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Productivity of joint agrocnosises of summer grain and leguminous crops

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The purpose. Development of separate elements of technique of growing mixtures of grain (oats, spring triticale) and leguminous crops (spring vetch, lupin (Lupinus angustifolius)) on slope lands for increasing total yield of grain and improvement of its quality. **Methods.** Field and laboratory, measuring-gravimetric analysis, laboratory-chemical, infra-red spectroscopy (Infrarapid-61), mathematical-statistical, calculation-comparative. **Results.** Formation of productivity of agrocnosises of summer grain and leguminous crops is probed at cultivation on slope lands of Carpathian region. It is determined that at seeding mixtures of grain and leguminous crops indexes of productivity increased in comparison with one-crop sowings and depended on fertilizing. The highest they were at importation of $N_{32}P_{32}K_{32}$ at seeding oats and lupin (4,0+0,8 million viable seeds/hectare) — 5,39 t / hectare, and also in a mixture of spring triticale with lupin (4,0+0,8 million viable seeds/hectare) — 5,54 t/hectare. Productivity in sowings with fertilization in comparison with control (without fertilizing) was increased by 1,19 and 1,34 t/hectare accordingly. At seeding mixture grain with vetch productivity was lower. The high content of crude protein is gained in oats-lupin and triticale-lupin mixtures — 18,7 – 19,7 and 17,8 – 19,1% (in control without fertilizers) and 20,2 – 20,6 and 18,4-19,6 % (on the background of $N_{32}P_{32}K_{32}$) accordingly. Exit of crude protein from a unit of area increased with fertilization and depended on a mixture. The highest results were gained at seeding mixtures of oats and lupin — 1,084 – 1,054 t/hectare (depending on seeding rate of gramineous ingredient) on the background of fertilizer ($N_{32}P_{32}K_{32}$). At seeding triticale-lupin mixtures the exit of crude protein was lower and made 1,011 – 0,987 t/hectare. **Conclusions.** At growing mixtures of grain and leguminous crops productivity indexes and quality of grain increased and depended on the background of fertilizing.

Key words: *leguminous crops, oats, spring triticale, lupin (Lupinus angustifolius), spring vetch, productivity.*

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The problem of plant protein deficiency causes interest in the cultivation of leguminous crops, as they are its valuable source, balanced by the amino acid composition, and also play an important role the fertility-improving of soil [1, 2]. Leguminous cultures in general and lupine narrow-leaved, in particular, are of particular importance due to the increased concentration of protein in the grain and are practically indispensable for the production of protein supplements for barley, oats, corn and other low protein crops. According to the composition of grain, legumes differ from other crops, including cereals, high content of macro-nutrients. By the content of essential amino acids, lupine protein is practically the same as soy, has the same biological value for the feed industry. Moreover, its cost is the lowest among all legumes [3]. Production of lupine protein by energy consumption is 1.5-2.0 times cheaper than other legumes, and 3.5-4.0 times than grain cereal crops [4, 5]. angustifolia lupine

Lupine angustifolia (blue) more promising, since it has one of the important advantages over white and yellow species - it is early lameness and resistance to anthracnose [6]. It is able to accumulate in the grain up to 34-45% crude protein, and in one kilogram of grain can contain 265-324 grams of digestible protein.

A vetch contains in grain from 22 to 37 % protein [7]. Sowing of vetch provide the yield of crude protein at the level of 0.53-0.91 t / ha, including 0.47-0.8 t / ha of digestive, 2.85-4.12 t / ha of feed units, supply of feed units. crude protein is 187-223 g, digestible - 164-196 g [8]. Therefore, it is not only valuable green crops but also can promote the value of other forage at their compatible use.

Taking into account a deficit vegetable protein and degradation of soils at the high cost of mineral fertilizers and practical absence of organic, leguminous plants deserve the special attention. Due to the ability to link by means of tuberculous bacteria nitrogen from air they abandon much nitrogen in the yellowed bits and pieces, what assist the fertility-improving of soil. For vegetation period leguminous plants bind 80-150 kg of nitrogen in an operating substance, that equivalently to bringing 300-400 kg of ammoniac saltpetre. In addition, for their account the anthropogenic loading diminishes on soil, gets better him the ecological state. Therefore, the introduction of crops using a variety of legumes is one way to preserve the soil fertility.

In the conditions of region of Carpathians, where soils need nitric fertilizers, under leguminous it follows expansion of areas to give a priority value. The special attention is deserved by a angustifolia lupine, as it can normally heights, to develop and form high harvests on weak-acid and sour soils. In addition, it is able to absorb phosphorus from difficult soluble forms of fertilizer and soil reserves and leave behind itself in the soil 150-200 kg / ha of biological nitrogen. Although the soil-climatic conditions of the forest-steppe zone of the West and the Carpathian region are favorable for their cultivation, these crops do not occupy the proper place in the structure of the crop area.

The basis for obtaining high yields of grain or leguminous crops is the formation of crops of optimal density. Therefore, it is important to study the rates of seeding of mixtures and their species composition [9]. Optimal correlation of vetch and oat in the mixed sowing assists achieving of leguminous component [10]. For the development of scientific principles for the formation of highly effective agrocenoses of spring cereals and legumes, it is important to determine the composition of the mixture and to establish the optimal component ratio [11].

The purpose of the research was to determine the optimal composition of cereals (oats, triticale) and legumes (vetch, lupine) for growing on sloping lands, which would increase the gross grain harvest and improve its quality.

Conditions and methods of research. The object of scientific research was the varieties: oat (Avena sativa L.), Arkan variety, triticale, Hlibodar Kharkivsky variety, vetch Vicia sativa L., Bilocerkivska variety, Lupinus angustifolius L., Flamingo variety. The ratio of components in the blends was: 0.8 million similar lupine seeds or wicks and 3 and 4 million similar oat seeds or triticale per 1 ha. In single-seeded crops, oats and triticale were sown at a rate of 5.5 million similar seed per hectare, while vika and lupine were 1.2 million similar seed. Mineral fertilizers ($N_{32}P_{32}K_{32}$) were added according to the experimental scheme. Repeat experiment six times. The total area of the plot is 19.3 m^2, accounting for 12 m^2.

Harvesting was carried out by means of mid-field threshing of grain by Sampo combine, followed by weighing and recalculation for 14% humidity.

The experimental work was carried out at the fields of the Institute of the Carpathian region of the NAAS on gray forest surface gleyed soil with the following agrochemical parameters of the soil (in a layer 0-20 cm): humus (by Tyurin) - 1.5-1.6%, alkaline hydrolyzed nitrogen (according to Cornfield) - 105-110 mg, mobile phosphorus (according to Kirsanov) - 111-114 mg, exchangeable potassium (according to Kirsanov) - 101-107 mg per kg of soil. Under the current gradation, such soil has very low nitrogen supply, phosphorus and low calcium. The reaction of the soil solution (pH_{sol} - 5.75) is slightly acid.

Weather conditions in the years of research were somewhat different from the main hydrothermal indicators (heat, moisture) from the average long-term values. The growing season in 2016 was characterized by an elevated (by 2.2 °C) air temperature and a lower than normal amount of precipitation (68.8 % of the norm). Temperatures (1.6 °C) and lower by 87.1 mm, precipitation (61.0 % of the norm) was noted higher in comparison with the average values of the year, and in 2017, in 2018, an elevated temperature regime (2.5 °C), however, rainfall exceeded the norm (104.4 %), which contributed to the active growth and development of the leguminous component.

Research results. During the research period (2016-2018), the dependence of the crop yields on the composition of the mixes, the norm of seeding of the grain component and fertilizer was revealed. In single-seeded crops without using mineral fertilizers, the actual yield was 3,11 t / ha (oats), 3,10 (triticale), 1,26 (vetch) and 2,66 t / ha (lupine) (tabl 1).

Table 1 - Grain yield depending on the investigated factors, AV for 2016-2018

Variants	Fertilization		Increase to control t / ha
	without fertilizers (control)	$N_{32}P_{32}K_{32}$	
Oats (5.0 mln seeds / ha)	3,11	4,00	0,89
Triticale (5,0 mln seeds / ha)	3,10	4,33	1,23
Vetch (1,2 mln seeds / ha)	1,26	1,91	0,65
Lupine (1,2 mln seeds / ha)	2,66	3,21	0,55
Oats + vetch (4,0 +0,8 mln seeds / ha)	4,15	5,26	1,11
Oats + vetch (3,0 + 0,8 mln seeds / ha)	3,57	5,06	1,49
Oats + Lupine (4,0 + 0,8 mln seeds / ha)	4,20	5,39	1,19
Oats + Lupine (3,0 + 0,8 mln seeds / ha)	3,99	5,10	1,11
Triticale + vetch (4,0 + 0,8 mln seeds / ha)	3,77	5,20	1,43
Triticale + vetch (3,0 + 0,8 mln seeds / ha)	3,40	4,59	1,19
Triticale + lupine (4,0 + 0,8 mln seeds / ha)	4,20	5,54	1,34
Triticale + lupine (3,0 +0,8 mln seeds / ha)	3,80	5,02	1,22

With the introduction of N32P32K32, the yield increased, oats and triticale grew up by 0.89 and 1.23 t / ha, respectively, and 0.65 and 0.55 t / ha for vetch and lupine respectively.

For the cultivation of a mixture of grain and leguminous crops, yields increased and depended on the background of fertilization. The highest were $N_{32}P_{32}K_{32}$ for oat and lupine sowings (4.0 + 0.8 million seeds / ha) - 5.39 tons / ha; as well as in the mixture of wild triticale and lupine (4.0 + 0.8 million seeds / ha) - 5.54 t / ha. The increase in the options without fertilization was 1.19 and 1.34 t / ha.

For the sowing of cereals with harvested crops, the yield was lower compared to lupine mixtures: 0.13-0.40 t / ha in oat-vetch and 0.34-0.43 t / ha in triticale-vetch.

Use as a grain component of oats in mixtures with performances has little advantage over triticale. Yields of oatmeal mixtures were higher than triticale-wicker ones. For cultivation of the studied mixtures without introducing mineral fertilizers, the grain yield on the seedling varieties of oats from the seedlings was 4.15 t / ha, provided that it was sowed at the rate of 4.0 mln seeds / ha, and 3.57 t / ha for sowing 3.0 mln seeds / ha. In combination, the triticale with a yield of 0.38-0.17 t / ha was smaller and amounted to 3.77 t / ha and 3.4 t / ha respectively. For the introduction of $N_{32}P_{32}K_{32}$, the yield of oatvetch mixtures grew by 1.11-1.49 t / ha, and the triticale-vetch grew by 1.43-1.19 t / ha.

The conducted studies showed that the content of raw protein depended on the norm of seeding of grain crops, components of the mixture and fertilizer (table 2). In the non-fertilized areas, the protein

content was 9.0-9.9% in cereals (oats, triticale) and 20.6-30.6% in legumes (vetch, lupine), with the addition of $N_{32}P_{32}K_{32}$ increased by 0.7- 0.8 and 0.3-0.8 %.

Table 2 - Content of raw albumen in grain and his exit on unit of area, AV for 2016-2018

Варіант	Without fertilizers (control)		$N_{32}P_{32}K_{32}$	
	Raw protein,%	Output of protein, t / ha	Raw protein,%	Output of protein, t / ha
Oats (5.0 mln seeds / ha)	11,4	0,35	12,5	0,496
Triticale (5,0 mln seeds / ha)	9,5	0,295	10,4	0,454
Vetch (1,2 mln seeds / ha)	22,0	0,274	22,5	0,427
Lupine (1,2 mln seeds / ha)	30,8	0,819	31,5	1,009
Oats + vetch (4,0 +0,8 mln seeds / ha)	15,5	0,639	16,3	0,870
Oats + vetch (3,0 + 0,8 mln seeds / ha)	15,7	0,568	16,6	0,841
Oats + Lupine (4,0 + 0,8 mln seeds / ha)	18,7	0,784	20,2	1,084
Oats + Lupine (3,0 + 0,8 mln seeds / ha)	19,7	0,788	20,6	1,054
Triticale + vetch (4,0 + 0,8 mln seeds / ha)	14,6	0,552	15,2	0,797
Triticale + vetch (3,0 + 0,8 mln seeds / ha)	15,4	0,522	15,9	0,760
Triticale + lupine (4,0 + 0,8 mln seeds / ha)	17,8	0,745	18,4	1,011
Triticale + lupine (3,0 +0,8 mln seeds / ha)	19,1	0,705	19,7	0,987

It was established that in cereals and legumes crops higher results on the content of raw protein were obtained for the seeding of cereals with lupine: in non-fertilized areas its content was in the range of 17.8-19.7%, depending on the norm of seeding of the grain component, whereas in mixtures with a run of 2,0-3,7% was lower. A similar trend was observed for the introduction of mineral fertilizers (N32P32K32). The maximum content of crude protein (20.6%) was obtained for seeding 3.0 million seed per hectare of oats and 0.8 million seed per hectare of lupine and fertilization of crops.

The output of raw protein per unit area varied with the same regularity as its content, that is, it increased with the introduction of fertilizers and depended on the composition of the mixture. The highest results for this indicator were obtained for the sowing of oats mixture (4.0 million s.s. / ha) and lupine (0.8 million seeds / ha) - 1,084 t / ha on the background of mineral nutrition (N32P32K32). A mixture of triticale yarrow with lupine at the same seeding rate provided a lower yield of raw protein as a control without fertilizers (0.039 t / ha) and fertilizer N32P32K32 (0.073 t / ha).

The vetch-oat mixes provided the output of raw protein in the range of 0,568-0,639 t / ha on unfertilised crops and 0,841-0,870 t / ha for $N_{32}P_{32}K_{32}$. The lower yield of crude protein was noted in the triticale-vetch mixtures.

Conclusions

The obtained results give grounds to assert that on the sloping lands of the Carpathian region, for the sowing of a mixture of spring triticale or oats (4.0 million similar seed per hectare) with lupine (0.8 million

similar seed per hectare), the mineral fertilizer $N_{32}P_{32}K_{32}$ can be obtained grain yield exceeding 5.0 t / ha and yield of protein per unit area over 1.0 t/ ha.

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