3 % and on a background of $N_{40}P_{20}K_{20}$ – for 9,0–12,5 %, compared to 4 million of seeds/ha). Increasing the plants density also worsened and other indicators of spring wheat plants – decreased the formation of stem and plants weight, irrespective of appli-cation the mineral fertilizers (table 3).

In average for years of researches, the second sowing period (5 days after the first) through rains, those passed after the first sowing term, provided even sprouts and fast-gaining of above-ground mass of spring wheat plants. The study of plants samples after stem-elongation phase sho-wed that despite a bit late sowing time, the plant height at the second sowing period was almost equal at density of 4 million of grains/ha to the first period, but at overcrowding of plants to 5 and 6 million of grains/ha – were even higher for 2,5–1,0 cm on a background without fertilizers and 4,5–2,5 cm on background of $N_{40}P_{20}K_{20}$ respectively. But the plants weight during the second sowing period and index of tillers were slightly lower than at the first period, irrespective of application the mineral fertilizers, especially at overcrowding.

3. Biometric parameters of spring wheat plants depending on sowing time, seeding rate and fertilization, stem-elongation stage (means for 2011–2014)

Sowing time	Seeding rate, million of seeds/ha	Plant height, cm	Number of nodal roots, pcs.	Plant weight, g	Index of tillers
Without fertilizers					
First sowing period	4	68,7	5,4	0,97	1,11
	5	66,1	5,0	0,84	1,06
	6	65,3	4,2	0,75	1,00
Second sowing period	4	68,8	5,4	0,89	1,07
	5	68,6	5,2	0,83	1,05
	6	66,3	3,7	0,66	1,00
$N_{40}P_{20}K_{20}$					
First sowing period	4	71,7	5,6	1,16	1,15
	5	69,5	5,1	1,09	1,15
	6	68,6	4,9	0,99	1,13
Second sowing period	4	72,3	5,4	1,13	1,17
	5	74,0	5,5	1,05	1,16
	6	71,1	4,4	0,88	1,13

Analysis of spring wheat yield structure showed that on a background without fertilizers plant height at the second sowing period was lower compared to the first sowing period an

average of 2,2–7,0 cm, and on the variants with application of $N_{40}P_{20}K_{20}$ at density 4 million of seeds/ha this
index does not changed significantly, but at the density of 5 and 6 million of seeds/ha plant height was even on 1,6–5,4 cm higher than at first sowing period (table 4).

4. Formation the structure elements of spring wheat crop yield depending on sowing time, seeding rate and fertilization (means for 2011–2014)

Fertilization	Seeding rate, million of seeds/ha	Ear length, cm	Index of productive tillers	Amount of grains per ear, pcs.	Grain weight, per plant, g	1000 kernel weight, g
First sowing period						
Without fertilizers	4	4,0	1,0	16,1	0,60	33,3
	5	4,0	1,2	16,0	0,50	32,1
	6	3,7	1,1	15,9	0,40	31,3
$N_{40}P_{20}K_{20}$	4	5,0	1,3	18,8	0,70	37,0
	5	4,5	1,3	18,6	0,53	36,3
	6	4,0	1,2	18,4	0,44	36,0
Second sowing period						
Without fertilizers	4	3,9	1,2	16,3	0,57	34,3
	5	3,5	1,2	16,3	0,47	32,6
	6	3,0	1,0	15,8	0,37	32,8
$N_{40}P_{20}K_{20}$	4	5,1	1,3	18,6	0,66	38,5
	5	5,0	1,3	18,5	0,58	37,9
	6	4,5	1,2	17,9	0,42	36,8

Depending on the factors that has been studied, changed and other structural indicators of plants. Thus, on a background without fertilizers ear length in a variants of second sowing period compared to the first sowing term, declining for 2,5–18,9 %, and on a background of $N_{40}P_{20}K_{20}$ in the second sowing period the ear length, on the contrary increased for 2,0–12,5 %.

The ear length also depends on the plants density. The smallest this parameter was at sowing density at 6 million of seeds/ha – 3,7 cm on a background without fertilizers and 4,0 cm on a background of $N_{40}P_{20}K_{20}$ during the first sowing period and respectively – 3,0 and 4,5 cm at the second sowing period.

Number of grains per ear, depending on sowing time influenced not significantly (0,5–2,7 %), which could be explained the good moisture supplying during the ripening seeds. Parameter of weight of 1000 kernels of spring wheat mostly increased under the application of mineral ferti-lizer. So, depending on sowing time on the background without fertilizers, it increased at second sowing time only for 0,5–1,8 %, and on the background of $N_{40}P_{20}K_{20}$ – 4,9–6,7 % compared to the first sowing time. It was also established that more plumpness of grain observed at seeding rate 4 million of seeds/ha, irrespective of sowing time.

5. Effect of sowing time, seeding rate and fertilization on spring wheat productivity (means for 2011–2014)

Fertilization (B)	Seeding rate, million of seeds/ha (C)	Crop yield (t/ha) at sowing period (A)	
		first	second
Without fertilizers	4	2,42	2,39
	5	2,45	2,41
	6	2,33	2,23
$N_{40}P_{20}K_{20}$	4	2,65	2,63
	5	2,69	2,64
	6	2,64	2,54
LSD_{05}, for factors: A – 0,02; B – 0,02; C – 0,02; AB – 0,02; AC – 0,03; BC – 0,03; ABC – 0,04			

Grain yield of spring wheat at sowing in the first period on the background without fertilizers and at application of $N_{40}P_{20}K_{20}$ was highest in variants at seeding rate of 5 million of seeds/ha and was respectively 2,45 and 2,69 t/ha.

It will be remarked that the crop yield of spring wheat in both backgrounds of fertilization and sowing time increased with increasing the seeding rate of seeds to 5 million of seeds/ha (2,4–4,3 %), and at rate of 6 million of seeds/ha decreased for 8,9–15,2 %.

Conclusions. Analyzing the experimental data, we can conclude that in drought conditions the effective agrobiological measure to improve grain productivity is sowing time, seeding rate and fertilization, the correct selection of which significantly affects the increase of ecological plasticity and crop yields of spring wheat variety Spadschyna.

Substantiated, that more adapted to the arid Steppe conditions was spring wheat, which seeded at physical maturity soil that during the years of the experiment provided the highest crop yield. Research has established that spring wheat planted with seeding rate of 5 million of seeds/ha significantly better respond to increasing agricultural chemistry background.

Revealed that cultivation of spring wheat by application of $N_{40}P_{20}K_{20}$ and agrotechnical measures listed above provides the greatest grain yield – 2,69 tons per hectare.

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