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The Influence of Pesticides and Plant Growth Promoter Albit on Performance and Cultivation Efficiency of Pea

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Abstract

This article discusses scientific substantiation of possibility to achieve high performance of pea due to application of pesticides and Albit growth promoter. In order to achieve the established target field tests and laboratory studies were performed in 2012–2014 investigating into the influence of pesticides, times and dosage frequency of Albit growth promoter on performance chemical composition and nutrition value of Flagman 10 leafless pea. It is established that the maximum yield of crude protein has been achieved upon application of pesticides in combination with Albit at seedling stage (586 kg/ha), seedling + budding (578 kg/ha), seedling + budding + pod formation (574 kg/ha); application of plant protection agent and growth promoter at seedling stage promoted the highest accumulation of crude fiber and calcium in seeds, and the content of crude fat without application of pesticides in combination with Albit was maximum at pod formation stage. The considered factors did not lead to increase in the content of crude ash, NFE, and phosphorus. In addition, these factors did not influence significantly gross available energy and energetic feed units in pea seeds. It has been found that upon pea cultivation it is economically reasonable to apply pesticides in combination with Albit growth promoter at seedling stage. This provides maximum net income (14.6 thousand rub/ha).

Key words: pea, pesticides, Albit, performance, protein, fiber, crude fat, crude ash, NFE, phosphorus, calcium, gross and available energy, energetic feed unit, expenditures, net income, cost efficiency, prime cost.

INTRODUCTION

Food security of Russian Federation is one of the most important trends of provision of Russian national security, a factor of preservation of its statehood and sovereignty, an important constituent of demographic policy, a required condition of implementation of strategic national priority – improvement of the quality of life of Russian citizens by guaranteed high living standards [3; 5].

The main target of agroindustrial complex is increase in production of vegetable protein. One of the approaches to solution of this problem is to increase planting acreage and yield of pea. This should be based on application of drought resistant varieties of leafless pea. However, procedures of their cultivation should be improved under actual regional conditions of soil and climate. For instance, this involves application of pesticides and Albit growth promoter.

Pea is a valuable leguminous plant characterized by high content and biological usefulness of protein in seeds, high digestibility and good palatability. Peculiar interest is attracted by the influence of growth promoters not only on yield but also on its quality. Numerous researchers mention that increase in crude protein in leguminous and grain crops can be promoted by growth promoters and other elements [1; 2; 4; 8; 10; 12].

An important property of feeding quality is content of fiber. It should be in the range of 17–30%, and when it is higher or lower the quality of feeding is deteriorated. Application of growth promoters did not change content of crude fiber, fat and ash, nitrogen-free extracts (NFE) in field beans. Normal development of living organisms requires for macroelements: phosphorus, potassium, and calcium. Their content in leguminous plants depends on agrometeorological conditions, agricultural technologies, including application of growth promoters [10].

EXPERIMENTAL

In order to achieve the established target field tests and laboratory studies were performed in 2012–2014 in experimental fields No. 4, 29 and 43, OOO Morginskoe, Dubensky district, Mordovia, according to the following flowchart:

Factor A. Plant protection agents.

1 W/o plant protection (reference).

2 With plant protection (spraying with Brake insecticide, 0.05 l/ha onto seedlings and with Shar-Pei insecticide, 0.3 l/ha at budding stage; treatment by Pulsar herbicide, 0.75–1.0 l/ha at stage 1–3 of pea leafs; Rex-duo fungicide, 0.4–0.6 l/ha at seedling and budding stages).

Factor B. Albit growth promoter. 1. W/o treatment (reference). 2. Treatment at seedling stage, 50 ml/ha. 3. Treatment at seedling and budding stages (double). 4. Treatment at seedling, budding, and pod formation stages (triple). 5. Treatment at budding stage. 6. Treatment at pod formation stage.

Plot allocation in experiment: systematic with three replications. Plot surface area of the first order– 60 m^2 (5 × 12 m), that of the second order – 10 m^2 (2 × 5 m). Observations, recordings and analysis upon the experiments were performed according to valid procedures. Chemical composition of seeds was determined according to valid State standards, content of crude protein in plants: Russian standard GOST 51417–99; crude fat: Russian standard GOST 13496.15–97; crude ash: Russian standard GOST 26226–95; crude fiber: Russian standard GOST 13496.2–91, using an FT-10 near-IR analyzer. Seeds were

analyzed using a NIR SCANER–4250 analyzer in agrochemical laboratory of feeding factory OOO Kombi-S.

Contents of main and by-products, gross and available energy (for cattle), energetic feed units, digestible protein in the yield were calculated with accounting for digestibility coefficients by M. F. Tomme, Zootechnic analysis of feed stuff. [7; 11].

Seed yield was determined by quadrant sampling method for all replications. The experiments were carried out and the acquired data were processed using dispersion analysis by Dospekhov (1985) aided by statistical software. Economic efficiency was determined using the estimation procedure of economic efficiency of application of R&D projects, new machinery, inventions and technical innovation in agriculture [9].

RESULTS AND DISCUSSION

Our researches demonstrated that in average in 2012–2014 treatment with pesticides resulted in increase in yield of crude protein by 50.0% (Table 1).

Its maximum value was observed upon application of Albit at seedling stage. In addition, upon double and triple spraying by growth promoter with pesticides its advantage was detected in terms of particular variances. Interaction between the factors was observed.

Highest yield of crude protein in pea seeds (averaged by experiment) was in 2012 - 604 kg/ha, in 2013 and in 2014 - 392 and 368 kg/ha, respectively.

We found that application of pesticides increased content of crude protein in pea seeds by 1.69% (Table 2).

Table 1. Raw protein yield in pea seeds, kg/ha (average in 2012–2014)

Background of plant protection (A)	Variants of Albit application (B)						In average with regard to factor A
	1	2	3	4	5	6	
W/o pesticides (reference)	395	443	347	342	359	296	364
With pesticides	487	586	578	574	518	531	546
In average with regard to factor B, HCP_{05} = 34	441	515	462	458	438	414	455
HCP_{05} =19, HCP_{05} for frequent variations = 48							

Table 2. Influence of pesticides and Albit on chemical composition of pea seeds (%) on oven-dry basis (in average in 2012– 2014)

Background of plant protection (A)	Variants of Albit application						In average with regard to factor (A)
	1	2	3	4	5	6	
Crude protein,%							
W/o pesticides (reference)	19.90	19.92	19.68	19.71	19.76	19.61	19.76
With pesticides	21.11	21.02	21.57	22.14	20.98	21.30	21.35
In average with regard to factor B	20.50	20.47	20.62	20.92	20.37	20.46	20.56
Crude fat,%							
W/o pesticides(reference)	1.22	1.29	1.36	1.44	1.48	1.64	1.40
With pesticides	1.03	1.08	1.00	1.14	1.15	1.10	1.08
In average with regard to factor B	1.12	1.18	1.18	1.29	1.32	1.37	1.24
Crude fiber,%							
W/o pesticides(reference)	1.50	1.63	1.42	1.47	1.21	1.22	1.41
With pesticides	1.56	1.94	1.52	1.76	1.39	1.66	1.64
In average with regard to factor B	1.53	1.78	1.47	1.62	1.30	1.44	1.52
Crude ash,%							
W/o pesticides(reference)	3.75	3.68	3.69	3.26	3.31	3.25	3.49
With pesticides	3.61	3.44	3.50	3.55	3.31	3.29	3.45
In average with regard to factor B	3.68	3.56	3.60	3.40	3.31	3.27	3.47
Crude NFE,%							
W/o pesticides(reference)	73.84	74.06	73.98	73.15	74.44	74.10	73.93
With pesticides	72.48	71.97	72.30	72.37	72.96	72.90	72.50
In average with regard to factor B	73.16	73.02	73.14	72.76	73.70	73.50	73.22
Calcium,%							
W/o pesticides(reference)	0.18	0.18	0.19	0.19	0.19	0.21	0.19
With pesticides	0.21	0.46	0.22	0.21	0.20	0.18	0.25
In average with regard to factor B	0.20	0.32	0.20	0.20	0.20	0.20	0.22
Phosphorus,%							
W/o pesticides(reference)	0.35	0.34	0.42	0.38	0.38	0.37	0.37
With pesticides	0.40	0.36	0.39	0.44	0.40	0.40	0.40
In average with regard to factor B	0.38	0.35	0.40	0.41	0.39	0.38	0.38

Its maximum concentration (20.92%) was achieved upon triple addition of Albit which is by 0.42% more in comparison with reference. In the same variant with pesticides (22.14%) it dominated upon consideration of variances. The highest content of crude protein in pea seeds (22.50%) was achieved in 2014, when in the time from pod formation to seed maturing hydrothermal index was 0.36, in 2012 – 20.25% (hydrothermal index = 1.12) and it was minimum in 2013 – 17.92–19.94% (hydrothermal index = 1.36-1.10).

The variant with pesticides promoted decrease in concentration of crude fat by 0.37%. It dominated upon addition of Albit at pod formation stage (1.37%). In the same variant without pesticides (1.64%) this property was maximum for particular variances (Table 2). Maximum concentration of crude fat in seeds (1.39%) was detected in 2014, lower in 2013 – 1.26%, and minimum in 2012–1.10%, that is, this property increased proportionally to aridity index in the time from pod formation to seed maturity.

We observed the trend of increase in content of crude fiber in pea seeds by 0.23% (1.64%, Table 2) upon application of plant protection agents. Its maximum concentration was detected in the variant with application of Albit at seedling stage, 1.78%, higher by 0.26% in comparison with reference. In the same variant with pesticides this property dominated (1.94%), which is by 0.44% higher in comparison with reference. Content of crude fiber in seeds was maximum (1.89%) in 2014 (hydrothermal index in the time from pod formation to seed maturing was 0.32), and minimum in 2013 (1.07%–1.54%).

The considered factors did not increase the content of crude ash in pea seeds (Table 2). Its dominating concentration (3.55%) was in 2012, its minimum value (3.38%) – in 2014, average value (3.38%–3.56%) – in 2013. With increase in aridity it began to decrease.

In the course of our experiments the considered factors did not increase content of NFE in pea seeds (Table 2). Its highest content (75.06%) was in 2012, its minimum value (71/19%) – in 2014, and intermediate value (75.06%) – in 2013.

Application of pesticides increased calcium content by 0.06% (0.25%, Table 2). Its maximum value was achieved upon addition of Albit at seedling stage (0.32%). In the same variant with pesticides (0.46%) it dominated in terms of particular variances. In the three years of studies (in average per experiment) the highest accumulation of this element (0.30%) was in 2012, and the lowest value was observed in 2013 (0.18%) and in 2014 (0.20%).

The considered factors did not increase significantly phosphorus concentration in pea seeds (Table 2). Its highest concentration in seed (0.40%) was detected in 2012 and 2014, and in 2013 it constituted only 0.33%.

Correlation dependences between chemical composition of pea with seed yield, biometrical properties of chemical compounds are summarized in Table 3.

The dependences were strong between content of crude protein in seeds, crude fiber and seed yield; crude protein and leaf coverage; crude protein, fiber and K_{PAR}; NFE and crude fat. Moderate correlation dependences were detected between content of crude fiber and protein. They were expressed by significant equations of linear regression.

Strong inverse correlations were detected between content of crude fat, NFE with seed yield; NFE with leaf coverage; crude fat and NFE with crude protein; NFE and crude fiber; crude fiber and fat; NFE and K_{PAR}; moderate inverse correlation existed between content of crude fat with K_{PAR} and leaf coverage. They were expressed by significant equations of linear regression.

Table 3. Correlation dependences

Correlation dependences	Statistic "r"	Regression equations	Significant for x
Content of crude protein – seed yield	0.90	Y = 16.5+1.5x	1.7–3.5
Content of crude protein – leaf coverage	0.87	Y = 15.74+0.26x	14.6–22.1
Content of crude fiber – seed yield	0.84	Y = 0.70+0.32x	1.77–3.32
Content of crude protein – K_{PAR}	0.84	Y = 15.06+4.68x	0.96–1.48
Content of crude fiber – K_{PAR}	0.81	Y = 0.31+1.03x	0.96–1.48
Content of NFE – crude fat	0.78	Y = 69.23+3.22x	1.10–1.64
Crude fiber – Crude protein	0.66	Y = –0.145+0.14x	19.9–22.2
Content of crude fat – seed yield	– 0.90	Y = 2.14 – 0.35x	1.77–3.32
Content of NFE – seed yield	– 0.84	Y = 76.74 – 1.35x	1.77–3.32
Content of NFE – leaf coverage	– 0.82	Y = 77.44 – 0.23x	14.6–22.1
Content of crude fat – crude protein	– 0.82	Y = 5.04 – 0.18x	19.9–22.2
Content of NFE – crude protein	– 0.81	Y = 89.43 – 0.79x.	19.9–22.2
Content of NFE – crude fiber	– 0.80	Y = 77.63 – 2.88x	1.21–1.94
Content of crude fiber – crude fat	– 0.74	Y = 2.42 – 0.72x	1.10 –1.64
Content of NFE – K_{PAR}	– 0.73	Y = 77.87 – 3.95x	0.96–1.48
Content of crude fat – K_{PAR}	– 0.67	Y = 2.24 – 0.85x	0.96–1.48
Content of crude fat – leaf coverage	– 0.65	Y = 2.06 – 0.04x	14.6–22.1

Table 4. Nutrition value of pea seeds

Background of plant protection (A)	Variants of Albit application						In average with regard to factor (A)
	1	2	3	4	5	6	
Available energy, MJ/kg							
W/o pesticides (reference)	18.42	18.45	18.43	18.55	18.52	18.58	18.49
With pesticides	18.49	18.51	18.52	18.59	18.54	18.56	18.54
In average with regard to factor B	18.46	18.48	18.47	18.57	18.53	18.57	18.51
Available energy, MJ/kg							
W/o pesticides (reference)	13.42	13.45	13.43	13.49	13.51	13.54	13.47
With pesticides	13.46	13.84	13.49	13.46	13.50	13.51	13.54
In average with regard to factor B	13.44	13.64	13.46	13.48	13.50	13.52	13.51
Energetic feed units (EFU)							
W/o pesticides (reference)	1.28	1.28	1.28	1.28	1.28	1.29	1.28
With pesticides	1.28	1.32	1.28	1.28	1.29	1.29	1.29
In average with regard to factor B	1.28	1.30	1.28	1.28	1.28	1.28	1.28
Content of digestible protein in energetic feed unit, g							
W/o pesticides (reference)	156	156	154	153	154	153	154
With pesticides	165	160	168	173	163	165	166
In average with regard to factor B	160	158	161	163	159	159	160

Moderate direct correlations were observed between content of phosphorus and crude protein (r = 0.53), calcium and crude fiber (r = 0.60), leaf coverage (r = 0.47), yield (r = 0.48) and K_{PAR} (r = 0.43); calcium (r = 0.45) and phosphorus (r = 0.42) with leaf coverage; weak direct correlations were detected between concentration of crude ash (r = 0.14) and phosphorus (r = 0.24) with seed yield, phosphorus (r = 0.29) and crude ash (r = 0.08) with K_{PAR}, crude ash (r = 0.01) and calcium (r = 0.25) with protein, crude ash (r = 0,23) and phosphorus (r = 0.07) with fiber, NFE with ash (r = 0.05).

Inverse moderate correlations were stated between calcium (r = –0.65) and NFE, crude ash (r = –0.34) and crude fat; weak inverse correlations were seen between calcium (r = –0.29), phosphorus (r = –0.24) and crude fat; calcium (r = –0.08), phosphorus (r = –0.08) and crude ash; phosphorus (r = –0.20) and calcium; NFE (r = –0.27) and phosphorus; crude ash (r = –0.16) and leaf coverage.

In the considered years weak negative correlation dependence (r = –0.02) was detected between yield of pea seeds and zinc content, weak correlation (r = 0.25) - with content of iron and molybdenum (r = 0.16), moderate correlation (r = 0.42) - with manganese concentration.

In leading countries of the world with well-developed cattle breeding nutrition value of feed stuff is estimated by content of gross energy, available energy, energetic feed units (EFU), and digestible protein in EFU [6].

Our researches demonstrated that in average in 2012–2014 the considered factors did not influence significantly the gross energy in pea seeds (Table 4).

In the course of time (2012, 2013, 2014) this property did not change (in average per experiment 18.46–18.60 MJ/kg), despite the fact that in pod formation–seed maturing period moistening was varying.

Concentration of available energy in pea seed varied insignificantly (Table 4). This property was approximately the same in time (13.44 and 13.59 MJ/kg).

Application of pesticides and Albit did not influence EFU (Table 4). This property was approximately the same in time (1.28 and 1.29).

The variant with pesticides increased the content of digestible protein in one EFU of pea seeds by 7.8% (Table 4). Spraying of vegetating plants by Albit did not influence significantly this property. It dominated in terms of particular variances, in comparison with reference ones (156 g), with pesticides upon double and triple (168 and 173 g) addition of growth promoter. The content of digestible protein in one EFU (175 g) was the highest in highly dry year 2014. If we assume that this property is 100%, then in 2012 it was 84.0%, and in 2013 86.8% of this level.

Calculations of economic efficiency demonstrate that with application of plant protection agents the cost of gross products increased by 40.8% (27.34 thousand Rub/ha, Table 5).

The maximum was achieved upon addition of Albit at seedling stage (26.64 thousand Rub/ha). In the same variant with pesticides this property dominated upon consideration of particular variances (29.79 thousand Rub/ha).

Application of plant protection agents increased expenses by 33.2% (15,23 thousand Rub/ha). The maximum was achieved upon triple application of Albit (13.79 thousand Rub/ha). In this variant with pesticides their advantage was observed in terms of particular variances (15.72 thousand Rub/ha).

Application of plant protection agents increased net income by 50.6% (12,11 thousand Rub/ha). The maximum was achieved upon application of Albit at

seedling stage (13.36 thousand Rub/ha, average for factor B). In the same variant with pesticides this property dominated upon consideration of particular variances (14.60 thousand Rub/ha).

Addition of plant protection agents caused decrease in prime cost of pea seeds by 5.8% (5,03 thousand Rub/ha). The minimum was achieved with spraying of pea by growth promoter at seedling stage (4.48 thousand Rub/ha, average for factor B), in the same variant without pesticides (4.36 thousand Rub/ha) similar regularity was observed upon consideration of particular variances.

Application of plant protection agents increased cost efficiency by 12.0% (79.4%). The maximum was achieved upon addition of Albit at seedling stage (101.4%). In this variant without pesticides (106.6%) this property dominated upon consideration of particular variances.

CONCLUSIONS

The highest yield of raw protein was achieved with application of pesticides in combination with Albit at seedling stage, seedling + budding, seedling + budding + pod formation. Maximum concentration of raw protein in pea seeds was achieved with application of pesticides in combination with triple application of Albit (20.92%). Application of plant protection agents and growth promoters provided the highest accumulation of raw fiber (1.94%) and calcium (0.46%) in seeds, as well as crude fat – without pesticides in combination with Albit at pod formation stage (1.64%). The considered factors did not lead to increase in the content of crude ash (3.75–3.26%), NFE (73.84–74.44%), and phosphorus (0.35–0.42%). Strong direct correlation dependences existed between content of crude protein (r = 0.90), fiver (r = 0.84), as well as inverse correlations – crude fat (r = – 0.90) and NFE (r = – 0.84) – and seed yield. In addition, these factors did not have significant influence on gross available energy and EFU in pea seeds. Maximum concentration of digestible protein in 1 EFU in comparison with reference value (156 g) was observed with application of pesticides in combination with double and triple (168 and 173 g) application of growth promoter. It has been found that upon pea cultivation it is economically reasonable to apply pesticides in combination with Albit growth promoter at seedling stage. This provides maximum net income (14.6 thousand rub/ha).

Table 5. Economic efficiency of application of pesticides and Albit upon pea cultivation as per 1 ha (in average per three years)

Background of plant protection (A)	Variants of Albit application	Seed yield, t/ha	Gross product value	Expenses per 1 ha	Net income	Prime cost of seeds, thousand rubles/t	Cost efficiency, %
			thousand rubles/ha				
W/o pesticides (reference)	1	2.31	20.79	11.02	9.77	4.77	88.6
	2	2.61	23.49	11.37	12.12	4.36	106.6
	3	2.08	18.72	11.49	7.23	5.52	63.4
	4	2.04	18.36	11.86	6.5	5.81	54.8
	5	2.14	19.26	11.35	7.91	5.3	69.6
	6	1.77	15.93	11.17	4.76	6.31	42.6
In average w/o pesticides		2.16	19.42	11.38	8.04	5.34	70.9
With pesticides	1	2.76	24.84	14.90	9.94	5.40	66.7
	2	3.31	29.79	15.19	14.60	4.59	96.1
	3	3.16	28.44	15.32	13.12	4.85	85.6
	4	3.20	28.8	15.72	13.08	4.91	83.2
	5	2.88	25.92	15.04	10.88	5.22	72.3
	6	2.92	26.28	15.21	11.07	5.21	72.8
In average with pesticides		3,04	27.34	15.23	12.11	5.03	79.4
In average with regard to factor B	1	2.54	22.82	12.96	9.83	5.08	77.6
	2	2.96	26.64	13.28	13.36	4.48	101.4
	3	2.62	23.58	13.40	10.18	5.18	74.5
	4	2.62	23.58	13.79	9.79	5.36	69.0
	5	2.51	22.59	13.20	9.40	5.26	71.0
	6	2.34	21.10	13.19	7.92	5.76	57.7
In average for a test		2,60	23.38	13.30	10.00	5.18	75.2

Note. Pea sale price – 9 000 ruble per ton.

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