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The Efficiency of Eastern Galega (*Galega orientalis*) Cultivation

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ABSTRACT: Taking into account the increasing need for eastern galega seeds, it is necessary to look for effective ways to increase their yield. One of the methods is the use of plant protection products and the Albite growth regulator. The purpose of the research was to provide the scientific rationale for the economic and energetic viability of using crop protection agents and the Albite growth regulator on seed stands of *Galega orientalis*. The effect of these factors on yield capacity was studied in the field experiments (2012-2014) and the economic and energetic efficiency of the agricultural methods was calculated. Field experiments, observations, analyses, accounting and processing of the obtained results were carried out according to modern methods used in crop production. The studies showed that the highest yield of *Galega orientalis* seeds was obtained against the pesticide-free background when plants were sprayed with the Albite growth regulator at the beginning of spring regrowth and budding phases and against the pesticide background during the spring regrowth phase; it was higher than in the control by 55.3% and 50.1%. The highest conditional net profit (92.1 thousand rubles/ha) and bioenergetic coefficient (2.8), as well as the lowest production costs (6.12 thousand rubles/t) and energy-output ratio (7.2 GJ/t) of seeds, were achieved without using plant protection products but with the use of Albite during the vegetation of galega in the phase of spring regrowth and budding.

Keywords: Bioenergetic coefficient, conditional net profit, costs, energy balance, energy expenditure, gross energy yield, gross production value, production costs, profitability, seed energy-output ratio.

I. INTRODUCTION

In recent years, the proportion of fodder grasses has been increasing around the globe and is 58% on average in Russia. This trend is substantiated by the fact that perennial grasses are highly adaptive, productive, and the cheapest feed can be made from them. Therefore, intensification of field feed production implies the increase in the planting acreage of perennial leguminous crop *Galega orientalis*. This can be made possible by increasing the seed production of this crop. The use of pesticides and the Albite growth regulator contributes to their yield increase [1, 2].

In the Primorsky Territory, the use of sodium humate contributed to an increase in the yield of eastern galega seeds by 27-30%, while their sowing qualities improved [3]. In the Central region of Russia, on sod-podzolic medium-loamy soil, spraying of eastern galega plantings in the branching phase with growth regulators led to an increase in productivity by 4.5–75.0%, and in the control phase – to 6.8 t/ha of dry matter [4].

Studies of another grain legume crop – peas – on leached chernozem in the Republic of Mordovia showed that the use of plant protection products increased grain yield by 40.7% (3.04 t/ha). The highest yield was observed when Albite was used during the seedling phase (2.96 t/ha); it was by 16.5% higher than in the control. In terms of particular differences, this parameter was higher than in the control (2.31 t/ha) in the variant with the use of Albite and chemical protective agents during the seedling phase (3.31 t/ha), during the seedling and budding phases (3.16 t/ha), and during the seedling and budding phases and the formation of beans (3.20 t/ha), which was by 43.3%, 36.8%, and 38.5% higher than in the control, respectively [5]. It is economically and energetically viable to use crop protection agents and Albite during the seedling phase. This allows achieving the highest net profit (14.6 thousand rubles/ha) and bioenergy efficiency coefficient (2.58) [6].

In the conditions of the Penza region on leached chernozems, spraying of awnless brome with Albite in the phases of regrowth and ear formation contributed to the formation of seed yield of 354 kg/ha, which was 2.4 times higher than in the control [7, 8]. The use of tank mixture of the Corsair herbicide (3 kg/ha) and Albite (40 ml/ha)for the vegetative Hungarian clover led to the achievement of seed yield of 464 kg/ha, it was higher than in the control by 45% [9, 10]. The use of potassium humate caused an increase in the dry matter yield of goat's rue by 24.3%, in the control the yield amounted to 4.53 t/ha [11].

The high economic efficiency of the use of growth regulators during the vegetation period of grain crops in the Republic of Mordovia was demonstrated [12, 13]. Kuchlan *et al.*, 2017; Meena *et al.,* and Sumathi *et al.,* also noted that growth regulators increase grain legume crops productivity [14-16].

Thus, in previous studies, it has been mainly indicated that the eastern galega yield increased due to the additional use of herbicides and growth regulators applied separately, and there were practically no studies of the combined use of fungicides, insecticides, herbicides, and one or two-time use of the Albite growth regulator. The advantage of this research consists in a two-factor experiment as the complex effect of plant

protection products and Albite on the seed yield of this important crop has been studied.

The aim of the study was to provide economic and energetic substantiation for the use of crop protection agents and the Albite growth regulator on seed crop of *Galega orientalis* in the Republic of Mordovia.

The research objectives were:

– study of the effect of the studied factors on the net profit, profitability, and seed production cost.

– determination of the dynamics of the energy balance, bioenergetic coefficient, and energy-output ratio of seeds depending on the use of crop protection agents and the Albite growth regulator.

II. MATERIALS AND METHODS

The studies were performed in 2012-2014 at the "Biosfera" LLC in the Staroshaygovsky district of the Republic of Mordovia. On the fodder crop rotation field No. 3, 12, 13, and 14-year-old galega was used.

Experiment design: Factor A. Plant protection products (plant protection background). 1. Without plant protection products. 2. With plant protection products (pesticide background – treatment with insecticides Break (0.05 l/ha) during the phase of spring regrowth and Sharpei(0.3 l/ha) during the budding phase; treatment with herbicides Bazagran (2.0 l/ha) and Miura (1.5 l/ha) during the phase of spring regrowth; treatment with Rex-Duo fungicide (0.4-0.6 l/ha) during the phase of spring regrowth and budding). Factor B. Application of the Albite growth regulator. (1) Without treatment (control). (2) With treatment (40 ml/ha) during the phase of spring regrowth. (3) With treatment during the phases of spring regrowth and budding (repeated twice). (4) With treatment during the phases of spring regrowth, budding, and formation of beans (repeated three times). (5) With treatment during the budding phase. (6) With treatment during the phase of the formation of beans.

The primary plot area was 60 m^2 (12 × 5 m) and secondary plot area was 10 m^2 (2 × 5 m). The experiment was performed in three replicates; the arrangement was systematic. In accordance with our tasks, the laboratory and field methods were used in experimental research. The object of the study was the eastern galega of the Yalginsky variety.

The field experiments, observations, and accounting were carried out in accordance with the methodological instructions by Dospekhov [17]. For the herbage yield accounting, plants from a 3 m^2 section from each plot were mowed in triplicate after brown discoloration occurred in 100% of the beans. Economic efficiency was calculated according to the Methodology for determination of the economic efficiency of the use of the results of scientific research, new technology, and rationalization proposals in agriculture [18] and methodology described by Eryashev & Vasilkin (2013) [19].

III. RESULTS

Our studies showed that the use of plant protection products reduced seed yield by 11.3%, probably, due to inhibition of plants by herbicides, as well as a decrease in numbers of pollinators caused by the use of insecticides (Table 1).

Table 1: The effect of pesticides and Albite on the yield of eastern galega seeds (average for 2012-2014).

Pesticide background (A)	Albite deadline background(B)	Seed yield, kg/ha	Yield increase	
			kg/ha	%
No pesticides (control)	1	385	—	—
	2	540	155	40.2
	3	598	213	55.3
	4	469	84	21.8
	5	441	56	14.5
	6	441	56	14.5
On average against the pesticide-free background		479	—	—
Use of pesticides	1	264	–121	–31.4
	2	578	193	50.1
	3	424	39	10.1
	4	473	88	22.8
	5	412	27	7.0
	6	396	11	2.8
On average against the pesticide background		425	–54	–21.3
Use of Albite, on average (B)	1	324	—	—
	2	559	235	72.5
	3	511	187	57.7
	4	471	147	45.4
	5	426	102	31.5
	6	419	95	293
On average for the experiment		452	67	17.4
LSD_{05} of A = 17; LSD_{05} of B and AB = 30; LSD_{05} of particular differences = 42				

Table 2: Economic efficiency of the use of plant protection products and Albite in the cultivation of galega, per 1 ha (average for 2012-2014).

Pesticide background (A)	Albite deadline background(B)	Gross production value	Expenses for 1 ha	Conditional net profit	Profitability, %	Seeds production cost, thousand rubles/t
		thousand rubles/ha				
No pesticides (control)	1	61.6	3.0	58.6	1.953	7.81
	2	86.4	3.3	83.1	2.518	6.19
	3	95.7	3.6	92.1	2.558	6.12
	4	75.0	3.9	71.1	1.823	8.34
	5	70.6	3.2	67.4	2.106	7.37
	6	70.6	3.3	67.3	2.039	7.48
On average against the pesticide-free background		76.7	3.4	73.3	2.166	7.22
Use of pesticides	1	42.2	12.2	30.0	246	46.26
	2	92.5	12.4	80.1	646	12.44
	3	67.8	12.5	55.3	442	29.59
	4	75.7	12.8	62.9	491	27.16
	5	65.9	12.4	53.5	431	30.09
	6	63.4	12.6	50.8	403	31.18
On average against the pesticide background		67.9	12.5	55.4	443	29.45
On average for factor B	1	51.9	7.1	44.3	1.100	27.03
	2	89.4	7.8	81.6	1.582	9.31
	3	81.8	8.0	73.7	1.500	17.85
	4	75.4	8.4	67.0	1.157	17.75
	5	68.2	7.8	60.4	1.268	18.73
	6	67.0	8.0	59.0	1.221	19.33
On average for the experiment		72.3	7.9	64.4	1.304	18.34

Note: The selling price of eastern galega seeds is 160 rubles/kg. Factor B – application of the growth regulator Albite – variants are given according to the experimental scheme.

The advantage was observed with the introduction of Albite during the spring growth phase. In terms of particular differences, this parameter was higher against the pesticide-free background when the growth regulator was used twice, as well as against the pesticide background at the beginning of spring regrowth phase; it was higher than in the control by 55.3% and 50.1%, respectively. Combined overlap of factors was positive. The highest galega seed yield (714 kg/ha) was in 2013; it was 462 kg/ha in 2012 and 182 kg/ha in 2014.

On average, between 2012 and 2014, the use of pesticides decreased the gross production value by 11.5% (67.9 thousand rubles/ha) (Table 1). It was the highest when Albite was used during the phase of spring regrowth (89.4 thousand rubles/ha). In terms of particular differences, this parameter was higher against the pesticide-free background when the growth regulator was used twice (95.7 thousand rubles/ha).

The use of plant protection products contributed to a 3.7-fold increase in costs (12.5 thousand rubles/ha). They were the highest in the case of three-time Albite treatment (8.4 thousand rubles/ha). After the same treatment against the pesticide background, they were the highest in terms of particular differences (12.8 thousand rubles/ha).

The use of plant protection products contributed to a 24.4% decrease in conditional net profit (55.4 thousand rubles/ha). It was the highest when Albite was used during the spring regrowth phase (81.6 thousand rubles/ha). In terms of particular differences, this parameter was the highest against the pesticide-free background with the two-time use of the growth regulator (92.1 thousand rubles/ha).

Table 3: Energy efficiency of the use of plant protection products and Albite for the cultivation of galega per 1 ha (average for 2012-2014).

Pesticide background (A)	Albite deadline background(B)	Gross energy yield, GJ	Energy expenditure, GJ	Energy balance, GJ	Bioenergetic coefficient	Energy-output ratio of 1t of seeds, GJ
No pesticides (control)	1	7.7	3.9	3.8	2.0	10.1
	2	10.8	4.1	6.7	2.6	7.6
	3	12.0	4.3	7.7	2.8	7.2
	4	9.4	4.3	5.1	2.2	9.2
	5	8.8	4.0	4.8	2.2	9.1
	6	8.8	4.1	4.7	2.1	9.3
On average against the pesticide-free background		9.6	4.1	5.5	2.3	8.8
Use of pesticides	1	5.3	5.7	-0.4	0.9	21.6
	2	11.6	5.9	5.7	2.0	10.2
	3	8.5	5.8	2.7	1.5	13.7
	4	9.5	6.0	3.5	1.6	12.7
	5	8.2	5.8	2.4	1.4	14.1
	6	7.9	5.9	2.0	1.3	14.9
On average against the pesticide background		8.5	5.8	2.7	1.4	14.5
On average for factor B	1	6.5	4.8	1.7	1.4	15.8
	2	11.2	5.0	6.2	2.2	8.9
	3	10.2	5.0	5.2	2.0	10.4
	4	9.4	5.2	4.2	1.8	11.0
	5	8.5	4.9	3.6	1.7	11.6
	6	8.4	5.0	3.4	1.7	12.2
On average for the experiment		9.1	5.0	4.1	1.8	11.6

The use of pesticides led to a 4.9-fold decrease in profitability (443%). It was the highest when Albite was used during the seedling phase (1.582%). In terms of particular differences, this parameter was the highest against the pesticide background with the two-time use of the growth regulator (2.588%).

The use of plant protection products caused a 4.1-fold increase in the production costs of galega seeds (29.45 thousand rubles/ha). It was the lowest when the growth regulator was used during the spring regrowth phase (9.31 thousand rubles/ha). In terms of particular differences, this parameter was the lowest against the pesticide-free background with the two-time use of the growth regulator (6.12 thousand rubles/ha).

On average, in 2012-2014, the use of plant protection products reduced the gross energy yield by 11.5% (8.5 GJ/ha) (Table 3). Its highest value was recorded after Albite was used during the spring regrowth phase. In terms of particular differences, this parameter was the highest against the pesticide-free background with the use of the growth regulator during the spring regrowth and budding phases.

The use of pesticides contributed to a 41.5% increase in energy expenditure. It was the highest after the three-time use of Albite. In terms of particular differences, the same trend was observed after the same treatment against the pesticide background.

The use of plant protection products reduced the energy balance by 49.1%. It was the highest when Albite was used during the spring regrowth phase. This indicator was the highest in terms of particular differences against the pesticide-free background with the two-time use of the growth regulator.

The use of plant protection products caused a 39.1% decrease in the bioenergy coefficient. It was the highest when Albite was used during the spring regrowth phase. In terms of particular differences, it was the highest against the pesticide-free background with the two-time use of the growth regulator.

The use of plant protection products increased the energy-output ratio of 1 t of seeds by 64.8%. It was the lowest when Albite was used during the spring regrowth phase. In terms of particular differences, it was the lowest against the pesticide-free background with the two-time use of the growth regulator.

IV. DISCUSSION

The studies showed that the best yield, economic, and energy parameters in old seed crops of eastern galega were achieved at pesticide background by spraying of plants with Albite during the spring regrowth and budding phases of the vegetation period. A similar tendency was noted in the crops of peas by A.P. Eryashev [5, 6] and in winter cereals [12, 13]. Researchers Kuchlan [14]; Meena [15]; and Sumati [16] also reported on the effectiveness of using growth regulators during vegetation in legume plants. We did not find any data on comprehensive studies on the effectiveness of the use of pesticides and growth regulators on crops of eastern galega.

IV. CONCLUSION

Thus, the highest yield of eastern galega seeds was obtained against the pesticide-free background when the Albite growth regulator was used during the spring regrowth and budding phases, as well as against the pesticide background at the beginning of spring regrowth phase; it was higher than the in the control by 55.3% and 50.1%. The highest conditional net income (92.1 thousand rubles/ha), bioenergy coefficient (2.8), as well as lowest production costs (6.12 thousand rubles/t) and energy-output ratio (7.2 GJ/t) of seeds, were achieved without using plant protection products but with the use of Albite during the vegetation period in the phase of spring regrowth and budding. In the future, it is planned to continue research on the effect of other growth regulators on the productivity of eastern galega seed yield as compared to Albite.

Conflict of Interest. There are no conflicts of interest to declare.

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