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# Innovative approach to the development of hydroponic green feeds

To cite this article: P I Kalandarov and D A Abdullaeva 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1043** 012012

# Innovative approach to the development of hydroponic green feeds

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**Abstract.** This article discusses the results of a study on the cultivation of hydroponic green feed in the laboratory, the main purpose of the study is to study the effect of humidity on the root system of the green mass, to increase the timing and dependence of the increment on temperature and humidity. The experience of using automation elements in order to develop recommendations for the implementation of automation systems and computerization of a hydroponic installation using a programmable microcontroller is analyzed. Taking into account the problems of growing green mass for use as feed for the agricultural sector, the issues of photosynthesis are considered, the results obtained and methods for measuring the concentration of free hydrogen ions in water (pH) are shown, for these purposes the water quality was monitored using Sensorex sensors, the issues of sprouting are described, as well as measuring the moisture content of the root part of the green mass and the devices used for this purpose. The article concludes that the results of the research are based on the use of various innovative solutions, this is a system of transition to digital agriculture, as a result of growing hydroponic green feeds using automation elements to control and manage the receipt of primary initial state information. This, in turn, will allow the agricultural sector to be fully automated, free up useful areas of land, increase yields and reduce production costs.

## 1. Introduction

The organization of cultivation of innovative green hydroponic feed to improve the efficiency of dairy production today in the Republic of Uzbekistan is an urgent task.

Such a statement of the issue is inscribed in state documents, in particular, in the Decree of the President of the Republic of Uzbekistan dated July 29, 2021 No. PP-5202. In the roadmap for the implementation of the tasks defined in the special resolution of the 75th session of the United Nations General Assembly of May 18, 2021 "On declaring the Aral Sea region a zone of environmental innovations and technologies", working group V was created. region of the Aral Sea region.

The regulatory documents describe: ensuring environmental sustainability, digitalization and implementation of innovative approaches to the rational use of natural resources in the Aral Sea region (responsible - the State Committee for Ecology and Environmental Protection) and the organization of the supply and installation of equipment for growing hydroponic feed technology, as well as the organization of hydroponic feed production to increase the efficiency of dairy production.

However, to solve this problem, the main issue is the localization of the organization of the production of technological equipment in local conditions. This is a solvable problem, but from the point of view of science, it is poorly studied and insufficiently studied in the conditions of the country, and the results of scientific research are not sufficiently implemented in production.

In this regard, a systematic approach to solving problems is needed. An innovative approach and its results to solving this problem will allow us to study more deeply that, in the end, the technology of growing hydroponic green feed will interest entrepreneurs, farmers, scientists and florists.

This, in turn, will lead to the full development of farm animals and birds, which are directly dependent on nutrition. It is known that to the usual diet, balanced with a feed mixture of mixed fodder, silage, hay, vegetables, it is recommended to add hydroponic green feed (HGF) from sprouted grain of wheat, corn, barley, oats, etc. GZK feed brings to the diet 20% protein, natural vitamins of groups A, B, C, selenium and carotene, as well as other macronutrients.

Analyzing the technical support for growing hydroponic green feed systems, consider the state of affairs.

In many foreign countries, there are ready-made technical solutions, which allows developers to study in detail and make a design solution for implementation in the conditions of the republic.

Let's take an example: in particular, in Turkey (Izmir) [1], hydroponic systems for the production of green feeds are produced by the Agritom trademark, from the industry leader - Agri Makina Ltd. Agri Makina Ltd. is a significant and reputable manufacturer of feed hydroponic plants in the world, and is also a world leader in sales of industrial hydroponic feed systems. Production of hydroponic plants is carried out serially in the following production facilities:

- Container hydroponic systems from 100 to 500 kg/day;
- Modular hydroponic systems from 100 to 2 000 kg/day;
- Industrial hydroponic systems from 5 to 300 tons / day;

When organizing and implementing such technologies (hydroponic systems for the production of green fodder), it will free up sown areas, reduce the time spent on germination of seeds, all this will lead to a decrease in consumption and water costs. In addition, the main advantage of hydroponic green feeds is the presence of the quality of vitamins in the content of green feed, necessary for the life of the end user.

In turn, on the one hand, for entrepreneurs it will be the extraction of income to improve the material well-being of its participant, as well as the introduction of new green feeding technologies. On the other hand, in the organization and implementation of this technology, the target group will be the population, agricultural enterprises, small and medium-sized households, as well as large fattening enterprises.

The purpose of the study is to study the organization of hydroponic feed production, as well as the use of a systematic approach in the design of the construction of hydroponic structures and facilities, as well as the automation of the hydroponic system for the production of high-calorie environmentally friendly green feed in the territory of the Republic of Uzbekistan.

To achieve this goal, we have developed a program consisting of basic measures aimed at the stable provision of hydroponic green feed cultivation using automation systems.

In this regard, the organization of production of hydroponic green feed technology is an urgent task.

## 2.Materials and methods

Hydroponic methods are used to grow various types of greens, vegetables and berries in vertical greenhouses, allowing to significantly increase the volume of yield in a limited area.

To address these issues, it is necessary to develop technology, in particular hydroponic structures, where green food will be begged, as well as the use of automation elements for the control and regulation of systems and monitoring.

The National Research University "Tashkent Institute of Engineers of Irrigation and Mechanization of Agriculture" department "Automation and control of technological process and production" conducts a number of scientific researches in the field of preparation and cultivation of hydroponic green fodder using automation tools.

Experimental studies on the cultivation of HGF were carried out in the laboratory in accordance with the developed methods, on the basis of statistical processing of information and planning of a multifactorial experiment.

Preparation of seed material, similar to other researchers [2], for the germination of the HGF we used wheat of the 4th class, includes special types of treatment aimed at disinfecting seeds and stimulating their germination.

The weighed grain, then the disinfection of the seeds was soaked in a 0.01-1% solution of potassium permanganate, at room temperature for 15-20 minutes.

The use of automation elements, in particular, sensors (humidity, temperature) were used to control the microclimate and maturation of plants, which made it possible to use an artificial intelligence system to facilitate human labor and reduce production costs. The considered method of intelligent management of hydroponic green feed technologies in a greenhouse farm consists of three blocks: control of ambient temperature, amount of irrigation and water temperature, humidity of the root system [3]. a breakthrough in hydroponics, which will make it possible to predict the growth and balance of nutrition for plants.

The use of automation elements, when controlling the ambient temperature, irrigation, as well as root humidity, will allow monitoring the state of plant growth and providing the necessary agrotechnological care and monitoring the growth of products [4].

The studies were aimed at monitoring the state of the environment, for the normal provision of the parameters of the production process, including stable growth, as well as monitoring the vital activity of plants. The object of research is the root soil environment, where fruit crop systems, in particular wheat, ripen in trays with stable water supply. The analysis of literary sources [5-15] in the field of hydroponic green fodder, there is a tendency of uninterrupted water supply during the day. However, the problem of regulating the moisture content of the root part and the effect of the moisture content of the root system on stable growth, as well as the influence of various factors in ensuring the vitaminized proportion of the cultivated crop, have not been studied [16].

It is known that a larger amount of moisture will lead to suffocation of the root system of the plant, and a small amount, i.e. if there is not enough moisture, then another threat arises - the drying of the plant. A balance must be struck. Knowing how much daily moisture is required, you can set a timer that will provide automatic watering [17]. Using sensors with controllers, the water in the hydroponic system has always remained nutrient-rich.

## 3. Outcomes

Studies conducted on wheat of the 4th class, on the cultivation of hydroponic green feeds, and the composition of vitamins, especially protein, have shown that the growth of the culture is strongly influenced by moisture.

When growing hydroponic green feed in wheat, the root strongly absorbs water, as a result, ions are processed in the roots, their restoration and inclusion in organic compounds.

Experiments were carried out in laboratory conditions, where in trays the mound of moist wheat was 1500 g, at an ambient temperature of 20-25 ° C. Water consumption was about 1500 ml per day. Water was fed 4 times a day, the water temperature was about 22-26 ° C, with hardness up to 4 mg-eq / l.

When measuring the concentration of free hydrogen ions in water (pH) with the Device Professional PH 100, it was about 6.0. During the experiments, there was also such a tendency, when the pH level dropped below 5.5 or vice versa, the pH values became above 6.5, under these conditions the green mass did not get the nutrients necessary for survival, as a result of which there were losses. was monitored using Sensorex sensors, the overall view of which is shown in Figure 1.


**Figure 1**. General view of the Sensorex sensor and pH reading.

Sensorex Specification - PH Controller and ORP TX20: Measuring range (pH): -2.00 to 16.00 pH, resolution 0.01 pH, accuracy +/- 0.1 %; Temperature range: -10°C to 120°C, resolution 0.1°C, accuracy +/- 0.3°C; Operating ambient temperature: 0°C to 50°C; Temperature compensation: automatic/manual (-10°C to 120°C); Required power: 100-240 VAC, maximum load 500 ohms. Control type/relay output: 2 on/OFF switches / 5 A at 115 VAC or 2.5 A at 220V AC, resistive load only.

The use of a pH sensor made it possible to maintain the pH level of water, which could be observed by a hydroponic system fed water became too acidic or too alkaline. Water treatment was carried out once a month. Using electrical conductivity regulators (CS150TC) and pH, the process signaled the closure and opening of valves in the hydroponic installation when the water composition became unbalanced.

Illumination of sprouts with artificial light with an illumination of 1000-1200 lux per 1 m2 began on 4 - 5 days after soaking the grain, the duration of daylight was 18 - 24 hours per day. LED lamps were hung with each rack at a height of 40-60 cm.

The beginning of the measurement was made on the 3rd day, after the installation of planting material on the shelves of hydroponic installations. When growing hydroponic green feeds was accompanied by a loss of dry matter (CB) of the original grain. The greatest losses of CB are observed during the period of germination of the feed during the first three days.

Humidity affected the growth of the leaves of the green mass, with high humidity the plants were grown larger. Maximum growth, we observed at above 60%. It is considered more optimal to set the humidity at a rate of 65-75%. The root system will need a humidity of more than 85-90%, and for the germination of seeds, humidity must be maintained within 60-70%.

It is necessary to pay attention to the fact that the green mass itself emits a lot of moisture. The green mass prefers stability, so it is better not to allow sudden changes in humidity. The green mass is fed by sunlight, also artificial light, while consuming carbon dioxide necessary for photosynthesis, as a result of which the carbohydrate necessary for the plant is formed and oxygen is released. This reaction refers to the source of energy for metabolism and, ultimately, for the plant. It is known that the green mass breathes, both day and night, absorbing $CO_2$ for photosynthesis, absorbing oxygen, which, combining with a carbohydrate, as a result, releases carbon dioxide and energy.

In the king system, it was observed that the primary structure, which has high physiological activity, on 3-4 days during the period of active growth, the roots absorbed up to 95% of the total number of plant roots. The root system of hydroponic green feeds was constantly changing under the influence of water temperature. With a decrease in the importance of the roots to 50-60%, a decrease in the growth of active roots was noticeably observed.

The roots of plants had access to both solutions and air. The main mass of the hydroponic system was based on the principle of "periodic flooding" of the root system.

There was a change in the root system depending on changes in the environment. The control measurement of the moisture content of the root system was determined three times a day (9-00, 12-00, 17-00) during 3-4 days of the growing season. As a result of research, it was determined that the root system develops strongly, its thickness was about 5 to 8 cm.

To measure the moisture of the root part of the green mass, a moisture sensor was used, (contact probe YL-69) is designed to determine the moisture in the root part of the green mass in which it is immersed. Moisture information was determined by insufficient or excessive watering of seed germination. The system used consists of two parts [18]: the YL-69 contact probe and the YL-38 sensor (Figure 2).

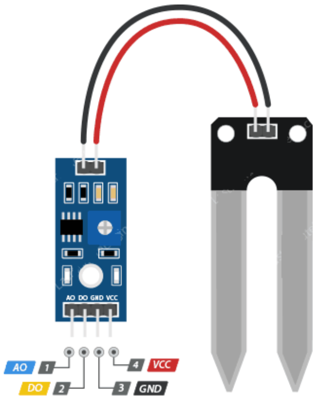


**Figure 2.** General view of YL-69 contact probe and YL-38 sensor.

The principle of operation of this system is as follows: a small voltage is created between the two electrodes of the YL-69 probe. If the root part of the green mass is dry, then in this case, the resistance is large and the current will be less. If the root part is wet, then the resistance is less, then the current is slightly greater. According to the results, the analog method the YL-69 probe is connected to the YL-38 sensor by two wires. Also, the YL-38 sensor has four pins for connection to the controller.

The YL-38 sensor is based on the LM393 comparator, which outputs voltage D0 (digital humidity level.) according to the principle: moist root system, then low logical level, if the root system is dry, then, high logical level.

The YL-38 sensor also has two LEDs that signal the presence of digital signals coming to the sensor and the level of digital signals at the output of D0. A distinctive feature of this system from others is that, the digital output D0 and LED level D0 allows you to use the module autonomously, without connecting to the controller. Technical characteristics of the sensor: supply voltage: 3.3-5 V; Current consumption 35 mA; Output: digital and analog; Module size: 16×30 mm; Probe size: 20×60 mm;

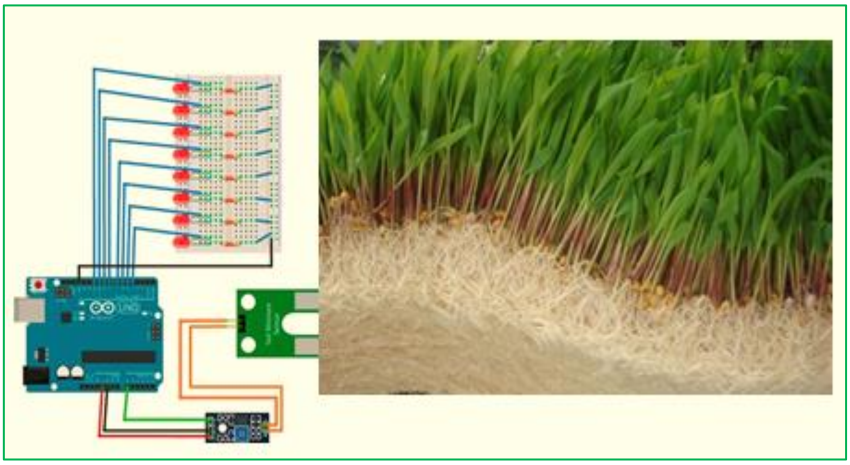

**Figure 3.** Measurement of the root system by the sensor.

Figure 3 shows the moisture control system of the root part of the green mass using the YL-38 daticer.

However, it can be argued that the results of the studies fragmentarily reflect the basic patterns of the thermal balance of the root system of hydroponic green feeds.

Figure 4 shows the process of photosynthesis of hydroponic mass.

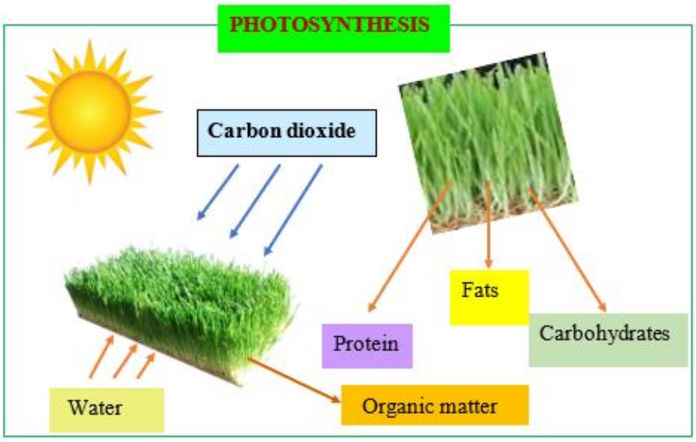


**Figure 4.** Factors affecting photosynthesis.

There are a number of factors that directly affect the process of photosynthesis of plants. First of all, the intensity of the process directly depends on:

- the carbon dioxide content,
- ambient air temperature,
- sufficient supply of water to the plant
- Light intensity

However, in order for the plant to develop optimally, it is important not only the presence of light energy, but also the spectrum of light, as well as the duration of the light period when the plant is awake and the dark period when it rests.

If you correctly adjust the length of daylight, then the stages of growth of the green mass can be controlled. So, in the green mass of a long day, you can adjust their vegetative stage, as well as the flowering time. In turn, for plants of a short day, the light period should remain at a certain level, because too long a period of light can significantly disrupt the time of its flowering. There is also a category of plants, which grow depending on the presence of light, but the duration of the dark and light period of the day does not affect them. Thus, by correctly adjusting the light, it is possible to achieve high-quality results in the process of growing different types of plants. Figure 5 shows the growth of the green mass over 7 days.

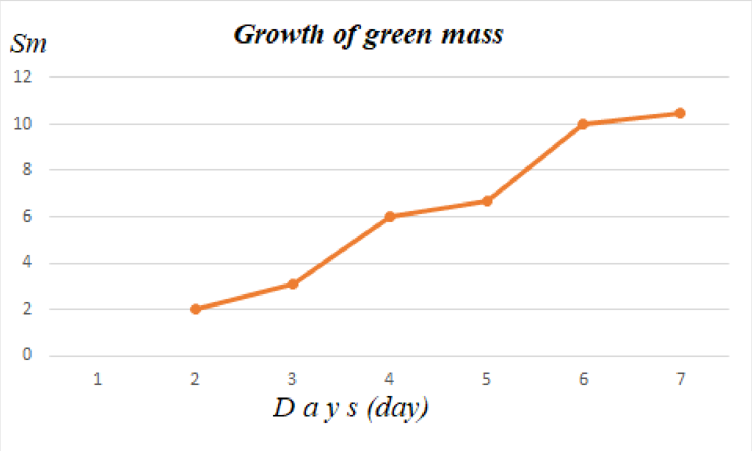


**Figure 5.** Growth of green mass.

In the course of experiments on the cultivation of hydroponic green feeds, it was revealed that, with an increase in the humidity of the root system, the thermal conductivity increases. With a change in humidity from 5 to 40%, it leads to an increase in thermal conductivity by 3-4 times.

The results are summarized in the following indicators:

1.The ambient temperature before the appearance of seedlings is 24-28°C.

2.Temperature with the appearance of seedlings:

a. daytime temperature 18-20oC;

b. night 15-18oC;

c. the temperature during the development of the root system is not lower than 25°C;

3.Humidity of the room - 69-65%;

4.Daylight 16 hours;

5.Daily ventilation of the room.

According to the results of the research, it was revealed that from 1 kg of grain (wheat) about 7 to 10 kg of hydroponic feed was obtained. Finished products were obtained in 7-12 days. Under the established regulations, for 7-8 days the height of the greens reached 10-12 cm.

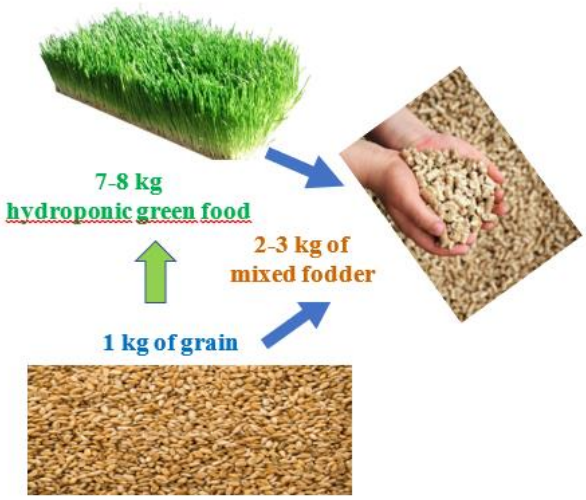


**Figure 6.** Indication of the yield of wheat and green mass.

Many researchers use special fertilizers that enhance the vegetative properties of plants [19]. In this case, the water must remain clean and free of impurities. Researchers applying various fertilizers to ensure that the green mass grows properly to get the right nutrients, but at the same time the water that is used in its automated hydroponic system must be constantly enriched with the right nutrients. The water quality of the hydroponic system must be monitored to ensure the right balance [20].

However, we did not use reinforcing fertilizers in our studies in the cultivation of HGF.

## 4. Findings

The analysis of the studies conducted confirms that changes in ambient temperature, soil moisture, directly affect the life cycle of the HGF.

Growing the HGF and automating the system will allow:

1. Attraction of investment funds for the organization of activities for intensive cultivation of agricultural crops;
2. Providing the year-round livestock market with high-quality, nutritious feed;
3. Study, implementation and localization of the experience of new green feeding technologies.

The analyzed results will be used in the future to develop an information system for monitoring the state of the biological object and developing automation for monitoring and regulating parameters for managing changes in the state of cultivation of the HGF.

The results of the research are based on the use of various innovative solutions. Elements of monitoring the thermal conditions of the root system, and the effect of humidity on crop growth, using automation elements, are the stages of the transition to digital agriculture. The development of the cultivation of HGF, and the use of automation elements to control and obtain primary initial information about the state of the process, will fully automate the agricultural industry, increase yields and reduce production costs.

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