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Practices of Raising the Cropping Power of Green Large Seed Lentil in the Volga Region Steppe.

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ABSTRACT

Lentil is considered to be one of the most promising crops in the world and in Russia which is distinguished by a valuable biochemical composition that has led to the sowing acreage increase. The technology of green lentil is specific and differs from traditional legumes and its separate elements are not well studied. Brief data on the lentil crop history, on advantages and problems of its production have been given in the article, the research results on raising its cropping power have been covered. It has been found in the study that cultivation of lentil with the use of the growth stimulating preparations in pre-sowing seed treatment – siliplant, zircon, epin-extra and bacterial fertilizers – rizotorfin, and extrasol increased yielding capacity of valuable high-protein grain, its symbiotic and photosynthetic activity that increased competitiveness of agrocenosis of a lentil plant and reduced agrotechnological production costs of the high-protein product cultivation.

Keywords: lentil, variety, photosynthesis, biological products, growth regulators

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IMPORTANCE

Protein is a biologically important component of the person's food and animals' feeds and its deficiency becomes in many cases the reason of physiological and functional disorders of a live organism. The physiological rate of protein consumption is 12% of the general caloric content of a person's daily ration, including 60-70% of animal origin protein.

Proteins are formed anew only in the plants from nitrogen free organic substances and inorganic forms of nitrogen [1]. Proteins of an animal organism are formed only from hydrolysis products of a protein molecule of the plants consumed by animals in the form of a forage. Thus, the synthesis of proteins of the fauna is in close dependence on vegetation [2].

Proteins are formed only in plants from the nitrogen free organic substances and inorganic forms of nitrogen, in this regard, the problem of vegetable protein on a global scale is one of the most burning issues of mankind.

As early as in the thirties of the last century academician D. N. Pryanishnikov proposed to assume the use of nitrogen catching crops as a basis of the protein deficiency solution, thinking that this source is "free" as all expenses on the leguminous crop cultivation are covered by animal husbandry.

A special value for the steppe of the Volga region in the territory of Russia is represented by lentil. In the history of this plant there are pages of a flourish and periods of sudden oblivion that had influence on yielding capacity, acreage, gross grain harvests, a state of research work on selection and seed breeding.

Today the crop is of commercial interest in the USA, Canada and Australia though in the last century Russia was the world leader in production of lentil grain and in the world export of dish-shaped lentil where its share was more than 85% [4, 5, 6].

At present lentil is one of the most widespread leguminous crops in the world. According to FAOSTAT in 2010 it was grown in 52 countries of the world. The harvested acreage is 4,2 million hectares, and gross grain harvest – 4,6 million tons. In the structure of production of leguminous crops lentil shares 4-5 place with beans after soy, French beans and peas. Leaders in production of lentil are Canada (the harvested acreage of 1,34 million hectares; gross grain harvest 1,9 million tons), India (1,3 million hectares; 900 thousand tons), Turkey (234 thousand hectares; 447 thousand tons).

Protein content in dish-shaped lentil fluctuates from 27,9 to 34,8%, at the same time proteins biologically valuable, consist, mainly, of water - and salt-soluble components – albumines and globulins. Free amino acids which provide good nutrients digestibility by a human body and animals are a part of lentil grain. As well as other legumes, lentil with the help of nodular bacteria fixes air nitrogen that contributes to not only an accumulation of protein in vegetative weight and seeds, but also to preservation of soil fertility.

The best varieties of lentil belong to large seed subspecies (ssp.macrosperma), a kind of nummularia L. and among them in due time the most widespread variety was Petrovskaya 4/105 which in the seventies of the last century made up 95% of all high-quality crops in the country and served more than 80 years in lentil production of Russia.

At present the variety Aida is well known (2012) which is distinguished by a high cropping power in the steppe of the Volga region (3,0 t/hectare).

Lentil varieties of the Russian selection show a high level of yielding capacity. So, during the State test in the Rostov region of the variety "Don" 3,14 t/hectare of seeds (2005) were harvested. In the Saratov region in 2003 with the lentil cultivation of the variety "Anfiya" (2006) the yielding capacity amounted to 3,2 t/hectare, of the variety "Svetlaya" (2008) – 3,05 t/hectare. In 2008 the use of "Nadezhda" variety in the Tambov region (2009) provided the grain yield of lentil in 3,38 t/hectare [7].

At present lentil is generally grown in the Volga Federal District, the most part falls on the Saratov region, also in the Voronezh, Penza regions, Tatarstan, Bashkortostan [8]. In the steppe of the Volga region the

cropping power of lentil seldom exceeds 1,0-1,2 t of grain from 1 hectare and the acreage of crop is very unstable. One of the reasons constraining the increase in production of lentil grain is a weak competitiveness of this crop to weed infestation.

It should be noted that climatic and soil conditions of the steppe of the Volga region conform in the best way to biological requirements of the crop. It is here the greatest acreage of dish-shaped lentil has been concentrated which does not have peers in quality of grain in the world market.

Dish-shaped lentil is of great economical value for the steppe of the Volga region. The crop is insufficiently studied till the present day, its varietal diversity has not passed tests in various soil and climatic zones and microzones of the Volga region that considerably narrows the boundaries of its distribution and is the reason of low and unstable productivity.

Biological potential of the lentil cropping power is very high, but its full realization requires strict observance of agrotechnology practices and technological discipline taking into account its biological features.

Along with the cultivation technology the leading role in the lentil production increase belongs to development and introduction of new varieties into production. Major shortcomings of the existing varieties: low yielding capacity and insufficient technological effectiveness [8, 9, 10]. They are distinguished by such biological features of lentil plants as short stems, a low attachment of pods, lodging, weak competitiveness in relation to weed infestation, lack of herbicides, unevenness of ripening, cracking of beans and fall of seeds, low resistance to abiotic and biotic stress [7].

Purpose of the study: development of practices directed at increasing the dish-shaped lentil cropping power in the steppe of the Volga region.

RESEARCH TECHNIQUE

In 2012-2014 we conducted the study directed towards the solution of problems of increasing the dish-shaped lentil cropping power.

Experiment 1. Photosynthetic productivity of varieties of lentil on black soils of the steppe of the Volga region. The scheme of the experiment provided the study of three varieties: 1. Petrovskaya 4/105 2. Vekhovskaya 3. Krasnogradskaya 250.

Experiment 2. Influence of bacterial and growth stimulating preparations on photosynthetic productivity and a harvest of lentil. The scheme of the experiment: 1. Control (water treatment) 2. Rizotorfin 3. Extrasol 4. Epin-extra 5. Zircon 6. Siliplant. Biological products and growth stimulants were applied in pre-sowing seed treatment of lentil varieties – Vekhovskaya (PSE-4), Krasnogradskaya 250 and Donskaya.

The field experiment was conducted in the territory of the farm “Korolyov V.” which is located in the Novoburassky district of the Saratov region. On natural zoning – it is a northern right-bank microzone, the major part of it is represented by the forest-steppe with moderately droughty climate.

The soil of the experimental field is characterized by slightly leached southern black soil that is distinguished by the average clayloam particle size distribution that is quite typical of the zone of the droughty Volga region steppe. Quality assessment of the seedbed preparation fluctuates on a microzone from 63 to 71 points.

Sowing on experimental plots was carried out in the earliest spring terms in the usual ordinary way with seeding norms 2,2 million emerging seeds on 1 hectare. Frequency of experimental options 4-fold, the area of experimental plots is 108 m ^{2}, registration plot – 72,8 m ^{2}, the placement of options and replications is systematic,
one- layered.

Weather conditions in the years of our study (2012-2014) were typical of this area in the region: abnormal and hot and dry weather was noted in the spring and summer period of 2012; in 2013, the period of

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vegetation of early summer crops was distinguished by the rainfall shortage in the first half of their growth and development period that naturally affected the survival rate of plants, a state and efficiency of agrocenosis; 2014 on temperature condition and moisture content of field agrocenosis was within mean annual rates.

Studies were conducted by the standard techniques [11], the agrotechnology used in experiments was standard for conditions of the Volga region steppe.

RESULTS

The crucial role in formation of the field crops yielding capacity is made by photosynthesis, i.e. assimilation of carbonic acid by plants from air. The lentil plant, as well as other legumes, develops its leaves gradually, in the process of growth of a stalk and lateral branches. Studying the features of development of a lentil plant, it has been revealed that the leaf surface and weight increase slowly, it also determined weak competitiveness of crops in relation to weed vegetation, especially on initial growth phases.

Depending on varietal features and cultivation conditions the lentil plant gives up to 3-6 developed lateral branches that in its turn branch off on branches of the second, third and subsequent orders and the stem mass of a plant by the phase of legume formation can reach 42% of all elevated biomass.

The strengthened accumulation of biomass in lentil takes place during the period from the beginning of blossoming prior to bean ripening that is connected with intensive development during this period of vegetative and reproductive organs (figure 1).

Of the studied varieties, in all stages of vegetation varieties Petrovskaya 4/105 and Krasnogradskaya 250 differed in the greatest gain of biomass.

Studying the process of the leaf surface formation showed that prior to the beginning of a flower budding the formation of leaves goes slowly, but already at the beginning of branching variety distinctions are manifested in the number of the formed leaves and their surface. So in the years with sufficient moisture content, in 15 days after the beginning of branching, the variety Petrovskaya 4/105 on average on one plant had about 15 leaves of 73,7 cm ^{2}, the variety Krasnogradskaya 250 –up to 18 leaves with an area - 93,2 cm ^{2}, and the variety Vekhovskaya (PSE-4) – had 22 leaves at the same time their area was 101,8 cm ^{2}.

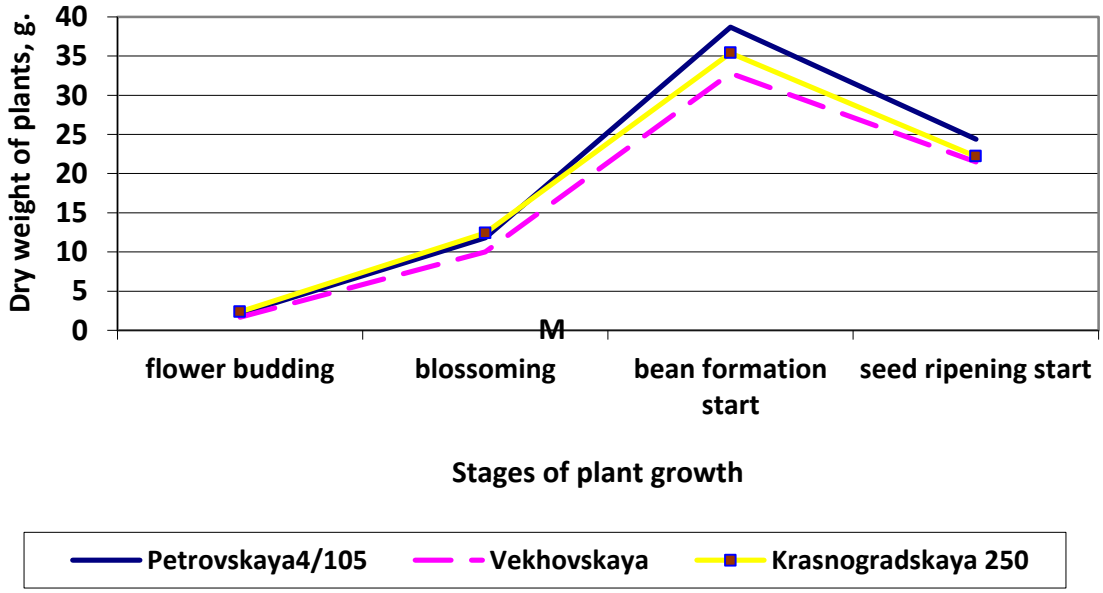

Fig. 1 – Dynamics of biomass accumulation by plants of various lentil varieties according to vegetation phases (on average for 2011-2014)

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The variety Krasnogradskaya 250 was distinguished by the greatest number of branches which had 3-4 branches on 1 plant (the first order) whereas the variety Petrovskaya 4/105 – 2, the variety Vekhovskaya – 2-3 branches. In rather droughty years in our experiments the lentil variety of Vekhovskaya was distinguished by the fewest number of leaves and fewer number of branches.

In the blossoming phase lentil had the most intensive process of branching and emergence of new leaves, and in the phase of the onset of bean formation the number of leaves in the crop reached a maximum extent. In our experiment the index of a leaf surface (ILS) in the variety Petrovskaya 4/105 reached 3,2-4,2 m ²/m ², the variety Krasnogradskaya 250 – 3,3-4,6, and Vekhovskaya – 3,1-4,2 m ²/m ². In the years of the increased moisture content during bean ripening the number of leaves in crops of lentil remained high – 3,1-4,2 m ²/m ², in droughty years – did not exceed 2,1-1,4 m ²/m ².

Agrocenoses of the lentil variety Krasnogradskaya 250 were distinguished by the greatest magnitude of photosynthetic potential where for 4 years of tests it had averaged 2,66 million m² • days per 1 hectare whereas with almost the same area of a leaf surface of the variety Petrovskaya 4/105 its magnitude was less by 0,34 million m² • days/hectare or by 14,6% (table 1).

Table 1: Photosynthetic efficiency of lentil varieties on black soils of the Volga region steppe (2011-2014)

Variety	ILS, m²/m²	PPS, mln. m²·a day	Net efficiency of photosynthesis g/m²	Biomass gain (BG), g/m²·a day.	Yield, kg/m²		Coefficient of economic efficiency
					dry biomass	grain	
Petrovskaya 4/105	2,70	2,32	2,33	5,42	0,54	0,216	0,40
Vekhovskaya (PSE-4)	2,86	2,58	2,15	4,54	0,55	0,203	0,37
Krasnogradskaya 250	2,78	2,66	1,83	4,88	0,48	0,182	0,38

We found that theoretically possible yielding capacity of lentil with the use of 2% photosynthetic active radiation can amount to 8,1 t/hectare of dry biomass. According to our data, in the period of filling seeds in beans of the lower layer loss of dry elevated biomass on average in plants of the variety Petrovskaya 4/105 made up 4,7 g. per day, in Vekhovskaya-5,7 and in Krasnogradskaya 250 – up to 10,4 g counting on 100 plants. From the point of view of photosynthetic activity of lentil varieties varieties Petrovskaya 4/105 and Vekhovskaya (PSE-4) were distinguished by the greatest adaptation to conditions of the marked continental climate, their plants formed biomass earlier with a sufficient reserve of plastic substances for further differentiation of the assimilates structure reserved in seeds.

One of the factors of increasing the crop yielding capacity is the use of biological products and growth regulators of plants [12]. We conducted a field experiment to evaluate modern preparations in cultivation technology of dish-shaped lentil.

One of the most important elements in the structure of any phytocenosis is its density, i.e. quantity of plants on a sowing unit. From applied by us bacterial and growth stimulating preparations in pre-sowing seed treatment of lentil rather fuller and amicable emerging crops in all years of the study were observed on options with zircon and siliplant (table 2).

Table 2: Influence of bacterial and growth stimulating preparations on field germination of lentil varieties, on average for 2012-2014.

Variety	Field germination rate, in %					
	control	rizotorfin	extrasol	zircon	siliplant	epin-extra
Vekhovskaya	78,6	78,8	82,5	86,2	86,7	85,4
Krasnogradskaya 250	76,4	77,2	80,3	85,2	85,8	84,3
Donskaya	78,1	78,5	81,4	85,6	86,2	84,7

Distinctions in field seed germination of lentil were determined both by varietal features of crops, and action of the preparations used in pre-sowing seed treatment. Studies have shown that pre-sowing soaking of seeds of lentil in solutions of zircon and siliplant considerably stimulated growth processes and accelerated the reproductive period onset in development of plants. An amplitude of fluctuations in terms of acceleration of flower budding, blossoming, formation of the first fruits between experimental and control options on the studied lentil varieties reached 5-8 days.

Pre-sowing seed treatment of lentil with bacterial and growth stimulating preparations has considerably raised not only field germination, but also intensified growth processes. On options with siliplant and zircon seed treatment the height of lentil plants, in the period of flower budding was higher, than on control by 8-12 (in Vekhovskaya), in a variety by 5-7 (in Krasnogradskaya 250) and by 6-8 cm (in Donskaya). Distinctions are also noted in a number of lateral branches from the lower elevated buds, in a number of leaves of plants that is quite a significant factor in formation of more tall, more dense crops, capable to compete with weed vegetation. Agrocenoses of experimental options differed from control and on the location of reproduction bodies: the greatest number of flowers and beans with the ripened seeds is noted on the main stalk and its lateral branches in the lower and middle layers of plants. The obtained data demonstrate that on options of pre-sowing seed treatment of lentil with preparations epin-extra, zircon and siliplant during fruit ripening in the lower layer continued their vegetation process that promoted normal ripening of fruits of a middle layer and the smallest loss of seeds of the first seed buds .

In experimental crops lentil seedlings of the variety Vekhovskaya (PSE-4) were distinguished by the greatest leaf surface and photosynthetic potential on options with the use in pre-sowing seed treatment of a siliceous preparation with a numerous set of minerals – siliplant and a biostimulator from the mix of hydroxycinnamon acids of zircon (table 3). On marked options lentil agrocenoses were different in the greatest leaf surface, photosynthetic potential, the greatest biomass yield and grain yield.

Table 3: Influence of bacterial and growth stimulating preparations on photosynthetic efficiency and yield of lentil variety Vekhovskaya (PSE-4) on average for 2012-2014.

Seed treatment option	ILS, m^2/m^2	PPS, mln. m^2·day/ha	NEP, g/m^2· a day	Dry biomass harvest, t/ha	Grain yield, t/ha
Control (water)	2,26	2,03	2,30	4,66	1,67
Rizotorfin, ж	2,38	2,02	2,25	4,88	1,85
Extrasol	2,65	2,44	2,28	5,56	2,22
Epin-extra	2,87	2,71	2,40	6,51	2,53
Zircon	2,88	2,78	2,56	7,12	2,84
Siliplant	3,06	3,03	2,60	7,88	3,31
$LSD_{0,5}$	0,17	-	-	-	0,28

On average for the years of our study (2012-2014) the leaf surface of lentil of the variety Vekhovskaya (PSE-4) on option with siliplant gave 30,6 thousand m ² per 1 hectare of crops that is more than the control variant by 0,8 thousand m ²/hectare, or by 35%.

CONCLUSION

Thanks to valuable economic and biological qualities green lentil is a promising crop for cultivation in the forest-steppe of the Volga region. We found that cultivation of lentil with pre-sowing seed treatment by growth stimulating preparations – siliplant, zircon, epin-extra and bacterial fertilizers – rizotorfin, and extrasol increased productivity of valuable high-protein grain due to strengthening symbiotic and photosynthetic activity.

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