The role of defecate and microbial nitrogen-fixing preparations in the formation of alfalfa variety yield in the conditions of the south of Primorsky Krai

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Abstract. Four-year studies revealed a positive role of the effect and aftereffect of the defecate and inoculation of seeds by virulent active strains of Rhizobium Synorhizobium meliloty on the productivity of green and dry alfalfa varieties VEGA 87. The total yield of green alfalfa has varied during four years of life (ten bites) from 142.2 t/ha in the control variant to 153.4-183.2 t/ha in the experimental variants. Total productivity of green mass in variant with application of lime increased by 18.3 %, in the variants with presowing treatment of the seeds with rhizobia strains – by 7.9-11.5 % and their combination – by 23.4-28.8 %. The yield of dry mass in the variant with application of defecate increased by 28.8 %, in the variants with presowing treatment of the seeds with rhizobia strains by 10.7-13.7 % and at their joint action by 37.6-42.0 %. The biggest increase in productivity of green and dry mass is provided by inoculation of the seeds with a promising A4 strain when applying defecate, and without the use of meliorant – inoculation of the seeds with the main production strain 425a. The application of defecate and bacterial preparations for presowing treatment of the alfalfa seeds is agronomically and economically profitable, it promotes to increase the environmental stability of the agricultural landscape and plants to stressful conditions, a balanced level of nutrition, increasing plant productivity and profitability (low cost) of their cultivation.

1. Introduction
The rapid increase in the area of acid soils restricts agricultural production all over the world. Acid soils in the world constitute 30-40 % of arable land. In Russia, according to the Ministry of agriculture, the area of acid soils has increased from 68 to 98 million hectares during the period from 1990 to 2004. Acid soils are especially pervasive in the non-chernozem belt, in the Urals and Primorye [1]. Adding lime reduces the mobility of toxic aluminum and manganese, improves the availability of phosphorus, calcium and molybdenum, promotes the formation of nodules on the roots of legumes and increases productivity [2-5]. The amount of liming in the Russian Federation has been sharply reduced in recent years. Under conditions of increasing cost of liming, attention should be paid to the use of lime containing industrial wastes and defecates [6]. Researchers have shown high agrochemical efficiency of the defecate, which does not give way to the standard agrochemicals, and in some cases it exceeds them. According to the All-Russian Institute of fertilizers and agro-soil science, the defecate is more effective than lime when applied in an amount equivalent to CaO. The experiments carried out in Altai established high efficiency of the defecate in comparison with other calcium-containing meliorants. Defecate introduced in meadow-chernozem soil had a positive effect on agrochemical indicators, its fertility and mineral nutrition of plants [8]. In 2009-2014 scientists of the...
Primorsky Scientific-Research Institute conducted research to determine the efficiency of the defecate in crop rotation and it was shown that the use of the defecate allows to regulate the reaction of the soil environment during the growing season in accordance with the biological requirements of the cultivated crop, changing the reaction from acid to alkaline. This profitable, prolonged-action agronomic technique can be recommended for implementation in the agricultural production of the Primorsky Krai [9]. Experiments conducted by Ivanova E. P. found out that when applying defecate as a meliorant, the fertility of meadow-brown bleached soil increases, as well as the yield and quality of alfalfa variable [10]. The presence of the specific virulent active strain of rhizobia plays an important role in plant productivity and soil fertility. Their role in reducing the use of agricultural resources – mineral fertilizers, replacing pesticides with microbiological preparations and protecting plants from stress is significant. Using microbiological preparations, the maximum effect from them can be obtained by careful selecting those that have the highest degree of expected properties in specific soil and climatic conditions. As a new crop for the territory alfalfa needs inoculation of seeds during sowing, and scientists from the Primorskaya State Academy of Agriculture and the Primorsky Scientific-Research Institute in cooperation with All-Russian Research Institute of Agricultural Microbiology (Saint Petersburg) are working on it.

The aim of the work is to study the effect of the defecation and inoculation of seeds by virulent active rhizobia strains on the yield of alfalfa varieties of the new generation VEGA 87.

2. Materials and Methods
In 2009-2012 in the south of Primorsky Krai on the territory of the collection nursery forage production department in the Primorsky Scientific-Research Institute of Agriculture we set up field experiments to study the influence of lime of LLC "Primorsky Sakhar", as well as different strains of nodule bacteria *Synorhizobium meliloty* on the growth, development and productivity of alfalfa variable. Strains of *Synorhizobium meliloty* nodule bacteria were provided by the All-Russian Research Institute of Agricultural Microbiology (Saint Petersburg). Researches, records and observations were carried out according to the Resource materials for conducting field experiments with forage crops [11]. Experimental data were processed by the method of dispersion analysis [12]. It was produced a single mowing of the plant mass in the year of sowing alfalfa, the mowing of the plant grass was done three times in the second and fourth years of life.

3. Results
We have established a positive role of the effect and aftereffect of the defecate and bacterial preparations on the productivity of green mass and dry substance of alfalfa variable (tables 1 and 2, figures 1 and 2).

**Table 1. Influence of the defecate and bacterial preparations on yield of green mass of alfalfa variable (2009-2012).**

| Variants | 1 year of life<sup>a</sup> | 2 year of life<sup>b</sup> | 3 year of life<sup>c</sup> | 4 year of life<sup>d</sup> |
|----------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1. Without CaCO₃- (control) | 8.25 | 56.87 | 46.65 | 30.47 |
| 2. CaCO₃–background | 9.75 | 65.08 | 54.74 | 38.60 |
| 3. A₄ | 9.54 | 60.39 | 49.37 | 34.12 |
| 4. A₅ | 9.87 | 60.52 | 52.40 | 33.29 |
| 5. 425a | 9.99 | 63.28 | 52.65 | 32.72 |
| 6. A₄ + background | 12.38 | 71.00 | 59.32 | 40.49 |
| 7. A₅ + background | 10.89 | 65.69 | 58.71 | 40.21 |
| 8. 425a+ background | 11.37 | 67.72 | 58.81 | 40.21 |

<sup>a</sup> average for three years of research (2009-2011);
<sup>b</sup> average for three years of research (2010-2012);
<sup>c</sup> average for two years of research (2011-2012);
<sup>d</sup> for one year of research (2012)
It is established for three trial experiments (2009-2011) that application of the defecate increases the productivity of green mass of alfalfa in the first year of life by 18.2 %, presowing processing of seeds by strains *Synorhizobium meliloty* increases by 15.6-21.1 %, and their combination – by 32.0-50.1 %. The inoculation of seeds has the greatest affect on increasing the yield of green mass by strain A4 while introducing the defecate, but without the use of meliorant this effect is obtained by inoculation of the seeds by the main productive strain 425a.

The positive influence of the studied factors on the second-year alfalfa herbage (2010-2012) was also noted by us. Thus, the use of defecate increases the yield of the second-year alfalfa green mass by 14.4 %, preseeding seed treatment with *Synorhizobium meliloty* strains-by 6.2-11.3 %, and their combination - by 15.5-24.8 %. It should be noted that exactly the second-year herbage formed the maximum yield of the green mass in our experience.

The aftereffect of the studied factors on alfalfa herbage of the third year of life (2011-2012) was expressed in an increase in the yield of green mass when using defecate by 17.4 %, pre-sowing treatment of seeds with *Synorhizobium* meliloty strains – by 5.8-12.9 %, and when combined – by 25.8-27.1 %.

The aftereffect of the studied factors on alfalfa herbage of the fourth year of life was estimated by us for one year (2012). We noted the increased aftereffect of the defecate on alfalfa herbage of the fourth year of life. Thus, the yield of green mass in the variant on the aftereffect of defecate increased by 26.7% compared to the control variant, and in combination with seed processing with *Synorhizobium meliloty* strains it increased by 31.9-33.9 %. In case of presowing treatment of seeds with rhizobia strains the yield of green mass was 7.4-11.9% higher than in the control variant.

The total collection of green mass for four years of alfalfa life (for 10 bites) is shown in the first figure.

![Figure 1. Total yield of alfalfa green mass variety Vega 87 from 1 ha depending on the studied factors](image-url)

The total yield of green mass of alfalfa variety VEGA 87 has changed for four years of life (ten mowing) from 142.2 t/ha in the control variant to 153.4-183.2 t/ha in the experimental variants (or by 7.9-28.8%). The largest total increase in the yield of green mass for ten cuttings is provided by inoculation of seeds with a promising strain A4 while introducing the defecate, and without the use of meliorant it is provided by inoculation of seeds with the main production strain 425a.
The experiments, previously conducted by E. P. Ivanova to establish the effectiveness of liming in the cultivation of alfalfa 1-3 years of life, obtained a yield increase of green mass from the lime equal to 12 \% [13], in our experience with the study of lime effectiveness, yield increase of alfalfa green mass 1-3 years of life was 15.9 \% that confirms the opinion of several scholars about the benefits of defecate compared to the lime when introducing the equivalent Cao amount.

Table 2. Influence of the defecate and bacterial preparations on yield of dry mass of alfalfa variable (2009-2012)

| Variants                          | Yield of dry mass, t/ha |
|-----------------------------------|------------------------|
|                                   | 1 year of life\(^a\) | 2 year of life\(^b\) | 3 year of life\(^c\) | 4 year of life\(^d\) |
| 1. Without CaCO\(_3\)- (control) | 1.98                   | 13.73                 | 12.67                 | 6.74                  |
| 2. CaCO\(_3\)-background         | 2.55                   | 16.67                 | 16.24                 | 9.74                  |
| 3. A\(_4\)                       | 2.32                   | 15.41                 | 13.68                 | 7.78                  |
| 4. A\(_3\)                       | 2.53                   | 15.11                 | 13.88                 | 8.77                  |
| 5. 425a                          | 2.49                   | 16.11                 | 14.14                 | 8.41                  |
| 6. A\(_4\) + background          | 3.40                   | 18.70                 | 17.61                 | 10.66                 |
| 7. A\(_3\) + background          | 2.86                   | 17.17                 | 17.83                 | 10.61                 |
| 8. 425a + background              | 2.91                   | 18.24                 | 17.83                 | 10.72                 |

\(^a\) average for three years of research (2009-2011); \(^b\) average for three years of research (2010-2012); \(^c\) average for two years of research (2011-2012); \(^d\) for one year of research (2012)

Analyzing the data in table 2 we noted that the studied factors significantly increase the yield of dry substance of alfalfa plant mass on average over three years of researches. Thus, the use of the defecate increases the yield of dry mass of alfalfa in the first year of life by 28.7 \%, presowing treatment of seeds with Synorhizobium meliloty strains- by 17.2 – 27.8 \%, and their combination enlarges by 44.4-71.7 \%. The greatest affect on increasing the yield of dry mass, as well as green mass, is provided by inoculation of seeds with a promising strain A4 when applying the defecate and by inoculation of seeds with the main production strain 425a without the use of meliorant.

As for the dry substance yield of alfalfa variety VEGA 87 vegetative mass for the following years, it should be noted that the application of the defecate increases the yield of dry mass of alfalfa of the second year by 21.4 \% and presowing processing of seeds strains Synorhizobium meliloty increases by 10.1-17.3 \%, their combination – by 25.1-36.2 \% compared to the control. The aftereffect of the studied factors on alfalfa herbage of the third year of life increases the yield of dry mass when using defecate by 28.2 \%, preseeding seed treatment-by 8.0-11.6 \%, and when combined – by 38.9-40.7 \%. The yield of dry matter increased by 44.5 \% on the alfalfa herbage of the fourth year of life after the effect of the defecate compared to the control variant, with presowing processing of seeds with rhizobia strains - by 15.4 – 30.1 \% and in combination of these two factors – by 58.2-59.1 \%.

In general, for 10 mows the yield of dry mass in the variant with the use of the defecate increased by 28.7 \%, it increased by 11.6-17.2 \% in the variants with preseeding treatment of seeds with rhizobia strains and it increased by 38.0-43.4\% with their combination.

The yield of dry substance according to the experimental variants is subject to the same rules as the yield of green mass, however, the quantitative values of dry matter additions are higher.

4. Conclusion
A significant increase in the yield of green and dry mass of alfalfa variable variety Vega 87 was found during the research. The total yield of green mass of alfalfa has changed for four years of life (ten bites) from 142.2 t/ha in the control variant to 153.4-183.2 t/ha in the experimental variants (or by 7.9-28.8 \%). The total yield of green mass in the variant with the use of the defecate increased by 18.3 \%, in the variants with preseeding treatment of seeds with rhizobia strains it increased by 7.9-11.5 \% and with their combination – by 23.4-28.8 \%. The yield of dry mass in the variant with the use of defecate
increased by 28.7 %, in the variants with preseeding treatment of seeds with rhizobia strains it increased by 11.6-17.2 %, and when they are combined – by 38.0-43.4 %.

![Graph showing the total yield of dry mass alfalfa variety Vega 87 from 1 ha in dependence of studied factors.](image)

**Figure 2.** Total yield of dry mass alfalfa variety Vega 87 from 1 ha in dependence of studied factors.

The greatest increase in productivity of green and dry mass is provided by inoculation of seeds with a promising strain A4 when applying the defecate, and without the use of meliorant the inoculation of seeds is done with the main production strain 425a.

The use of the defecate and bacterial preparations for presowing treatment of alfalfa seeds is agronomically and economically profitable, it contributes to increasing the environmental resistance of the agricultural landscape and plants to stressful conditions, a balanced level of nutrition, increasing plant productivity and profitability (low cost) of their cultivation.

The results of research on the effectiveness of the defecate served as the basis for creating a scientific project that won in All-Russian competition “My country is my Russia” in the category “Projects aimed at the development of innovation, science and education in Russian regions and municipalities” (II place – silver medal-Moscow, 2012).

**References**

[1] Koshkin E I 2010 *Fiziologiya ustoichivosti selskohozyaistvennykh kultur* (M: Bustard Publ)

[2] Lazarev N N 2011 The influence of liming on the yield of alfalfa-cereal grass mixtures in the conditions of the Moscow region *Forage production* 9 9–11

[3] Walworth J L 1990 Alfalfa response to lime, phosphorus, potassium, magnesium and molybdenum of acid ultisols *Nutrient Cycling in Agroecosystems* 24(3) 67–172

[4] Brauer D and Belesky D 2002 Effect of Lime and Calcium on Root Development and Nodulation of Clowers *Crop Science* 42 1640–46

[5] Scott B J, Ewing M A, Williams R, Humphries A W and Coomes N E 2010 Tolerance of aluminum toxicity in annual Medicago species and Lucerne *Australian Journal of Experimental Agriculture* 48 499–511

[6] Balabko P N, Slavyansky A A and Khusnutdinova T I 2012 Primeneniiye defekata pri vyraschivani kartofelya na dernovo-podzolistikh pochvah *Actual problems of ecology, Agrochemistry and soil science in the XXI century Mat. international Conf.* (Bryansk: bsha) pp 29–34
[7] Ivanov A N 2004 Vliyaniye defekata na svoistva, plodorodie serykh lesnykh pochv Bie–
Chumishskogo mejdurechya i urojainost selskohozyaistvennykh kultur. Avtoref. disser. kand.
agric. nauk (Barnaul: ASAU Publ)

[8] Sheudzhen A X, Gutorova O A and Bondareva T N 2018 Ecological and agrochemical
assessment of the effectiveness of defecate in rice crops Agriculture 6 27–30

[9] Chaika A K and Vashchenko A P 2017 Agrarnaya nauka v Primorye (XX–XXI vv.)
(Vladivostok: LLC "Rhea" Publ)

[10] Ivanova E P 2015 Effektivnost ispolzovaniya defekata i Synorhizobium meliloty pri
vozdelivanii lyucerni izmenchivoi v usloviyah Primorskogo kraya Problems of recultivation
of household waste, industrial and agricultural production. Proc. of the IV Intern. Ecol.
Conf. (Krasnodar: KSAU Publ)) vol 2 pp 85–89

[11] Novoselov Yu K, Kireev V N and Kutuzov G P 1997 Metodicheskiye ukazaniya po provedeniyu
polevykh opytov s kormovymi (Moscow: RASKHN Publ)

[12] Dospekhov B A 1985 Method of field experience (with the basics of statistical processing of
research results) (Moscow: Agropromizdat Publ)

[13] Yemelyanov A N and Ivanova E P 2008 The Influence of liming and mineral fertilizers on
the productivity, nutritional and energy value of alfalfa in the conditions of the Primorye
territory Achievements of science and technology agro–industrial complex 6 17–20