The effect of irrigation regime on lucerne yield for hay in conditions of unstable wetting

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Abstract. The main objectives of irrigated agriculture are: obtaining the greatest amount of quality products and the preservation of soil fertility. In this case, irrigated crop rotation is one of the factors for the reproduction of soil fertility, favourable phytosanitary conditions in crops and soil protection from erosion. The potential number of lucerne mowing is determined by the thermal resources of the area, and the actual is closely related to the conditions of optimum soil moisture. In the first year 2–4 mowing of lucerne can already be obtained in various areas of the country, over the next two-three years – 4-7 mowing, or 6–10 tons of hay per hectare in the first year and 120–225 centres in the next. Considering the reduction areas of irrigated and drained lands, it becomes relevant to the competent use of the available reclaimed land. The article presents scientifically-based lucerne irrigation regimes that meet the requirements of a plant in water at the lowest cost per unit of production, provides estimated water consumption data and suggests an economical water consumption for obtaining lucerne yield. Considering the irrigation regime of lucerne, the irrigation rate is significant. Since lucerne is a crop with a deeply penetrating root system, watering should be carried out with moistening of the entire root zone. The required amount of water per irrigation depends on the depth of the root system and the water holding capacity of the soil. The study of whether it is possible to obtain the desired effect with smaller irrigation rates is dictated by the increased capabilities of irrigation technology and these issues are presented in the scientific article. The article gives conclusions about the effect of various irrigation regimes on the formation of lucerne yields for hay.

1. Introduction
Irrigation by sprinkler is advisable to use on those crops that are not affected by disease when water contacts the leaves and requires high humidity, namely: lucerne, cabbage, greens, table beet, carrot, vegetable peas, radish, parsnip, pepper, eggplant, etc. With a number of positive actions, irrigation often improves the agrochemical properties of the soil. Watering at high temperatures contributes to the rapid decomposition of organic matter in the soil. Irrational use of irrigation of agricultural crops leads to its erosion and compaction, which reduces the efficiency of fertilizer use by plants. However, the experience of many agricultural producers proves that irrigation is an agrotechnical device that ensures high and stable yields of agricultural crops. Introduction to the crop rotation of perennial grasses, especially legumes, is of great importance for the preservation of soil fertility, and lucerne is such a crop ameliorant; in addition, lucerne allows to increase the duration of the feed conveyor to 40 days or more.
2. Materials and methods
The territory of the agricultural enterprise, where the research was conducted, is located in the third agro-climatic zone.

A characteristic feature of this zone is unstable moistening over the years by irregular precipitation throughout the year. The average long-term amount of precipitation is 600 mm. During the growing season falls 350–470 mm.

Agrotechnology crops on the options - generally accepted for cultivation zones. In the work’s course, field and laboratory research methods were used. The hydrothermal coefficient is 1.1-1.3, the sum of temperatures is 2100-3000.

All studies were carried out in accordance with guidelines for laboratory and practical research.

The determination of soil moisture was carried out by the weight method, according to B.A. Dospekhov (1987). The total water consumption was found by the method of D.A. Shtoiko.

3. Results and its discussion
The goal of our research was to determine the optimum water regime of the soil, which, in combination with the use of mineral fertilizers, ensures high yields of lucerne hay. To achieve it, the following tasks were set: to identify the effectiveness of various irrigation regimes of lucerne in the cultivation of hay; establish the total water consumption under various irrigation regimes; the influence of the water supply condition on the growth, development and yield of lucerne against the background of irrigation. Two irrigation regimes were investigated: moderate 65–70% and intensive - 75–80%. In the experiments, the zoned variety of Manychskaya lucern [4], (blue-sorted hybrid, drought-resistant, winter-hardy and mid-ripening) was used. The timing of irrigation was determined in various ways, but the most timely - using a moisture meter. Lucerne transport coefficient is quite high and ranges from 700 to 1200 units. It is resistant to atmospheric drought, but it is demanding on soil moisture. [1] In order to obtain a high yield of green mass, it is necessary to maintain an intensive moisture regime within 75–80% of FMC (field moisture capacity). In our experience, the greatest amount of water lucerne consumed in the flowering phase, when there is a maximum increase in the above-ground mass. The total moisture consumption per day during this period on average reached 50–60 m3 / ha. The least lucerne consumed water to form the first mowing, which is explained by the relatively low average monthly temperature and higher air humidity. The most intensive water consumption is in July - August. [2,3],

Ensuring an optimal moisture regime promotes better development after mowing, the formation of a powerful grass stand with high photosynthetic productivity. Different irrigation regimes had a great influence on the size of the assimilation apparatus. The leaf surface while maintaining soil moisture of 75–80% FMC is 83.5 thousand m2 / ha, with 65–70% - 62.6 thousand m2 / ha.

To maintain an optimal humidity regime, the correct setting of irrigation rates is of great importance. Usually, when calculating the irrigation rate, the depth of the active soil layer, from which moisture is intensively consumed, is taken as 1 m.

To determine the total water consumption of lucerne plants for the growing season, as well as for calculating the amount of watering for this zone, the method of D. A. Shtoiko was used. Using the average statistical data of the average daily temperature and relative humidity of the air, we calculated the water consumption for the calculated period, i.e. growing season.

| Month, decade | April | May | June | July | August | Total for the billing period |
|---------------|------|-----|------|------|--------|-----------------------------|
| Water consumption m3 / ha | 45.5 | 286.2 | 334.6 | 472.6 | 422.1 | 4382 |

The soil moisture in the structure of the total water consumption of irrigated options did not have a significant effect and ranged from 14.1 to 17.9%. When approaching the minimum humidity threshold
in the active soil layer of 0-70 cm, watering was prescribed. With an increased humidity threshold, the lucerne productivity increased. The total water consumption per unit area increased with rising of humidification conditions. The smallest total water consumption was observed with a moderate irrigation regime of 65 - 70% FMC.

Table 2. Total water consumption of lucerne (average for 2017-2018).

| Irrigation regime | Irrigation norm m3 / ha | Total consumption m3 / ha | Water consumption coefficient, m3 / t |
|-------------------|-------------------------|---------------------------|--------------------------------------|
| Moderate 65-70% FMC | 3600/6                 | 6490                      | 617                                  |
| Intensive 75-80% FMC | 5600/9                | 7704                      | 601                                  |

From table 2 it can be seen that the preliminary data on the calculation of the total water consumption are underestimated, since the amount of precipitation and irrigation were not taken into account. So, with a moderate humidification mode, the total water consumption was higher by 2108, and with intensive moisture - by 3918 m3 / ha. Such a high difference in computations means that errors may have been made when calculating irrigation rates.

The need of plants for moisture is characterized by the coefficients of transpiration and water consumption. The coefficient of water consumption allows us to determine the amount of water required to obtain the planned crop yield [5]. In our experience, the coefficient of water consumption of lucerne noticeably changed depending on the irrigation regimes. Its largest value was noted at moderate irrigation regime at a humidity of 65-70% FMC - 617 m3 / t, and with an increase in the level of moistening, the coefficient decreases.

Irrigation rate depended on the norms and the number of irrigations. So, with a moderate level of moisture at a rate of 600 m3 / ha and 6 irrigations, the irrigation rate was 3,600 m3 / ha. With an intensive level of moisture, 8–9 irrigations were carried out, and the norm reached 5,600 m3 / ha. The total water consumption changed in proportion to the change in the irrigation rate. The number of irrigations and their distribution is decisively affected by the fact that the above-ground mass is mowed several times during the year.

The highest demand for water is noted during the critical period, i.e. in the budding phase and at the beginning of flowering. This fact should be borne in mind when planning the crop irrigation regime; therefore, it is impossible to speak of a critical period regarding the lack of moisture when growing lucerne for hay.

Lucerne irrigation regime is determined by its biological features, the soil conditions of the area and the weather conditions of the year — primarily precipitation and temperature. The last two factors are caused by quantitative differences in the main elements of the irrigation regime (humidity before irrigation, irrigation rate, number of irrigations, duration of periods between irrigations), and a combination of natural factors and measures taken - quantitative and qualitative changes in yields.

Lucerne, despite drought tolerance, is very responsive to irrigation, better realizes the potential of productivity [5]. In the years of research from the sowing of lucerne obtained by three mowing during the growing season. On average, the harvest was obtained on all variants of the experiment.

Data on the yield of lucernahay are presented in table 3. As the level of moisture increased, the lucerne productivity increased. In our studies, the maximum yield was noted with an irrigation regime of 75-80% FMC. It was 12.5 t / ha over two years. In the variant with a moderate irrigation regime (65-70% FMC), the yield was 1.9-2.1t less. The effectiveness of small irrigation rates is theoretically due to the stratified use of water. Lucerne grows faster when it uses water from surface soil layers.
### Table 3. Effect of irrigation regimes on the yield of lucerne hay, t / ha.

| Irrigation regime       | Years of research | Irrigation regime average |
|-------------------------|-------------------|---------------------------|
| 65-70% FMC              | 11.6              | 10.5                      |
| 75-80% FMC              | 13.5              | 12.5                      |
| Average over the years  | 12.55             | 10.45                     |

The dependencies between evaporation, water consumption, biological coefficients and water consumption deficits established by years of research allow us to determine not only average long-term irrigation rates for these specific conditions, but also their probabilistic values in different years of humidity (table 3).

The conditions of the year were of great importance for the formation of the lucerne yield. So, 2017 was a milder year compared to 2016, however, with an intensive irrigation regime, we used 8–9 vegetation irrigation without taking into account the conditions of the year. With a moderate irrigation regime (65-70% of FMC), 5–6 vegetation irrigation was carried out at 600 m3 per hectare, and the yield was 10.5 t / ha.

If there is enough water for irrigation, then lucerne, especially in the first year of life, should maintain a humidity of about 80% of the total field capacity from heavier soils and about 70% on lighter ones, avoiding a significant reduction in these boundaries.

![Figure 1. The effect of irrigation regimes on the yield of lucerne for hay.](image)

When considering the mode of lucerne irrigation, the magnitude of the irrigation rate is essential. Since lucerne is a crop with a deeply penetrating root system, watering should be carried out with moistening of the entire root zone. The required amount of water per irrigation depends on the depth of the root system and the water holding capacity of the soil.

According to other studies, despite the peculiarities of lucerne, it can be irrigated in small doses, but more often, keeping a small soil layer moist. If you follow the changes in soil moisture in a smaller soil layer, for example 40-50 cm, and keep this layer wet by irrigation at a rate of 400-500 m3 per 1 ha, you can ensure a high yield. The number of irrigations, especially in the summer months, does not affect the dry matter yield. It is much more important to correctly determine the amount of water that plants should receive, and not the frequency of irrigation.

### 4. Conclusion

The study of whether it is possible to obtain the desired effect with smaller irrigation rates is dictated by the increased capabilities of irrigation technology. The effectiveness of small irrigation rates is
theoretically due to the stratified use of water. Lucerne grows faster when it uses water from surface soil layers.

The effect of small watering is explained by the location of the root system of plants. It has been established that 80% of lucerne roots located in a layer up to 100 cm are concentrated at a depth of up to 50 cm, that is, where there is enough nutrients and water supplied by precipitation and irrigation [6].

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