INOCULATION AS AN ELEMENT OF ENERGY SAVING IN THE CULTIVATION TECHNOLOGY OF GRAIN LEGUMES UNDER CONDITIONS OF THE FOREST-STEPPE OF UKRAINE

Serhiy Kolisnyk, Svitlana Kobak
Institute of Feed Research and Agriculture of Podillya of the Ukrainian Academy of Agricultural Sciences
fri@mail.vinnica.ua

Abstract
Highly effective, competitive and complementary strains *Rhizobium leguminozarum bv. viceae* B-9 for faba bean cultivar Bilun and *Bradyrhizobium japonicum* 71-T for soybean cultivar Femida that are recommended as a basis for production of bio-preparation for seed inoculation while growing annual grain legumes in agrocenosis of the Forest-Steppe are revealed.
Key words: soybean, faba beans, innoculation, Bradyrhizobium japonicum, Rhizobium leguminozarum bv. viceae, crop productivity.

Introduction

Improvement of nitrogen nutrition of plants is the main factor of the crop yield increase. Application of "industrial" nitrogen of mineral fertilizers provides balancing of soil deficiency in nitrogen. But industrial fertilizer production demands substantial energy costs. For example, in the USA nearly 2.5% of annual reserves of natural gas are spent on the synthesis of nitrogen fertilizers. Therefore, under conditions of global energy crisis there is a growing interest in biological systems that fix atmosphere nitrogen using sun energy accumulated in the process of photosynthesis (Posypanov, 1993). The study of this process is an urgent problem of biology and agricultural science. On the one hand, it is necessary to search potentiality of biological nitrogen fixation, and on the other hand, to make highly active competitive strains of bulb bacteria and other nitrogen fixers.

Grain-legume crops play an important role in mobilization of biological nitrogen that is essential for the general nitrogen balance in farming as well as for the increase of crop yield and protein content in it. It is known that the positive role of grain-legume crops in agriculture is connected with the activity of bulb bacteria with which these crops are in close symbiotic relations. Productivity of grain-legumes, increase of their adaptive potential, accumulation of biological nitrogen and protein depend substantially on the interrelations of macro- and microsymbionts in each case.

It should be mentioned that many cultivars of grain-legumes are not very susceptible to inoculation by active strains of bulb bacteria, as a result of which their root system is populated with "local" low active strains. That is why symbiosis must be considered from the point of view of a culture – nitrogen fixing bacteria and a variety – strain of nitrogen fixing bacteria. Results of researches carried out by I.A.Tykhonovych have shown that in soybean rhyzosphere, in spite of the presence of vigorous competitive strains of bulb bacteria, competitively weak strain was dominating as its genotype corresponded to the genotype of the host plants. In this case variety specificity of macrosymbiont has been shown (Tikhonovich, 1989). Application of highly effective strains of bulb bacteria in symbiosis with modern cultivars of grain-legumes has increased their productivity by 10-30% and protein content in seeds by 2-6%, even under condition of availability in the soil of aborigine bacteria or those that have been introduced earlier (Didovich et al., 2010). Thus, seed inoculation by bacteria fertilizers is a simple, cheap and compulsory agrotechnical measure that provides the increase of nitrogen fixing ability of grain legume crops, their yield capacity and improvement of the yield quality of both inoculated sowings and subsequent crops in rotation (Berestetskyi , 1978; Bazilinskaya, 1989).

Materials and Methods

Researches were carried out in 2006-2010 on the grey forest mid loamy soils, an arable layer of which (0-30 cm) contained 1.94% of humus.

Faba bean cultivar Bilun and soybean cultivar Femida selected by the Institute of Feed Research and Agriculture of Podillya of the Ukrainian Academy of Agricultural Sciences and grown according to the modern zone technology without application of mineral nitrogen fertilizers, insecticides and herbicides were sown; weeds were destructed using agrotechnical methods. The yield was harvested by combining with subsequent re-calculation of seed mass for 100% purity and 14% moisture content. The trials were repeated four times, variants were located systematically. The area of the registered plot was 25 m^2.

Rhizobia strains from the collection of the Russian Institute of Agricultural Microbiology of the RAAS and the Southern Research Station of the Institute of Agricultural Microbiology and Agro-industrial Production of NAAS were used in trials. Efficacy of symbiotic nitrogen fixation of stains *R.leguminozarum bv. viceae* with faba bean plants was estimated in comparison with production strains 248b, 0418, 0419, strains *Bradyrhizobium japonicum* with soybean plants – with strain-standard 634b and production strains M-8, 36 and variant without seed treatment of these crops according to methodical recommendations (Volcogon et al., 2010). In 1-2 hours before sowing the seed was watered (2% of mass) in control, in variants with strains – with water suspension of 7 day culture of rhizobia in such a proportion – 10^6 bacteria/seed. Statistic treatment of obtained results was carried out using the method of disperse analysis (Dospekhov,1985).

Results and Discussion

It is revealed that in all variants with inoculation bulb bacteria on the roots at the flowering phase of faba beans and soybean were rosy and big in comparison with control where formation of small root bacteria which had formed during infection by rhizobia of the soil population was observed.

In all variants with seed inoculation of faba beans and soybean, there was increase of their yields by 9.0-24.3 % and 4.2-13.6 % respectively in comparison with the control

Table 1

Faba bean seed yield depending on the influence of strains *Rhizobium leguminozarum bv. viceae*, t/ha (average for 2006-2009)

Trial variant	Crop yield, t/ha	Increase before control	
		t/ha	%
Without inoculation (control)	2.39	-	-
Production strains:			
248 b	2.72	0.33	13.7
0418	2.81	0.42	17.5
0419	2.91	0.52	21.8
Prospective strains:			
261	2.61	0.22	9.0
B-8	2.84	0.45	18.8
B-9	2.97	0.58	24.3
B-15	2.76	0.37	15.3
B-16	2.85	0.46	19.2
B-17	2.69	0.30	12.4
B-18	2.76	0.37	15.3
$LSD_{0,95}$, t/ha	0.103	-	-

Table 2

Soybean seed yield depending on the influence of strains *Bradyrhizobium japonicum*, t/ha (average for 2006-2010)

Trial variant	Crop yield, t/ha	Increase before control	
		t/ha	%
Without inoculation (control)	2.14	-	-
Strain-standard:			
634b	2.41	0.27	12.6
Production strains:			
M-8	2.26	0.12	5.6
36	2.23	0.09	4.2
Perspective strains:			
71-T	2.43	0.29	13.6
X – 2	2.38	0.24	11.2
640 b	2.36	0.22	10.3
19	2.31	0.17	7.9
33	2.31	0.17	7.9
$LSD_{0,95}$, t/ha	0.035	-	-

variant against a background of the soil population (Tables 1, 2).

Among production strains for faba beans, the best result was shown by bulb bacteria strain 0419. Seed yield of the crop was 2.91 t/ha that was 0.52 t/ha or 21.8 % more than in control and 0.1-0.19 or 3.6-7.0 % more in comparison with other production strains.

Seed inoculation by prospective strain B-9 provided maximum seed yield of cultivar Bilun 2.97 t/ha that was 24.3 % more than in control and 2.5 % more in comparison with strain 0419 that is the best one among production strains.

Seed inoculation of soybean cultivar Femida by various strains of bulb bacteria have shown that strain-standard 634b appeared to be the best one among production strains. Crop yield in this variant was 2.41 t/ha that was 0.27 t/ha or 12.6 % more than in control against a background of the soil population of rhizobia.

It should be mentioned that production strains of bulb bacteria M-8 and 36 provided a crop productivity of 2.26 and 2.23 t/ha that was 6.2 and 7.5 % less in comparison with strain-standard 634b and 2.0-7.0% less than in prospective strains of bulb bacteria.

Strain *Bradyrhizobium japonicum* 71–T appeared to be the most efficient selection strain for seed inoculation. It provides a 13.6 % seed yield increase in comparison with control, a 1 % increase in comparison with strain-standard 634 b and a 7.5 and 9.0 % increase – with production strains M-8 and 36.

It is determined that seed inoculation of faba bean and soybean both increases the level of crop productivity and improves seed quality, particularly it increases crude protein content.

Table 3

Influence of seed by strains *Rhizobium leguminozarum bv. viceae* on the crude protein content in faba bean seed, % (average for 2006-2009)

Trail variant	Crude protein content, %
Without inoculation (control)	26.84
Production strains:	
248 b	28.32
0418	27.17
0419	28.36
Perspective strains:	
261	27.83
B-6	27.24
B-8	28.61
B-9	28.84
B-15	27.87
B-16	27.85
B-17	27.67
B-18	29.03

Table 4

Influence of seed inoculation by strains *Bradyrhizobium japonicum* on the crude protein content in soybean seed, % (average for 2006-2009)

Trial variant	Crude protein content, %
Without inoculation (control)	34.19
Strain-standard:	
634 b	38.12
Production strains:	
M-8	37.29
36	37.91
Perspective strains:	
71-T	39.53
X – 2	38.92
640 б	35.62
19	38.16
33	38.33

Thus, seed treatment with both production and prospective strains of bulb bacteria increased crude protein content in faba bean seed by 0.33-2.19 % and in soybean seed by 1.43-5.34% in comparison with the control variant against a background of soil population of rhizobia populations (Tables 3, 4).

Thus, strains 0419 and 634 b appeared to be the most efficient strains among production ones for faba beans and soybean. They provided 28.36 % and 38.12 % crude protein contents in seed.

Strain B-18 appeared to be an effective one among perspective strains of bulb bacteria for faba beans. Crude protein content in this variant was 29.03 % that was 2.19 % more than in control and 0.67 % more in comparison with the best strain among production strains 0419.

The strain of bulb bacteria B-9 provided lower crude protein content 28.84 %.

Under condition of seed inoculation of faba beans by other strains of bulb bacteria, crude protein content in seed fluctuated from 27.17 to 28.61 %.

The highest crude protein content in soybean seed (39.53 %) provided a prospective strain of bulb bacteria 71-T that was 5.34 % more than in control and 1.41% in comparison with strain-standard 634b.

Under condition of soybean seed inoculation by other production and prospective strains of bulb bacteria, crude protein content fluctuated from 35.62 to 38.92 %.

Conclusions

It is experimentally proved that seed inoculation by selection strains *Rhizobium leguminozarum bv. viceae* and Bradyrhizobium japonicum improves plant growth and development and facilitates formation of high level of high quality faba bean and soybean seed yield when grown on grey forest mid loamy soils in the Forest-Steppe zone of Ukraine, even against a background of soil population of bulb bacteria.

Comparative evaluation of the results of various strains *Rhizobium leguminozarum bv. viceae* and *Bradyrhizobium japonicum* for seed inoculation of faba bean and soybean have shown availability of variety specificity of the strain activity that has been revealed through supply of the determined productivity of these crops.

Highly effective, competitive and complementary strains *Rhizobium leguminozarum bv. viceae* B-9 for faba bean cultivar Bilun and *Bradyrhizobium japonicum* 71-T for soybean cultivar Femida that are recommended as a basis for production of bio-preparation for seed inoculation while growing annual grain legumes in agrocenosis of the Forest-Steppe are revealed.

References

1. Берестецкий О.А. (1978) Фитокинины почвенных микроорганизмов и их экологическая роль. Фитотоксические свойства почвенных микроорганизмов (Phytokinines of soil microorganisms and their ecological role. Phytotoxic characteristics of soil microorganisms). Ленинград, С. 7-30. (Russia)
2. Базилинская М.В. (1989) Биоудобрения (Biofertilizers). Агропромиздат, Москва, 126 с. (Russia)
3. Волкогон В.В., Надкернична О.В., Толмакова Л.М. (2010) Експериментальна ґрунтова мікробіологія (Experimental soil microbiology). Аграрна наука, Київ, 464 с. (Ukraine)
4. Доспехов Б.А. (1985) Методика полевого опыта (Methodic of the field experiment). Агропромиздат, Москва, 351 с. (Russia)
5. Дидович С.В., Толкачев Н.З., Мельничук Т.Н. и др. (2010) Биопрепараты в агротехнологиях выращивания зернобобових культур (Biopreparations in agrotechnologies of grain-legume crops). Агромир, Крымский государтвенный аграрный учебно-консультационный центр, 8 с. (Ukraine)
6. Тихонович И.А. (1989) Использование генетических факторов макросимбионта для повышения эффективности биологической азотфиксации. Биологический азот в сельском хозяйстве СССР (The use of genetic factors of marcosymbiont for the increase of efficacy of biological nitrogen fixation. Biological nitrogen in agriculture in the USSR). Наука, Москва, с. 166—181. (Russia)
7. Посыпанов Г.С. (1993) Биологический азот. Проблемы экологии и растительного белка (Biological nitrogen. Problems of ecology and plant protein). Издательство ТСХА, Москва, с. 272. (Russia)