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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабаршысы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабаршысының Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді мультидисциплинарлы контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Вестник НАН РК» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Вестника НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному мультидисциплинарному контенту для нашего сообщества.

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STUDYING OF THE PHENOMENON OF PRE-HARVEST SPROUTING OF WHEAT GRAIN

Abstract. Pre-harvest sprouting (PHS) – the widespread phenomenon resulting in inferiority of grain, to decrease in its consumer qualities and respectively the prices. PHS occurs not only during the harvesting, being accompanied rains, but also in maturing of grain of cereals at the last stages of maturing. It is well known that the germination of wheat seeds is largely dependent on the wheat cultivars, the effect of molybdenum-treatment on the germination resistance has not been fully studied. We therefore focused our attention on the role of molybdenum, expecting that one possible factor responsible for the difference in germination resistance of different wheat cultivars is the presence of molybdenum in wheat seeds.

The results of our investigation indicate a direct correlation between the molybdenum content, the endogenous level of ABA and the activity of grain wheat α- amylase. It is shown that when processing wheat with a solution of molybdenum of both varieties, resistance to pre-harvest germination (PHS) was increased. Leaf spraying with a solution of molybdenum, both a resistant and a sensitive wheat cultivars to PHS, showed an increase in the endogenous content of Mo and ABA in wheat grain. However, the stable cultivar of wheat Lutescens-70 - contained 1.4 times Mo and the level of ABA in 1.8 times higher, compared to the unstable variety of wheat Novosibirskaya-67. It has also been shown that, in the treatment of Mo, α-amylase activity decreased in 5 times compared to the control variant. In this paper, we showed how tungsten (W), which competes with Mo, and can be incorporated into the molecule of the aldehyde oxidase enzyme, inactivating it. Therefore, the treatment of wheat with tungsten, led to a decrease in the endogenous content of Mo and ABA.

Key words: wheat, ABA, molybdenum, tungsten, α-amylase, pre-harvest germination.

ABA is a plant growth regulator involved in various processes, including the reaction of plants to environmental stress, seed maturation and seed dormancy [1]. In cereal crops, an optimum balance is most sought after; some dormancy at harvest is favored because it prevents germination of the physiologically mature grain in the head prior to harvest (that is pre-harvest sprouting (PHS), a phenomenon that leads to considerable damage to grain quality and is especially prominent in cool moist environments. ABA regulates key events during seed formation, such as the deposition of storage reserves, prevention of precocious germination, acquisition of desiccation tolerance, and induction of primary dormancy **[**2].

In nature, the grain germinates when the seed is considerably saturated with moisture and the dormancy process is disrupted. According to Bewley et.al. [3], the PHS appears in the absence of rest in particular, the germination is manifested at a temperature above 12 °C, under these conditions, the grain is in a state of "relative dormancy". The level of "rest" is controlled by environmental factors during the development of grain, especially temperature. Development and maturation of grain at 20-25 °C leads to a low level of "dormancy state" and is therefore considered highly sensitive to germination in the ear of the mother plant.

Embryonic regulators FUS3 and LEC2, which regulate many processes during the maturation of the seed (for example, repression during the 'post' period of seed germination and activation of the reserve protein genes of the grains), also involved in the control of biosynthesis of the GA. In the Arabidopsis mutants, the pathway of the GA that is defective in these genes (fus3 and lec2) becomes unregulated, which leads to an altered phenotype (for example, to the cellular formation of trichomes regulated by the GA process. FUS3 protein, represses the expression of the gene encoding the enzyme of the biosynthesis of HA. Repression of the AtGAox2 gene, the FUS3 protein, primarily occurs in the epidermal cells of the axis of the embryo, which differs from the expression of this gene during germination [4, 5].

In higher plants ABA is derived from an epoxy-carotenoid precursor that is oxidatively cleaved to produce xanthoxin [6, 7]. Following the cleavage reaction, xanthoxin is converted to ABA by a series of ring modifications to yield abscisic aldehyde, which is oxidized to ABA by aldehyde oxidase – AO (EC 1.2.3.14), a molybdenum containing enzyme [8].

Much attention is recently been focused on plant AO because of its involvement in the biosynthesis of ABA, a phytohormone which plays important roles in adaptation processes of plants to the environmental stresses and more importantly in the prevention of pre-harvest sprouting of seeds, in particular. AO in barely dry seeds is localized almost exclusively in the embryo and is related to ABA production in the dormant embryo [9].

Molybdenum is an essential component of the molybdenum cofactor (Moco), which enters the active center of most Mo-enzymes in plants [10]. Only four molybdenum-containing enzymes are found in plants, it is nitrate reductase (NR), aldehyde oxidase (AO), xanthine dehydrogenase (KDG) and sulfide oxidase (SO). AO catalyzes the oxidation of indole acetate aldehyde to indol-3-acetic acid (IAA) and abscisic aldehyde to ABA [11]. Mutations in either the apoprotein AO or enzymes involved in the biosynthesis of Mo-co and the activation of Mo-co are interrupted by the bioconversion of ABA[12]. A low level of ABA leads to the emergence of weak plants with intensive transpiration, with reduced stomatal control, reduced seed quiescence, weakened protective responses to adverse environmental factors [13].

Not so long ago, the molybdenum transporter MOT1, which plays an important role in the effective uptake of Mo by plants from the soil, was identified. It was shown that MOT1 is localized in cell membranes and exhibits a high affinity for plasma and mitochondrial membranes. Japanese scientists Yoko Ide et al. [14] conducted a study of the global effect of Mo and its deficiency and mutations in molybdate transporter (MOT1) on gene expression and on nitrogen and sulfate metabolism in Arabidopsis thaliana. Transcriptive analysis showed that the transcriptional level of nitrate reductase NR1 was highly induced with a deficit of Mo in mot1-1. The levels of amino acids, sugars, organic acids and purine metabolites have been significantly altered in plants with deficiency of Mo [15].

One of characteristics of grain germination in an ear, on a mother plant, is activity increase of hydrolyses, especially α-amylase which is often found even before manifestation of external signs of germination. Superfluous α-amylase activity of the sprouting grain leading to change of a carbohydrate complex, is the major damaging factor leading to sharp germination owing to what baking properties of grain decrease. the last researches showed genetic dependence of stability of grain to PHS in the course of its storage [16]. Existence of genetically various forms of α-amylase assumes their various regulation. So, for example, α-amylase late maturing (LMA) it is supervised by certain genes which are available not for all cultivars of wheat. Other forms α-амилазы α-amy 1 and α-amy 2 are characteristic for all genotypes of wheat [17]. Extent of their manifestation and influence on quality of grain depends on a ratio in grain of phytohormones ABA and GA [18].

The Republic of Kazakhstan belongs to the world leaders in the production of grain, while Kazakhstan grain is superior in quality to many world analogues. However, for all produced grain, the effect of germination on the root is inherent. Losses in quality of a crop in separate years reach 30-50% from a total gathering. The available statistics show that from the germination of Canada and Australia almost annually lose about 100 million US dollars for every 2 million tons of grain. Unfortunately, for our republic this kind of statistics is not available, although the losses from this phenomenon in the baking properties of wheat grain in Kazakhstan in different years reached almost 50% of the harvested crop.

It is well known that the germination of wheat seeds is largely dependent on the wheat cultivars, the effect of molybdenum-treatment on the germination resistance has not been fully studied. We therefore focused our attention on the role of molybdenum, expecting that one possible factor responsible for the difference in germination resistance of different wheat cultivars is the presence of molybdenum in wheat seeds.

Soil molybdenum availability to plants is affected by soil pH, becoming less available with decreasing pH. On the other hand, independently of pH, some lands are barren for lack of molybdenum in soil.

Deficiency and suboptimal levels of molybdenum could thus be expected to occur widely [19]. According to the data of the Institute for Soil Research of the Kazakh Academy of Sciences most soils of Kazakhstan contain 8-12 times less molybdenum than the critical concentrations required for vigorous plant development.

Materials and methods

Plant material. Two wheat cultivars, ***Lutescence-70*** and ***Novosibirskaya-67,*** differing in dormancy levels were used in our experiments were studied. Wheat seeds of different cultivars were obtained from the A.I. Baraev Kazakh Scientific-Re-search Institute of Grain Farming in Shortandy (Republic of Kazakhstan) in 2016. Wheat seeds was pre-germinated in incubator at

20 ^{o}C and planted in free-draining, 11-cm-diameter pots filled with quartz sand which had been acid washed. Plants were irrigated daily with a modified, molybdenum-deficient, Hoagland nutrient solution as described earlier by Cairns et al [20]. Plants at the flag leaf stage were treated with a 100 µM foliar spray of molybdenum applied as sodium molybdate ($Na_2MoO_4 \cdot 2H_2O$).

Individual ears were tagged at anthesis and harvested 60 days thereafter. The moisture content at this stage were approximately 16% and 20% for Lutescence-70 and Novosibirskaia-67, respectively. The seeds were subsequently stored at 5^{o}C for 7 days which brought the moisture content down to approximately 13% and 15%, respectively. The uniform seeds from the central part of each spike were harvested by hand when ripe. Thereafter the seeds were stored at –70^{o}C until needed for the various determinations. This procedure ensures that the dormancy level at harvest is maintained for at least 12 months.

For ABA determination the samples were thawed and the analyses were carried out on the embryo-half of each grain in order to avoid the dilution effect on ABA caused by the endosperm. Samples were milled and 50 mg of dry flour was extracted with water. ABA determination was performed according to [21] and the results were expressed as ng ABA per g of dry weight (DW).

The molybdenum content was determined with an atomic absorption spectrophotometer AAS-IN (Karl Zeiss, Germany). Molybdenum was extracted by the method of dry and humid mineralization from the plant material. Dry and wet mineralization were carried out by the following procedure: (a) Dry mineralization. Seeds were dried at 80^{o}C and then burned at 400^{o}C in an oven. The resulting ashes were suspended in concentrated HNO_3. The content of molybdenum in the supernatant after centrifugation in glass tubes was determined with a AAS-IN. (b) Humid mineralization. A fresh plant samples were mixed with concentrated HNO_3 and the mixture was heated in ceramic dishes under an air stream. Heating decreases the volume of the extract by evaporation: 50 ml was concentrated to 5 ml. This was then mixed again with concentrated HNO_3, centrifuged, and the content of molybdenum was determined in supernatant. Both procedures showed comparable results in molybdenum content.

AO activity was assayed monitoring the change of absorbance at 600 nm of the electron donor 2,6-dichloroindophenol (DCIP) [22]. Absorbance of enzyme products were measured using the spectrophotometer «Jenway». Seed parts part extracts were gel-filtered through the Sephadex G-25 enzyme activity determination. In addition, AO activity was detected following native polyacrylamide gels. The gels were immersed after electrophoresis in 100 mM sodium phosphate buffer (pH = 7.5) for 10 min followed by gentle shaking in a reaction mixture containing 0.1 mM phenasine metasulfate, 1 mM 3(4,5-dimethylthiazo-lyl-2)2,5-diphenyltetrazolium-bromide (MTT) and 1 mM indole-3-aldehyde [23].

Results and discussion

As mentioned above, tungsten as a chemical analog competes with molybdenum for incorporation into the enzyme complex and results in enzyme inactivation, particularly in the inactivation of aldehyde oxidase. The inactivation of nitrate reductase by tungstate was generally correlated with an accumulation of nitrate in plant tissues, implying that in vivo nitrate reduction really is affected. In this work we show that the substitution of tungsten for molybdenum decreases PHS-tolerance in wheat seeds.

In a pilot trial conducted in washed Mo-deficient sand with PHS-tolerant and sensitive wheat cultivars, a 100 µM molybdenum application at the flag leaf stage resulted in a more than 5.5 fold reduction in the number of seeds germinating in Lutescence-70 and 1.5 fold in ***Novosibirskyia-67*** over 10 day period (table 1). Application of tungsten to flag leaves sharply increased percent of seed germination in ***Lutescence-70*** while in ***Novosibirskaya-67*** application of tungsten increased it only slightly.

Table 1 – The effect of foliar applications of molybdenum and tungsten on germinability of the seeds in Lutescence-70 and Novosibirskaya-67

Treatment	Germination,%
Lutescence-70	
Control*	22-24
– Molybdenum**	36-38
+ Molybdenum***	7-9
+ Tungsten****	52-54
Novosybirskaya-67	
Control	55-60
– Molybdenum	65-67
+ Molybdenum	46-48
+ Tungsten	67-72

*Seeds from plants grown in natural Kazakh soil without foliar application of molybdenum or tungsten.
**Seeds from plants grown in Mo-deficient sand and without foliar Mo-application.
***Seeds from plants were grown in Mo-deficient sand and at flowering stage their flag leaves were sprayed with molybdenum.
****Seeds from plants were grown in Mo-deficient sand and at flowering stage their flag leaves were sprayed with tungsten.

Following this investigation the effect of molybdenum and tungsten on time course changes in seed germination of two wheat cultivars differing in PHS levels was studied. Germination of two cultivars Lutescence-70 and Novosybirskaya-67 over a 10 days period are shown in table 2.

Seeds from the Mo-treated plants of the PHS-tolerant Lutescence-70 cultivar sowed very low germination percent and had to be treated with 100 µM gibberellic acid (GA_3) before germination occurred. Even with this GA_3 treatment there was a significant difference in the dormancy between the seeds from Mo-deficient and Mo-treated plants (table 2). In the case of PHS-sensitive Novosibirskaia-67 there was also a considerable difference in the germination of seeds from Mo-deficient and the Mo-treated plants during the initial stages of the germination test but the final germination percentages did not differ significantly (table 2).

Table 2 – Time course changes in seed germination (%) of Lutescence-70 and Novosibirskaya-67 after foliar application of molybdenum or tungsten.

Cultivar/Treatment	Days seed germination				
	2	4	6	8	10
Lutescence-70					
– Molybdenum*	9	13	18	25	37
+ Molybdenum**	2	2	3	5	8
+ Molybdenum** + GA_3	55	63	70	83	90
+ Tungsten***	13	18	23	34	36
Novosybirskaya-67					
– Molybdenum	45	52	57	63	66
+ Molybdenum	43	44	46	58	62
+ Molybdenum + GA_3	55	65	70	82	86
+ Tungsten	45	57	62	65	69

*Seeds from plants grown in Mo-deficient sand and without foliar Mo-application.
**Seeds from plants were grown in Mo-deficient sand and at flowering stage their flag leaves were sprayed with molybdenum.
***Seeds from plants were grown in Mo-deficient sand and at flowering stage their flag leaves were sprayed with tungsten.

Seed ABA levels from molybdenum and tungsten sprayed plants and controls were monitored in seeds of both PHS-tolerant and sensitive cultivars (table 3). Foliar application of tungsten (100 μM) induced a decrease of aldehyde oxidase because of its involvement in the biosynthesis of ABA and to accordingly the endogenous content of ABA in the seeds are sharply decreased in both wheat cultivas . After 15 days of treatment, aldehyde oxidase activity had already decreased to 45% of the control and it continued to decline to low level (15% of the control). The decrease in aldehyde oxidase activity was accompanied by a drop in the amount of ABA.

Table 3 – Effect of foliar molybdenum or tungsten application on the molybdenum and ABA content in the seeds of Lutescence-70 and Novosibirskaia-67

Concentrations of applied Molybdenum or tungsten	Molybdenum content (μg/L)	ABA content (ng/mg DW)
Lutescence-70		
Mo-deficient	30 ± 7	0.30 ± 0.07
+ 25 μM molybdate	240 ± 55	0.45 ± 0.12
+ 50 μM molybdate	280 ± 85	0.53 ± 0.17
+ 100 μM molybdate	315 ± 75	0.65 ± 0.10
+ 100 μM tungstate	12 ± 3	0.20 ± 0.10
+ 200 μM tungstate	10 ± 2.5	0.20 ± 0.07
+ 300 μM tungstate	10 ± 2	0.15 ± 0.05
	Novosibirskaya-67	
Mo-deficient	25 ± 4	0.14 ± 0.02
+ 100 μM molybdate	225 ± 65	0.35 ± 0.02
+ 200 μM molybdate	255 ± 70	0.43 ± 0.04
+ 300 μM molybdate	285 ± 90	0.54 ± 0.07
+ 100 μM tungstate	10 ± 2	0.10 ± 0.02
+ 200 μM tungstate	8 ± 3	0.08 ± 0.02
+ 300 μM tungstate	9 ± 2	0.10 ± 0.03

Germination and ABA content of the seeds harvested from plants which had been sprayed at flag leaf stage with various concentrations show clearly that increasing molybdenum concentrations to decrease seed germinability. The decrease in seed germinability was linear over the concentration range of molybdenum applied whereas the ABA level was little affected by molybdate concentrations up to 100 μM. At higher than this concentration (up to 300 μM) there was a sharp increase in seed ABA level (table 3).

Presented data on figure 1, show the endogenous content ABA and molybdenum in PHS-resistant grain wheat. The molybdenum content of the seeds harvested from plants had been sprayed at flag leaf stage with various concentrations show clearly that increasing the endogenous content ABA. The decrease in seed germinability was linear over the concentrations up to 100 μM. At higher than this concentration (up to 300 μM0 there was a sharp increase in seed ABA level.

On the figure 2 are presented data of the endogenous content of ABA and Mo in PHS sensitive wheat grain to PHS. In the case of PHS-sensitive Novosibirskaya-67 there was also a considerable difference in the germination of seeds from Mo-deficient and the Mo-treated plants during the initial stages of the germination test but the final germination percentages did not differ significantly (table 2). Our further studies on the regulation of germination processes on two different genotypes of wheat showed a direct correlation between the endogenous contents of phytohormone ABA, the enzyme AO, and the endogenous content of molybdenum. The ABA level was both analyzed in the seeds treated with molybdenum experimental variants and in the control. The presented data (figures 1 and 2) show that the content of endogenous ABA in the Lutescens 70 grains is higher than that of the wheat-sensitive wheat variety Novosibirskaya 67. The processing of plants with different concentrations of Mo led to an increase in the level of endogenous Mo and ABA in the grains of both varieties.

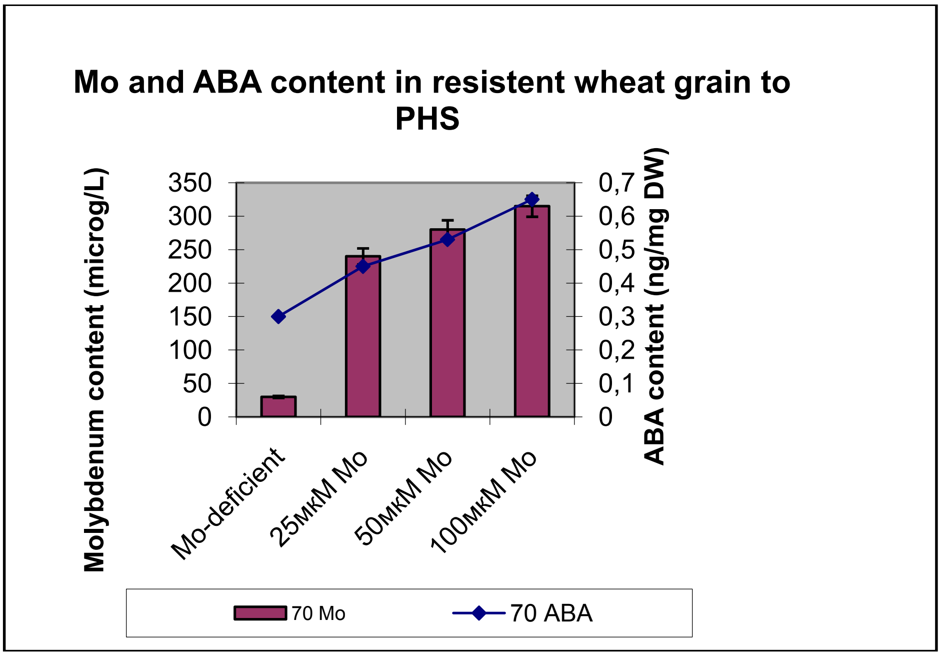

Figure 1 – The content of Mo and ABA in grain of PHS resistant wheat Lutescens-70

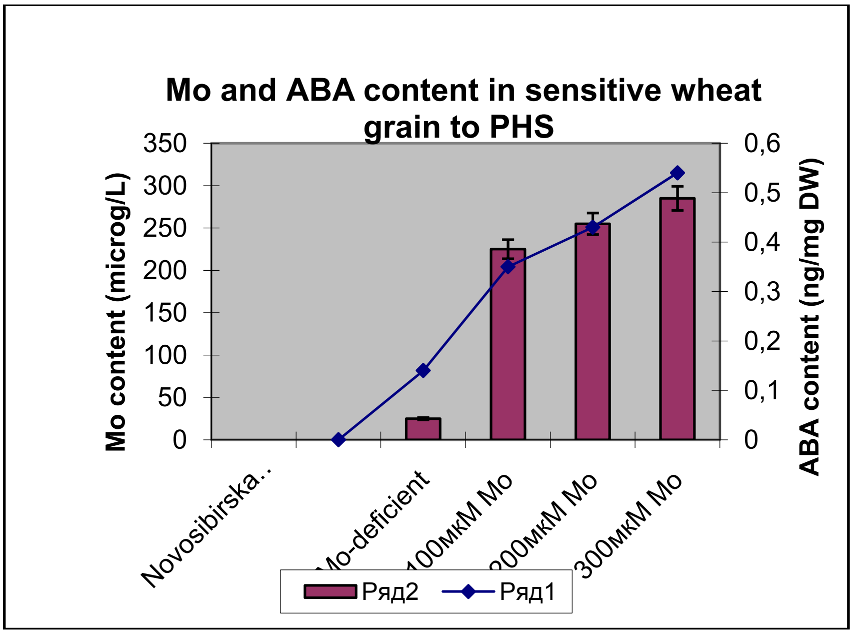

Figure 2 – The endogenous content of Mo and ABA in grain of PHS in sensitive wheat grain Novosibirskaya 67

Wheat seeds directly showed that an increase in Mo concentration leads to increase the endogenous content of ABA in seed Tungsten, a metal classified with Cr and Mo in the Periodic Table, can compete with molybdenum for incorporation into the enzyme complex and results in enzyme inactivation [24] In this work we show that how the substitution of tungsten for molybdenum effects on PHS-tolerance in wheat seeds. On the figure 3 are presented data the effect of tungstate on both endogenous Mo and ABA content in wheat grain. Foliar application of tungsten (100 µM) induced a decrease of aldehyde oxidase and content of ABA in the seeds. After 15 days of treatment, aldehyde oxidase activity had already decreased to 45% of the control and it continued to decline to low level (15% of the control). The decrease in aldehyde oxidase activity was accompanied by a drop in the amount of ABA.

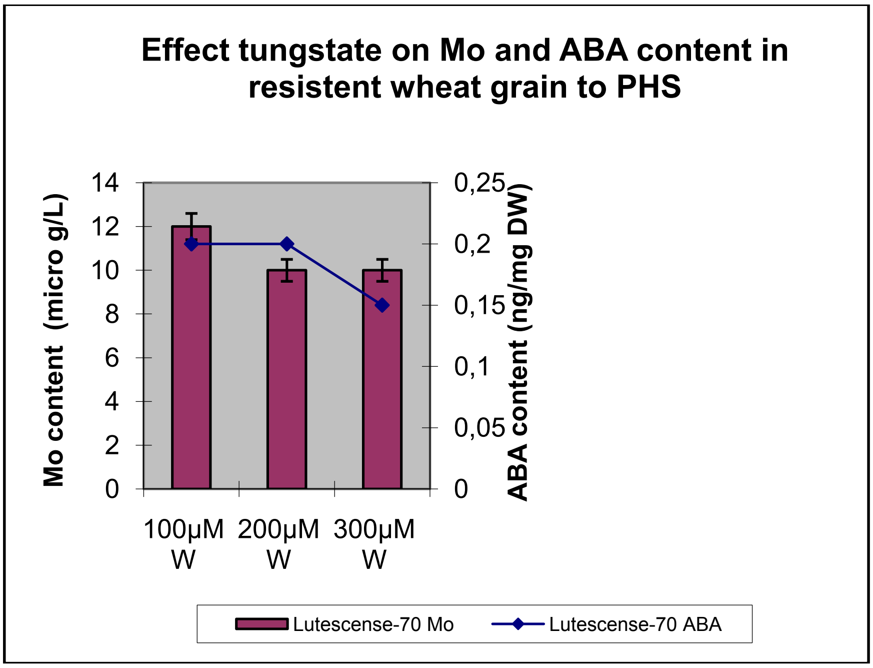

Figure 3 – The effect of tungstate on Mo and ABA content in grain of PHS resistant wheat Lutescens-70

In the process of germination of cereal crops seeds, such as barley, wheat, embryo of wheat synthesizes and secrete another phytohormone - gibberellin (GA), which causes transcription of amylase and protease. The expression of the amylase gene represses ABA during seed ripening or under unfavorable germination conditions.

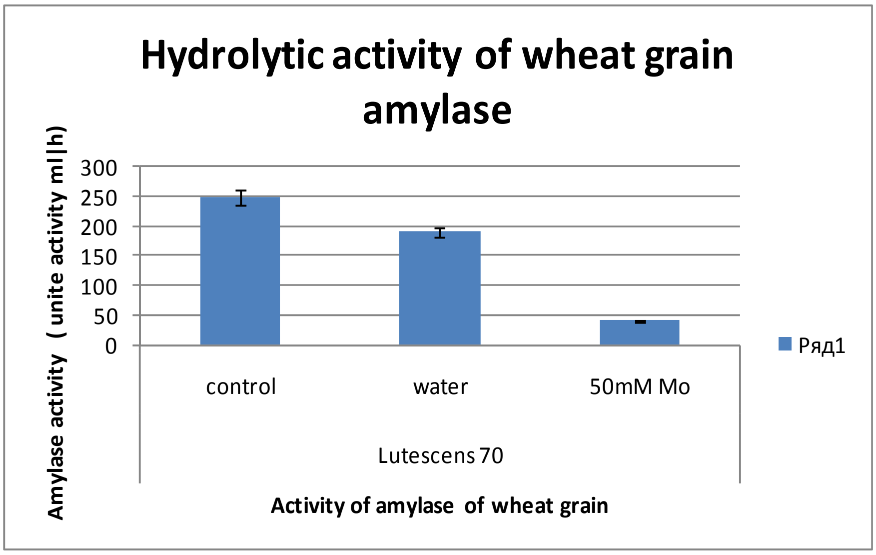

Figure 4 – The effect of Mo on the α-amylase activity

It is well known that the level of amylase activity directly correlates with the rate of germination. Our experiments on the treatment of seeds with a solution of molybdenum showed that the amylase activity decreased almost 5-fold on trial with control in the grain of wheat of the Lutescens 70 variety (figure 4). In a number of studies, it was found that the addition of Mo in physiological concentrations to developing embryos of some cereal species led to the prevention of premature germination through the blocking of the expression of specific germination enzymes [4]. These results showed that the endogenous content of Mo and ABA can play an important role in establishing and maintaining a state of rest in seeds. Mo is an important component of the molybdenum cofactor (MoCo), which is in the active center of most Mo-containing enzymes in plants [8-10].

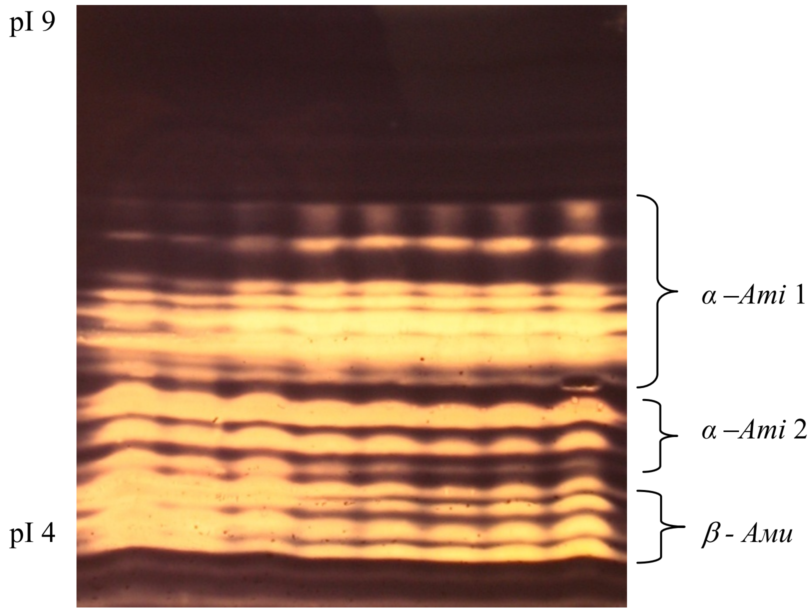

Figure 5 – Isofocusing of amylases from germinating grains of wheat α- Ami 1- α-amilase of germination;
α- Ami 1- α-amilase of maturation; *β - Ами* - β-amilase

It is known that premature germination, characteristic of many grain crops, including wheat, leads to a deterioration of the technological quality of the grain. At the biochemical level, this is due to the rapid activation of certain hydrolytic enzymes, primarily amylases, which break down the starch of the endosperm. At the same time among amylolysis enzymes leading role in the hydrolysis of the polysaccharide is given to α-amylase "germination". Figure 5 presents a typical IEF spectrum of amylolytic enzymes of germinating wheat grains

The results of our investigation indicate a direct correlation between the molybdenum content, the endogenous level of ABA and the activity of amylase, the main enzyme of seed germination. The results of this study clearly show that molybdenum applied as a foliar application increased the dormancy of both PHS-tolerant and sensitive wheat varieties. Although the evidence is still somewhat tenuous it would appear that the dormancy induction by molybdenum is mediated by an increase in levels of ABA. These results are in agreement with the findings of Farwell et al. [25] who found that foliar applications of the micronutrient increased dormancy in wheat in both controlled environment and field trials.

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БИДАЙ ДӘННІҢ ЖИНАУ АЛДЫНДАҒЫ ӨНУІҢ ТОҚТАТУДІҢ ЗЕРТТЕУ

Жинау алдындағы өну (ЖАӨ) – дәннің сапасын төмендетіп, оның тұтыну қасиеттері мен соған сәйкес бағасын түсіретін кең тараған құбылыс. ЖАӨ **өнімді** жауын астында жинау кезінде ғана емес, сонымен қатар, астық тұқымдастардың дәндерінің пісіп-жетілуінің соңғы кезеңдерінде де орын алады. Бидайдың дәнінің өнуі көбінесе бидайдың сортына байланысты болатыны жақсы белгілі, бірақ молибденмен өңдеудің дәндердің өнуге төзімділігіне тигізетін әсері жеткілікті зерттелмеген. Сондықтан, бидай дәндерінде молибденнің болуы – бидайдың әртүрлі сорттарының дәндерінің ЖАӨ-ге төзімділігінің арасындағы айырмашылықтарды анықтайтын факторлардың бірі болуы мүмкін деген болжаммен біз молибденнің роліне назар аудардық.

Зерттеулердің нәтижелері дәндегі молибденнің мөлшері мен эндогенді АБҚ-ның мөлшерінің және а-амилазаның белсенділігінің арасындағы тіке корреляцияны көрсетті. Бидайдың екі сорттарын молибденмен өңдегенде олардың жинау алдындағы өнуіне (ЖАӨ) төзімділігі жоғарылайтыны көрсетілді. Бидайдың ЖАӨ-ге төзімді, сол сияқты оған сезімтал сорттарының жапырақтарына молибденнің ерітіндісін бүріккенде дәннің ішіндегі молибденнің және АБҚ-ның мөлшерінің жоғарылайтыны анықталды. Бірақ, бидайдың сезімтал Новосибирская-67 сортымен салыстырғанда төзімді Лютесценс-70 сортында Мо 1.4 есе және АБҚ-ның деңгейі 1.8 есе жоғарылады. Сонымен қатар, бақылау вариантымен салыстырғанда молибденмен өңдегенде а-амилазаның белсенділігі 5 есе жоғары болатыны анықталды.

Ұсынылып отырған жұмыста молибденнің химиялық аналогы – вольфрам (W) альдегидоксидазаның құрамына кіріп, оны белсенділігінен айыратынын көрсеттік. Сондықтан, бидайды вольфраммен өңдеу эндогендік Мо мен АБҚ-ның мөлшері төмендеуіне алып келді.

Түйін сөздер: бидай, АБҚ, молибден, вольфрам, а-амилаза, жинау алдында өну.

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ИЗУЧЕНИЕ ПРЕДУБОРОЧНОГО ПРОРАСТАНИЯ В ЗЕРНЕ ПШЕНИЦЫ

Предуборочное прорастание (ППР) – широко распространенное явление, приводящее к неполноценности зерна, снижению его потребительских качеств и соответственно цены. ППР происходит не только во время сбора урожая, сопровождающийся дождями, но и в период созревания зерна злаковых на последних стадиях созревания. Хорошо известно, что прорастание семян пшеницы во многом зависит от сорта пшеницы, однако не достаточно изучено как влияет молибден на устойчивость к прорастанию зерна пшеницы. Поэтому мы сосредоточили наше внимание на роли молибдена, что одним из возможных факторов, определяющих разницу в устойчивости к прорастанию различных сортов пшеницы, является присутствие молибдена в семенах пшеницы.

Результаты исследования показали, прямую корреляцию между содержанием молибдена в зерне, эндогенным содержанием АБК и активностью α-амилазы. Показано, что при обработке раствором молибдена пшеницы обоих сортов, повышалась устойчивость к предуборочному прорастанию (ППР). Листовое опрыскивание раствором молибдена как устойчивого сорта пшеницы, так и чувствительного сорта к ППР, показали повышение эндогенного содержания Мо и АБК в зерне пшеницы. Однако устойчивый сорт пшеницы Лютесценс-70 – содержал в 1,4 раза Мо и уровень АБК-в 1,8 раза выше, по сравнению, чем неустойчивый сорт пшеницы – Новосибирская-67. Также было показано, что при обработке Мо активность α-амилазы снизилась в 5 раз по сравнению с контрольным вариантом.

В этой работе мы показали, как вольфрам (W) , который конкурирует с Мо и может встраиваться в молекулу фермента альдегидоксидазы, инактивируя ее. Поэтому**,** обработка пшеницы вольфрамом, приводила к снижению эндогенного содержания Мо и АБК.

Ключевые слова : пшеница, АБК, молибден, вольфрам, α-амилаз, предуборочное прорастание

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