Influence of classical agrotechnics of crop cultivation on soil fertility in a forest ameliorated agro-landscape

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Abstract. The article presents the analysis of soil-climatic characteristics of forest ameliorated agrolandscape. It was found that in the conditions of light chestnut soils, the use of the classical farming system, namely, the combination of sideral fallow and cultivation of row crops and leguminous crops contributes to the accumulation of moisture in the soil. In the meter layer soil moisture in the agrolandscape was 14.35%, in the forest belt 10.65%. The ameliorative effect of the forest belt on reducing the proportion of physical clay in the granulometric fractions of soils under the forest belt was noted. At the same time, the organic carbon stock in the ameliorative protective forest belt averaged 21.3 tC/ha in the root-inhabited 30 cm soil layer, while in the agrolandscape - 23.0 tC/ha.

1 Introduction

Ecologization of agriculture promotes wide introduction of resource-saving technologies into production. There is a constant development and improvement of crop cultivation methods. Various methods of mechanical tillage can include classical system, system with minimum tillage, No-till and others. In the world practice, the most widespread is the complete abandonment of tillage, which leads to the destruction of soil composition and structure [1, 2, 3]. Prolonged and intensive use of agricultural fields leads to changes in the content of soil chemical composition [4, 5]. However, these soil treatments are possible only with the use of special equipment, application of necessary nutrients and plant protection products. The introduction of modern farming systems into production can also be complicated by soil and climatic peculiarities of territories and negative economic effect from their realization.

In the dry-steppe zone of Volgograd region, management of moisture reserves and soil fertility is possible by changing the structure of crop rotations, fertilizer application, application of soil tillage, etc. The work of domestic land users and scientists substantiated and successfully develops such direction in agriculture as agroforestry. Protective afforestation significantly improves the growing conditions of agricultural plants in steppe and semi-desert areas with harsh climate, poor water availability and limited soil fertility [6, 7, 8, 9].

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The purpose of this work is to determine the water-physical properties of soils and calculate the organic carbon stocks of a forest ameliorated agrolandscape using the classical farming system.

2 Research methodology

The research was conducted on the territory of Tinguta settlement (Narimanovskoye rural settlement) of Svetloyarsk district, Volgograd region.

The research program included taxation and ameliorative assessment of the condition of the field-protective forest strip (PFB). Morphometric characteristics and species composition of tree and shrub plantations were determined. The diameter of tree trunks was determined with a measuring fork at a height of 1.2 m, and height was determined with an altimeter. Soil moisture was determined by thermostat-weight method.

Soil samples were taken at different distances from the forest strip - H (height of the strip, m). To determine the organic carbon content, soil samples were taken layer by layer in 10 cm increments to a depth of 30 cm. To determine soil density, samples were taken by the method developed by N.A. Kachinsky using a cutting ring. Density is determined by weight method.

Organic matter reserves (Stock OC, t/ha) in each 10-cm layer of the studied soils were determined by the formula:

$$\text{Stock OC} = \text{Content OC} \times \text{BD} \times h,$$

Content OC – absolute average organic carbon content in the layer (%),

BD – soil density (g/cm^3),

h – layer thickness, cm.

Organic carbon stocks in a given layer (0-30 cm) were calculated by summing the stocks in the corresponding 10 cm layers.

3 Results and discussion

The object of research is located Tinguta village, Svetloyarsk district, Volgograd region: longitude 44°23´17´´E, latitude 48°17´33´´N, accuracy 3.9 m. (Figure 1).

Fig. 1. Tinguta settlement, Svetloyarsky District, Volgograd Oblast

The protective forest strip of the study area is located on the south-western side of the field, geographical coordinates N 49°05'28.2“, E 44°06'51.1”. The forest strip is 2 rows long, represented by squat elm (*Utmus laevis*). Forest currant (*Ribes nigrum L.*) grows on the sides of the tree structure. The age of plantations is 30-37 years, the width of the forest belt is 12 m. In the shrub layer there is dog rosehip (*Rósa canína*). The forest belt has an openwork structure, with an average of 23.3% openwork along the profile. Stand height was 8-9 m, shrub height was 1.5-2.0 m, stand diameter averaged 17 cm.

At the object of research the classical agrotechnique is applied - combination of sideral fallow with subsequent cultivation of leguminous crops.

A typical feature of the climate of the research site is an active wind regime throughout the year. In summer time the circulation of air masses is weakened, winds of western and north-western directions prevail. But the winds of the eastern direction have a rather high probability of occurrence. They usually cause hot and dry weather, while the western winds bring cool and humid air. The average annual air temperature is 10.7-11.0 0 0C and the annual precipitation is 300-450 mm

Soil sampling showed that soil moisture was lower in the forest belt, averaging 10.65% at a depth of 0-100 cm. In the field, moisture accumulation was more intensive, in the meter layer of soil and at different distances from the FB it amounted to 11.71- 17.99 % (Table 1).

Table 1. Calculation of soil moisture indices of the investigated object

Soil layer, cm	**Soil moisture**				
	LP	**5H**	**10H**	**15H**	**20H**
0-10	6.86	13.51	15.55	8.87	10.53
10-20	6.74	15.05	16.46	9.81	12.21
20-30	7.07	13.57	19.70	11.65	12.60
30-40	11.06	18.47	20.30	14.52	15.81
40-50	13.38	18.31	20.18	16.20	17.04
50-60	14.46	17.09	18.28	17.94	17.11
60-70	15.63	13.35	17.12	15.55	15.38
70-80	12.60	11.83	17.32	10.49	14.05
80-90	12.47	9.41	17.16	6.65	11.90
90-100	6.19	7.74	17.87	5.45	12.06
average	10.65	13.83	17.99	11.71	13.87

Density determination is necessary to assess the agrophysical characteristics of the soil. In this work, soil density was taken into account when calculating the organic carbon stock and assessing the suitability for crop cultivation. Soil density in the upper root-inhabited layer of the field (0-30 cm) was 1.2-1.4 g/cm^3, which is favorable for growing crops (Table 2).

Table 2. Soil density of the investigated object, g/cm^3.

Place of selection	**Soil layer, cm**	**Density, g/cm^3**
FB	0-10	1.12
	10-20	1.62
	20-30	1.53
5H	0-10	1.23
	10-20	1.33
	20-30	1.22
10H	0-10	1.30
	10-20	1.34
	20-30	1.45
15H	0-10	1.45
	10-20	1.52
	20-30	1.46

20H	0-10	1.27
	10-20	1.51
	20-30	1.51

The results of tests for pH, dense residue and organic carbon content in 30 cm soil layer were obtained (Table 3). Hydrogen index characterizes the soils of the study area as slightly alkaline and moderately alkaline. It was noted that in the forest belt the maximum carbon content is in the upper 10 centimeter layer of soil and amounted to 0.68%, leaf fall contributes to a more intensive accumulation of organic matter in this layer. Further with increasing depth of soil horizon the content of organic carbon gradually decreases. In layer 20-30 the carbon content amounted to 0.35%. In the agrocenosis at different distances from the forest belt the content of organic carbon and its distribution by horizons differs from its content and distribution in the forest belt. In view of applied plowing there is mixing of soil horizons as a result of which there is redistribution of crop residues and organic matter in the arable layer.

Indicators of organic carbon content in the meter layer of soil were determined. The highest content of the element is in the 0-20 cm layer, then there is a gradual decrease in the content with increasing depth of the soil horizon.

Table 3. Results of soil analyses of the study area

Place of selection	**Soil layer, cm**	**pH**	**Dense residue,%**	**C, %**
FB	0-10	7.39	0.183	0.68
	10-20	7.47	0.156	0.52
	20-30	7.46	0.146	0.35
5H	0-10	8.07	0.104	0.52
	10-20	7.67	0.198	0.69
	20-30	7.76	0.185	0.45
10H	0-10	7.74	0.189	0.79
	10-20	7.49	0.187	0.78
	20-30	7.62	0.286	0.72
15H	0-10	7.61	0.139	0.38
	10-20	7.67	0.171	0.32
	20-30	7.60	0.156	0.34
20H	0-10	8.05	0.127	0.49
	10-20	7.91	0.126	0.53
	20-30	7.74	0.122	0.73

The analysis of granulometric composition showed that in general the soils of the studied agroforest landscape are represented by medium loam. Directly in the forest belt there is a decrease in the content of physical clay and soils change from light loamy to medium loamy. The agro-forest landscape is generally represented by medium loam, but heavy loam and light clay are found at different distances from the forest belt (Table 4).

Table 4. Granulometric composition of soil (according to Kachinsky)

Place of selection	**Soil layer, cm**	**Fraction size, mm / content, %**							**Name of soil**
		1.0-0.25	**0.25-0.05**	**0.05-0.01**	**0.01-0.005**	**0.005-0.001**	**<0.001**	**Physical clay**	
FB	0-10	3.36	55.47	16.90	5.52	5.73	13.03	24.28	Medium loam
	10-20	2.29	63.67	15.16	5.06	4.56	9.26	18.88	Light loam
	20-30	3.84	62.00	15.50	4.64	5.16	8.86	18.66	Light

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									loam
5H	0-10	2.01	44.81	25.84	3.71	9.30	14.33	27.34	Medium loam
	10-20	2.09	43.61	26.94	3.88	9.87	13.62	27.37	Medium loam
	20-30	2.80	35.14	33.28	3.25	9.55	15.98	28.78	Medium loam
10H	0-10	1.60	33.22	28.35	10.11	11.42	15.30	36.83	Heavy loam
	10-20	1.38	25.24	37.12	7.96	10.82	17.48	36.26	Heavy loam
	20-30	1.24	12.00	41.72	10.55	11.55	22.93	45.03	Light clay
15H	0-10	2.99	58.86	15.50	4.28	7.25	11.13	22.66	Medium loam
	10-20	3.18	58.59	15.34	3.92	4.90	14.09	22.91	Medium loam
	20-30	2.69	53.76	16.45	5.92	3.17	18.01	27.1	Medium loam
20H	0-10	0.67	36.25	23.21	4.44	10.95	24.48	39.87	Heavy loam
	10-20	1.25	50.03	22.97	4.73	9.84	11.18	25.75	Medium loam
	20-30	1.62	49.50	24.67	5.98	8.33	9.90	24.21	Medium loam

At the time of survey, the field was under black fallow, the predecessor - siderate mustard, the field cultivation was classical. Soil density in the 0-30 cm layer varied from 1.2 to 1.6 g/cm3. Organic carbon content in the 0-30 cm layer had the following values: in LP - 0.52%, 5H - 0.55%, 10H - 0.76%, 15H - 0.34%, 20H - 0.58% (Table 5).

Table 5. Organic carbon stocks of the study area, t C/ha

Place of selection	**Horizon layer (cm)**	**Absolute average content of Sorghum in the layer (%)**	**BD - soil density (g/cm^3)**	**h - layer thickness, cm.**	**Carbon stocks (Stock Corgh, t C/ha**	**Carbon stocks (Stock Corgh, t C/ha), in 30 cm layer**
FB	0-10	0.68	1.12	10	7.62	21.31
	10-20	0.52	1.61	10	8.37	
	20-30	0.35	1.52	10	5.32	
5H	0-10	0.52	1.22	10	6.34	20.97
	10-20	0.69	1.33	10	9.18	
	20-30	0.45	1.21	10	5.45	
10H	0-10	0.78	1.30	10	10.14	30.88
	10-20	0.78	1.33	10	10.37	
	20-30	0.72	1.44	10	10.37	
15H	0-10	0.38	1.44	10	5.47	15.29

	10-20	0.32	1.52	10	4.86	
	20-30	0.34	1.45	10	4.96	
20H	0-10	0.49	1.27	10	6.22	24.97
	10-20	0.53	1.50	10	7.95	
	20-30	0.72	1.50	10	10.80	

Thus the stock of organic carbon of the research object in Tinguta settlement of Svetloyarsk district of Volgograd region in the 30 cm layer in the forest belt amounted to 21.31 t C/ha, at a distance of 5H - 20.97 t C/ha, 10H - 30.88 t C/ha, 15H - 15.29 t C/ha, and 20H - 24.97 t C/ha.

4 Conclusions

The article presents the analysis of soil-climatic characteristics of forest ameliorated agrolandscape. As a result of the obtained research it was found that in the conditions of light chestnut soils, the use of the classical farming system, namely the combination of sideral fallow and cultivation of row crops and leguminous crops contributes to the accumulation of moisture in the soil. In the meter layer soil moisture in the agrolandscape was 14.35%, in the forest belt 10.65%. The ameliorative effect of the forest belt on reducing the proportion of physical clay in the granulometric fractions of soils under the forest belt was noted. At the same time, the organic carbon stock in the ameliorative protective forest belt averaged 21.3 tC/ha in the root-inhabited 30 cm soil layer, while in the agrolandscape - 23.0 tC/ha.

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