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AGRO-PRODUCTION GROUPING OF SOILS OF THE GANJA-GAZAKH CADASTRAL REGION

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Abstract. The agro-industrial grouping of soils is considered as an important continuation of soil appraisal, as well as an important measure for improving the rational use of land, the correct, scientifically based placement of agricultural plants and ensuring their high productivity. For the Ganja-Gazakh zone of Azerbaijan with intensive agricultural production, a qualitative assessment and agro-production grouping of soils is relevant and necessary. To solve this problem in 2018-2020, soil and field studies were carried out, 32 soil profiles were laid, and laboratory analyzes of selected soil samples was carried out. Based on the methodological recommendations of Gavrilyuk (1984) and Mammadov (1990) the basis bonitet scale of the study area was compiled. Mountain-brown soils were taken as a standard, and using correction factors (salinization, solonetzization, cultivation, erosion, gleying, etc.), the bonitet scores of soil varieties were determined. Based on the bonitet scores of soil varieties the agro-production grouping of soils of the Ganja-Gazakh cadastral region was carried out. It was found that the largest area on the considered territory is occupied by good quality soils - 40.11%; next in terms of occupied area are conditionally unsuitable soils - 19.35%, in third place are soils of medium quality - 17.65%. High quality soils occupy 64437.78 ha (13.97%), while low quality soils occupy 41305.20 ha (8.96%) of the area.

Keywords: *agro-production grouping, Ganja-Gazakh, good quality soils, bonitet scores.*

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1. Introduction

In Azerbaijan the agro-production grouping of soils is usually carried out in two directions: on the basis of their genetic and production characteristics and on the basis of their bonitet scores. Agricultural production grouping on the basis of genetic and production characteristics can be divided into 2 subtypes: complex agro-production grouping and special agro-production grouping.

A complex agro-production grouping is a grouping according to the complex properties and characteristics of soil taxonomic units. Carrying out a grouping in this form pursues the goal of a general assessment and registration of land resources. Valuable works was carried out in our Republic in the field of grouping soils according to complex properties and characteristics in the 60-70s of the XX century (Volobuyev *et al.*, 1967; Mikayilov & Mamedov, 1979).

A special agro-production grouping of soils is a grouping according to some attribute or property of the soil (according to salinity, alkalinity, erosion, etc.) of the soil taxonomic unit. The main purpose of such methodology is to assist in the preparation of agro-reclamation and reclamation projects that serve to eliminate factors that limit the productivity of agricultural plants and soil fertility, and there are some works in this direction (Karmanov, 1991). Starting from the 90s of the last century, preference has

been given to the grouping of soils on the basis of soil quality scores (Mamedov, 1990; Kiryushin, 2011; Kapustyanchik, 2013).

With the development of work in the field of soil evaluation, taking into account the characteristics of soil fertility and agrotechnical requirements, soils with the corresponding bonitet scores began to be included in agro-production groups, and these groups were more specific. Therefore, in the study of soil valuation, an agro-production group is considered as an association in groups of soil taxonomic groups that are close in terms of bonitet scores. According to some researchers, the agro-production grouping of soils according to the yield points has a number of advantages (Smirnova *et al.*, 2011, 2015; Gliessman, 2015; Sapozhnikov *et al.,* 2016).

The agro-production grouping can also be divided into two groups: special and general.

A special agricultural production grouping is a grouping of soil taxonomic units according to bonitet scores in accordance with the requirements of a single crop (Morev, 2017).

As an example of a special agro-production group, one can show the studies conducted by Mamedov (2003) in the Lankaran region under the culture of tea, cereals, grapes, and vegetables. The general agro-production grouping is given on the basis of the agronomic value of the soil, without taking into account the requirements of one or a group of plants. Research in this direction is of great importance for the correct placement of agricultural crops and the assessment of the current state of the land fund. We can also note the work (Aliyeva, 2016).

Agro-production groupings of soils, compiled on the basis of indicators characterizing soil fertility, is clear, correct, and more acceptable in agriculture and forestry (Bulgakov, 2013; Comerford *et al.,* 2013; Harms, 2015; Orvar & Brynhildur, 2016). The grouping based on the evaluation of soils will serve for the rational use of lands and their qualitative accounting.

In this paper we were guided by these provisions and carried out the agro-production grouping of soils on the basis of appraisal, using the third type of soil grouping, that is, on the basis of soil properties that determine their quality as an environment for agricultural plants.

2. Methods and materials

The Ganja-Gazakh cadastral region includes the plains and foothills of the Gazakh, Agstafa, Tovuz, Shamkir, Samukh, Goygol and Goranboy administrative regions of Azerbaijan. The total area of the cadastral region is 461201.92 ha or 5.3% of the country's territory (Babayeva, 2010).

Soil appraisal, the agro- production grouping of soils in the Ganja-Gazakh cadastral region was carried out on the basis of the following methods: “Guidelines for the evaluation of soils of grape and tea crops in the Azerbaijan SSR.”, (1979); “Guidelines for the evaluation of soils in Azerbaijan”. (1973); “Guidelines for the assessment of soils for the purposes of the land cadastre of the Azerbaijan SSR”. (1979), “Principles of compiling maps of the agro-production grouping of soils in Azerbaijan”. (1992); methodological recommendations of Gavrilyuk (1984) and Mamedov (1990).

When compiling the basis bonitet scale, we adopted a hundred-point comparison system, where we calculated according to the following formula 1 (Mamedov & Jafarov, 1997):

$$B = M_a/M_s \cdot 100 \quad (1)$$

where, B is the bonitet score of the soil feature; M_a is the actual value of the soil feature; M_s - the value of the same feature of the soil, taken as a standard.

The bonitet scores of soil varieties were calculated using the following formula 2, where the basis soil bonitet score was multiplied by correction coefficients, taking into account its additional properties (salinization, solonetzization, cultivation, erosion, gleying, thickness) (Mamedov, 1990):

$$B_v = B_t \cdot C_s \cdot C_e \cdot C_c \cdot C_g \cdot C_{sl} \cdot C_l, \quad (2)$$

where, B_v is the score of the assessed soil variety; B_t is the score of the type or subtype of soil on the main scale;

Correction coefficients:

C_s - on the degree of salinity;

C_e - on the degree of erosion;

C_c - on the degree of cultivation;

C_g - on the degree of gleying;

C_{sl} - on the degree of solonetzization;

C_l - on the soft layer thickness.

The weighted average soil bonitet score of the study area was determined by the formula 3 (Mamedov, 1990):

$$B = \frac{b_1 a_1 + b_2 a_2 + b_3 a_3 + \cdots}{A} \quad (3)$$

where, B is the weighted average soil bonitet score of the territory;

$b_1, b_2, b_3, \ldots$ – bonitet score of soil varieties;

$a_1, a_2, a_3, \ldots$ – area of soil varieties, ha;

A- the total area of the territory, ha.

3. Results and discussions

In order to carry out the agro-production grouping of soils in the Ganja-Gazakh cadastral region, we using the Gavrilyuk (1984) and Mamedov (1990) methodology, set the goal of conducting a general agro-production grouping based on the soil bonitet scores.

As can be seen from Table 1, the main land fund of the Ganja-Gazakh cadastral region is represented by 15 types and subtypes of soils; 5 of them are located in the foothills and 10 - on the plains and lowlands. The mountain-brown typical soils with the highest fertility rates were taken as a standard, the quality score of which was taken as 100, then, in relation to them, the quality scores of the remaining soils were calculated and the basis bonitet scale was compiled (Table 1).

Using the correction factors as salinity, solonetzization, erosion, gleying, the level of cultivation and the soft layer thickness, the expanded bonitet scale of soil varieties in the Ganja-Gazakh cadastral region was compiled.

At the last stage, we carried out an agro-production grouping of soils in the study area on the basis of an expanded bonitet scale.

Depending on the features of the horizontal and vertical distribution of soils in the Ganja-Gazakh cadastral region, on soil fertility, expressed in scores, as well as on soil requirements for reclamation, agro-reclamation and agrotechnical measures, 5 agro-production groups were identified at the research object (Table 2).

Table 1. The basis bonitet scale of soils of the Ganja-Gazakh cadastral region

No No	Name of soils	Humus, t/ha score			Nitrogen, t/ha score		Phosphorus, t/ha score		Sum of absorbed bases meg/100g score		Bonitet score
		0-20	0-50	0-100	0-20	0-50	0-20	0-50	0-20	0-50	
1	Mountain brown typical	80,7 100	153,1 100	04,5 100	4,3 100	10,0 100	4,3 100	10,0 100	33,9 100	36,1 100	100
2	Mountain brown steppe	63,1 78	102,9 67	54,7 76	3,5 84	9,1 91	3,5 83	8,5 85	31,1 91	33,5 93	81
3	Mountain gray-brown ordinary	73,1 91	126,4 83	149,2 73	4,0 95	9,7 97	3,8 90	9,0 90	31,1 92	32,0 89	85
4	Mountain grey-brown light	52,1 65	98,0 64	137,3 67	3,8 90	9,0 90	3,6 84	8,4 84	24,8 73	25,1 70	74
5	Brown-meadow	72,8 90	126,6 83	158,4 77	4,2 98	10,1 101	3,7 87	8,8 88	30,1 89	30,9 86	86
6	Gray brown dark	78,7 98	134,8 88	165,1 81	4,3 102	10,1 101	3,8 90	8,8 88	31,7 93	32,9 91	90
7	Gray brown ordinary	75,4 77	123,5 63	174,2 83	4,3 108	8,2 85	3,6 85	7,6 76	27,4 81	29,2 81	74
8	Gray brown light	48,0 59	80,0 52	124,8 61	3,4 79	6,9 69	3,4 79	7,6 76	21,7 64	23,5 65	66
9	Gray brown gaja	39,8 49	70,6 46	120,9 59	3,6 85	8,2 82	3,1 73	7,6 76	20,4 60	19,7 55	64
10	Gray brown meadow	64,0 79	113,5 74	152,1 74	3,7 87	8,1 81	3,5 82	7,4 74	29,1 86	28,8 80	78
11	Gray	38,6 48	73,1 48	117,6 58	3,4 81	6,6 67	3,4 81	8,0 80	21,7 64	21,3 59	63
12	Meadow-gray light	44,5 55	83,6 55	129,2 63	3,3 78	7,5 75	3,3 78	7,5 75	24,1 71	25,3 70	68
13	Alluvial-meadow-forest	61,8 77	90,5 59	134,9 66	3,6 86	8,7 87	3,4 80	8,7 87	25,7 76	26,8 74	74
14	Alluvial-meadow	59,2 73	84,9 55	127,0 62	3,7 87	8,6 86	3,5 82	8,0 80	25,2 74	27,7 77	72
15	Meadow-swamp	65,1 81	117,7 77	141,5 69	3,7 88	8,7 87	3,5 83	8,1 81	29,7 88	30,4 84	79

Table 2. Agro-production grouping of soils of the Ganja-Gazakh cadastral region

Quality group of soils	Name of soils	Score	Area	
			Ha	%
I Group high-quality soils 100-81 scores	Mountain-brown typical	100	3800.98	0.82
	Mountain-brown carbonate	100	2127.80	0.46
	Irrigated brown meadow	91	9391,08	2,04
	Irrigated dark gray-brown	95	5039,46	1,10
	Cultured ordinary gray-brown	104	4385,97	0,95
	Cultured light gray-brown	92	3940,6	0,85
	Mountain-brown steppe	81	14488,58	3,14
	Irrigated ordinary mountain gray-brown	90	2063,43	0,45
	Dark gray-brown	90	3841,10	0,83
	Irrigated gray-brown meadow	83	15358,73	3,33
	Average score for the group	**89**	**64437,78**	**13,97**
II Group good quality soils 80-61 scores	Immature mountain-brown	80	11367,66	2,46
	Immature irrigated mountain gray-brown	72	3269,46	0,71
	Solonetzic ordinary mountain gray-brown	77	2143,72	0,46
	Immature ordinary mountain gray-brown	74	13426,69	2,91
	Ordinary gray-brown	74	14674,89	3,18
	Irrigated ordinary gray-brown	78	26219,18	5,68
	Irrigated solonetzic ordinary gray-brown	71	39798,78	8,63
	Gray-brown meadow	78	2092,24	0,45
	Irrigated solonetzic gray-brown meadow	74	6390,47	1,39
	Leached alluvial-meadow	72	592,41	0,13
	Gleyey meadow swamp	77	247,34	0,06
	Carbonate meadow swamp	79	1072,55	0,23
	Weakly eroded immature mountain-brown	64	1803,81	0,40
	Solonetzic light gray-brown	67	3167,96	0,69
	Merged ordinary gray-brown	67	6748,79	1,47
	Solonetzic ordinary gray-brown	67	3082,51	0,67
	Saline ordinary gray-brown	67	16448,08	3,57
	Irrigated gaja ordinary gray-brown	68	6243,91	1,35
	Long-term irrigated light gray-brown	70	3397,29	0,74
	Long-term irrigated solonetzic light gray-brown	63	1982,56	0,43
	Irrigated solonetzic light gray-brown	63	3420,98	0,74
	Irrigated light gray-brown	70	7464,89	1,62
	Gaja light gray-brown	64	2421,85	0,53
	Saline gray-brown meadow	69	277,14	0,06
	Residual-carbonate saline gray-brown meadow	69	952,79	0,21
	Saline light meadow gray	61	3010,94	0,65
	Irrigated solonetzis light meadow gray	65	3221,86	0,70
	Weekly saline meadow-swamp	70	47,92	0,01
	Average score for the group	**73**	**185024,53**	**40,11**
III Group medium quality soils 60-41 scores	Solonetzic light gray-brown	59	1420,02	0,31
	Saline light gray-brown	60	4197,54	0,90
	Solonetzic gray	57	4204,18	0,91
	Irrigated solonetzic gray	60	8313,30	1,81
	Layered poorly developed alluvial-meadow	58	3321,18	0,72
	Poorly developed alluvial-meadow	58	717,57	0,16
	Weakly eroded poorly developed irrigated ordinary mountain gray-brown	50	2031,47	0,44
	Irrigated low-power saline brown meadow	49	2196,03	0,47
	Weakly eroded immature ordinary gray-brown	48	13274,16	2,88
	Moderately saline long-term irrigated solonetzic gray-brown	43	9872,92	2,14
		50	8215,25	1,78
	Moderately saline long-term irrigated ordinary gray-brown	45	14549,60	3,15
		44	2003,18	0,44
	Moderately saline long-term irrigated light gray-brown	46	6326,63	1,37
	Weakly eroded poorly developed irrigated gray	47	600,50	0,13
	Saline gray			
	Moderately saline meadow-swamp			

	Average score for the group	**50**	**81207,63**	**17,61**
IV Group low quality soils 40-21 scores	Moderately saline long-term irrigated solonetzic light gray-brown	40	20752,34	4,51
	Gleyey gray-brown meadow	34	108,70	0,02
	Weakly eroded saline gray	32	1444,55	0,31
	Moderately saline solonetzic gray	36	4327,03	0,94
	Gypsum saline gray	40	3158,81	0,68
	Saline solonetzic gray	36	2645,88	0,57
	Deeply saline solonetzic gray	40	2847,21	0,62
	Gleyey alluvial-meadow-forest	33	404,49	0,09
	Highly saline weakly eroded immature ordinary gray-brown	27	1085,09	0,24
	Moderately eroded immature ordinary gray-brown	28	4531,10	0,98
	Average score for the group	**37**	**41305,20**	**8,96**
V Group conditionally unsuitable soils <20 scores	Takyr solonchaks	<20	2636,77	0,57
	Technogenic soils	<20	7334,69	1,59
	Soil complexes	<20	1533,11	0,33
	Other derivatives (rubbly-fine-grained deposits of rivers, reservoirs and lakes, sloping deposits, exposed salt rocks, etc.)	<20	77722,21	16,86
	Average score for the group	**<20**	**89226,78**	**19,35**
	Total	**59**	**461201,92**	**100**

I Group high quality soils (100-81 scores). This group includes high-quality soils with favorable properties and regimes for growing agricultural plants. This group included mountain brown typical and carbonate cultivated soils; gray-brown dark and ordinary, powerful, cultivated soils.

These high-quality soils usually do not require special agro-reclamation measures. They are characterized by a thick humus layer, favorable granulometric composition, good structure and water-air regime. The total area of soils of this group in the study area is 64437.78 hectares, which is 13.97% of the total soil area.

II Group – good quality soils (80-61 scores). The soils of this group also differ in relatively favorable structure, water-air regime and humus composition. However, compared with the soils of group I, the fertility indicators of these soils are somewhat lower and their bonitet score ranges from 80-61 scores.

This group includes soils: mountain brown and mountain gray-brown, incompletely developed; gray-brown solonetsous, slightly saline meadow-bog soils, etc. For these soils, when they are used for cereals, cotton, annual fodder plants, and vegetables, field protection measures and compliance with protective, agrotechnical and reclamation measures are required. The total area of soils of this group in the Ganja-Gazakh cadastral region is 185024.53 hectares, which is 40.41% of all soils.

III Group – medium quality soils (60-41 scores). These include gray-brown light and ordinary, slightly eroded, medium-thick, slightly saline and solonetzic soils; gray-brown, alluvial-meadow and meadow-marsh medium-thick, slightly saline and solonetzic soils. These soils, in comparison with the soils of groups I and II, due to unfavorable properties and regimes, cannot provide high productivity without the use of agrotechnical and reclamation measures.

However, with the correct use of agrotechnical and reclamation measures, these soils will be able to produce high productivity of annual and perennial grasses and can produce a high yield of cereals, tobacco, garden and vegetables. The total area under the soils of this group is 81207.63 hectares, which is 17.61% of the soils of the region.

IV Group - low quality soils. These soils in the quality scale are estimated within the range of 21-40 scores. These include gray-brown medium solonetsous; common gray-brown, medium eroded, thin, medium saline soils; gray-brown medium and strongly salinesoils. The low ecological values of these soils, exposure to varying degrees of salinity and alkalinity require expensive land reclamation and restoration measures.

V Group - conditionally unsuitable soils (<20 scores). These soils are spread over 89226.78 hectares (19.35%) of the Ganja-Gazakh cadastral region, mainly represented with takyr solonchaks, technogenic soils, soil complexes and other derivatives (rubbly-fine-grained deposits of rivers, reservoirs and lakes, sloping deposits, exposed salt rocks, etc.). These lands were not assessed as unsuitable for agricultural use, and the grade was conditionally taken below 20 points.

The agro-production grouping of soils in the Ganja-Gazakh cadastral region based on their bonitet scores made it possible to identify their weighted average scores and the area for individual quality groups of soils (Table 3).

The Table 3 shows that the largest area in the territory of the cadastral region is occupied by good quality soils - 40.11%; next in terms of occupied area are conditionally unsuitable soils - 19.35%, in third place are soils of medium quality - 17.65%. High quality soils occupy an area of 64437.78 ha (13.97%), and low quality soils - 8.96% of the entire territory of the region.

Table 3. Average bonitet score of agro-industrial groups of soils of Ganja-Gazakh cadastral region

Quality group of soils	Weighted average scores	Area	
		Ha	%
I Group - high-quality soils	89	64437,78	13,97
II Group - good quality soils	73	185024,53	40,11
III Group - medium quality soils	50	81207,63	17,61
IV Group - low quality soils	37	41305,20	8,96
V Group - conditionally unsuitable soils	<20	89226,78	19,35
Total	**59**	**461201,92**	**100**

In addition, a diagram was compiled to visually describe the distribution of soils in the Ganja-Gazakh cadastral region by agrogroups.

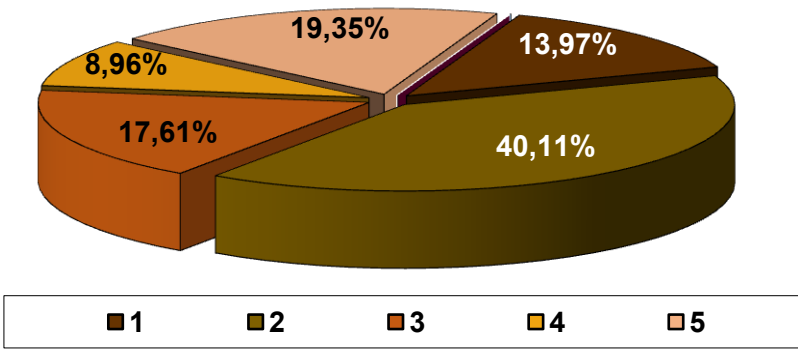

Fig. The distribution of soils in the Ganja-Gazakh cadastral region by agrogroups:
1- high-quality soils; 2- good quality soils; 3 - medium quality soils; 4 - low quality soils;
2- 5 - conditionally unsuitable soils

The agro-production grouping of soils of the Ganja-Gazakh cadastral region serves the rational use and proper placement of crops within the cadastral region.

4. Conclusions

- The soils of the Ganja-Gazakh cadastral region were assessed according to soil properties (reserves of humus, nitrogen, phosphorus, potassium in t/ha and the amount of absorbed bases, meq / 100 g of soil) and the main bonitet scale of soil was compiled. Mountain-brown typical soils were taken as a standard. According to the studies, dark gray-brown soils received 90 scores, meadow-brown soils - 86 scores and ordinary mountain gray-brown soils - 85 scores, these are quite highly fertile soils of the region, the gray-brown soils are the most infertile soils of the territory - 63 scores.
- A expanded bonitet scale of soil varieties was compiled, taking into account correction coefficients (according to the degree of salinization, solonetzization, cultivation, erosion, gleying, soft layer thickness), on the basis of which a agro-production grouping of soils of the Ganja-Gazakh cadastral region was carried out and the soils were combined into 5 groups. For each group, weighted average bonitet scores were calculated: Group I - High quality soils (100-81 scores) - 89 scores, area 64437.78 ha (13.97%); Group II - good quality soils (80-61 scores) - 73 scores, area - 185024.53 ha (40.11%); Group III - medium quality soils (60-41 scores) - 50 scores, area - 81207.63 hectares (17.61%); Group IV - low quality soils (40-21 scores) - 37 scores, area 41305.20 hectares (8.96%), conditionally unsuitable lands occupy the territory of 89226.78 hectares (19.35%). The fact that low-quality and conditionally unsuitable soils make up more than 28.0% of the total area of the territory, caused the average quality score of the whole area to fall significantly to 59 points.

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