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PHOTOSYNTHETIC PERFORMANCE INDICATORS OF VARIEGATED ALFALFA DEPENDING ON THE SOWING METHOD IN THE FOREST STEPPE OF THE MIDDLE VOLGA REGION

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ABSTRACT

Undercrop cultivation of alfalfa is economically justified, since in the year of sowing, cover crops give a full harvest, and also one mowing of alfalfa for hay is carried out, moreover the special preparation of the soil for grasses is not re-quired.

In the conditions of the Middle Volga region, the experiment was laid on leached chernozem in 2017 - 2019, where they studied the sowing of variegated alfalfa under the crops of spring wheat, barley, oats, harvested for grain and an-nual grasses - for green fodder, and studied the options for coverless sowing, where the weeds were mowed twice and the herbicide Pivot was applied at the beginning of alfalfa branching. The total biological yield is determined by the leaf area and its photosynthetic activity. Therefore, the purpose of the research is to determine the indicators of alfalfa photosynthetic activity for an objective as-sessment of the influence of cover crops on their forage productivity. It has been established that a more intensive increase in the assimilation surface of alfalfa in the first year of life to 31.6 and 30.6 thousand m^2/ha occurs on coverless sowing with the application of the Pivot herbicide and two-fold mowing of weeds. The dry matter yield was 2.1 and 2.0 t/ha, respectively. A decrease in the illumination of alfalfa plants sown under crops, where the leaf area did not exceed 13.0...15.3 thousand · m^2/ha, slowed down the photosynthesis processes. Moreover, a more intensive growth of its photosynthetic organs was noted under the crop of barley, the cereal-legume mixture reduced the leaf area by 0.5 thousand m^2/ha, the pho-tosynthetic potential was 898...1051 thousand m^2 day/ha.

Keywords: alfalfa, photosynthesis, leaf area, net productivity of photosynthesis, photosynthetic potential, cover crops

INTRODUCTION

One of the most important forage grasses that solve the problem of plant protein and soil fertility increase is alfalfa, (Gorkovenko, 2007), which occupies more than 35 million hectares worldwide (Bogatyreva *et al.,* 2019). Its productivity is largely determined by the growing conditions in the first year of life, both when grown in its pure form and under the cover of annual crops. At the same time, water, food and light regimes deteriorate in undercrop plants. This causes melting-out of grass formation and decrease in productivity.This problem can be solved by shortening the period of stay of alfalfa under crops, reducing the density of the cover crop and their species diversity (Vasilko *et al.,* 2013; Eryashev *et al.,* 2020).

However, the undercrop cultivation of alfalfa is economically justified, since in the first year of its life, cover crops give a full harvest, and also one mow of alfalfa for hay is carried out, and a special soil preparation for grasses is not required (Averkin *et al.,* 2017). Alfalfa does not occupy a separate area and is better protected from weeds (Zholik *et al.,* 2018; Votnitsev, 2020).

For each region, the optimal cover crop should be established experimentally, since the data available in the literature are often correct only for those conditions where the studies were carried out (Platunov *et al.,* 2008).

On coverless forage sowing of alfalfa, weeds are destroyed in 20-30 days after germination,as a rule, by mowing at a plant height of 15-20 cm (Zholik *et al.,* 2018; Shchebarskova *et al.,* 2018).

As a long light plant, at the beginning of development, alfalfa tolerates slight shading.Sensitivity of seedlings to a lack of light isquite high in the first 30-40 days. An increase in illumination, after mowing weeds or harvesting a cover crop, accelerates the growth and development of plants, the processes of photosynthesis, but the seed productivity of alfalfa decreases (Votintsev *et al.,* 2020).

The most important characteristics of the production process of any agricultural crop are the indicators of photosynthetic activity, the value of which is determined by the conditions of photosynthetic apparatus formation and the duration of its functioning (Kshnikatkina *et al.,* 2019; Kozyreva *et al.,* 2020). The creation of highly productive perennial grasses depends on the correct choice of cover crop.

In this regard, the objective of the research is to determine the indicators of photosynthetic activity of alfalfa for an objective assessment of the influence of

cover crops on its forage productivity.

MATERIALS AND METHODS

The experimental work was carried out in 2017-2019. at the experimental field of a separate subdivision of the Federal State Budgetary Scientific Institution "Federal Scientific Center for Fiber Crops" in Penza (until 2019 - Penza Research Institute of Agriculture). The object of research was variagated alfalfa of Daria variety (*Medicago sativa* L. nothosubsp. varia (Martyn) Arcang).The plough-layer of leached medium-thick heavy-loamy chernozem is characterized by the following agrochemical indicators: humus content - 6.2-6.5% (GOST 26213-91),easily hydrolyzable nitrogen - 85-97 mg/kg (according to Cornfield's method), labile phosphorus and exchange potassium 165-176 and 133-152 mg/kg of soilпочвы (GOST 26204-91), respectively, the reaction of the soil solution is close to neutral (pHsol 5.6-5.8) (GOST 26483-75).The forecrop is winter wheat.

Soil cultivation consisted of fall tillage, early spring harrowing, pre-sowing cultivation and compacting. The sowing was carried out annually in the first ten days of May with a CH-16 seeder in a row method with a seeding rate of 6 million germinating seeds per hectare. In cover crops it is reduced by 30% of the total, according to the recommendations for their cultivation in the Penza region. The plot area is 25 m^2,the experiment was repeated four times.

To reduce the hardness of seeds and increase their germination, alfalfa sowing material was wounded. On the day of setting the experiment, the seeds were inoculated with Gumariz enriched with microelements. After the sowing, the soil was compacted withstar-wheeled rollers.

The experimental scheme included the sowing of alfalfa under the crops of spring wheat, barley, oats, which were harvested for grain and annual grasses - for green fodder (vetch and oat mixture), and also the options for coverless sowing were considered, where the weeds were cut twice and the herbicide Pivot, SC was applied (1 l/ha) at the beginning of alfalfa branching.

The experimental work was carried out according to the guidelines for conducting field experiments with fodder crops of the VNII of fodders named for V.R. Williams (1983) and the method of field experiment modified by B.A. Dospekhov (1985). The area of the assimilation surface of plants in crops was determined by the method of A.A. Nichiporovich (1961), the net productivity of photosynthesis - according to the formula proposed by L. Briggs, F. Kidd, C. West. The main indicators of productivity were studied according to generally accepted methods.

One of the most important indicators of meteorological conditions is the hydrothermic coefficient (HTC), which reflects moisture content, namely, the relation between temperature and precipitation (Selyaninov, 1930). In terms of hydrothermal conditions, the years were characterized as dry (HTC - 0.4) and dry (HTC - 0.8), with significant differences not only by year, but also by month (Fig 1).

In the first year of research (2017), precipitation in May was 60% more than normal. At the same time, the hydrothermic coefficient was 1.8, and for the period May-September - 0.8. The prevailing weather conditions made it possible to form a good vegetative mass of cover crops, which negatively affected the undercover crops of alfalfa.At the same time, it was dry in the summer months (HTC – 0.4). After harvesting cover crops for grain (mid-August), alfalfa plants were found in severe drought conditions.And only precipitation in thefirst ten-day period of Septemberincreased its viability. The amount of precipitation that fell in May 2018 was only 43% of the norm, which negatively affected the germinating ability of seeds.At the end of the month, late spring frosts were observed, from which alfalfa plants did not suffer, as they are able to withstand a drop in temperatures down to minus 5-6 ºC. For the entire growing season, the HTC was 0.4, which corresponds to drought. The average daily air temperature was 17.6°C, exceeding the long-term average by 1.5°C. The summer was dry and hot. There was 2.3 times less precipitation during the growing season than the climatic norm. 2019 was also droughtly in terms of humidification (HTC - 0.7). The average daily air temperature during the growing season was at the level of the previous year with a precipitation deficit of 30%.

Plants of variegated alfalfa grown under cover, did not reach the flowering phase in the year of sowing, the plants without cover - bloomed in the second half of August with a a growing season of 111 ... 117 days.

RESULTS AND DISCUSSION

Photosynthesis is a unique biological phenomenon, in the process of which sunlight is used by wildlife for the synthesis of organic compounds with high efficiency. Being the most important process in the life of plants, it determines their supply of nutrients necessary for growth and development, and ultimately for obtaining a high-quality harvest, since up to 90-95% of dry plant biomass is formed as a result of photosynthesis and rapid transport of assimilators.Therefore, in the formation of the crop, this process plays a leading role (Nichiporovich, 1961). Plants that use solar energy more fully have the objective ability to form a larger biological mass (Volodina *et al.,* 2019).

One of the main but the most variable indicators of the photosynthetic activity of crops is the size of the leaf surface, with the help of which the energy of solar radiation is captured and is converted into the potential energy of organic matter in the process of photosynthesis (Nichiporovich, 1961). Many researchers note that the formation of the assimilation surface depends on the biological characteristics of the culture, weather conditions, and most significantly on the elements ofagrotechnics (Stoy, 1973; Lamb, 2003).

Variant	Year			
	2017	2018	2019	average
Coverless sowing:				
two-fold mowing of weeds	35.9	22.6	33.4	30.6
application of Pivot herbicide	37.4	22.8	34.7	31.6
Cover crops:				
spring wheat	12.7	8.9	18.3	13.3
barley	15.6	10.7	19.5	15.3
oats	14.3	8.3	16.4	13.0
annual herbs for green fodder (vetch and oats)	15.0	10.3	19.1	14.8

Table -1 The assimilation surface of variegated alfalfa on the first year of life, depending on the cultivation method, thousand m^2/ha

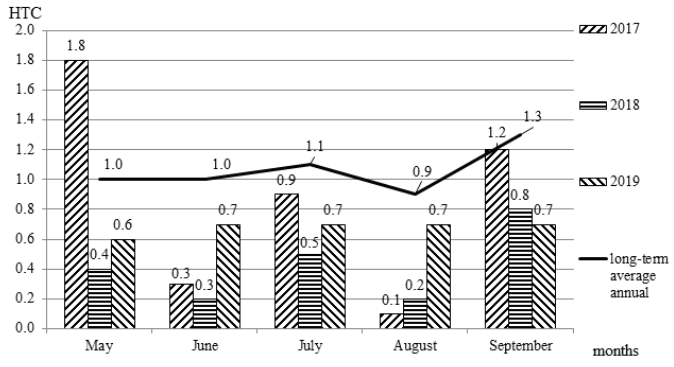

Fig.1: Hydrothermic coefficient in the years of study

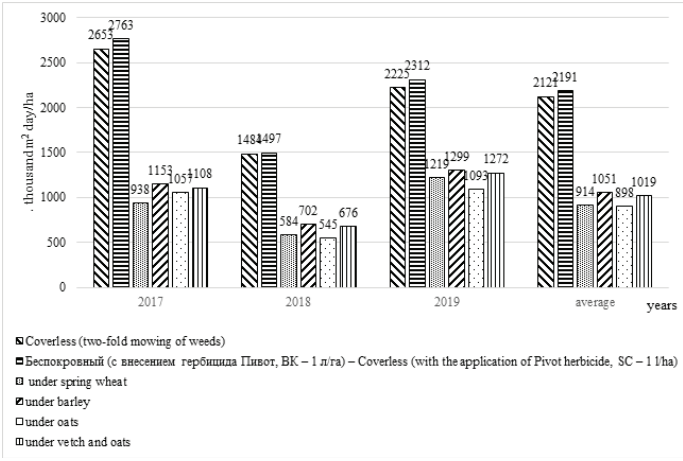

Fig.2: Photosynthetic potential of variegated alfalfa in the first year of life depend-ing on the cultivation method, thousand m^2 day/ha

As a result of three-year research (2017 - 2019), it was found that in the first year of life variegated alfalfa formed the leaf area within the range of 13.0 ... 31.6 thousand m^2/ha (Table 1). The most intense growth of the photo-synthesizing surface took place on crops of alfalfa without cover - 30.6 ... 31.6 thousand m^2/ha. Moreover, the most optimal conditions for the plants were formed in the plant formation with the application of Pivot herbicide, since the weed component did not compete with cultivated plants.In the undercover crops of alfalfa the processes of photosynthesis were less intensive due to a lack of illumination, the leaf area was 2.0...2.4 times less and made up 13.0...15.3 thousand m^2/ha. Moreover, the most favorable conditions developed under the cover of barley. Early harvesting of annual grasses for green forage reduced the area of alfalfa assimilation surface only by 0.5 thousand m^2/ha and made up 14.8 thousand m^2/ha.

The meteorological conditions of the growing season had a significant impact on the development of the photosynthetic apparatus of alfalfa, and the most optimal were in 2017, when the HTC was 0.8. It should be noted that the emergence of seedlings was influenced by the autumn-winter deposit of moisture.Precipitation in the third ten-days period of May, which exceeded the norm by 2.4 times, contributed to a more intensive growth of the above-ground mass of cover crops, thereby reducing the illumination of alfalfa, which led to a weak development of its assimilation apparatus.This pattern remained throughout the growing season and on cover crops the area of functioning alfalfa leaves was 12.7...15.6 thousand m^2/ha, and the best conditions for it were under the cover of barley. Alfalfa sowing without cover was able to form the largest leaf area, which was 35.9 and 37.4 thousand m^2/ha, respectively after two-fold mowing of weeds and herbicide treatment.

The next year of sowing (2018), the average daily temperature exceeded the norm by 2.7 ºC, moreover there was 2.4 less precipitation during the growing season. This significantly influenced the formation of the photosynthetic surface of alfalfa, which was 1.4...1.7 times less than in the previous year of research. The leaf area on coverless sowing made up 22.6...22.8 thousandm^2/ha, on cover crops – 8.3…10.7 thousand m^2/ha, moreover under the dry conditions (HTC – 0.4),barley, as a cover crop, reduced the growth rate of alfalfa leaf area less than others.

The assimilation surface of alfalfa in the third year of setting the experiment (2019) on coverless sowing reached 33.4...34.7 thousand m^2/ha. However, the area of leaves when sown under the cover of agricultural crops was 1.2...2.1 times higher than in previous years of research. Probably, uniform precipitation during the growing season influenced the development of not only cover crops, but also alfalfa, the leaf area ofwhich was 16.4...19.5 thousand m^2/ha.

An indicator that determines the productivity of the photosynthesis process is the photosynthetic potential (PhP), which takes into account the leaf area and the time of leaf surface operation (Gushchina, 2013; Belkina *et al.,*

2017).

On average, over three years, the PhP for the variants of the experiment changed significantly and amounted to 898...2191 thousand m^2 · day/ha (Figure. 2).In the first year of the variegated alfalfa life, the largest leaf area was observed for plants under coverless cultivation, therefore, they accumulated solar energy more intensively and the PhP was 2121...2191 thousand m^2 · day/ha. The most optimal conditions developed on crops with herbicidal treatment of alfalfa in the branching phase with Pivot. The PhP values are 2.1...2.4 times lower under cover crops. However, the best development was observed in the variant where barley harvested for grain was used as a cover crop. PhP in this case amounted to 1051 thousand m^2 · day/ha, under the cover of the early-harvested grass-and-legume mixture for green fodder, it decreased by 32 thousand m^2 · day/ha.

The photosynthetic potential, as well as the leaf surface area, depends on the year water availability (Kshnikatkina *et al.,* 2019). Due to the better development of the assimilation surface, the highest PhP (1153...2663 thousand m^2 day/ha) was noted in 2017, which was the most favorable in terms of moisture and temperature.

The accumulation of dry mass of plants is influenced not only by the area of the assimilation surface and the time of its operation, but also by the productivity of each unit of leaf surface, which is assessed as an important indicator as the net photosynthesis productivity (NPhP) (Nichiporovich, 1961).

NPhP variegated alfalfa in the first year of life was in the range of 0.75…0.95 g/m^2•day. The highest indicator was formed on coverless sowing with the application of the herbicide Pivot, since the plants slightly shaded each other, which contributed to the accumulation of 2.11 t/ha of dry matter.

The net productivity of plant photosynthesis under barley was higher than under other cover crops. However, the vetch and oat mixture for green fodder reduced the activity of functioning leaves by only 1%. At the same time, 0.7…0.9 t/ha of dry mass was obtained.

CONCLUSION

On the basis of three-year studies, it has been established that a more intensive increase in the leaf surface of alfalfa in the first year of life occurs on coverless sowing with the Pivot herbicide application and two-fold mowing of weeds. Dry mass yield was 2.1 and 2.0 t/ha, respectively. Cover crops, shading alfalfa plants, reduce the leaf surface area by 52...59%, the photosynthetic productivity of the crop by 53...59%, and the net photosynthesis productivity by 14.7...21.0%. Therefore, the indices of the photosynthesis productivity are not stable and strongly depend on environmental conditions and the degree of human impact on the plant organism.

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