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Cover Crops As Sources Of Nutrients Increasing Productivity Of Soya Sown With Wide-Space Methodin The Climate Of The Amur Region, Russia.

Vladimir Epifantsev, AN Panasyuk* Ya A Osipov, AA Tzyban, and AN Demko.

Far East Research Institute of Mechanization and Electrification of Agriculture, Russian Federation, Amur Region,5, Vasilenko Str., Blagoveshchensk-675027

ABSTRACT

The article presents the experiments carried out to study the width of soybean row-spacing and the selection of cover crops (green manure crops) as sources of nutrients used in soybean fields. Rape, soybean-oat mixture and weed vegetation can be the most accessible, relatively inexpensive plants to serve as nutrients increasing the productivity of soybean crops and soil fertility reproduction. As for cover crops, it is better to sow rape, for its top yield exceeds that of soy-oat mixture 1.5 times and as to variant of weed vegetation - 3.04 times. The cover crops can be sown at different times and occupy the field before they are incorporated into the soil during the phase of the beginning of earing orear formation of cereals and budding of legumes and cabbage crops in order to obtain the maximum amount of green mass and accumulation of nutrients in the soil, or in the strips between the rows in case of wide-space sowing of soya with the help of paw-shaped plowshare, seeder СП-4.6 (strip width-20 cm), row-spacing40 cm.

Keywords: soybean, wide-space sowing, cover crops, weed vegetation, rape, soya-oat mixture.

Corresponding author

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INTRODUCTION

Soybean is a valuable protein-oil crop of agriculture in many countries of the world. Currently, it is grown in 90 countries, in Russia 0.7 – 1% of the total area of world soybean crops. The use of modern varieties (hybrids) and intensive technology under favorable conditions makes it possible achieve record yield of soybean – 19.2 t/ha [4].

Far East Federal District of Russia (Primorsky, Khabarovsk Krai, Amur Region), has more than 88% of soybean crops and produces more than 86% of its gross harvest in the country. In the structure of sown areas of the Amur Region, the share of soybeans amounts to 72%. The crop yield of cereals from 1990 till 2014 increased almost by 0.6 t/ha, whereas the yield-capacity of soybean only by 0.1 t / ha [11]. There are many reasons for the slow growth of productivity of soybean crops: the lack of science-based crop rotations and high-yielding varieties, slow introduction of new technologies, machines, plant protection and fertilization associated with rising energy prices, etc. You can reveal the productive capacity of varieties through understanding the mechanisms of adaptability and resistance of soybeans to adverse effects of abiotic, biotic, anthropogenic and other factors. Proper management of these mechanisms in the process of growth and development of plants will smooth the negative effects on plants, increase the fertility of arable soil and soybean yield.

Soya, like other green plants, autotrophic organisms, synthesizes organic matter from inorganic substances and accumulates the energy of the sun.

If the soil does not have enough nutrients available for plant nutrition, they grow and develop poorly, and give a low yield. Green mass (green manure), straw, crop residues decompose, being incorporated into soil (turned under), increase the nutrient reserves in the soil and provide environmentally friendly products. When sowing the same crop for several years in the same field there is a unilateral depletion of the soil, crop yield reduces, the phenomenon of soil fatigue appears. As it was shown by experiments in the USA and Canada, soybean cultivation in monoculture way for 50 years with sufficient amount of fertilizers, effective pest and disease control provides stable harvest [5]. However, high doses of fertilizers and pesticides upset the balance in ecosystems, pollute the environment and reduce safety and increase the cost of production. Therefore, the search for affordable, relatively cheap, environmentally safe sources of fertility improvement and the development of technological schemes for their application in soybean crops is quite an urgent topic of scientific research at the present stage of the development of agricultural science and production.

The aim of the research is to select the most affordable, relatively inexpensive plant species as sources of nutrients to increase the productivity of soybean crops and soil fertility.

CONDITIONS AND METHODS

In 2016-2018 the research were carried out in the experimental field of the Far East Research Institute of Mechanization and Electrification of Agriculture, located in the Amur Region. The soil type is meadow-chernozem-like. The thickness of the topsoilis up to 30 cm. Humus content in plough-layer ranges from 2 to 3%, mobile phosphorus is average, exchange potassium is high. The reaction of the soil solution is slightly acidic.

Weather conditions in the Amur Region are characterized by unstable temperature conditions, frequent rains, sometimes strong, reaching the criterion of a dangerous phenomenon, high relative humidity which often results in over wetting of the soil during the periods of plant growth and harvesting (table. 1).

Table 1: Weather Conditions in Summer Vegetation Period (data of the Hydro meteoro logical Service of Blagoveshchensk)

Month	Decade	Air temperature, (°C)			With an Average long-standing company,	With Precipitation, mm			Average long-standing company, mm
		2016 year	2017 year	2018 year		2016 year	2017 year	2018 year	

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					(t °C)				
June	1	15,4	14,9	19,3	17,2	21	11	24	26
	2	17,0	19,7	16,1	19,3	26	50	123	30
	3	18,7	22,4	18,4	20,1	53	36	21	35
Per month		17,0	19,0	17,9	18,8	100	97	168	91
July	1	22,3	26,7	21,0	21,4	14	29	42	39
	2	22,2	21,4	22,8	21,9	3	34	34	44
	3	22,3	19,4	23,0	21,4	22	26	83	48
Per month		22,3	22,5	22,3	21,5	39	89	159	131
August	1	21,8	20,9	21,3	20,8	18	78	11	45
	2	19,6	23,9	19,5	19,2	46	4	5	42
	3	16,8	14,9	19,6	17,8	19	39	84	38
Per month		19,4	19,9	20,1	19,2	83	121	100	125
For season		19,6	20,5	20,1	19,8	222	307	427	347

The method of sowing and the area of plant nutrition significantly influence the yield and quality of soybean seeds. When increasing the width of the row-spacing to maintain the optimal feeding area at a given seeding rate, it is necessary to reduce the seeding step (distance between plants). This allows us to fight weeds for a long time, but when plants are thickened in a row, the shaded area in the protective zone increases, and the weeds, being deprived of light, are suppressed [6, 7].

Soy is a short-day light-sensitive crop[2]. It does not need light of great intensity, but requires uniform illumination of the entire plant. With a long light day, the development of plants slows down and flowers fall off. During the formation of seeds in the beans, the assimilates from the leaf enter only the bean that is in the base of this leaf. If the leaf is darkened or dead, the bean will suffer or die. So as the soybean are poorly competitive culture in comparison with weeds, pre – sowing and inter-row tillage are important agro technical technique aimed at reducing the contamination of crops, preserving fertility, creating favorable water and air regimes to ensure optimal conditions for growth and development of plants. In this regard, experiments on soybean resistance to stress and fertility reproduction were conducted.

Experiment 1 Influence of width of row-spacing on soybean yield. Experiment scheme: the versions of the row-spacing width: 15 cm, 45 cm (control), 60 cm, 80 cm and 90 cm. Sowing with row-spacing of 60, 80 and 90 cm: paw-shaped plowshare was used for sowing, strip width 20 cm

Experiment 2 The formation of the biomass of the vegetation between the rows of soybeans. Scheme of experiment: Variant: 1. Weed vegetation (control), 2. Rape, 3.Soya + oat Before sowing: complete cultivation of soil. Soybean was sown with row-spacing of 45 cm. Rape and soybean-oat mixture were sown on the experimental plots bypaw-shaped plowshare(strip width -20 cm). In the course of the experiments we sowed the variety of soybean Lazurnaya. The seeding rate: 800 thousand germinable seeds per 1 ha or 120 kg / ha, the sowing period in year 2016 – May 25, in year 2017 –June1, in year 2018 – June 27.Crop tending: conventional[12], in wide row-spacing of experiment 1 - two cultivations. Mowing of vegetation in experiment 2 was done in the phases of ear formation of cereals and budding of other plants. Allocation of variants – rendomized, replication - 3 times[3].

FINDINGS AND THEIR DISCUSSION

The period from sowing till emergence of seedlings, depending on the year of research, lasted 7-10 days in 2016, 6-9 days in 2017 and 5-7 days in 2018.

The height of soya was mostly from 40 to 58 cm, but some places had low plants 24-31 cm. On average the plants had 15-22 pieces of inflorescences and beans of any size, of them 2 to 8 reached lengths of 1 cm or more. In years2016-2017 the phases of soybean growth and development in the experiments came 5-7 days earlier than in 2018.

The highest yield of soybean was achieved in year 2016 by using row-spacing 60 cm. It was higher than in the case of gapless sowing by 0,21 t/ha. The differences in these variants were within the error of the

experiment. The lowest soybean yield was registered with row-spacing of 80 cm. It was significantly inferior to the best variant (by 0.4 t/ha). Control variant of wide-space sowing (45 cm) also significantly exceeded the yield of the variant with the row-spacing of 80 cm by 0.29 t/ha. In succeeding years of the research, gapless sowing was excluded from the scheme of the experiment, but we added wide-space sowing with row-spacing of 90 cm. In year 2017 having favorable combination of weather conditions (warmth and moisture), soybean yield in the experiment was significantly higher than in 2016 and 2018.Significant differences were registered between the best variant of the experiment (row-spacing of 60 cm) and variants with the row-spacing of 45 and 90 cm, but as to the row-spacing of 80 cm, these differences were within the experiment error. The lowest yield in the experiment was observed in year 2018, when the decisive factor was the belated period of sowing. The findings of the experiment in year 2018 showed significant differences between the variants of wide-space sowing 60 cm and 80 cm, 60 cm and 90 cm, which were inferior to the control and the best variant of the experiment (by 0.29-0.33 t/ha). Between the control variant and the best variant the differences were within the accuracy of the experience. In all years of research differences in variants of the experiment were significant Fϕ> F05, the null hypothesis Ho: d = 0 is rejected. On average, for three years of the research, the best variant was the wide-space sowing of 60 cm, which provided the increase in yield of 26.5% in comparison with the widely used row-spacing of 45 cm. Sowing of soybean with row-spacing of 80 cm in almost all the years, except for 2017, was significantly inferior to control (table. 2.).

Table 2: Influence of Row-Spacing on Soybean Yield

Inter-row spacing, cm	Yield, (t/ha)				Increase	
	2016 year	2017 year	2018 year	average	t / ha	%
15	1,43	-	-	-	-	-
45 control	1,53	2,09	0,78	1,47	-	-
60	1,64	2,50	0,81	1,65	+0,18	+26,46
80	1,24	2,22	0,52	1,33	-0,14	-9,52
90	-	1,84	0,48	-		
NSR_{05}, t/ha	0,21	0,28	0,03			

The potential of soybean is fully revealed in the structural, well-drained, humus-rich soils of chernozem type with a subacid reaction of the soil solution. The optimum acidity for soya-pH 6,0-7,0. In order to have the yield of 2.0 t / ha you need 38-40 kg of nitrogen, 30-40 kg of phosphorus and 30-40 kg of potassium. According to the data of the Primorskaya Experimental Station (Russia), having yield of 2 t/ha of seeds with the appropriate amount of straw, soybean shall stand 142 kg of nitrogen, 32 kg of phosphorus and 35 kg of potassium. Having the content of available forms of P2O5 and K2O more than 15 mg / 100 g of soil, soya yields 1.4-1.5 t / ha without fertilization in all soil and climatic zones suitable for cultivation. Beginning from seedlings emergence till flowering, it consumes N 16%, P2O512%, K2O 25%, CaO 10-11%,MgO 6-8% and sharply reduces the yield if they are not enough in the soil, since at this time the nodes, branches and flowers are formed. Beginning from flowering till seeding (ripening) it uses intensively N 78%, P2O582% and K2O 50%. The consumption of nutrients finishes by the end of vegetation. Nodule bacteria begin to fix nitrogen only in 20-25 days after seedling emergence. Molybdenum stimulates the nitrogen fixation by root nodule bacteria and takes part in phosphate metabolism and accelerates the growth of roots and development of nodules. This determines the characteristics of the fertilization system of the crop. In order to have the yield of 3,3 t/ha you need nitrogen 224-250 kg, phosphorus – 63, potassium – 101, Ca – 73, Mg – 34, sulfur – 22,8, trace elements 2.4 kg. Organic fertilizers are well mineralized at optimal soil temperature and humidity [8, 9, 10].

The productivity of the biomass of green manure depends on the species composition of plants.

Calculation and weighing of plants involved in the experiment showed the following species composition of biomass of cover crops (table. 3.)

Table 3: Species Composition of Biomass of Cover Crops

Variant of the experiment	Number of plants per 1 ha, (thousand pieces)						Ratio of cultivated plants to weeds
	Soya	oats	rapeseed	chicken millet	amaranth	and other weed species	

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Weeds	36	38	0	468	278	20	0,1:1
Rapeseed	0	0	2013	2	3	15	100:1
Soya + oats	333	146	0	3	2	8	32:1

Maximum number of cultivated plants were noted in the variant of the experiment where rape was used as a mulching plant: it amounted to 100:1 in the ratio of cultivated plants to weeds, and minimum was found in the variant of weed vegetation - 0, 1:1. The largest number of plants per 1 ha, thousand pieces, was noted in the variant of green manure biomass obtained from rape crop. In the same variant their largest biomass was noted also – 39.04 t / ha (table. 4).

Table 4: Duration of Formation and Productivity of Biomass of Cover Crops

Variant of the experiment	Period from sowing to maximum productivity, day	Number of plants per 1 ha, (thousand pieces)			Green biomass, (t / ha)		
		highest	lowest	average	highest	Lowest	average
Weeds	60	1234	446	840	15,8	4,44	9,76
Rapeseed	50	2320	1840	2013	39,04	24,36	32,56
Soya + oats	55	600	240	479	18,84	14,08	17,34

The highest yield of live (green) top was produced in the variant using rape as a cover crop- 32.56 t/ha. It exceeded the yield of variant soy+oats 1.5 times, and weeds 3.04 times. However, the yield of the roots of rape was inferior to soybean-oat (by 1.16 t / ha), but superior to weed vegetation (2.42 times as much). As for the yield-capacity of total biomass, the rape green manure was number one - 43,79 t/ha, the yield of soy-oat green manure was lower by 14.06 t/ha and the smallest yield of live biomass was produced by weeds. The obtained data are confirmed by calculation of the ratio of the top to the root mass. Rape has tap root system with one weakly branching root and top with a large number of wide leaves, which provides ratio of plant parts 2,9 : 1. Soybean-oat mixture in its composition has two classes: monocotyledonous plants (oats) in which the ratio of the top and underground biomass is 1-1,5:1 and dicotyledonous (soy) with a ratio of 1,3-1,5:1, which in the mixture provide the ratio of 1,4:1(table. 5).

Table 5: Productivity of Parts of Biomass of Cover Crops

Variant of the experiment	Yield of wet biomass, (t/ha)			Ratio of the aboveground mass to the mass of roots, (%)
	Above ground	Roots	of all	
Weeds	9,76	4,65	14,41	2,1:1
Rapeseed	32,56	11,23	43,79	2,9:1
Soya + oats	17,34	12,39	29,73	1,4:1

The composition of weed vegetation is not stable and during the vegetation season changes - winter weeds grown in early spring are inseminated and replaced by early spring ones, and they, in turn, by late spring weeds. The cycle of development of perennials is also individual. They begin to vegetate very early and having accumulated nutrients take a rest, others on the contrary, after a certain time of rest begin to grow and multiply rapidly. Methods of propagation of weeds are also very different, so when turning the biomass of weeds under the soil one should pay attention to the weeds which are particularly malicious for the crop and turn them under before flowering or formation of vegetative organs of reproduction.

Depending on the type of vegetation, the chemical composition of the raw biomass of the top and roots differs (table. 6).

Table 6: Nutrient Content in the Biomass of Cover Crops, (% of live mass)

Plant	Aerial phytomass of the				Root residues			
	N	P_2O_5	K_2O	CaO	N	P_2O_5	K_2O	CaO
Weeds	0,43	0,14	0,51	0,32	1,12	0,17	0,53	0,81
Rapeseed	0,45	0,16	0,54	0,40	1,36	0,21	0,52	0,95
Soya + oats	0,53	0,16	0,48	0,30	1,21	0,19	0,46	0,76

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Calculations show that weeds accumulate more potassium and nitrogen in the top and roots. Soy-oat mixture - nitrogen and potassium in the top, and nitrogen in roots Rape exceeds the soya-oat mixture 1.6 times in the amount of nitrogen accumulated in the top, and the weed vegetation - 3.5 times. Rape accumulates potassium in the top twice as much as the soya-oat mixture does. The amount of nutrients accumulated in the roots is not significantly inferior to the soya-oat mixture (table. 7).

Table 7: Nutrients Accumulated in Parts of the Biomass of Cover Crops, kg / ha

Experiment version	Aerial phytomass of the				Root residues			
	N	P_2O_5	K_2O	CaO	N	P_2O_5	K_2O	CaO
Weeds	41,97	13,66	49,77	31,23	52,08	7,91	24,65	37,67
Rapeseed	146,52	52,09	169,31	130,24	152,73	23,58	58,39	106,69
Soya + oats	91,90	27,74	83,23	52,02	149,92	23,54	56,99	94,16

Among the total biomass, the largest amount of nutrients is accumulated by rape green manure. It accumulates 1.2-1.6 times as much as soy-oat green manure, and weed vegetation is the least productive as green manure. It is inferior to rape green manure in accumulation of nutrients (3.15-3.19 times) (table. 8).

Table 8: Nutrients Accumulated in the Total Biomass of Cover Crops, kg / ha (after incorporation into the soil to a depth of 0-20 cm)

Experiment version	Yield of wet biomass, (t/ha)	Nutrients			
		N	P_2O_5	K_2O	CaO
Weeds	14,41	47,2	10,79	37,21	34,45
Rapeseed	43,79	149,63	37,84	113,85	118,45
Soya + oats	29,73	120,91	25,64	70,11	73,09

The side ration (incorporation into soil) was done by modernized rotary plow with pan-breakers designed by the Far East Research Institute of Mechanization and Electrification of Agriculture. At the speed of the tillage unit 11.16 km / h, the working bodies of the plow provide high-quality loosening of the soil to the depth of 14.3-14.9 cm, and no more than 27% of plant residues remains on the soil surface. The standard deviation of the depth of tillage within ±2 cm On average, for three years of experiment, having yield 1,5 t/ha after rape and soya-oat mixture incorporation into soils as green manure, soya does not need application of mineral nitrogen and potassium, but after the weed vegetation you need to use all three main elements - N,P2O5, K2O. The dose of phosphorus at this yield after rape green manure is 2.7 times as less as the dose in case of incorporation of soy-oat mixture. When soybean yields 2.0 t / ha, the rape green manure, being incorporated into soil, provides crops with nitrogen and potassium, but it is necessary to introduce phosphorus 22 kg/ha. Incorporation of weed vegetation and soya-oat mixture as green manure does not provide sufficient nutrients for the soybean. When yield of soybean is 2.0 t/ha you need to supply all elements of nutrition, soy-oat green manure needs nitrogen 4.9 times as less as when weeds side ration is used, phosphorus 1.4 times as less, and potassium 2.8 times as less (table. 9).

Table 9: Amont of Nutrients to Be Introduced by Fertilizers to Have Yield of Soya, kg/ha

Experiment version	1,5, (t / ha)			2,0, (t / ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Weeds	57,8	34,21	28,79	92,80	49,21	50,79
Rapeseed	0	7,16	0	0	22,16	0
Soya + oats	0	19,36	0	19,09	34,36	17,89

SUMMARY

So rape, soybean-oat mixture and weed vegetation can be the most accessible, relatively inexpensive plants to serve as nutrients increasing the productivity of soybean crops and soil fertility reproduction. As for cover crops, it is better to sow rape, for its top yield exceeds that of soy-oat mixture 1.5 times and variant of

weed vegetation - 3.04 times. The cover crops can be sown as single-species crops and multi-species crops and occupy the field before they are incorporated into the soil during the phase of the beginning of earing or ear formation of cereals and budding of legumes and cabbage crops in order to obtain the maximum amount of green mass and accumulation of nutrients in the soil or in the strips between the rows in case of wide-space sowing of soya with the help of paw-shaped plowshare, seeder СП-4.6 (strip width-20 cm), row-spacing 40 cm. The side ration should be done with rotary plough.

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