Key directions for improving the efficiency of leguminous crops cultivation

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Abstract. Modern agricultural science pays more and more attention to methods of ecologization and biologization of agriculture, because these methods can be a solution to reduce the anthropogenic load on agricultural landscapes and allow getting environmentally friendly products. The cultivation of legumes itself is already a powerful factor of biologization, allowing to accumulate biological nitrogen in the soil, and the use of a complex of biological stimulants and microfertilizers is an important reserve for increasing the yield and quality of legumes. The paper is devoted to improving the economic efficiency of leguminous crops (for example, peas) by applying innovative approaches to the treatment of crops with biological growth stimulators. The objects of research are peas of the Estafeta and Spartak varieties zoned for the Oryol region, selected by the FSBSI FSC LGC. The following preparations of JSC “Shchelkovo Agrochem” were used for the scientific experiment: Scarlet fungicide mordant, Biostim Start amino acid biological stimulator, Biostim oil fertilizer with microelements, and Intermag Profi multicomponent microfertilizer. It was found that the use of biological preparations for pea vegetation in the 6-7 leaf phase in the future has a positive effect on the equalization of crops by 40-54%, depending on the variant and variety; promotes the stimulation of nodule formation in experimental variants; increases the biological yield and quality indicators of the obtained pea seeds. The cost estimation of additional costs for biologization of the production process is given, as well as the economic feasibility of developing such innovations on the example of peas. The work was carried out within the framework of the research topic: “Creation of new genotypes of grain legumes with high productivity, grain quality, increased resistance to the most dangerous diseases and abiotic factors” (№ 0636-2019-000 9).
1. Introduction

According to the Decree of the President of the Russian Federation dated 01.12.2016 No. 642 “On the strategy of scientific and technological development of the Russian Federation”, one of the primary tasks today is to achieve food security and food independence of Russia, reduce technological risks in the agro-industrial complex. The priority for the next 10 to 15 years of scientific and technological development is the innovative development of the domestic market of products and services, the stable position of Russia in the foreign market, which will ensure: the transition to a highly productive and environmentally friendly agricultural economy, the development and implementation of systems for the rational use of chemical and biological protection of agricultural plants.

Today, the transition to a highly productive and environmentally friendly agricultural economy is a trend in crop production and in the agro-industrial complex as a whole [1, 2].

In our opinion, growing a crop such as peas is ideal for biologization (as a transition stage to ecologization).

Today, peas are a promising, popular, export crop. This is the most precocious leguminous crop, which has both food and feed value; a good precursor, because of nitrogen fixation.

Russia is the world’s second largest producer and exporter of peas, conceding only to Canada. Other major producers are France, China and India. At the same time, peas in Russia account for no more than 2% of the total production of cereals and legumes. About 35% of the peas produced in the country are exported. At the end of 2018, pea exports from Russia reached 1.14 million tons, according to the Federal State Statistics Service.

National market products consist of 99% of domestic peas. Over the past 15 years, pea consumption in Russia has been relatively stable with a slight upward trend and is at the level of 1-1.2 million tons, according to the Federal State Statistics Service.

The acreage of peas is growing every year, with an increase of 19.7% since 2008. Thus, in 2018, 1434.7 thousand hectares were occupied for pea crops in the country. Over the studied 10 years, the increase in the gross pea harvest was 83.3%. In 2018, the gross pea harvest was 2303.1 thousand tons, according to the Federal State Statistics Service.

The average annual yield of peas in Russia in 1991-2000 was 11.5 C/ha, in 2001-2010 increased to 16.7 C/ha, in 2011-2018 reached 18.1 C/ha. Thus, the yield of peas is growing steadily and annually.

The top three regions for pea production in 2018 included: Stavropol and Krasnodar territories (324.0 thousand tons and 174.3 thousand tons, respectively), Rostov region (166.6 thousand tons). The leader in yield is the Oryol region, where in 2018, 30.8 C of peas were obtained from one hectare. Also, according to the Federal State Statistics Service, the Tambov region can be distinguished by the yield per hectare – 21.3 C/ha and the Krasnodar territory – 21.1 C/ha.

The aim of this work is to provide economic justification for new technologies for producing environmentally safe products, including the management of plant growth and development during vegetation through the use of foliar top dressing by domestic amino acid biological stimulators (Biostim) and microfertilizers for leaf top dressing (Intermag) and to determine their impact on improving the productivity and quality of grain of new varieties of legumes.

The novelty of the research is that for the first time in the conditions of the Central Federal district of the Russian Federation, elements of vegetation management of new and traditional pea varieties are being developed on the basis of more rational and differentiated use of natural and biological resources to solve the problems of organic farming and obtain environmentally safe products while maintaining high productivity.

2. Materials and methods

In 2019, we studied the effect of separate and joint use of the fungicidal protectant Scarlet, ME with microfertilizer-biological stimulator with trace elements for legumes Biostim Oilseed and multicomponent microfertilizer Intermag Profi Pod and legumes, as well as with the amino acid biostimulator Biostim Start on the qualitative and quantitative indicators of the final crop.
Laboratory experiments were carried out in the laboratory of leguminous crops breeding of the FSBSI FSC LGC on pea varieties (Estafeta and Spartak) of the 2018 harvest, grown in the FSBSI FSC LGC of the Oryol region. For each variant of the experiment, 50 seeds were taken. Repetability – 4 times. The method of P.P. Vavilov was used in the work, the work on determining the energy of germination and viability was carried out according to GOST 12038-84.

Seed germination was carried out on 3 layers of moistened filter paper in Petri dishes, the germination temperature was 20 degrees Celsius, in the dark, with pre-cooling for seeds at rest. Seeds were washed with water at room temperature for 2-3 minutes before germination, then dried with filter paper. The germination energy was determined in peas on the 4th day; laboratory germination on the 8th day.

Field experiments were conducted in the crop rotation of the experimental field of the SEPC “Integration” of the Oryol State Agrarian University.

The objects of the study were peas of two varieties: Estafeta and Spartak.

Estafeta variety: short duration variety. The length of the growing season from germination to full maturation is 84 days. The average yield over the years of competitive variety testing in 2016-2018 was 37.3 C/ha. The maximum yield of the variety was noted in 2017 and amounted to 47.7 C/ha. The variety is characterized by high resistance to lodging (5.0 points). The grain of the variety has a good digestibility and excellent taste and can be recommended for food purposes. The variety is undergoing state testing in the Central black earth region;

Spartak variety: a new morphological type of variety “chameleon” has a longline heterophylly. The average yield in the Oryol region was 16.9 C/ha (at the level of standard varieties). The maximum yield was obtained in the Lipetsk region in 2008 (55 C/ha). The average growing season is 66-89 days. Plant height 46-87 cm. Resistance to falling is high. Medium drought-resistant. Resistance to lodging is on average 1.1 points higher than leaf standards. Weight of 1000 seeds - 200-240 g. Susceptible to root rot. The protein content of the grain is 22.2-24.8%, has good commercial and culinary qualities, included in the list of valuable varieties by quality.

The scheme of the experiment consisted of five variants:

1. C (Control (without treatment));
2. V1 (Pre-sowing treatment of seeds with Scarlet fungicide, ME at a dose of 0.4 l/t (in advance, 14 days before sowing));
3. V2 (Pre-sowing treatment of seeds with a fungicidal protectant Scarlet, ME (in advance, 14 days before sowing) + amino acid biological stimulator Biostim start at a dose of 0.4 l/t + 1.2 l/t (basic treatment));
4. V3 (Basic treatment + leaf (non-root) top dressing once in the phase of 6-7 leaves with a fertilizer-biological stimulator with microelements for oilseeds, legumes Biostim Oil + microfertilizer Intermag Profi Pod and legumes at a dose of 2.0 l/ha+2.0 l/ha);
5. V4 (Basic treatment + leaf (non-root) top dressing twice in the phases of 6-7 leaves and budding - the beginning of flowering by fertilizer-biological stimulator with microelements for oilseeds, legumes Biostim Oil + microfertilizer Intermag Profi Pod and legumes at a dose of 2.0 l/ha+2.0 l/ha).

The experiment is repeated four times. The total area of the plot is 8.2 m², the accounting area is 5.5 m². The establishment of the experiment was carried out according to the method of field experience [3]. The yield was taken into account separately. The obtained yield results are brought to standard humidity and 100% purity.

For statement of experiment the following products of JSC “Shchelkovo Agrokhim” were applied: Scarlet M” (100 g/l imazalil + 60 g/l tebuconazole), a fungicidal protectant intended for pre-sowing treatment of seeds of cereals, corn, sunflower, soy, rapeseed, peas against a wide range of diseases.

Biostim Start. Amino acid biological stimulator of germination, stimulator of root system development, relieves stress after transplantation in crops. It is intended for pre-sowing (pre-planting) treatment of seeds of cereals, legumes, technical, oilseeds, vegetables, flower and ornamental crops, as
well as for root fertilizing when growing and transplanting seedlings, root fertilizing of berry crops, fruit trees, vineyards, ornamental trees and shrubs.

Biostim oil. Fertilizer – biological stimulator with microelements for oilseeds and legumes. Designed for foliar (leaf) feeding spring (winter) rapeseed, colza, camelina, sunflower, legumes, legume grasses, fiber flax, oil flax during the growing season to maintain the balance of nutrients during the growing season, protection from the effects of biotic stresses, improving resistance to disease, improve the quality and quantity of the crop.

Intermag Profi. Multi-component fertilizer for foliar feeding (cereals, beets, corn, legumes and beans, potatoes). Advantages: high content of trace elements compared to dry fertilizers; more effective than dry products such as NPK + micro maintains the balance of trace elements in critical periods of crop development; technological liquid form; compatible with most pesticides; increases drought and frost resistance; increases resistance to diseases and stress.

3. Results

Today, one of the urgent problems facing agriculture is its biologization. Biologization is an actual direction in modern agriculture [4, 5, 6]. One of the elements of biologization is pre-sowing treatment of seeds with biologically active substances, as well as their introduction during the growing season, which allows getting safe products and reduce the pesticide load [7, p.98]. Seed treatment before sowing is much more cost-effective than the traditional approach, as it eliminates the processing of crops during the growing season. Therefore, it is necessary to develop the composition of a protective and stimulating composition for pre-sowing treatment of leguminous seeds, which has adaptogenic and anti-stress properties.

The aim of this work was to develop and scientifically substantiate the most cost-effective scheme for applying biologically active substances as pre-sowing seed treatment and vegetation treatment.

The research objective was to examine the validity of the developed part of the preparation for the development of pea seedling in the initial periods of ontogenesis; evaluation of quality indicators of pea seeds according to variants of experience; the influence of these elements on biological yield of peas of studied varieties and its structure; the economic justification of used technologies.

Evaluation of the energy of pea seed germination showed significant differences in the experimental variants. Thus, the use of the preparation for pre-sowing seed treatment contributed to a 2% increase in the number of sprouted seeds compared to the control and average varieties [8, 10].

Protective and stimulating properties of the preparation for pre-sowing treatment of Scarlet, ME had a noticeable effect on seed germination under artificial water stress. Simulation of this abiotic stress factor was carried out by creating conditions for germination in growing plants between layers of cotton fabric at a humidity of 40-50% of the total moisture capacity, while in the control version this indicator was 80 %. The germination energy in the experimental variants exceeded the control by 11% in the seeds of the Estafeta variety and by 8 % in the Spartak variety [8, 11].

There were no differences in the laboratory germination of pea seeds by variants and by varieties. However, the high intensity of growth of seedlings under the influence of pre-sowing seed treatment is certain. The length of the germ-prototypes surpassed the control options: Estafeta variety by 34%, and Spartak by 29%; the length of the main root: Estafeta variety - by 19%, and Spartak by 13%; the number of lateral roots of both varieties exceeded the control by 30%.

Acceleration of the root system was faster in experimental plants, and lateral roots appeared later in control plants. The same pattern was observed in the development of primordial leaves.

Thus, the tested preparation for pre-sowing seed treatment had an expressed stimulating effect on the growth and development of pea seedlings, including under water stress, provided better nutrition for experimental plants, which will undoubtedly affect adaptive stability in the field and, as a result, the quantitative and qualitative characteristics of crop yields. Further study of the effect of pre-sowing treatment on the development of pea plants was continued in the phases of growth and development in the field.
Determination of field germination in peas, conducted in the microphase of the 4th leaf, showed that the germination of peas in experimental variants increased by 23.3 - 26.7% compared to the control, in the Estafeta variety and in the Spartak variety - by 17.9%.

The study of the growth processes of pea plants in the microphase of 9-10 leaves showed that the highest plants were noted in the V3 variant of the Estafeta variety and V4 of the Spartak variety. Variants V1 and V4 of the Estafeta variety differed in the greatest equalization of crops. We note that, despite the low field germination, it was the V3 variant of the Spartak variety that was most leveled in comparison with other variants and controls.

Evaluation of the development of the root system of pea plants according to the experimental variants, carried out in the microphase of 10-12 leaves, showed that the smallest differences in root weight in processing options were observed in peas of the Spartak variety and this indicator was at the control level for all tested variants.

Peas (Pisum sativum L.), a widespread agricultural crop and an important model object of genetics, can form triple symbiotic systems consisting of plants, fungi, and nodule bacteria [9]. In assessing the development of symbiotic apparatus of the root system by options of experiment it was noted that the total number of nodules on the roots of a variety of Spartak was much higher than plant of Estafeta variety, which can be explained by drought tolerance varieties and long absence of rains at the time of the measurements. The average increase in the number of nodules in the Spartak variety compared to the control was up to 82%, and in the Estafeta variety this indicator was about 58%. Regarding the processing options, it can be noted that the largest number of nodules was recorded in the V3 variant of the Spartak variety and the V2 variant of the Estafeta variety.

Analyzing the quality indicators of seeds of peas, it can be noted that the lowest number of thin grains met for variants V3 and V4 of Estafeta variety (3.0 and 3.1%, respectively), whereas the corresponding figures of the control was 4.3%; for Spartak variety variant V4 had a 3.1% of these grains, and the monitoring indicators at this grade was 5.3%.

The quality indicators of peas also include the protein content, figure 1.

![Protein content in pea seeds, %](image)

Figure 1. Protein content in pea seeds, %.

Analysis of the obtained samples for protein content variants showed the advantage of the variant with one leaf dressing (V3) in both varieties: Estafeta -25.8%, Spartak - 25.7%, against the control figures of 24.2% and 25.2%, respectively.

An important indicator is the biological yield, table 1.

The biological yield was calculated based on the stem density of 100 PCs per m², depending on the treatment options, in four repetitions.
The calculation showed that the largest mass of a thousand seeds was in plants of the V3 variant of the Spartak variety and the V4 variant of the Estafeta variety. In terms of the average number of seeds in a bean of Estafeta variety, the V1 variant (4.1 units), from the Spartak variety - V1 (4.6 units), but this figure was lower than the control (4.8 units).

According to the average number of beans per plant, the V3 variant of the Estafeta variety stands out from all the variants.

Thus, according to the combination of qualitative and quantitative indicators, the highest biological yield was observed in the V3 and V4 variants of the Estafeta variety and the V4 variant of the Spartak variety. These variants showed the most significant increase in yield, in the Estafeta variety by 31% and 31.7%, respectively, and in the Spartak variety by 25%, table 2.

Table 1. Biological (potential) yield based on the stem density of 1 million plants per ha, depending on processing options.

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| Variety | Variant | Average number of beans per 1 plant, PCs | Average number of seeds per 1 bean, PCs | Weight of 1000 seeds, g | The average yield, according to the replications, t/ha | Yield increase, t/ha |
|---------|---------|----------------------------------------|----------------------------------------|-------------------------|--------------------------------------------------------|----------------------|
| Estafeta | C       | 4.0                                    | 3.6                                    | 214.7                   | 3.09                                                   | -                    |
|         | V1      | 3.8                                    | 4.1                                    | 221.2                   | 3.45                                                   | + 0.36               |
|         | V2      | 4.1                                    | 3.2                                    | 219.4                   | 3.63                                                   | + 0.54               |
|         | V3      | 5.4                                    | 3.4                                    | 220.6                   | 4.05                                                   | + 0.96               |
|         | V4      | 4.0                                    | 3.4                                    | 221.8                   | 4.07                                                   | + 0.98               |
| Spartak | C       | 2.5                                    | 4.8                                    | 218.8                   | 2.63                                                   | -                    |
|         | V1      | 2.4                                    | 4.6                                    | 214.0                   | 2.43                                                   | - 0.2                |
|         | V2      | 2.6                                    | 4.4                                    | 223.6                   | 2.68                                                   | + 0.05               |
|         | V3      | 3.0                                    | 3.9                                    | 229.9                   | 2.77                                                   | + 0.14               |
|         | V4      | 3.8                                    | 3.8                                    | 224.2                   | 3.29                                                   | + 0.66               |
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Source: calculations by Polukhina M.G.

Based on the gross harvest, the yield of peas was calculated, table 2.

On average, the difference between biological and gross yield was 20%.

Table 2. Yield (gross harvest) of peas depending on the processing variant.

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| Variety | Variant | Yield t/ha | Replications | The average for the replications | Yield increase, t/ha |
|---------|---------|------------|--------------|----------------------------------|----------------------|
|         |         |            | I    | II   | III  | IV   |                    |                      |
| Estafeta| C       | 2.38       | 2.53 | 2.59 | 2.39 | 2.47 | -                  |                      |
|         | V1      | 2.62       | 2.74 | 2.85 | 2.83 | 2.76 | + 0.29             |                      |
|         | V2      | 3.42       | 2.82 | 2.63 | 2.75 | 2.90 | + 0.43             |                      |
|         | V3      | 3.09       | 3.32 | 3.37 | 3.18 | 3.24 | + 0.77             |                      |
|         | V4      | 3.22       | 3.54 | 3.05 | 3.22 | 3.26 | + 0.78             |                      |
| Spartak | C       | 1.90       | 1.98 | 2.38 | 2.14 | 2.10 | -                  |                      |
|         | V1      | 1.80       | 1.95 | 2.02 | 2.00 | 1.94 | - 0.16             |                      |
|         | V2      | 2.32       | 1.89 | 2.16 | 2.22 | 2.14 | + 0.04             |                      |
|         | V3      | 2.11       | 1.98 | 2.40 | 2.38 | 2.22 | + 0.11             |                      |
|         | V4      | 2.50       | 2.31 | 2.91 | 2.81 | 2.63 | + 0.53             |                      |
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Source: calculations by Polukhina M.G.
The greatest increase in yield was observed in variants V3 and V4 of the Estafeta variety (7.7 and 7.8 C/ha) and V4 of the Spartak variety (5.3 C/ha).

As there was no noticeable difference in yield between variants V3 and V4 of the Estafeta variety, we can recommend the processing scheme for the V3 variant for further use. This variant gave a yield of 32.4 C/ha, which significantly exceeds the average yield of the variety in the region (16.9 C/ha).

To carry out technological operations for the biologization of pea cultivation, additional costs are required for: the fungicidal protectant Scarlet ME; biological preparations: Biostim Start, Biostim oil and Intermag Pro.

Thus, the V3 variant of the Estafeta variety (one leaf treatment) will require about 3,927 rubles per hectare, and the V4 variant (two leaf treatments) will require 7854 rubles, respectively. Taking into account that when using the preparations of the V3 variant (one leaf treatment), the cost of the additional crop received is 20700 rubles, and when using the V4 variant (two leaf treatments) – 21,000 rubles, it can be noted that the use of double leaf treatment is impractical from an economic point of view. Net of expenses for biological preparations, the increase in profit per hectare is 16,773 and 13,146 rubles, respectively, excluding the cost of application.

Based on the data obtained, it can be noted that the Spartak variety is not suitable for biologization, as it is adapted to intensive cultivation technologies. With the average yield of the variety in the region - 37.3 C/ha, none of the processing variants could approach the average yield for the variety.

4. Discussion

As a result of the research, the following conclusions were formulated:

1. Pre-sowing treatment of seed material significantly stimulates the growth and development of pea seedlings, including in conditions of water stress, providing better nutrition. In addition, pre-sowing treatment gave an increase in the germination of peas in the Estafeta variety in the range of 23.3-26.7%, and in the Spartak variety - by 17.9%. All this ultimately has a positive effect on the quantitative and qualitative characteristics of crop yields;

2. Application of biological preparations:
   • during the growing season in the phase of 6-7 leaves in the future, it has a positive effect on the equalization of crops from 40 to 54% depending on the variant and variety compared to the control;
   • promotes the formation of nodules (increase nitrogen fixation of peas). On average, the increase in the number of nodules in the Spartak variety compared to the control was up to 82%. In the Estafeta variety, the increase in the number of nodules, compared to the control, was about 58%;
   • improves the quality of the obtained pea seeds, reducing the number of thin grains. In the Estafeta variety by 1.3 and 1.2% (variants V3 and V4) compared to the control; in the variety Spartak by 2.2% (variants V4) compared to the control;
   • increases the protein content of the grain compared to the control;
   • increases the biological yield, depending on the processing option. In the Estafeta variety by 31% and 31.7% (variant V3 and V4, respectively) and the variety Spartak - by 25% (variant V4);
   • gives an increase to the gross collection. In the Estafeta variety, the increase was 7.7 and 7.8 C/ha (variant V3 and V4, respectively), in the Spartak variety - by 5.3 C/ha (variant V4);
   • gives an increase in profit on average up to 16773 rubles per hectare without taking into account the cost of making a deposit;

3. Experiment has shown that not all pea varieties are equally responsive to the elements of biologization. So it became clear that the Spartak variety in the application of biological preparations cannot achieve their full potential.

5. Summary

In conclusion, we would like to note that the fulfillment of a number of tasks set by the strategy of scientific and technical development of the Russian Federation, the Doctrine of food security of the Russian Federation, development programs at various levels, including obtaining environmentally
friendly agricultural products in the shortest possible time, is possible only when biologization
techniques are introduced into production. Regarding crop production, it can be noted that for the
further successful development of the industry, selection, in this case of peas, should be carried out not
only in the direction of increasing productivity and product quality, but also in the direction of
obtaining new highly productive varieties that are responsive to biologization.

6. References

[1] Zotikov V I, Sidorenko V S, Gryadunova N V 2018 Development of legume production in the
Russian Federation (Scientific and Production Journal Legumes and cereals) 2(26) 4–10
[2] Barinova E A 2019 Food security assessment of the Ivanovo region (Russian Economic
Bulletin) 2(5) 20-25
[3] Dospekhov B A 1985 Methodology of field experience Textbook: M. Agropromizdat 352
[4] The 1st international conference of wheat landraces for healthy food systems (June 13 - 15,
2018, University of Bologna, Italy) (Proceedings on Applied Botany, Genetics and Breeding)
2018 179 (1) 128-129
[5] Yamashkin Yu V 2020 Quality and safety of food products in modern socio-economic
conditions: problems and prospects (Russian Economic Bulletin) 3(3) 89-93
[6] Balkizov M Kh, Abazova M V 2018 On ways to improve the efficiency of the rural economy in
the Kabardino-Balkar Republic (Modern Economy Success) 1 38-42
[7] Kostin V I, Isaychev V A, Kostin O V 2006 Elements of mineral nutrition and growth
regulators in the ontogenesis of agricultural plants M Kolos 290
[8] Zubareva K Yu, Polukhina M G 2019 Composition for pre-sowing seed treatment (Bulletin of
agricultural science) 4 16-20
[9] Afonin A M, Leppyanen I V, Kulaeva O A, Shtark O Y, Tikhonovich I A, Dolgikh E A,
Zhukov V A 2020 A high coverage reference transcriptome assembly of pea (Pisum sativum
L.) mycorrhizal roots (Vavilov Journal of Genetics and Breeding) 24 (4) 331-339
[10] Erokhin A I, Tsukanova Z R, Latyntseva E V 2017 Effectiveness of complex application of new
forms of preparations on pea seeds (Scientific and Production Journal Legumes and cereals)
1(21) 28–33
[11] Grudkina M, Polukhin A, Grudkina T 2019 Factors increasing the effectiveness of state support
in agriculture (IOP Conference Series: Earth and Environmental Science) 274 012113
[12] Zotikov V I, Sidorenko V S ,Gryadunova N V 2018 Development of production of leguminous
crews in the Russian Federation (FGBNU «The all-russia research institute of legumes and
groat crops») 2(26) 4–10
[13] Barinova E A 2019 Assessment of food security of the Ivanovo region (Russian Economic
Bulletin) 2(5) 20-25
[14] Dospekhov B A 1985 Field experiment technique. Textbook Moscow: Agropromizdat 352
[15] The 1st international conference of wheat landraces for healthy food systems (June 13 - 15,
2018, University of Bologna, Italy) (Proceedings on Applied Botany, Genetics and Breeding)
2018 179 (1) 128-129
[16] Yamashkin Yu V 2020 Quality and safety of food products in modern socio-economic
conditions: problems and prospects (Russian Economic Bulletin) 3(3) 89-93
[17] Balkizov M Kh , Abazova M V 2018 On ways to increase the efficiency of rural economy in the
Kabardino-Balkar Republic (Modern Economy Success) 1 38-42
[18] Kostin V I, Isaiachev V A, Kostin O V 2006 Elements of mineral nutrition and growth
regulators in ontogeny of agricultural plants Moscow: Kolos 290
[19] Zubareva K Yu, Polukhina M G 2019 Composition for pre-sowing seed treatment (Bulletin of
Agrarian Science) 4 16-20
[20] Afonin A M, Leppyanen I V, Kulaeva O A, Shtark O Y, Tikhonovich I A, Dolgikh E A,
Zhukov V A 2020 A high coverage reference transcriptome assembly of pea (Pisum sativum
L.) mycorrhizal roots (Vavilov Journal of Genetics and Breeding) 24 (4) 331-339
[21] Erohin A I, Tsukanova Z R, Latynceva E V 2017 Efficacy of complex application of new forms of preparations on pea seeds (FGBNU «The all-Russia research institute of legumes and groat crops») 1(21) 28–33

[22] Grudkina M, Polukhin A, Grudkina T 2019 Factors increasing the effectiveness of state support in agriculture (IOP Conference Series: Earth and Environmental Science) 274 012113

[23] Yaitskaya E A 2018 Directions of development of integration of science and production in the agro-Industrial complex (Modern Economy Success) 3 72-75

[24] Melikhova E V, Rogachev A F 2018 Modeling and optimization of resource allocation in the implementation of technological innovations in irrigated agriculture (Modern Economy Success) 4 113-119