ISSN 1819-1894

Asian Journal of Agricultural Research

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS Asian Journal of Agricultural Research

ISSN 1819-1894
DOI: 10.3923/ajar.2016.154.161

Research Article
Optimization of Feed Acreages Structure in Unstable Moistening Zone

[1,2]Ivan Fiodorovich Gorlov, [1,2]Marina Ivanovna Slozhenkina, [3]Olga Pavlovna Shakhbazova, [3]Vera Vasilievna Gubareva, [1,3]Elena Yurievna Zlobina and [1,3]Ekaterina Vladimirovna Karpenko

[1]Volga Region Research Institute of Manufacture and Processing of Meat-And-Milk Production, Rokossovskogo Street 6, 400131 Volgograd, Russian Federation, Russia
[2]Volgograd State Technical University, Lenin Avenue, 28, 400005 Volgograd, Russian Federation, Russia
[3]Don State Agrarian University, Krivoshlykov Street 24, 346493 Persianovsky, Rostov Region, Russian Federation, Russia

Abstract
Background and Objective: The aim of the work was to study the possibilities of intensifying the forage production on the basis of optimization of the cropland area structure of forage crops to provide the dairy cattle with feed in an unreliable moistening zone in the Russian Federation. **Methodology:** The optimal feed acreage structure, which was meant for the farm firms with intensive crop farming and dairy cattle breeding in the unstable moistening zone to be provided with their own field production forages, has been established. The optimization concept of the feed acreage structure, which was adapted to the zonal soil and climatic conditions, has been suggested. The concept is also based on the application of economically sound technologies of the fodder crop cultivation studied and on the methods of mathematical modeling in economics. The statistical result analysis was made according to the dispersion analysis. **Results:** The study has been determined that in unstable moistening zone, maize for silage, fodder beet, Sudan grass should be cultivated according to the intensive technology and medick to the extensive technology. For the intensive crop farming and dairy cattle breeding farm firms, the following fodder crop acreage structure is optimal: The maize for silage and soiling food take 33.0%, the annual grasses for hay and soiling food 33.0%, the perennial grasses for hay and soiling food 30.0% and the fodder beet 4.0%. This structure provides the maximum qualified net profit from 1 ha to110.2 € ha^{-1}, the feed unit yield 4060.4 f.u. ha^{-1}, with their prime cost 59.7 € t^{-1}. **Conclusion:** The proposed integrated approach to optimize the cropland area structure of forage crops allows developing an economically sound structure of arable land for any agricultural enterprise that can ensure the maximum revenue per hectare. A differentiated approach to the cultivation technology contributes to improving the soil fertility, productivity and quality of agricultural production.

Key words: Fodder production, econometric model, economical efficiency, organic agriculture

Received: April 18, 2016 Accepted: May 17, 2016 Published: June 15, 2016

Citation: Ivan Fiodorovich Gorlov, Marina Ivanovna Slozhenkina, Olga Pavlovna Shakhbazova, Vera Vasilievna Gubareva, Elena Yurievna Zlobina and Ekaterina Vladimirovna Karpenko, 2016. Optimization of feed acreages structure in unstable moistening zone. Asian J. Agric. Res., 10: 154-161.

Corresponding Author: Ivan Fiodorovich Gorlov, Volga Region Research Institute of Manufacture and Processing of Meat-And-Milk Production, Rokossovskogo Street 6, 400131 Volgograd, Russian Federation, Russia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Fodder production is the biggest, multifunctional and a mediate feature of agriculture. It determines the state of the livestock farming and has a great impact on countries development. It also plays one of important role in solving the key problems of crop farming, soil conservation and soil enrichment, environment conservancy, hardening of agricultural ecosystems and cultivated lands[1-5]. Now a days the primary objective of the fodder production is providing the feature with the high-quality bulky feed, which should contain 10.5-11.0 MJ of volume energy and 15.0-18.0% (cereals), 18.0-23.0% (legumes) of crude protein[6,7]. These feeds permit getting daily milk yields of 20-25 kg even with concentrates intervention to be avoided[8,9]. The decrease of concentrated feed ratio demands radical changes in the crop acreage structure towards considerable extension of the feed acreage due to the optimization of annual and perennial grass for the hay, haylage, soiling food, soilage and silage crop acreages[10-14].

Solving the key problems of the feed acreage structure optimization based on the adaptation to the regional climatic soil parameters with variable intensity technologies providing high economical effectiveness and sustainable yield to be selected is essential today and has fundamental research and practice importance[15].

Massive reduction of feed acreage in drought-afflicted regions of the South of Russian Federation because of extension of the feed acreages of economically advantageous crops, which are in demand, resulted in disorder of the farming rotation and the agrotechnics, depletion of soil fertility and determined the loss of the feed acreage capability. The feed acreage structure improvement is one of the fodder production intensification reserves, which avoids the need to take ancillary costs.

At the study time there is no concept of systematic approach to the optimization of the feed acreage structure. The implementation of this approach suggested is possible with the mathematical model approach to be applied. The modern mathematical models implemented are separate optimization boxes developed for crop farming, livestock farming, fodder production with lack of their correlation and interrelation. It's high time to actualize this systematic approach to the farming industry simulation considering all the factors that influence its effectiveness both at the level of particular farm firm and at the regional level.

MATERIALS AND METHODS

The field studies were conducted in the agricultural production cooperative «Kolkhoz n.a. S.G. Shaumyan» in the unstable moistening zone of Russian Federation-Myasnikovskiy rayon of the Rostov region. The soil of the trial field is typical mycelial-calcareous chernozem on loessial loam. The soil contains humus 3.6-3.9%, total nitrogen 0.22-0.24%, total phosphorus 0.17-0.18% and gross potassium 2.50-2.60%. The soil coverage with mineral nitrogen has a low value, exchange potassium has an increased value and phosphorus moving table has a low one.

The average annual temperature was for 10.9°C during the years of the analysis and exceeded the long-time average annual temperature by 1.0°C. The average annual temperature in the period of 2011-2012 was 10.6°C, in 2011-2012 it was 10.4°C, in 2013-2014 it was11.8°C, which is more than the long-time average annual temperature by 0.7, 0.5 and 1.9°C, respectively. The total depth of rainfall in 2011-2012 was 447.2 mm and in 2012-2013 agricultural year the depth of rainfall was 493.2 mm. The 2013-2014 agricultural year was very contrary, the depth of rainfall was 362.6 mm, which is 105.9 mm less than the long-time average annual value.

The fodder crop cultivation technologies were divided into the intensive, semi-intensive (normal) and extensive (control) ones according to their intensity level. The technology intensity degree was defined by the breed or hybrid intensity, the amount of applied fertilizers, the plant protection products as well as the number of tillage operations[16]. The scheme of the fodder crop cultivation experiment with variable intensity technologies to be applied is shown in Table 1-4.

The total allotment area for the medick and the Sudan grass for hay cultivation was 216 m^2 (7.2×30.0 m) for maize for silage and fodder beet was 336 m^2 (11.2×30.0 m). The registration plot for the maize for silage, the fodder beet was 84 m^2 for the Sudan grass and the medick was 120 m^2. The repeatability of the experiment is triple. The variant arrangement method is systematic. The trial establishment, the observations and the recordings were made according to the field experience method of Dospekhov[17]. The harvest recordings of maize for silage, medick and Sudan grass was made with a forage harvester E 281 in direct combining to be used and the fodder beet harvest recordings to be made manually. The statistical result analysis was made according to the dispersion analysis method[18] by using PC program "Statistika 12.0". The simulation of the acreages structure was implemented with the use of the economic and mathematical model, approved at the Scientific-technical Council of Don State Agrarian University within the linear optimization standard programme LPX88.

Table 1: Scheme of feed crops cultivation experiment (A fodder beet)

	Technology		
Intensification factors	Intensive	Semi-intensive	Extensive
Breed, hybrid	Hybrid kyuros	Hybrid magnum	Ekkendorf
Fertilizers	$N_{180}P_{90}K_{60}$	$N_{120}P_{60}K_{30}$	N_{60}
Chemical crop protection products			
• Protectants	Apron gold, KS-3 (L t^{-1})+Kruiser, KS-10 (L t^{-1})	Apron gold, KS-3 (L t^{-1}) +Kruiser, KS-10 (L t^{-1})	Maksim, KS-2 (L t^{-1})
• Herbicides	Betanal 22, KE-1 (L ha^{-1}) Karibu, SP-0.03 (kg ha^{-1}) Uragan Forte, VR-3 (L ha^{-1}) Fyusiland, KE-1 (L ha^{-1})	Betanal 22, KE-1 (L ha^{-1}) Karibu, SP-0.03 (kg ha^{-1}) Furore super 7.5, EMV-1 (L ha^{-1})	Furore super 7.5, EMV-0.7 (L ha^{-1}) Betanal 22, KE-1 (L ha^{-1})
• Fungicides	Alto super, KE-0.5 (L ha^{-1})	-	-
• Insecticides	BI-58 New, KE-0.8 (L ha^{-1})	BI-58 New, KE-0.8 (L ha^{-1})	BI-58 New, KE-0.8 (L ha^{-1})
Soil cultivation	Disking 2 times for 10-12 cm depth, ploughing for 27-30 cm depth, 3 times cultivation for 6-8 cm depth, inter-row cultivation 2 times, preemergence and postemergence harrowing	Disking one time for 8-10 cm depth, ploughing for 27-30 cm depth, cultivation 1 time for 6-8 cm depth, inter-row cultivation one time, preemergence harrowing	Disking for 8-10 cm depth, ploughing for 27-30 cm depth, cultivation 1 time for 6-8 cm depth, inter-row cultivation one time, preemergence harrowing
Predecessor	Winter wheat	Winter wheat	Winter wheat

Table 2: Scheme of feed crops cultivation experiment (A medick for hay)

	Technology		
Intensification factors	Intensive	Semi-intensive	Extensive
Breed	Donskaya 2	Donskaya 2	Manycheskaya blue hybrid
Fertilizers	$N_{30}P_{90}K_{90}$	$P_{60}K_{60}$	$P_{30}K_{30}$
Chemical crop protection products			
• Insecticides	Sharpey, ME- 0.2 (L ha^{-1})+Bi-58 New, KE-1 (L ha^{-1})	BI-58 New, KE-1 (L ha^{-1})	Sharpey, ME-0.2 (L ha^{-1})
Soil cultivation	Disking 2 times for 10-12 cm depth, ploughing for 27-30 cm depth, cultivation 3 times for 6-8 cm depth, prevernal harrowing and 2 times after hay crop	Disking 1 раз for 8-10 cm depth, ploughing for 25-27 cm depth, cultivation 3 times for 6-8 cm depth, prevernal harrowing and after hay crop	Ploughing for 25-27 cm depth, cultivation 3 times for 6-8 cm depth, prevernal harrowing
Predecessor	Winter wheat	Winter wheat	Winter wheat

Table 3: Scheme of feed crops cultivation experiment (A Sudan grass for hay)

	Technology		
Intensification factors	Intensive	Semi-intensive	Extensive
Breed	Bystritsa	Bystritsa	Chernomorka
Fertilizers	$N_{60}P_{40}K_{90}$	$N_{30}P_{20}$	
Chemical crop protection products			
• Herbicides	Banvel, VR-0.4 (L ha^{-1})	Banvel, VR-0.4 (L ha^{-1})	Banvel, VR-0.4 (L ha^{-1})
• Insecticides	BI-58 New, KE-1 (L ha^{-1})	Sharpey, ME 0.2 (L ha^{-1})	-
Soil cultivation	Disking 2 times for 10-12 cm depth, ploughing for 23-25 cm depth, cultivation 3 times for 6-8 cm depth, harrowing 3 times after hay crop	Disking one time for 8-10 cm depth, chiseling for 23-25 cm depth, cultivation 2 times for 6-8 cm depth, prevernal harrowing 6-8 cm depth	Disking one time for 8-10 cm depth, см, chiseling for 20-22 cm depth, cultivation 2 times for
Predecessor	Winter wheat	Winter wheat	Winter wheat

RESULTS AND DISCUSSION

Fodder crop capacity by variable intensity technologies: The influence of variable intensity of the cultivation technologies on the fodder crop yield has been established as the result of the research (Table 5). With respect to the intensification degree, the following types of agricultural technologies are known[16]:

Table 4: Scheme of feed crops cultivation experiment (A maize for silage)

Intensification factors	Technology: Intensive	Semi-intensive	Extensive
Breed, hybrid	Hybrid furio	Hybrid krasnodarskaya 382	Donskaya vysokoroslaya
Fertilizers	$N_{150}P_{60}K_{90}$	$N_{100}P_{30}K_{30}$	$N_{60}P_{20}$
Chemical crop protection products			
• Protectants	Apron gold, KS-1.5 L t^{-1} +Kruiser, KS-5 (L t^{-1}) Gezagard, KS-1.5 (L ha^{-1})+Dual gold, KE-1.0 (L ha^{-1})	Apron gold, KS-1.5 L t^{-1} Milagro, KS-0.9 (L ha^{-1})+Banvel, VR-0.4 (L ha^{-1})	Apron gold, KS-1.5 L t^{-1} Banvel, VR-0.6 (L ha^{-1})
• Herbicides	Milagro, KS-0.9 (L ha^{-1})+Banvel, VR-0.4 (L ha^{-1})		
• Fungicides	Alto super, KE-0.5 (L ha^{-1})	-	-
• Insecticides	Eforia, KS-0.2 (L ha^{-1})	Eforia, KS-0.2 (L ha^{-1})	Karate zeon, MKS-0.15 (L ha^{-1})
Soil cultivation	Disking 2 times for 10-12 cm depth, ploughing for 27-30 cm depth, cultivation for 6-8 cm depth, inter-row cultivation 2 times	Disking for 8-10 cm depth, ploughing for 25-27 cm depth, cultivation for 6-8 cm depth, inter-row cultivation one time	Ploughing for 25-27 cm depth, cultivation for 6-8 cm depth, inter-row cultivation one time
Predecessor	Winter wheat	Winter wheat	Winter wheat

Table 5: Fodder crop capacity by variable intensity technologies

	2012	2013	2014	Average		
					Extra yield	
Technology	t ha^{-1}	t ha^{-1}	t ha^{-1}	t ha^{-1}	t ha^{-1}	%
Maize herbage						
Extensive (control)	14.42	11.66	11.96	12.68	-	-
Semi-intensive	19.30	16.84	18.22	18.12	5.44	42.9
Intensive	32.44	29.54	19.56	27.18	14.5	114.3
$HCP_{0.05}$ (t ha^{-1})	2.17	1.38	2.13	-		
$S\bar{x}$ (%)	2.49	1.81	3.25	-		
Fodder beet						
Extensive (control)	29.56	29.41	29.32	29.43	-	-
Semi-intensive	36.12	34.08	34.86	35.02	5.59	19.0
Intensive	48.20	46.09	47.01	47.10	17.67	60.0
$HCP_{0.05}$ (t ha^{-1})	1.61	3.93	2.54	-		
$S\bar{x}$ (%)	1.07	2.72	1.74	-		
Sudan grass for hay						
Extensive (control)	3.92	3.58	3.42	3.64	-	-
Semi-intensive	3.84	3.63	3.72	3.73	0.09	2.5
Intensive	6.22	6.02	6.24	6.16	2.52	69.2
$HCP_{0.05}$ (t ha^{-1})	0.66	0.35	0.17	-		
$S\bar{x}$ (%)	3.59	2.01	0.12	-		
Medick for hay						
Extensive (control)	3.34	2.98	3.16	3.16	-	-
Semi-intensive	3.86	3.42	3.43	3.57	0.41	12.9
Intensive	4.10	4.69	4.41	4.40	1.24	39.2
$HCP_{0.05}$ (t ha^{-1})	0.22	0.20	0.66	-		
$S\bar{x}$ (%)	1.48	1.37	4.55	-		

- Extensive technologies focused on the natural soil fertility without (or with limited) fertilizers and chemical crop protection products to be applied. Highly adaptive varieties of crops with low but stable productivity potential are used
- Normal technologies provided with mineral fertilizers and pesticides in low concentrations that allow developing conservation cropping systems, maintaining the average level of soil cultivation, eliminating the deficit of mineral elements, which are in a critical minimum and obtaining products of satisfactory quality. These technologies use adaptive crop varieties
- Intensive technologies designed for planned high quality crop yield in a system of continuous control over production crop process. The intensive technologies ensure optimal mineral nutrition of plants and their protection from pests and lodging. These technologies use intensive crop varieties and create conditions to completely reach their biological potential

Despite the variety of existing farming systems and related agricultural technologies, at the regional level, an integrated system of agricultural technologies should be developed for each agricultural enterprise, depending on the availability of financial and material resources. This system includes technologies of various intensity degrees is adapted to the soil and climatic conditions and corresponds to the biological potential of crops. This optimal integrated technology system determines the most efficient set of crops in crop rotation and thus, a rational structure acreage needed for sustainable and effective development of all sectors of agricultural production[8,15]. On the ground of the science based regulations and the dairy cattle feeding allowances[19,20] the actual nutrient concentration in the feed, the annual need of milk cows of 600 kg with yield of milk more than 6500 kg and the average need of young stock with the average daily gain not less than 700 g in crops and nutrients in conditions of the silage concentrated feeding in winter was defined.

Among the cultivated feed crops, the biggest green crop extra yield has been achieved using the semi-intensive and intensive technologies of the maize for the silage cultivation and equaled 42.9 and 114.3% to control. The maximum maize herbage yield equaled 27.18 t ha^{-1}. By the extensive technology the yield of the Sudan grass for hay equaled 3.64 t ha^{-1}, by the semi-intensive technology it equaled 3.73 t ha^{-1} and by the intensive technology the yield equaled 6.16 t ha^{-1}. By the semi-intensive technology the extra yield equaled 2.5% and by the intensive technology it equaled 69.2%. In 2012-2013 by the semi-intensive technology, the extra yield is inconsiderable. In 2012-2014 by the extensive technology, the yield of the medick for hay equaled 3.16 t ha^{-1} on an average, by the semi-intensive technology it equaled 3.57 t ha^{-1} and by the intensive technology it equaled 4.40 t ha^{-1}. By the semi-intensive technology the crop yield was higher by 12.9% as compared with the extensive technology and the crop yield under the intensive technology is 39.2% more as compared with the extensive technology. In 2014 the extra yield by the semi-intensive technology is inconsiderable. The fodder beet yield by the extensive technology equaled 29.43 t ha^{-1}, the extra yield by the semi-intensive technology equaled 19.0% and by the intensive technology it equaled 60.0%.

Optimization of the feed acreage structure depending on the cultivation technologies: Only the application of economical and mathematical methods enables interrelation of all technological elements within a unified system of arable farming, which permits to implement the optimal feed acreage structure at a commercial farm unit. At this point the experience of linear optimization models application in developing arable farming systems, based on example of Kurgan Region of Russian Federation[21] and based on example of Novosibirsk Region[22], seems to be of great importance. In the pointed articles the most important thing was the differentiation of the arable farming in view of the intensification level and the interaction of the intensification factors. The results of the multifactorial long-term stationary experiments were used as an information base.

In this study the optimization of the feed acreage structure was implemented with the use of A MS «Optim», developed by the authors. The A MS «Optim» allowed to implement the system approach in the study, considering the grain production, the fodder production and the livestock farming as the elements of a complex production system, which a farm firm is, in their interrelation and coordination. The A MS includes models of a preparatory complex, where the main part of the input information is defined, a mathematical model of the optimization of the acreages structure and output information, which was imported into the result, allowing to get and to analyze different variants of the optimal acreage structure and to choose the most efficient one. The preparatory complex models are designed to determine the TEC, which were divided into three main groups: The specific input normals (aij), characterizing the costs of i-resource for the j-activity item, the production yield coefficient (vij), such as crop productivity, cattle productivity, nutrient content in a crop item, etc., the proportionality constant (wij), which helped to correlate between the crop groups and the crop types in the feed allowance, the acreage structure and the livestock population balance. The mathematical model of the acreage optimization structure is a system, comprising 220 limits (equations and inequations), in which all main conditions of a farm firm functioning are formalized. The mathematical model is written in a matrix form in the file optim.lp in a standard set of the applied programmes LPX88, designed for solving the tasks of linear programming. The model of the optimization of the acreage structure has a block-diagonal structure and consists of 12 interconnected blocks. The basic elements of the model are 210 variables the main ones are the acreages for corn growing, grain legume and industrial crops, with the areas for the commercial grain, forage, seeds and others to be differentiated in the plant growing block. The variables on the livestock farming represent a large cattle population with subdivision into full-age groups and the fodder crop acreages, necessary for providing the features with complete feed of their own production.

The variables particularization with the differentiation of their use and the technical and economical coefficients of the variables, which had been determined with the technologies of variable intensity degree, allowed to set the optimal correlation of the grain crop areas, to define optimal proportions between the commercial grain production, the fodder production and the livestock farming, to ground the correlation between fodder crops in the acreage structure and to define the optimal structure of agricultural crop acreages according to the intensity degree of the cultivation technologies for the given farm firm. The mathematical model developed is acceptable for the research of a wide range of agricolous and agro economical problems. It allows to simulate different production conditions and to evaluate technologies. The optimality criterion in the model is the profit maximum, obtained from all branches of a farm firm. The livestock farming model block includes the following parts: Head cattle balance, livestock farming production as well as need in green, juicy, roughage, concentrated feed and its production. The main procedure of the fodder production and fodder use model is a conjugated search for optimal allowances and correlations of features, crops and technologies. The technical and economical coefficients of the cattle balance block were calculated according to the science based structure of the dairy cattle herd. For the fuel-energy complex calculations of the livestock farming production block, the fodder need and production block, the productivity and feeding level of the dairy cattle husbandry was analyzed in the farms in the Priazov zone of the Rostov region.

The modeling of the optimal feed acreage structure using the most economically profitable cultivation technologies was implemented on example of the agricultural production cooperative «Kolkhoz n.a. S.G. Shaumyan» in Myasnikov rayon of the Rostov region as one of the unstable moistening zone of Russian Federation. The total dietary requirement for the present dairy cattle was taken into account. The optimization of the crop area structure helped to analyze three structure alternatives obtained to choose and to prove the optimum one. The first structure alternative involved a unit weight of the perennial grass (medick) 37.0% in the crop area structure, the annual grass (Sudan grass) 26.0%, the maize for silage and green crop 33.0% and the fodder beet 4.0%. The second alternative assumed the maximum ratio of the perennial grass for hay to be 47.0% in the crop area structure. The ratio of annual grass for hay and green feed as well as maize for silage acreage was decreased to 23.0 and 26.0%, respectively, with the fodder beet acreage to be unalterable and to equal 4.0%. In the third variant of the feed acreage structure in the unstable moistening zone of the South of Russian Federation, the ratio of the annual grass for hay and green feed was increased to 33.0%, the ratio of the perennial grass was increased to 30%, the ratio of maize for silage and green feed was decreased to 33.0% in the feed acreage, the ratio of the fodder beet in feed acreage ratio was 4.0%.

Economical effectiveness of fodder cropping by variable intensity technologies: The average values calculated as economic indicators late 2014, the RUR/EUR exchange rate was 63.0: The economical analysis has indicated that the cost increase with the technology intensity to be enhanced is not always repaid by the extra yield (Table 6).

In each natural-economic region and a particular enterprise, low-cost technologies of crop cultivation, adaptive to local conditions and based on the intensification of biological factors in agriculture, must be developed and implemented. This differentiated approach to the cultivation technologies has a significant impact on improving the soil fertility, productivity and quality of agricultural production[1,10,14]. Modern agricultural technologies are complexes of control operations over production processes of agricultural crops in agrocenoses, in order to achieve planned productivity and product quality while ensuring ecological safety and particular economic efficiency[3,11]. Adaptive strategy of agriculture based on biologization of intensification processes is the main factor in ensuring the efficiency of energy resources, nature preservation and profitability[15].

The increase of the fodder cropping intensification costs is economically viable for the maize for silage seeds, similar results were observed by Williams *et al.*[5] and Fitzgerald *et al.*[6], the fodder beet, similar results were observed by Khogali *et al.*[7], Mogensen and Kristensen[12] and Nadaf *et al.*[13] and the Sudan grass: Similar results were observed by Serekpaev *et al.*[14]. The best indicator values of the economical effectiveness have been achieved using the intensive fodder cropping technology for the pointed crops.

The prime costs of the maize herbage for silage, fodder beet, Sudan grass by the intensive technology are 6.6, 2.5 and 2.2%, respectively, that is less than the prime costs compared with the control.

The qualified net profit of the maize for silage by the intensive cultivation technology equaled 164.5 € ha^{-1}, of the fodder beet by the intensive cultivation technology 163.0 € ha^{-1}, of the Sudan grass for hay by the intensive cultivation technology was 73.4 € ha^{-1}, which exceeded the indicator values controlled by 152.4, 74.9 and 80.7%, respectively. The highest cultivation profitability of the maize herbage for silage was provided by the intensive technology and equaled 46.5%, of the fodder beet 27.9%, of the Sudan grass for hay it equaled 42.9%. Some extra expenses on the intensification (32.3-70.0%) of the medick seeding economically failed, increasing the costs of production by 16.9-22.1% and reducing the qualified net profit by 5.2-14.8% compared with the indicator values controlled. The highest profitability 69.3% was achieved by the extensive technology.

Table 6: Economical effectiveness of fodder cropping technologies

Technology	Costs (€ ha^{-1})	Prime costs (€ ha^{-1})	Qualified net profit (€ ha^{-1})	Profitability (%)
Herbage of maize for silage				
Intensive	353.3	13.0	164.5	46.5
Semi-intensive	257.8	14.2	87.3	33.9
Extensive (control)	176.4	13.9	65.2	36.9
Fodder beet				
Intensive	584.1	12.4	163.0	27.9
Semi-intensive	518.7	14.8	37.2	7.2
Extensive (control)	374.0	12.7	93.2	24.9
Sudan grass for hay				
Intensive	171.0	27.8	73.4	42.9
Semi-intensive	129.1	34.6	18.9	3.9
Extensive (control)	103.8	28.5	40.6	39.1
Medick for hay				
Intensive	151.1	34.4	58.4	38.6
Semi-intensive	117.6	32.9	52.4	44.6
Extensive (control)	88.9	28.1	61.6	69.3

The crop acreages, the yield of fodder units per hectare, their prime costs and the qualified net profit were defined for each of three alternatives studied. In the 1st variant, the yield was 3924.7 f.u. ha^{-1} with the prime cost to equal 60.5 € t^{-1} and the qualified net profit to be 106.5 € ha^{-1}. In the 2nd variant the yield was 3755.2 f.u. ha^{-1} with the prime costs to equal 64.7 € t^{-1} and the qualified net profit to be 103.6 € ha^{-1}. In the 3rd alternative the yield was 4060.4 f.u. ha^{-1}, the prime costs equaled 59.7 € t^{-1} and the qualified net profit was 110.2 € ha^{-1}. The tilled area necessary to meet the annual dietary requirement of the dairy cows and their young cattle as well as the concentrated feed to provide the annual average production of the dairy cows of more than 6500 kg of milk with daily average young stock gain to equal 700 g were 3.35, 2.44 and 2.29 ha in the three alternatives, respectively. The best results were achieved in the third structure alternative.

CONCLUSION

- In unstable moistening zone, maize for silage, fodder beet, Sudan grass should be cultivated according to the intensive technology and medick to the extensive technology
- For the intensive crop farming and dairy cattle breeding farm firms, the following fodder crop acreage structure is optimal: The maize for silage and soiling food take 33.0%, the annual grasses for hay and soiling food were 33.0%, the perennial grasses for hay and soiling food were 30.0%, the fodder beet-4.0%
- The richest crop yield was achieved using the intensive crop cultivation technology
- The most economically effective cultivation technology of maize for silage, fodder beet and Sudan grass is the intensive technology and the extensive technology for medick
- This structure provides the maximum qualified net profit from 1 ha to 110.2 € ha^{-1}, the feed unit yield was 4060.4 f.u. ha^{-1}, with their prime cost 59.7 € t^{-1}

SIGNIFICANCE STATEMENTS

The total dietary requirement for the present dairy cattle was taken into account. The optimization of the crop area structure helped to analyze three structure alternatives obtained to choose and to prove the optimum one. The fodder crop cultivation technologies were divided into the intensive, semi-intensive and extensive ones according to their intensity level. The technology intensity degree was defined by the breed or hybrid intensity, the amount of applied fertilizers, the plant protection products, as well as the number of tillage operations. The crop acreages, the yield of fodder units per hectare, their prime costs and the qualified net profit were defined for each of three alternatives studied. The best results were achieved in the third structure alternative.

ACKNOWLEDGEMENT

The authors are grateful to the Russian Science Foundation for the financial support in the implementation of this research according to the scientific project # 15-16-10000, NIIMMP.

REFERENCES

1. Ivanov, A.L., 2006. Agriculture must be flexible, differentiated. Zemledelie, 2: 2-3.
2. Kosolapov, V.M., 2009. Feed crop production in agriculture economic of Russia: Conditions, problems, prospects. Econ. Agric. Process. Enterprises, 9: 6-10.
3. Kosolapov, V.M., I.A. Trofimov and L.S. Trofimova, 2014. Forage production in agriculture, ecology and natural recourses using. Izdatel'skij dom Tipografija, Moscow.
4. Ramazanova, R., 2012. Commercialization of innovative technologies in agro-ecology: Problems and solutions. PRADEC Conf. Proc., 1: 125-128.
5. Williams, I.D., S.F. Ledgard, G.O. Edmeades and R.J. Densley, 2007. Comparative environmental impacts of intensive all-grass and maize silage-supplemented dairy farm systems: A review. Proc. New Zealand Grassland Assoc., 69: 137-143.
6. Fitzgerald, J.J., J.J. Murphy, F.P. O'Mara and N. Culleton, 1998. Maize silage for milk production. Teagasc Moorepark Dairy Production Research Centre, Co. Cork, Fermoy.
7. Khogali, M.E., Y.M.I. Dagash and M.G. El-Hag, 2011. The feeding value of fodder beet (*Beta vulgaris* var. Crassa) versus fodder sorghum Abu sabein (*Sorghum bicolor* L. moench) under Sudan conditions. Assiut Vet. Med. J., 57: 34-54.
8. Grignani, C., L. Zavattaro, D. Sacco and S. Monaco, 2007. Production, nitrogen and carbon balance of maize-based forage systems. Eur. J. Agron., 26: 442-453.
9. Kosolapov, V.M., I.A. Trofimov, L.S. Trofimova and E.P. Yakovleva, 2012. Fodder' production is one of the basic growth factors for productivity and agricultural steadiness. Zemledelie, 4: 20-22.
10. Kambal, A.E., 1984. Comparative performance of some varieties of sorghum, maize and pearl millet for forage production in different seasons. Sudan Agric. J., 10: 46-62.
11. Martin, J.H., W.H. Leonard and D.L. Stamp, 1976. Principles of Field Crop Productions. Macmillan Publishing Co. Inc., New York.
12. Mogensen, L. and T. Kristensen, 2003. Concentrate mixture, grass pellets, fodder beets, or barley as supplements to silage *ad libitum* for high-yielding dairy cows on organic farms. Acta Agric. Scand. Sect. A Anim. Sci., 53: 186-196.
13. Nadaf, S.K., Y.M. Ibrahim, M. Akhtar, M.G. El Haj and A.H. Al-Lawati, 1998. Performance of fodder beet in Oman. Ann. Arid Zone, 37: 377-382.
14. Serekpaev, N.A., A.A. Nogaev, S.K. Bekbulatov and T.M. Seilkhanov, 2013. Chemical composition of sudan mass herbage depending on sowing dates if cultivated in droughty conditions of Akmolinsk Region of Kazakhstan republic. Middle-East J. Sci. Res., 14: 843-846.
15. Zhuchenko, A.A., 2012. Strategy of adaptive intensification in plant industry: Conceptual ideas, priorities and criteria. Econ. Agric. Process. Enterprises, 12: 1-6.
16. Kiryushin, V.I., 1995. The Methodology of Development Adaptive and Landscape Cultivation Technology. Kolos, Moscow, Russia.
17. Dospekhov, B.A., 1985. The Methods of Field Experience. Agropromizdat, Moscow, Russia.
18. Johnson, R.A. and G.K. Bhattacharyya, 2010. Statistics Principles and Methods. 6th Edn., John Wiley and Sons, Inc, USA.,.
19. Kalashnikov, A.P., V.I. Fisinin, V.V. Shcheglov and N.I. Kleimyonov, 2003. The Rates and Diet in Farming. RAAS, Moscow, Russia.
20. Kavardakov, V.Y., A.F. Kaydalov and A.F. Baranikov, 2008. Feeding Cattle (Study Guide). Feniks, Rostov-on-Don, Russia.
21. Ovsyannikov, V.I., A.N. Sukhorukova, S.M. Ovsyannikova, G.N. Kharin, G.P. Popov and K.I. Nikiforova, 1983. Modeling of systems of agriculture based on long-term field experiments. Sibirskij Vestnik Sel'skohozjajstvennoj Nauki, 1: 3-12.
22. Kiryushin, V.I., A.I. Yuzhakov, N.L. Romanova and A.N. Vlasenko, 1990. Modeling zonal systems of agriculture based on field experiments. Vestnik Sel'skohozjajstvennoj Nauki, 8: 99-105.