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ного материала различными химическими препаратами. За последние десятилетия для защиты семян пшеницы от головнёвых заболеваний было создано достаточно большое количество фунгицидов-протравителей семян. Но не все они способны полностью ингибировать развитие гриба Tilletia caries. Для нужд производства необходимы средства, обладающие максимальным эффектом. По этой причине возникает необходимость скрининга существующих протравителей семян для выявления наиболее действенных. Цель наших исследований состояла в оценке биологической эффективности современных фунгицидов в отношении возбудителя твёрдой головни пшеницы.

Опыты проводились в полевых условиях, на искусственном инфекционном фоне. В качестве материала исследований использовался семенной материал озимой пшеницы сорта Скипетр. Семена пшеницы заражали телиоспорами возбудителя твёрдой головни (Tilletia caries Tul.) из расчета 2 грамма спор на 100 грамм семян [4]. Затем их обрабатывали химическими препаратами: Дивиденд Стар КС, 1 л/т; Суми 8 КС, 2 л/т; Винцит СК, 2 л/т и Виал ТТ ВСК, 0,4 л/т. В контроле семенной материал был без обработки. Через сутки семена высевали на делянках. Площадь делянки 0,3 м^2, повторность четырёхкратная. По достижению растениями пшеницы фазы восковой спелости их убирали с делянок и определяли количество здоровых и больных колосьев. Распространенность заболевания и биологическую эффективность испытываемых препаратов рассчитывали согласно общепринятым формулам.

Как показали проведённые исследования, испытываемые протравители семян проявляли неодинаковый уровень эффективности в отношении возбудителя твёрдой головни озимой пшеницы (таблица). Полностью (на 100 %) ингибировали развитие заболевания фунгициды Дивиденд Стар и Суми 8. Препараты Виал ТТ и Винцит снижали уровень поражения растений возбудителем твёрдой головни на 59,7 и 80,6 %, соответственно. Поражение растений в контроле составило 19,6 %.

Таблица

Эффективность протравителей семян против возбудителя твёрдой головни озимой пшеницы (сорт Скипетр)

Препарат, норма расхода	Поражение твёрдой головнёй, %	Биологическая эффективность, %
Дивиденд Стар КС, 1 л/т	0,0	100,0
Суми 8 КС, 2 л/т	0,0	100,0
Винцит СК, 2 л/т	3,8	80,6
ВиалТТ ВСК, 0,4 л/т	7,9	59,7
Контроль	19,6	-

Исходя из выше изложенного, можно сказать, что испытание фунгицидов-протравителей семян в условиях искусственного инфекционного фона позволило оценить их биологическую эффективность в отношении возбудителя твёрдой головни пшеницы. Выявлены наиболее действенные препараты Дивиденд Стар и Суми 8, способные полностью ингибировать развитие заболевания. Результаты исследований могут быть использованы в производстве, при выборе оптимальных средств для обеззараживания семенного материала пшеницы.

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SPRING BARLEY PRODUCTIVITY IN DEPENDENCE ON MINERAL NUTRITION

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Abstract

Considering the sown areas and yields of spring barley out of many cereal crops in Ukraine as well as in the area of world agriculture it takes one of the priority places. In general, the sown area of spring barley in the world is about 75 million hectares. In Ukraine it is sown on an area of about 3-5 million hectares. Barley grain is in great demand, it is widely used as a fodder and for food purposes, in addition it is used for the brewing industry as an indispensable raw material.

According to the results of the research it was established that barley is a very valuable agricultural crop. We have determined that more effective conditions for preservation of spring barley plants in the crop will be under the condition of introducing mineral fertilizers in the dose of $N_{90}P_{60}K_{60}$ into the pre-sowing cultivation and when growing after winter rape predecessor. Under these conditions, the density of plants at the time of harvesting ripeness was 275 pcs / M2, and the survival rate was 68.8%. Nitrogen fertilizers N60 applied during pre-sowing cultivation on the variants with phosphorous-potassium nutrition ($P_{60}K_{60}$) ensured the height of spring barley plants at the heading stage, which was 38 cm after rape, 37 cm after maize and 35 cm after sunflower.

Keywords: barley, precursor, mineral fertilizers, height, density, individual productivity.

Statement of the problem: Barley is one of the most common crops in world agriculture and has been grown since prehistoric times. In the world structure of sown areas barley takes the fourth place after wheat, rice and corn, and in Ukraine by this index it is second only to winter wheat. Such a wide spread of barley is connected with its universal use. The total demand of the state in barley grain greatly exceeds the level of modern production. Unstable gross production of spring barley grain in different years had a noticeable influence of yield fluctuations [1].

Nowadays agriculture in Ukraine is considered to be the main branch of economy, stably forms high net profit. That is why the task of increasing the production of agricultural products, including grain, is so acute. Growth of grain production is provided mainly by the output and introduction of new varieties and hybrids, as well as by the improvement of existing production technologies. Domestic scientists - breeders created a wide range of high-quality high-yield varieties of various crops, including spring barley [2-4]. High-intensive, intensive and semi-intensive varieties with high yield potential and grain quality, adapted to the specific growing conditions, are recommended to the producers of enterprises of various forms of ownership [5].

Summary of the basic material: Sowing barley seeds in the field is the most responsible technological process, which significantly affects the time of appearance and completeness of the ladder, the subsequent growth and development of plants. It is known that in the Forest-steppe zone of the right bank in the spring there are sharp fluctuations in temperature, due to which a significant portion of the seeds 20-30%) does not germinate even with remarkable rates of laboratory germination (95-100%). Therefore, ensuring high field germination is one of the most important tasks of agricultural technique, because the level of future yields largely depends on it.

KWS Dante's spring barley seeding rate in the experience that in 2019 and 2020 was 4 million germinating seeds per hectare. Of course, the soil conditions at the time made adjustments to the field germination.

Research revealed that the indicators of thickness of spring barley plants in the phase of full sprouting were influenced by both the predecessors and the level of mineral nutrition (Table 1.). When spring barley was grown with winter rape on the control without fertilizers the plant density was 302 pcs/M2, or 75,5% of field germination. The variant with mineral fertilizers at a dose of $N_{60}P_{60}K_{60}$ plant density was 315 pcs / M2 or 78.8% of field germination. Increasing the dose of nitrogen to 90 kg a.d. on phosphorus-potassium background was the reason that the density of plants of spring barley in the period of complete germination was 327 pcs / m2, which was 81.8% of field germination.

Sowing of spring barley after the preceding corn on grain contributed to the fact that the variant without fertilizers plant density at the time of complete germination was 300 pcs / M2, which was 75% of field germination. Application of 60 kg a.d. of nitrogen, phosphorus and potassium provided a similarity of 313 pcs / m2 plants, or 78.3% of field germination. When $N_{90}P_{60}K_{60}$ was applied, the number of barley plants in the period of full germination was 325 pcs/m2, i.e., field germination was 81,3%.

Table 1.

Effect of predecessor and mineral fertilizers on field germination and plant density of spring barley in the phase of full sprouting (Average for 2019-2020).

Predecessor	Level of mineral nutrition	Plant density, pcs/M^2	Field germination, %
Winter rape	No fertilizer	302	75,5
	$N_{60}P_{60}K_{60}$	315	78,8
	$N_{90}P_{60}K_{60}$	327	81,8
Corn (for the grain)	No fertilizer	300	75,0
	$N_{60}P_{60}K_{60}$	313	78,3
	$N_{90}P_{60}K_{60}$	325	81,3
Sunflower	No fertilizer	298	74,5
	$N_{60}P_{60}K_{60}$	309	77,3
	$N_{90}P_{60}K_{60}$	321	80,3

At spring barley growing on the variant with sunflower predecessor the lowest similarity indices were noted, namely at the variant without fertilization - 298 pcs/M2, that was 74,5% of field germination. When fertilizers were applied, the similarity indicators slightly improved and were 309 pcs/M^2 and 77.3%, respectively, when using $N_{60}P_{60}K_{60}$ and 321 pcs/M^2 and 80.3% - when using $N_{90}P_{60}K_{60}$.

Observing the dynamics of densities of spring barley plants during the growing season, it was noted that this indicator decreased slightly during the growth and development of plants as a result of fallout. This phenomenon was caused by a number of biotic and abiotic environmental factors.

The positive role of winter rape as a precursor for spring barley plants was noted. On this variant there was the greatest number of preserved plants (Table 2). Thus, on the variant without fertilizers the number of spring barley plants was 238 plants/M2, i.e., survival rate was 59,5%. When N_{60} was added to the preplanting

cultivation on the background of $P_{60}K_{60}$ densities of spring barley plants during the lean period was 260 pcs/M^2, the survival rate was 65,0%. When the dose of nitrogen was increased to 90 kg a.d. on phosphorus-potassium background, the preservation of barley plants in the crop at the period of slope ripeness was 68.8%, while the density was at 275 pcs/m2 plants.

Table 2

Effect of fore crop and mineral fertilizers on plant density and survival of spring barley plants during harvesting ripeness
(Average for 2019-2020).

Predecessor	Level of mineral nutrition	Plant density, pcs/M^2	Field germination, %
Winter rape	No fertilizer	238	59,5
	$N_{60}P_{60}K_{60}$	260	65,0
	$N_{90}P_{60}K_{60}$	275	68,8
Corn (for the grain)	No fertilizer	225	56,3
	$N_{60}P_{60}K_{60}$	254	63,5
	$N_{90}P_{60}K_{60}$	266	66,5
Sunflower	No fertilizer	217	54,3
	$N_{60}P_{60}K_{60}$	248	62,0
	$N_{90}P_{60}K_{60}$	257	64,3

When using corn on grain, as a predecessor, on the option without fertilizer the density of plants at harvesting ripeness was 225 pcs/m^2, thus the survival rate was 56.3%. With the application of full mineral nutrition at a dose of 60 kg. a.d., the density of barley plants at harvest time was 254 pcs. /m^2, and survival respectively - 63,5%. The application of 90 kg a.d.p. of nitrogen fertilizers in the preplanting cultivation on the background of $P_{60}K_{60}$ resulted in making the barley stalk density at the harvesting period 266 pcs/m^2 of plants and, consequently, the survival rate - 66,5%.

During the study it was found that sunflower was worse for spring barley predecessor. Especially indicative was the dry 2020. Because of the low moisture reserves in the soil after sunflower crops spring barley crops during the growing season compared with other predecessors. Thus, on the version without mineral fertilizers densities of spring barley plants during the harvesting ripeness was 217 pcs/M^2, which in terms of survival was 54.3%. Cultivation of spring barley on a background of $N_{60}P_{60}K_{60}$ contributed to the fact that the survival rate of barley plants at harvest time was 248 pcs/M^2, or 62% of the crop. Slightly better preservation of plants with sunflower precursor was observed on the variant with $N_{90}P_{60}K_{60}$. At the same time, preservation of spring barley plants for the period of slope ripening was 257 pcs/M2, and survival rate was 64.3%.

Thus, the best conditions for preservation of spring barley plants in the sowing in the phase of slope ripeness are noted when mineral fertilizers in the dose of $N_{90}P_{60}K_{60}$ are applied. There is also a marked advantage of winter rape as a precursor for spring barley compared with corn or sunflower.

During the growing season of spring barley, we carried out phenological observations of the onset of the main phases: sprouting, tillering, emerging into the tube, earing, and full ripeness. Passage of these stages depends on environmental conditions. It is known that there are regularities and interrelation between development phases, stages of organogenesis and formation of productivity elements.

During the studies it was found that the period of sowing - full sprouts did not practically differ depending on the predecessor and levels of mineral nutrition and amounted to 10-11 days (Table 3).

Table 3

Duration of interphase periods of spring barley depending on Doses of mineral fertilizers and the influence of the fore crop, days (Average for 2019-2020).

Predecessor	Level of mineral nutrition	Sowing -full sprouts	Vegetation periods				
			Ladder tillering	tillering - coming out of the tube	appearing in the tube - earing	earing - full ripeness	full sprouting - maturing
Winter rape	No fertilizer	11	12	18	27	31	88
	$N_{60}P_{60}K_{60}$	10	13	19	28	32	92
	$N_{90}P_{60}K_{60}$	10	14	19	28	33	94
Corn (for the grain)	No fertilizer	11	12	18	26	30	86
	$N_{60}P_{60}K_{60}$	10	13	19	27	31	90
	$N_{90}P_{60}K_{60}$	10	14	19	27	32	92
Sunflower	No fertilizer	11	12	18	24	29	83
	$N_{60}P_{60}K_{60}$	10	13	19	25	30	87
	$N_{90}P_{60}K_{60}$	10	14	19	25	31	89

The process of tillering to a large extent depends on environmental factors and is regulated by elements of the technology of cultivation. In our case, it was noted that the greatest influence on the duration of the interphase periods had equal mineral nutrition. So, the period "seedlings - tillering" on the variant without fertilizer lasted 12 days, at application of $N_{60}P_{60}K_{60}$ - 13

days, and at application of $N_{90}P_{60}K_{60}$ - 14 days regardless of a preceding.

Duration of the interphase period "tillering - exiting a tube" for the variant without mineral fertilizers, after any predecessor was 18 days. Application of mineral fertilizers during pre-sowing cultivation prolonged this period by 1 day, which was 19 days.

It is known that favorable conditions for plant life somewhat lengthen the interphase periods. In our case, the best conditions were formed after winter rape, as a predecessor, then went corn on grain, and at the end of sunflower.

It was noted that spring barley sown with winter rape as a predecessor the duration of the period "heading - earing" was 27 days in the version without fertilization and 28 days with the addition of mineral fertilization.

When using corn as a predecessor of spring barley the duration of the period "earing - earing" on the non-fertilized variant was 26 days. Application of full mineral fertilizer prolonged this period to 29 days.

On the variant without fertilizers the duration of the period "emerging into the tube - earing" with sunflower predecessor was 24 days and with the fertilizers - 25 days.

The study found that the duration of the period "earing - full ripeness" depended on both the fore crop and the level of mineral nutrition.

Thus, this period was 31-33 days in the variant with rape. The duration of the period "earing - full ripeness" depending on the fertilizer was 30-32 days. The shortest this period was with the sunflower fore crop and amounted to 29-31 days.

Taking into consideration the above-mentioned periods of the plant's growth and development the duration of the period "shoots - ripening" for the spring barley which was grown after the winter rape was 88 days - for the variant without fertilization, 92 days - with the application of $N_{60}P_{60}K_{60}$, and 94 days - with the application of $N_{90}P_{60}K_{60}$.

At the variant with corn and without mineral fertilizers spring barley had the period "full sprouting - ripening" duration of 86 days, when $N_{60}P_{60}K_{60}$ was used - 90 days, when increasing the nitrogen dose to 90 kg a.d. on phosphorus-potassium background - 92 days.

The use of sunflower as a preceding event for spring barley resulted in the fact that the period "full sprouting-ripening" was 83 days in the variant without fertilizers. The application of 60 and 90 kg a.d. nitrogen on the phosphorus-potassium background ($P_{60}K_{60}$) prolonged this period to 87 and 89 days, respectively.

Thus, the role of the precursor and mineral fertilizers in the duration of the growth and development phases was noted. Optimization of conditions of spring barley slightly prolonged the phase, in turn, positively influenced the yield.

A characteristic indicator of growth processes that affects the formation of spring barley yield is its height. Stem growth in spring barley plants takes place mainly in the lower part of the internode, where the young tissue is located, protected by the base of the leaf sheath. Stem elongation usually ends after the phase of complete plant vicoloshuvannya. Stem height in spring barley is a genetic property of the variety, but is subject to particularly wide variation under the influence of growing conditions. When there is a lack of moisture, the spikelet does not fully emerge from the sheath of the upper leaf. It is the length of the upper internode that is an important indicator of the plant's moisture supply during flowering and at the beginning of grain formation.

It is known that during the growing season the height of spring barley plants increases irregularly. For example, plants have almost the same height during tillering and emergence phase. This can be explained by the growth of plant mass to a greater extent, and in the late phases of earing and flowering there is an intensive growth of plants in height. The cessation of growth processes occurs in the phase of lactiferous ripeness, as all the plastic substances are directed to the filling of the seeds.

Our research revealed that the height of spring barley plants from the phase of full sprouts to full maturity constantly increased and depended on both the levels of mineral nutrition and on the cover crop.

It was noted that in the phase of tillering the height of barley plants varied insignificantly and amounted to 5-6 cm in the whole experiment (Table 4). A more significant difference in the height of barley plants was manifested in the phase of spring barley emergence into the tube. Thus, when growing after winter rape, the height of spring barley was 9-11 cm, after corn - 8-10 cm, and after sunflower also 8-10 cm.

Table 4.

Effect of fore crop and mineral fertilizers on the height of spring barley plants, cm, (average for 2019-2020)

Predecessor	Level of mineral nutrition	Growth and development phases of spring barley plants			
		tillering	ear emergence	earing	full maturity
Winter rape	No fertilizer	5	9	31	55
	$N_{60}P_{60}K_{60}$	5	10	38	62
	$N_{90}P_{60}K_{60}$	6	11	47	66
Corn (for the grain)	No fertilizer	5	8	30	52
	$N_{60}P_{60}K_{60}$	5	9	37	57
	$N_{90}P_{60}K_{60}$	6	10	45	64
Sunflower	No fertilizer	5	8	28	50
	$N_{60}P_{60}K_{60}$	5	9	35	55
	$N_{90}P_{60}K_{60}$	6	10	43	63

A more significant difference in the height of spring barley plants was observed in the earing phase. So, on the variant without fertilizers barley plants height was 31 cm - after winter rape, 30 cm - after corn and 28 cm after sunflower.

Application of N_{60} before sowing on the background of $P_{60}K_{60}$ provided the height of spring barley plants in the heading stage at 38 cm after rape, 37 cm after maize and 35 cm after sunflower.

Application of $N_{90}P_{60}K_{60}$ contributed to intensive growth of plants in height. The barley with rape was at the phase of earing the height of 47 cm, with maize - 45 cm and with sunflower - 43 cm.

The last measurements of plant height indicators we conducted in the phase of full ripeness. It was noted that the height of barley on the variant with winter rape as a precursor was 55 cm - in the variant without fertilization, 62 cm - when $N_{60}P_{60}K_{60}$ was applied, and 66 cm - when $N_{90}P_{60}K_{60}$ was used.

When using corn as a fore crop for barley the height of the latter's plants in the phase of full maturity was 52 cm without fertilizer. The application of 60 kg a.i. on phosphorus-potassium background increased the height of spring barley plants to 57 cm, whereas the application of 90 kg a.i. - to 64 cm.

Cultivation of spring barley after sunflower and on the variant without fertilizers allowed to get the height of plants in the phase of full ripeness at the level of 50 cm. The application of mineral fertilizers in the rate of $N_{60}P_{60}K_{60}$ allowed to increase the height parameters to 55 cm, whereas $N_{90}P_{60}K_{60}$ - to 63 cm.

One of the important indicators characterizing the rate of growth and development of plants at different stages of ontogenesis is the average daily linear growth. They clearly characterize the intensity of plant growth, in particular spring barley. To calculate it, we took the indices of height in one or another phase and divided by the number of days of its passage. Thus, the indices of linear growth of spring barley by phase and for the whole vegetation period were determined.

In the tillering phase average daily linear growth of spring barley was 0.38 - 0.43 cm a day depending on the levels of mineral nutrition (Table 5).

Table 5

Effect of intensification factors on indicators of average daily linear growth of spring barley plants, cm / day,(Average for 2019-2020).

Predecessor	Level of mineral nutrition	Average daily growth in the phase (cm / day)			
		tillering	ear emergence	earing	full maturity
Winter rape	No fertilizer	0,42	0,50	1,00	0,63
	$N_{60}P_{60}K_{60}$	0,38	0,53	1,19	0,67
	$N_{90}P_{60}K_{60}$	0,43	0,58	1,42	0,70
Corn (for the grain)	No fertilizer	0,42	0,44	1,00	0,60
	$N_{60}P_{60}K_{60}$	0,38	0,47	1,19	0,63
	$N_{90}P_{60}K_{60}$	0,43	0,53	1,41	0,70
Sunflower	No fertilizer	0,42	0,44	0,97	0,60
	$N_{60}P_{60}K_{60}$	0,38	0,47	1,17	0,63
	$N_{90}P_{60}K_{60}$	0,43	0,53	1,39	0,71

Somewhat higher values of average daily growth were noted in the phase of the emergence of the tube. Thus, with winter rape on the fore crop without fertilizers it was 0,50 m per day, with $N_{60}P_{60}K_{60}$ - 0,53 cm / day, and with $N_{90}P_{60}K_{60}$ - 0,58 cm / day.

Indicators of average daily linear growth of spring barley in the phase of exiting a tube that for the fore crop of sunflower, corn were the same and amounted to 0.44 cm / day - to the variant without fertilizers, 0.47 cm / day - when applying $N_{60}P_{60}K_{60}$ and 0.53 cm / day - with the use of $N_{90}P_{60}K_{60}$.

Barley plants showed intensive growth in height in the earing phase, which is associated with the physiological characteristics of the plant. Excluding the effect of the fore crop, the average daily linear growth was 0,97-1,0 cm / day, when using $N_{60}P_{60}K_{60}$ - 1,17-1,19 cm / day. Whereas application of mineral fertilizers in the rate of $N_{90}P_{60}K_{60}$ increased linear growth of spring barley plants in the heading stage up to 1.39-1.42 cm / day.

If we pay attention to the average daily linear growth of spring barley plants from the phase of complete sprouting to the phase of full ripeness (average daily growth during the growing season), we can see a significant influence of the levels of mineral nutrition on the process of growth in height. The lowest rate of growth was on the version without fertilizers and amounted to 0.60-0.63 cm / day, at application of $N_{60}P_{60}K_{60}$ - they were in the range of 0.63-0.67 cm / day. The highest rates of average daily linear growth were noted at the application of mineral nutrition in the rate of $N_{90}P_{60}K_{60}$, and depending on the precursor, they were 0.70-0.71 cm / day.

Thus, the positive role of mineral fertilizers, including nitrogen fertilizers in the formation of high growth from the phase of plants in the tube until the phase of harvesting ripeness.

Conclusions: The best conditions for keeping the spring barley plants in sowing in the phase of skinny ripeness are observed under the condition of introducing mineral fertilizers in the dosage of $N_{90}P_{60}K_{60}$ during pre-sowing cultivation and when growing after the winter rape. Under these conditions, the density of plants at harvesting ripeness was 275 pcs/M2, and survival rate was 68,8%.

Duration of the period "complete shoots - ripening" for the spring barley which was grown after the winter rape was 88 days - for the variant without fertilization, 92 days - with the application of $N_{60}P_{60}K_{60}$, and 94 days - with the application of $N_{90}P_{60}K_{60}$.

The application of N_{60} before sowing on phosphorus-potassium background ($P_{60}K_{60}$) provided the height

of summer barley plants in the heading stage at 38 cm after rape, 37 cm after maize and 35 cm after sunflower.

The lowest rate of spring barley average daily growth during the whole vegetation period was in the control without fertilization - 0,60-0,63 cm / day; after application of $N_{60}P_{60}K_{60}$ it was in the range of 0.63-0,67 cm / day. Whereas the highest rates of average daily linear growth were observed upon application of $N_{90}P_{60}K_{60}$ in preplant cultivation, and depending on the precursor they were 0,70-0,71 cm / day.

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