Changes in the amino acid composition depending on the pre-sowing treatment of seeds

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Abstract. The use of green mass of annual leguminous crops allows to get a rich amount of protein feed. Therefore, the quality of the green mass must be ensured in the context of sustainable crop production and feed efficiency. Apparently, the use of pre-sowing seed treatment with different-sized metal particles and growth regulators can affect the amino acid composition of crops. In the conducted work, it was found that pre-sowing treatment of seeds with UFP MoO2 increased the content of essential amino acids in peas - 5.75%, millet - 3.61, and in barley with UFP SiO2 - 4.01%. Similarly, UFP MoO2 stimulated the content of proline in the biomass of peas-1.82%, millet-0.15%, barley-0.32% compared to the control.In mixed crops of peas, millet, and barley, the content of leucine-isoleucine increased by -0.36%, lysine-0.13%, tyrosine - 0.04%, proline - 0.76%, threonine-0.36%, alanine - 0.27%, histidine - 0.02%, and glycine - 0.25% compared to the control. The amount of essential amino acids in the mixed crop under the action of the UFP MoO2 increased by 1.38%.

1 Introduction

By 2050, the world's population is expected to reach 9.7 billion people [1] and global demand for meat and milk is projected to increase by 57% and 48%, respectively. As a result, livestock production is projected to increase by 21% between 2010 and 2025. [2] Current feed includes cereals and legumes, which are used as green animal feed. The global demand for animal protein is constantly growing, which leads to an increase in the cost of animal feed. To meet the growing demand for animal products, it is necessary to develop methods to increase the green mass from forage crops.

Currently, the use of ultrafine particles (UFP) has become popular, to create easily digestible materials by animals and not harmful to the environment.

In recent years, many experiments have been conducted to determine the effect of ultrafine particles on crop yields. [3] Thus, it is known that UFPs have positive morphological effects, such as increasing the speed of seed germination, improving root formation, as well as the accumulation of vegetative mass. UFPs are involved in the transfer of electrons, increase the activity of plant enzymes, promote the conversion of

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nitrates into ammonia, intensify the processes of respiration and photosynthesis of plants, synthesize enzymes and amino acids.

In experiments [4], an increase in the content of proline, aspartic and glutamic acids, a decrease in the amount of essential amino acids, mainly due to lysine, leucine and isoleucine in barley grain, was found.

The aim of the work is to study the effect of pre-sowing seed treatment with ultrafine particles and growth regulators on the amino acid composition of the green mass of annual forage crops in both ordinary and mixed sowing.

2 Research methodology

The research was carried out in a microfield experiment in the central zone of the Orenburg region, the village of Nezhinka. The soil is southern carbonate middle loamy, medium-thick chernozem. The experiment was laid out as a completely randomized project. The experimental plots were randomly redistributed throughout the experimental plot. The area of the experimental plot was 0.009 ha. The object of the study was the seeds of spring barley (Hordeumvulgare L.) of the Natali variety, peas (Pisumsativum) of the Yamal variety and millet (Panicum) of the Orenburg 27 variety, in ordinary and mixed sowing. Agricultural machinery is common in the central zone of the Orenburg region.

The consumption of UFP is equal to 100 g per 1 ton. In the experiment, AgroVerm growth regulators were used at a dose of 1 l per 1 ton; Ribav Extra at a dose of 10 ml per 1 ton. For the preparation of solutions, precise samples of MoO_3 (10^{-4} mg/l), Fe_3O_4 (10^{-4} mg/l) and SiO_2 (10^{-4} mg/l) were placed in glass vessels with distilled water. The seeds were treated with the finished solution after dispersion in an ultrasonic bath for 30 minutes at a frequency of 35 kHz.

For mixed sowing of disproportionate crops, the method of gluing seeds with starch glue in a ratio of 1:1 on special drum-type equipment was used. To do this, starch glue was added to the finished solution with UFP in a ratio of 1:1 and mixed in a LabSpin laboratory agitator for 5 minutes. After infusing, peas, barley and millet seeds were added in a ratio of 1:2:1, followed by drying.

Seeding was carried out according to the following scheme: ordinary seeding method with row spacing (15 cm distance between seeds peas-5 cm; millet-1.5 cm; barley-2 cm): (1) control, (2) UFP MoO_3, (3) UFP Fe_3O_4, (4) UFP SiO_2 (5) AgroVerm, (6) Ribav Extra; mixed seeding (with row spacing 15 cm and minimum distance between seeds) (7) control, (8)UFP Fe_3O_4. (9) UFP MoO_3, (10) UFP SiO_2. The sowing was carried out on May 8, the harvest was carried out on July 16, 2020.

3 Results and discussion

Depending on the pre-sowing seed treatment, the maximum content of crude protein in peas, millet, and barley in the green mass was observed in the variants of peas UFP MoO_2, SiO_2, which was 12.7 %, 12.3%, respectively, in barley when processing seeds UFP MoO_2, 11.6 %, in millet when using UFP SiO_2 -11.5 %. The minimum amount of protein in peas, millet, and barley was contained in the control variants and it was 9.6 %, 8.3%, 8.2%, respectively.

Table 1. Effect of pre-sowing seed treatment on
the amino acid composition of biomass (pea millet barley) in ordinary sowing

Amino Acid Option	Arginine	Lysine	Tyrosine	Phenylalanine	Histidine	Leucine+Isoleucine	Methionine	Valine	Proline	Threonine	Serine	Alanine	Glycine	Total Amino Acids	Nitrogen Content, %
Peas															
Control	0,25±0,22	0,30±0,2	0,22±0,19	0,42±0,46	0,18±0,22	1,14±1,35	0,22±0,33	0,48±0,59	0,58±0,63	0,87±0,67	0,32±0,41	0,55±0,66	0,56±0,60	6,34±0,26	2,5±0,33
MoO_2	0,39±0,36	0,60±0,50	0,32±0,27	0,57±0,47	0,24±0,20	1,60±0,26	0,30±0,19	0,74±0,44	2,40±0,46	1,55±0,36	0,46±0,21	0,82±0,62	0,69±0,44	10,29±0,26	3,2±0,27
Fe_3O_4	0,38±0,18	0,55±0,36	0,26±0,21	0,43±0,4	0,24±0,18	1,23±0,41	0,30±0,22	0,58±0,62	2,10±0,37	1,11±0,47	0,49±0,15	0,61±0,54	0,56±0,36	7,84±0,21	3,1±0,25
SiO_2	0,39±0,33	0,53±0,49	0,24±0,21	0,40±0,23	0,25±0,27	1,12±0,52	0,19±0,12	0,61±0,45	2,28±0,41	1,10±0,85	0,50±0,41	0,59±0,35	0,55±0,28	8,25±0,42	3,1±0,20
AgroVerm	0,40±0,35	0,51±0,38	0,29±0,21	0,59±0,35	0,21±0,15	1,56±0,94	0,43±0,21	0,69±0,36	0,86±0,58	1,39±1,2	0,44±0,26	0,78±0,65	0,68±0,34	7,83±0,34	3,1±0,83
Ribav Extra	0,30±0,21	0,41±0,27	0,25±0,19	0,46±0,24	0,17±0,09	1,34±0,99	0,30±0,15	0,61±0,48	0,68±0,42	1,15±0,19	0,38±0,27	0,65±0,29	0,60±0,31	7,3±0,29	2,9±0,33
Millet															
Control	0,22±0,17	0,30±0,22	0,17±0,17	0,32±0,27	0,13±0,08	0,95±0,98	0,16±0,04	0,44±0,35	0,90±0,45	0,40±0,29	0,22±0,12	0,55±0,42	0,40±0,32	5,16±0,51	2,3±0,27
MoO_2	0,32±0,27	0,38±0,17	0,18±0,13	0,43±0,34	0,17±0,10	1,18±1,04	0,23±0,18	0,53±0,49	1,05±0,84	0,54±0,22	0,28±0,15	0,65±0,32	0,49±0,35	6,43±0,29	3,1±0,37
Fe_3O_4	0,29±0,19	0,36±0,31	0,18±0,12	0,38±0,26	0,15±0,12	1,01±0,65	0,16±0,12	0,49±0,38	0,99±0,62	0,50±0,29	0,26±0,13	0,58±0,37	0,48±0,33	5,83±0,74	2,8±0,23
SiO_2	0,30±0,21	0,34±0,24	0,22±0,12	0,42±0,34	0,17±0,11	1,09±0,67	0,19±0,15	0,49±0,33	1,03±0,77	0,53±0,40	0,29±0,17	0,61±0,41	0,45±0,29	6,15±0,66	2,9±0,33
AgroVerm	0,28±0,12	0,32±0,18	0,21±0,08	0,38±0,19	0,23±0,15	1,00±0,54	0,17±0,11	0,48±0,36	0,99±0,69	0,58±0,35	0,28±0,25	0,70±0,52	0,46±0,31	6,08±0,64	2,7±0,26
Ribav Extra	0,27±0,14	0,32±0,21	0,21±0,14	0,38±0,26	0,19±0,16	1,00±0,54	0,21±0,16	0,46±0,28	1,02±0,62	0,53±0,31	0,27±0,18	0,60±0,18	0,46±0,28	5,92±0,51	2,4±0,61
Barley															
Control	0,40±0,43	0,35±0,26	0,21±0,14	0,42±0,33	0,18±0,07	0,73±0,45	0,12±0,09	0,44±0,25	0,71±0,87	0,40±0,28	0,31±0,21	0,47±0,38	0,34±0,25	5,08±0,64	2,4±0,26
MoO_2	0,60±0,33	0,44±0,36	0,29±0,13	0,50±0,43	0,22±0,17	1,07±0,39	0,17±0,04	0,56±0,22	1,03±0,64	0,53±0,31	0,33±0,23	0,61±0,44	0,44±0,31	6,11±0,36	3,0±0,51
Fe_3O_4	0,50±0,28	0,42±0,24	0,27±0,18	0,43±0,34	0,17±0,12	1,07±0,67	0,15±0,12	0,54±0,28	0,88±0,67	0,59±0,41	0,32±0,16	0,71±0,56	0,47±0,16	6,52±0,51	2,7±0,35
SiO_2	0,52±0,38	0,48±0,28	0,30±0,24	0,51±0,37	0,16±0,15	1,17±0,98	0,19±0,07	0,54±0,23	0,98±0,45	0,60±0,31	0,36±0,21	0,73±0,33	0,51±0,31	7,05±0,98	2,6±0,74
AgroVerm	0,45±0,23	0,43±0,24	0,23±0,17	0,37±0,28	0,16±0,07	0,92±0,68	0,12±0,07	0,50±0,30	0,81±0,66	0,57±0,27	0,30±0,23	0,68±0,27	0,49±0,28	6,03±0,54	2,7±0,84

Ribav Extra	0,43±0,18	0,31±0,26	0,24±0,17	0,40±0,29	0,12±0,04	0,95±0,64	0,15±0,06	0,47±0,24	0,75±0,34	0,52±0,26	0,32±0,18	0,64±0,41	0,43±0,24	5,73±0,87	2,6±0,20

Note: * –Differences with control are significant at p≤0.05

The effect of pre-sowing treatment of seeds of annual forage crops activated the process of nitrogen accumulation in the green mass of peas in the variant with the use of UFP MoO_2, which was 3.2 %, in millet-3.1 %, in barley-3.0 %.

With an increase in the amount of protein and nitrogen in the green mass of peas, millet, and barley, the content of almost all amino acids changed. The total number of them in peas increased when using UFP MoO_2 by - 3.86 %, millet - 1.27 %, and barley when processing seeds with UFP SiO_2-1.97 %.

Pre-sowing treatment of UFP MoO_2 seeds increased the proline content in the biomass of peas-1.82 %, millet-0.15 %, barley-0.32 % compared to the control.

When pre-sowing seeds were treated with UFP MoO_2 and growth regulators, the content of threonine in peas increased by 0.68 %, leucine+isoleucine in millet by 0.25 %, and alanine in barley by 0.14 %.

The content of amino acids increased in the variants when using ultrafine particles MoO_2 in peas by 5.75%, millet by 3.61, and in barley when using UFP SiO_2 - 4.01%.

The maximum amount of nitrogen in the mixed sowing of annual crops (peas, millet, barley) was recorded when using the UFP MoO_2 -3.35 %.

Table. 2. The effect of pre-sowing seed treatment on the amino acid composition of the biomass of peas, millet, and barley in mixed sowing.

Amino Acid Option	Arginine	Lysine	Tyrosine	Phenylalanine	Histidine	Leucine+Isoleucine	Methionine	Valine	Proline	Threonine	Serine	Alanine	Glycine	Total Amino Acids	Nitrogen Content, %
peas+millet+barley															
Control	0,27±0,51	0,36±0,90	0,27±0,93	0,40±0,27	0,16±0,25	1,02±0,17	0,14±0,13	0,50±0,08	0,97±0,11	0,73±0,12	0,33±0,16	0,52±0,05	0,45±0,12	6,12±0,36	2,35±0,72
MoO_2	0,37±0,13	0,49±0,67	0,31±0,64	0,50±0,95	0,19±0,81	1,38±0,50	0,36±0,33	0,61±0,55	1,73±0,23	1,09±0,17	0,45±0,27	0,79±0,46	0,70±0,17	8,97±0,62	3,35±0,74
Fe_3O_4	0,30±0,05	0,39±0,04	0,29±0,05	0,47±0,46	0,17±0,64	1,25±0,43	0,24±0,24	0,60±0,20	1,08±0,17	0,72±0,45	0,38±0,49	0,62±0,74	0,59±0,11	7,1±0,92	2,4±0,29
SiO_2	0,35±0,40	0,50±0,74	0,30±0,37	0,50±0,43	0,18±0,54	1,34±0,39	0,26±0,60	0,64±0,39	1,52±0,92	0,95±0,81	0,40±0,74	0,69±0,43	0,63±0,66	8,26±0,46	3,15±0,79

Note: * –Differences with control are significant at p≤0.05

Features of pre-sowing single treatment of UFP MoO_2 seeds were revealed in increasing in the content of leucine-isoleucine by 0.36 %, lysine by 0.13 %, tyrosine by 0.04 %, proline-0.76 %, threonine by 0.36 %, alanine by 0.27 %, histidine by 0.02%, glycine by 0.25% compared to the control and the amount of essential amino acids by 1.38 %. Also, among the essential amino acids, the content of threonine increased most significantly. The content of proline, which is related to interchangeable amino acids, and its share in proteins with the use of UFP MoO_2 exceeded the control by 0.76 %, which is consistent with the results [9].For example, the treatment of TiO_2 1000 mg/kg^{-1} with UFP the concentration of phenylanin in barley grain increased [5].Treatment of plants with cadmium increased the content of proline in wheat, and a number of other free amino acids: threonine, phenylalanine, terosine, and meotin [6].In oats, when the concentration of copper in the soil was <59.4 mg / kg (1 M HCl), the content of most amino acids increased. Significant differences with the control were found for threonine, glutamic acid, glycine, alanine, isoleucine, leucine, tyrosine, phenylalanine, lysine, and arginine. The content of isoleucine, alanine, glycine, threonine, and phenylalanine increased most significantly (by 1.3-1.4 times). [4] In pea seedlings treated with silicon, the accumulation of proline increases [7-12].

4 Conclusions

The quality of the ground part of the crops is a prerequisite for the sustainable development of agriculture. Since the green mass of leguminous crops is one of the main sources of protein, the quality of leguminous crops requires special attention. Using pre-sowing seed treatment, we were able to cover a wide range of changes in the amino acid composition both in individual crops and in their mixtures. This systematic approach allowed us to identify the influence of UFP on the change in the amount of amino acid composition. Our results show that the treatment of UFP MoO_2 seeds increased the nitrogen content of peas by 3.2 %, millet-3.1 %, barley-3.0 %, essential amino acids in the ground weight of peas-5.75 %, millet-3.61 %, barley-4.01 % when processing UFP SiO_2 seeds, which increased the quality of plant products. We observed a positive effect of pre-sowing treatment of UFP seeds when mixed sowing of annual crops. Thus, the use of MoO_2 increases the content of essential amino acids in comparison with the control by 1.38 %, the maximum nitrogen content was also noted in the MoO_2 variant - 3.35 %.

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