Artificial Ecological System – Hydroponics: The Wheat Grains Germination Rate

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Abstract*: This article presents the results of wheat grains germination using the hydroponic method with the use of various waters rich in nutrients, including the water from the river, the water from a fish tank, and the water from a well. During the germination, the average seeds germination rate reached 98 %. On the 3rd day after the germination, the length of sprouts significantly increased by 3.3 – 35.2 %, compared to the reference value. On the fifth day, the germination rate increased by 9.2 – 35.0 %, compared to the reference. At the end of the germination, the number of roots was approximately the same in all samples, but the length was significantly greater in the third and fourth test samples by 64.1 – 84.1 %, and the second sample was 2.2 times higher than the reference sample. The studies were performed in the framework of the Grant of the President of the Russian Federation for State Support of Young Russian Scientists MD-1886.2019.11.

***Keywords*: hydroponic fodder, grain germination, wheat, hydroponics, germination rate, grain germination speed.**

I. INTRODUCTION

In a couple of decades, no population will remain in the villages. The results of research show that over 50 years, almost all the population of our planet will live in cities. Moreover, today, most of the soil that can produce crops is already used. Part of it is severely damaged [1], [2].

This acute problem should be solved today. It is no less important than the disappearance of natural resources. The only solution seems to be moving the agriculture to the city. This will also solve the issue of crops transportation.

Due to the use of the latest achievements of technology and the science in this area, hydroponics has been developing at an incredible speed in recent years. The state-of-the-art hydroponic systems use exclusively plastics. Even the pumps are made with an epoxy coating. The durability and safety of such materials make their joint use with neutral substrates a direct path to success. The use of plastics has promoted getting rid of expensive and inconvenient metal structures of tanks and troughs [3], [4].

With the development of pumps, plastic sanitary fittings, timers, solenoid valves and other equipment suitable for the use in the hydroponic system, hydroponics can now be fully automated, which will allow reducing primary and production costs.

An equally important achievement in the field of hydroponics was the development of balanced nutrition for the plants. Although studies in this sector are still ongoing, the obtained developments are already widely used.

Various countries of the world are actively participating in the process of developing the hydroponics technology. Interest in this system has been shown by such states as Australia and New Zealand, countries of Southern Africa, Italy and Spain, Israel, and the Scandinavian countries. In Europe, many vegetables and berries are grown with the use of the hydroponic system. For example, strawberries grow faster, and picking of berries is much easier. The use of state-of-the-art nutrient solutions provides an opportunity to significantly increase the yield of the crop and reduce the area used for growing [5].

Hydroponic systems are becoming increasingly important today. Due to the increased demand and the large-scale involvement of the market, the cost of structures and the cost of hydroponics decrease. Developments in the area of designing the systems make it possible to grow plants not only compactly on the same level, but also to fill the volume of the premises used for this process, thereby saving the working area, and greatly improving the yield of the end product. With that, the labor costs for keeping the plants are markedly reduced.

Since today the issue of obtaining high-quality agricultural products is acute, there is the need for affordable and available domestic food products, which is particularly important for the Krasnodar region, since it is mainly an agricultural region [6].

Rational and balanced in all nutrients and bioactive substances diet formulation is critical for improving the productivity of animals and poultry. To ensure a stable feed base for agricultural animals and poultry, to reduce the feed cost, new energy-saving technologies are to be used, and inexpensive feed resources are to be involved, including wastes from agricultural and industrial production. To obtain efficient biological products, inexpensive ways of biological processing of fodder grains may be needed [6].

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The biological value of the diets may be increased by feeding to animals the green fodder based on the plants grown hydroponically.

This is true year-round, but especially in the winter and in the spring, when the deficiency of vitamins, enzymes, and minerals is the most evident.

The process of grain germination takes considerable time; therefore, it is important to accelerate the process while maintaining the quality of the target product [6].

Seeds germination is the process of seed transition from dormancy to corcule growth. Currently, various types of plant raw materials are used for germination: cereals (wheat, rye, barley, oats, millet, maize, spelt, buckwheat), legumes (soybeans, chickpeas, peas, lentils, lupins, mung beans), and annual and perennial herbaceous plants (flax, amaranth, holy thistle). Grain germination is a process that has no analogs in nature in terms of the vigor, the speed and the variety of biochemical transformations. The process of germination is most significantly determined by three factors: humidity, temperature, and the presence of oxygen [4], [5].

Dry seeds of cereals have the moisture content of up to 15 %, i.e., (hydration) water is tightly bound to proteins, which ensures normal respiration. With increasing humidity, free water appears, which dramatically increases the intensity of respiration and other metabolic processes. Under the influence of free water, the permeability of the cell walls improves [3].

The porous structure of the fruit shell of grain is well adapted for rapid absorption of the moisture. However, fruit shells cannot keep the moisture; this function is performed by the seed shell, the aleurone layer of the endosperm, and the corcule itself.

Water enters the grain mainly from the corcule. In a whole grain, cell structures are dry colloidal structures, the micelles of which greatly attract water. The free moisture in the grain ensures enzymes and nutrients migration into the solution, as well as their migration to the corcule. This creates favorable conditions for enzymes penetration into the endosperm, which convert reserve insoluble substances of the grain into the ones soluble and easily digestible by the corcule. As a result of enzymes activation, biochemical processes in the grain accelerate, especially respiration. Normal aerobic respiration depends on the availability of oxygen in the environment [7].

Grain water absorption capacity and the speed of water penetration into it are determined by several factors, most important of which are vitreousness, proteins quality, initial moisture level, grain plumpness and size, grade and growing region. Grain, being a capillary-porous colloidal body, has a cell structure and mesh of macro- and micropores, and features adsorption (the ability to absorb water and water vapors) and desorption (ability to return moisture), i.e., hygroscopicity.

The conditioning process, sorption as a complex phenomenon, involves absorption (sealing water molecules on the surface of the grain), adsorption (penetration of water into the grain by diffusion), capillary condensation (adsorption of water with condensation in the capillaries of the grain), and chemisorption (absorption of water by the grain, accompanied by the reaction that results in chemical changes in constituent parts of the grain).

For all wheat varieties it is characteristic that during the germination, the grain first adsorbs water, and, as it is saturated, the rate of moisture penetration gradually reduces. The endosperm of hard wheat is denser than that of soft wheat. The lower is the vitreousness, the lower is the density of the endosperm, which determines an increased rate of water adsorption. Shells of durum wheat absorb water much faster than shells of soft wheat, and water spreads throughout the shells faster than throughout the endosperm. This can be explained by the structure of these parts, in particular, by the presence of ducts, capillaries, and voids in the membranes, which are significantly less numerous than in endosperm [1], [8]. Grain germination requires sufficient moisture, aeration, and optimum temperature.

Cheaper and nontraditional available feeds are of great interest in the process of poultry growing and keeping. Such an efficient feed additive is hydroponic green feed. Being rich in vitamins and mineral elements, it ensures increasing the nutritional value and the digestibility of the feed and increasing poultry productivity. Analysis of literary sources shows that green feed grown using the hydroponic method, contains a lot of vitamins A, D, E, C, microelements, and other nutrients.

Nowadays, seed germination is actively used in hydroponics — the technology of seed growing on porous artificial environments with high moisture- and air capacities. This technology allows to significantly reduce the production area; however, it does not affect the time needed for obtaining wheat sprouts. Therefore, the problem of improving the existing technology for obtaining wheat sprouts remains relevant.

When creating aquaponic plants for growing sturgeon fish species, it becomes possible to not only obtain vegetable food but also to filter water that is rich in metabolic byproducts of sturgeon fish. Therefore, the water from fish tanks where sturgeon fish had been kept was used for wheat germination [8], [9].

These studies were aimed at comparing the speed of wheat grains germination by the hydroponic method with the use of water of various natures to determine its nutritional value.

II. METHODS

The wheat grains germination experiment was performed at the fish farm of OOO Albashi in the Leningrad district of the Krasnodar region in the spring and summer of 2019. At the farm, sturgeon fish in basins and cages, and herbivorous fish in ponds and in the regulated flow of the Albashi River are grown. There is also a water well. To determine the optimal duration of growing, wheat was germinated for seven days.

Four samples of 100 grains in each were taken from the seeds of the main crop for determining the germination rate and germination vigor [10].

Wheat grains from the first (reference) sample were covered with the tap water, from the second sample – with the river water from the regulated flow of the Albashi river, from the third sample – with the water from a sturgeon fish tank, and from the fourth sample – with the water from the water well.

The obtained data were processed by the method of variational statistics [11].

III. RESULTS

In the germination of the four samples of 100 seeds each, the germination rates were 97, 99, 99, and 98 %, and the average germination rate was 98 %. For the average germination rate of 98 %, the permissible deviation is ±3 %. Since the actual deviations of the results of analyzing individual samples from the average germination rate do not exceed the permissible value, the analysis is not to be repeated.

From the results obtained, it follows that the length of the sprouts on the third day significantly increased in the second sample that was filled with the water from the river – by 35.2 % ($P < 0.01$), while in the third and the fourth samples, a tendency to increase by 19.8 and 3.3 % was noted (Table I).

Table-I: Wheat grains germination vigor

Value	Sample 1 (tap water) — reference	Sample 2 (river water)	Sample 3 (the water from the fish tank)	Sample 4 (the water from the well)
Day 3 sprouts, mm	3.03 ± 0.29	4.1 ± 0.26**	3.63 ± 0.24	3.13 ± 0.21
Day 5 sprouts, mm	4 ± 0.17	5.4 ± 0.67*	5.73 ± 0.58**	4.37 ± 0.64
Day 5 roots, pcs.	2.23 ± 0.16	2.2 ± 0.2	2.4 ± 0.16	2.2 ± 0.18
Day 5 greatest root length, mm	10.93 ± 1.23	20.13 ± 2.3***	24.4 ± 1.85***	17.97 ± 2.31**

*Note: * – P < 0.05, ** – P < 0.01, * * * P < 0.001*

On the fifth day of the germination, the length of sprouts was significantly greater in the second and the third groups by 35.0 ($P < 0.05$) and 43.3 % ($P < 0.01$); in the fourth group, a tendency to an increase by 9.2 % was noted.

On the fifth day of the germination, the number of roots was approximately the same in all samples, but their length was significantly greater in all experimental samples by 84.1 % ($P < 0.01$), 2.2 times, and by 64.1 % ($P < 0.01$).

This is an evidence of the fact that the water saturated with nutrients accelerates the growth of wheat grains.

IV. DISCUSSION

M. L. Gordievskikh et al. [12] in the study of accelerating the plants growth and development through the use of organic irrigation solutions in hydroponic feed production managed to accelerate wheat growth by 6 – 8 % through the simultaneous use of the action of ultrasound and ozone, which created the conditions for obtaining an organic solution (vermi-solution) with higher agronomic characteristics [12]. The authors were able to increase the length of the sprouts in the samples of wheat by 9.2 – 43.3 %, which is an evidence of advisability of using the water saturated with nutrients for accelerating the germination vigor of wheat grains.

In the germination of four samples with 100 seeds in each, the average seed germination reached 98 %. The maximum germination rate was observed in the third sample (99 %), which had been filled with the water from the fish tanks, which may be explained by the high concentration of nutrients in it facilitating seed germination.

The length of the sprouts on the third day significantly increased in the second sample that had been filled with the water from the river – by 35.2 % ($P < 0.01$), while in the third and the fourth samples, a tendency to increase by 19.8 and 3.3 % was noted.

At the end of the germination, the length of sprouts was significantly greater in the second and the third groups by 35.0 ($P < 0.05$) and 43.3 % ($P < 0.01$); in the fourth group, a tendency to an increase by 9.2 % was noted.

At the end of the germination, the number of roots was approximately the same in all samples, but their length was significantly greater in all experimental samples by 84.1 % ($P < 0.01$), 2.2 times, and by 64.1 % ($P < 0.01$).

V. CONCLUSION

The obtained data show that it is highly advisable to use the water from a tank for growing sturgeon fish and regulated flow of the Albashi River in the conditions of a fish farm, which is rich in nutrients for growing with the use of hydro- and aquaponics.

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