Документ подписан простой электронной подписью
Информация о владельце:
ФИО: Махаева Наталья Юрьевна
Должность: Проректор по учебной и воспитательной работе, молодежной политике ФГБОУ ВО "Ярославский ГАУ"
Дата подписания: 02.02.2024 11:01:58
Уникальный программный ключ:
fa349ae5f25a45645da89cfbd7187284ea10f48e8

IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

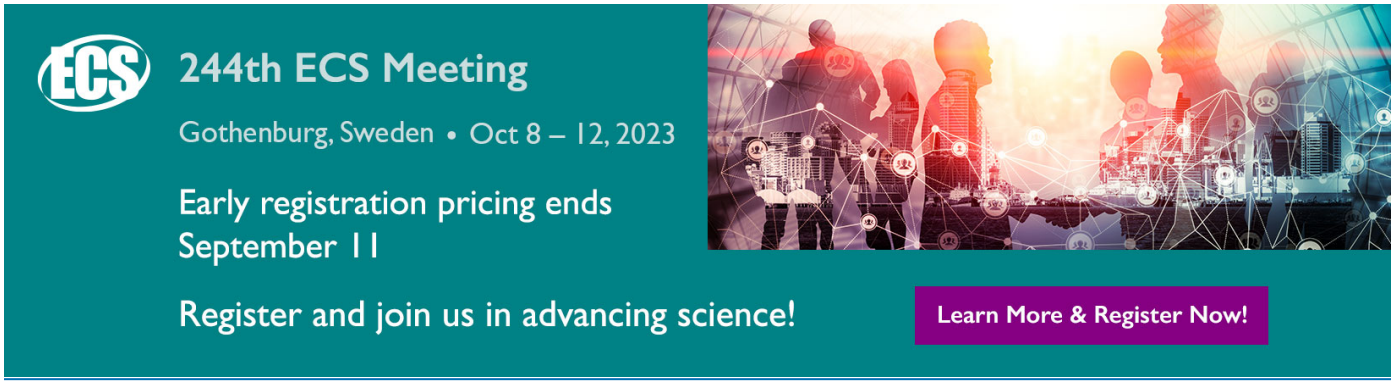
Phytosanitary indicators of fodder crops under using organic cultivation technology

To cite this article: A M Trufanov *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1229** 012003

View the article online for updates and enhancements.

You may also like

- Quality and Quantity of Sorghum Hydroponic Fodder from Different Varieties and Harvest Time
R. Chrisdiana
- Cooling effects of increased green fodder area on native grassland in the northeastern Tibetan Plateau
Wenqi Liu, Yuting Zhou, Jinwei Dong et al.
- Method of increasing the mixed fodder nutritional and energy value
V V Matyushev, I A Chaplygina, A V Semenov et al.



This content was downloaded from IP address 95.25.224.189 on 28/08/2023 at 10:00

Phytosanitary indicators of fodder crops under using organic cultivation technology

A M Trufanov[1], A N Voronin[1], S V Shchukin[1], Ya S Romanina[1] and A V Tikhonov[2]

[1] Department of Agronomy, FSBEI HE Yaroslavl State Agricultural Academy, 58, Tutaevskoe highway, Yaroslavl, 150042, Russia
[2] Yaroslavl Scientific Research Institute of livestock breeding and forage production – Federal State Budget Scientific Institution "Federal Williams Research Center of Forage Production and Agroecology", 1, Lenin street, Mikhailovsky village, Yaroslavl Region, 150517, Russia

E-mail: a.trufanov@yarcx.ru

Abstract. The article provides data based on a four-year study of five cultivation technologies of different intensity, including organic. On the example of seven crops of fodder crop rotation, the effectiveness of controlling phytosanitary indicators - the number and mass of weeds, the spread of diseases and the number of insect pests, which are an obstacle to the widespread use of ecological cultivation technologies, was studied. The results of the research made it possible to recommend perennial grasses up to 3 years of use for inclusion in fodder crop rotations in order to improve the phytosanitary condition of crops, and corn in order to obtain high fodder crop rotation productivity. For the cultivation of forage crops, the use of organic technology is fully justified, as it contributed to the reduction in the abundance of weeds, minimized the prevalence of diseases of annual and perennial grasses, corn, reduced the number of pests; provided increase in productivity compared to extensive technology.

1. Introduction

Organic farming is recognized as a potential approach to achieve a more sustainable food system and promote rural development [1]. Compared to conventional, it is more environmentally friendly in terms of reducing pollution, pressure on biodiversity with a positive impact on soil quality [2].

However, like any farming system, it has a number of problems. This is mainly due to lower productivity (crops and animals), which is about 20-34% less than in conventional agriculture [3]. It is usually determined by a lack of nutrients, the presence of weeds, pests and diseases [4-5].

In intensive technologies, weeds, especially perennials, are not an insoluble problem [6], but in ecological agricultural technologies, this problem can come to the fore and become an barrier to the organic production of agricultural crops [7-8].

However, the optimal combination of biological and mechanical methods of weed control, opportunities open up to reduce the pesticide load on agrophytocenosis up to the complete exclusion of their use in the plant protection system without the risk of a significant increase in weediness and a decrease in yield [9-10]. It can be used in the introduction of organic farming [11].

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

Phytopathogens and insect create more serious problems for ensuring food security, which lead to reduced yields and annual losses of billions of dollars in the global economy, despite the fact that pest and pathogen control methods are very limited in organic farming conditions [12-13].

Therefore, studies aimed at establishing the most effective technologies for cultivating fodder crops based on their phytosanitary condition and productivity are relevant and of scientific and practical interest.

2. Materials and methods

The studies were carried out in 2018-2021 in the joint field experiment of the Yaroslavl Research Institute of Animal Husbandry and Feed Production – branch Federal Research Center "VIK named after V.R. Vilyams" and the Department of Agronomy of the Yaroslavl State Agricultural Academy on soddy-podzolic medium loamy soil. The scheme of the experiment includes the factor "crop rotation": annual grasses (oat-vetch mixture) with oversowing of perennial grasses (mixture of alfalfa, timothy grass meadow, meadow fescue) - perennial grasses - cereals for green mass (wheat, triticale) - barley for grain - corn for silage; and the factor "cultivation technology": extensive - without fertilizers and pesticides; intensive - mineral fertilizers are applied differentially for crop rotation at average rates + organic fertilizers; high-intensity - mineral fertilizers are applied differentially for crop rotation at higher rates + organic fertilizers + chemical plant protection; organic - without mineral fertilizers and pesticides, with the use of organic fertilizers; biological - limited use of mineral fertilizers (minimum norms) + organic fertilizers. The area under crop is 600 m^2 - plots of the first order, cultivation technologies are being studied on plots of the second order with an area of 120 m^2.

The number of weeds was carried out by using a 1 m^2 frame to account for perennial weeds and 0.125 m^2 frame – to account for annual weeds. Accounting areas were allocated by the method of randomization. The dry mass of weeds was determined by drying to a constant weight in a thermostat at a temperature of 105 ° C and weighed to an accuracy of 0.1 g.; the registration of damage of crops by diseases was carried out with the selection of 2 samples of 20 plants with and determination of the prevalence and intensity of the disease; the number of insect pests was determined by the visual method on test plots of 0.25 m^2 and catching with a net (mowing); the yield of all field crops was taken into account by a plot method; the content of feed units in the forage crops was determined in the chemical analytical laboratory; statistical methods are analysis of variance (ANOVA) and correlation-regression analyses.

The weather conditions during the study period were varied and covered possible options: 2018 and 2021 were characterized by increased air temperature, but differed greatly in the moisture (in 2018, the amount of precipitation was at the level of long-term data, in 2021, their excess was observed), and 2019 and 2020 were close in terms of thermal properties to the average long-term observations, while in terms of precipitation, the growing season of 2020 was the most waterlogged.

3. Results

The number of weeds is an objective indicator of weed infestation of crops, the most commonly used to assess the abundance of weeds. The indicator of the total number of weeds significantly decreased during the cultivation of perennial grasses, and with an increase in the period of use to three years, it decreased from 3.6 times to 7.0 times compared with annual grasses (table 1).

The number of both groups of weeds significantly decreased - perennial (by 59.7% on average) and annual (by 8.8 times). In our experiment, the total number of weeds was also lower in the next two crops of the crop rotation (cereals and barley by 53.2%), and for perennial weeds, the decrease was significant (1.4-2.4 times).

The studied cultivation technologies contributed to a significant decrease in the number of perennial weeds compared to the control extensive (from 22.7% on organic to 63.0% on biological), while the total number of weeds and the number of annual weeds decreased insignificantly. It was the ecological cultivation technologies - biological and, especially, organic, that reduced the total number of weeds to the greatest extent - by 10.5% and 15.4%, respectively.

Along with the number of weeds, their dry weight is one of the indicators of the abundance of weeds, characterizing their competitiveness for life factors. In our studies, the index of dry mass of weeds was in correlation with their abundance: there was a significant direct correlation between the total number and mass of weeds ($r = 0.69$, $r^2 = 0.47$, $p = 0.0000005$), so and indicators of their groups - perennial ($r = 0.73$, $r^2 = 0.53$, $p = 0.000001$) and annual ($r = 0.58$, $r^2 = 0.34$, $p = 0.0002$).

Table 1. Indicators of the abundance of weeds on average for the studied factors (average for the period 2018-2021).

Variant	Number of weeds (pcs./m^2)			Dry mass of weeds (g/m^2)		
	total	perennial	annual	total	perennial	annual
Crops						
Annual grasses with sowing perennial grasses	71.2	12.3	58.9	41.9	21.5	20.4
Perennial grasses for first year of use	19.3	7.3	12.0	12.3	9.1	3.2
Perennial grasses for second year of use	14.3	6.9	7.4	9.3	8.8	0.5
Perennial grasses for third year of use	10.3	8.9	1.4	8.5	8.3	0.2
Cereals (wheat, triticale)	46,5	5.1	41.4	27.7	4.8	22.9
Barley	46.3	8,8	37.5	31.0	14.9	16.1
Corn	58.5	15.0	43.5	96.6	21.2	75.4
Cultivation technologies						
Extensive	44.2	11.9	32.3	33.2	13.7	19.5
Intensive	40.3	8.6	31.7	36.6	11.5	25.1
High intensive	40.2	8.2	32.0	39.8	14.2	25.6
Organic	38.3	9.7	28.6	29.3	10.8	18.5
Biological	39.9	7.3	32.6	39.0	13.0	26.0

It was more effective to reduce the dry weight of weeds by growing perennial grasses in crop rotation, and their use for up to three years can completely remove annual species (to a weight of less than 1.0 g/m^2) and reduce the weight of perennials to the minimum values (up to 8.3 g/m^2, i.e. 2.6 times), this effect also affected the next crop (cereals), providing a significant reduction in the mass of perennial weeds (4.5 times) compared to annual grasses. At the same time, the cultivation of row crop - corn, especially under using of manure, led to the maximum weediness, especially with annual weeds (the mass increase was 3.7 times compared to annual grasses).

As for cultivation technologies, in comparison with the control extensive, almost all of them contributed to an increase in dry weight, and a significant increase was at high-intensity (by 19.9% by total weight and 32.0% by weight of annual weed species), intensive (by 29.9% by weight of annual weeds) and biological (by 34.0% by weight of annual weeds). Only organic technology contributed to the trend of decreasing dry weight (total by 13.3%, weight of perennial species - by 26.9%, annual - by 4.9%).

When analyzing the diseases of forage crops in crop rotation, indicators of the abundance and development were taken into account (table 2). In general, was noted the manifestation of signs of fungal infections.

In the context of cultivation technologies, significant differences were absence with a trend towards a decrease in abundance by 0.5% when using intensive technologies and an increase by 1.5-2.2% when using ecological ones. At the same time, the development of diseases was practically at the same level.

Harmful insects are often a factor in reducing crop yields, especially when it is impossible to use chemical methods of their control. On average, over the period of our research (2018-2021), there was

a significant negative (inverse) correlation between the total number of insect and the productivity of fodder crop ($r = -0.63$, $r^2 = 0.40$, $p = 0.00004$).

Table 2. Phytosanitary indicators of forage crops on average for the studied factors (average for the period 2018-2021).

Variant	Diseases		Number of insects (pcs./m^2)
	abundance (%)	development (points)	
Crops			
Annual grasses with sowing perennial grasses	19.9	1.3	16.5
Perennial grasses for first year of use	16.9	1.1	12.9
Perennial grasses for second year of use	15.5	0.8	17.3
Perennial grasses for third year of use	28.6	1.0	17.5
Cereals (wheat, triticale)	47.8	1.8	16.9
Barley	25.9	1.3	15.3
Corn	19.4	0.8	7.7
Cultivation technologies			
Extensive	20.2	1.1	15.8
Intensive	19.7	1.1	11.3
High intensive	19.8	1.1	12.3
Organic	21.7	1.0	14.4
Biological	22.4	1.2	13.0

In our experiment, the cultivation of corn contributed to the least spread of pests - the decrease compared to annual grasses was significant and amounted to 2.1 times. The cultivation of perennial grasses of the first year of use also contributed to a decrease in the number of pests compared to annual ones by 27.9%, while in grasses of the second and third years of use, the number of pests increased to the level of annual grasses (16-17 pcs./m^2). The cultivation of barley tended to decrease by 7.8%, while the cultivation of cereals - an increase of 2.4%.

When comparing cultivation technologies, a clear pattern was revealed for the decrease in the total number of harmful insects when using technologies with the use of fertilizers compared with extensive control technology. The use of mineral forms of fertilizers in addition to organic fertilizers at low (on biological technology), medium (on intensive technology) and high (on high-intensity technology) norms led to a significant decrease in the indicator, respectively, by 21.5%, 39.8% and 28.5%. The use of only organic forms of fertilizers in the technology of the same name contributed to the trend of reducing the number of pests by 9.7%.

The crops reacted differently to their cultivation according to different intensity technologies. On average, corn contributed to the highest yield of fodder units (13618 fodder units/ha), significantly exceeding all crops of the crop rotation, except for perennial grasses of the first and second years of use (table 3).

Compared to annual grasses, the increase in corn productivity was 3.2 times, with perennial grasses on average - 2.5 times, with cereals - 4.0 times, with barley - 4.2 times. When comparing cultivation technologies, there was a significant increase in productivity on intensive technologies compared to the control (by 52.3% in intensive and 64.8% in high-intensity), on variants of ecological technologies, the increase in productivity was as a trend (39.5% in biological and 26.8% in organic). It should be noted that, despite the absence of mineral fertilizers and pesticides in organic technology, the productivity of fodder crops did not significantly decrease both in comparison with intensive and high-intensity technologies - there was a downward trend, respectively, by 20.1 and 29.9%.

Table 3. The productivity of fodder crops on average for the studied factors (fodder units/ha) (average for the period 2018-2021).

Variant	Productivity of fodder crops (fodder units/ha)
Crops	
Annual grasses with sowing perennial grasses	4235
Perennial grasses for first year of use	6724
Perennial grasses for second year of use	5872
Perennial grasses for third year of use	4040
Cereals (wheat, triticale)	3389
Barley	3225
Corn	13618
Cultivation technologies	
Extensive	4410
Intensive	6718
High intensive	7266
Organic	5594
Biological	6151

4. Discussion

The effect of reducing the number and mass of weeds in perennial grasses can be used as a phytocenotic method of controlling weeds in other crops. In our experiment, this effect was traced in two subsequent crops of the crop rotation. The decrease in the abundance of weeds in forage crops when using organic technology indicates the possibility and prospects of its introduction as a way to control weeds. The lower efficiency of this technology was revealed in reducing the abundance of diseases and phytophages (pests) in forage crops in comparison with intensive technologies, including pesticides and mineral fertilizers in medium and high rates. However, this did not lead to a significant decrease in the productivity of crops, but in the variant with organic technology, the quality of products increased, for example, due to the presence of a larger amount of the legume component in the grasses mixture, a decrease in the proportion of forbs, and also by increasing the percentage of more valuable forage parts of the corn.

5. Conclusion

On soddy-podzolic soils, in order to obtain more than 6,000 fodder units per hectare of crop rotation area, it is recommended to introduce a seven-field fodder crop rotation with the inclusion of perennial grass mixtures for up to three years of use, which have a significant phytosanitary effect, as well as corn as the most productive crop (over 13.000 fodder units / ha per year).

Under these conditions, it is advisable to use organic cultivation technology, which provides for the use of organic fertilizers (grain straw, manure at a rate of 60 t/ha for corn, green manure). This system optimizes the phytosanitary indicators of crops and soil: it reduces the abundance of weeds by 13.3-15.4%, minimizes the abundance of diseases of annual and perennial grasses, corn, and also reduces the number of pests by 9.7%. In addition, it provides an average increase in productivity of 26.8% compared to the control, while improving the yield quality of the crops.

References

[1] Kujala S, Hakala O and Viitaharju L 2022 Factors affecting the regional distribution of organic farming. *Journal of Rural Studies* **92** 226-236

[2] Tuomisto H L, Hodge I D, Riordan P and Macdonald D W 2012 Does organic farming reduce environmental impacts? – A meta-analysis of European research. *Journal of Environmental Management* **112** 309-320

[3] De Ponti T, Rijk B and van Ittersum M K 2012 The crop yield gap between organic and conventional agriculture. *Agricultural Systems* **108** 1-9
[4] Korsaeth A 2008 Relations between nitrogen leaching and food productivity in organic and conventional cropping systems in a long-term field study. *Agriculture, Ecosystems & Environment* **127** 177-188
[5] Lee Marzano S, Wander M M, Villamil M B, Ugarte C M, Zaborski E R and Eastburn D M 2014 Organic Amendment and Transitional Cropping System Effects on Crop Diseases. *Agronomy Journal* **106** 519-527
[6] Strehlow B, de Mol F and Gerowitt B 2020 Herbicide intensity depends on cropping system and weed control target: Unraveling the effects in field experiments. *Crop Protection* **129** 105011
[7] Melander B, Holst N, Rasmussen I A and Hansen P K 2012 Direct control of perennial weeds between crops – Implications for organic farming. *Crop Protection* **40** 36-42
[8] Teasdale J R, Coffman C B and Mangum R W 2007 Potential Long-Term Benefits of No-Tillage and Organic Cropping Systems for Grain Production and Soil Improvement. *Agronomy Journal* **99** 1297-1305
[9] Vlasenko N G and Korotkikh N A 2012 P Pluses and minuses of the agrotechnical method of plant protection *Plant Protection and Quarantine* **2** 16-19
[10] Bazdyrev G I 2005 Efficiency of long-term use of soil protection technologies *News of the Timiryazev Agricultural Academy* **4** 32-40
[11] Trufanov A M, Voronin A N and Shchukin S V 2020 Efficiency of weed control in feed crops cultivation by organic technology. *Materials of the III International Scientific Conference: AGRITECH-III-2020: Agribusiness, Environmental Engineering and Biotechnologies, Volgograd, Krasnoyarsk* 42056
[12] Khatri S, Dubey S, Shivay Y S, Jelsbak L and Sharma S 2023 Organic farming induces changes in bacterial community and disease suppressiveness against fungal phytopathogens *Applied Soil Ecology* **181** 104658
[13] Costa C A, Guiné R P F, Costa D V T A, Correia H E and Nave A 2019 *Pest Control in Organic Farming* (Woodhead Publishing) 90