vol.1, No.1, 1-4 ISSN 1805-3602

Effect of perennial grasses on nutrient supplies of Southern black soil and subsequent crop yield

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Received for publication: 12 March 2012.
Accepted for publication: 7 April 2012.

Abstract

The present paper gives the comprehensive analysis of the effect of traditional and nontraditional grasses on soil nutrition status and subsequent crop yield. Substantial contribution of perennial grasses to soil organic matter accumulating is assessed. It has been observed that humus content and nutrition components changed throughout grass cultivation. Phytomelioration impact of five leguminous species and three nonleguminous on Southern black soil fecundity is overviewed.

Among spring wheat yield components, the significance of influence of different grasses is underlined. The study evaluates the benefits of legume grasses in comparison to nonlegumes.

Key words: soil fertility, Southern black soil, phytomelioration, spring wheat, alfalfa, bird's-foot trefoil.

Introduction

Substantial shortages of physical and energetic resources incorporated with cutbacks of soil conservation and anthropogenic impact on the environment resulted in soil-degradation and minimizing crop yields, especially grain crop yields.

The efficient use of phytoresource is the most important conquer factor to cover increasing soil-degradation and cutting of crop yields. The benefits of it have mostly been assessed by academic A.A. Zhuchenko who pointed phytomelioration as an implement of bio-agronomy including affects from grasses and other green crops (Zhuchenko, 1990).

Such a situation demands comprehensive changes in planning the very structure of cultivated lands aiming to increase areas for planting perennial green crops. It implies stabilization of fodder supplies and containment of detrimental activities on soil-fecundity. Replacing annual green crops to perennials allows dissolving not only a fodder issue but increasing fertility as well. Currently, along with using traditional perennial grasses (alfalfa, sainfoin, awnless brome, etc.) new green crops are also wide-spread (bird's-foot trefoil, feed sorrel, hill mustard).

This work aims to estimate the level of organic matter accumulation in nontraditional green crops compared to its amount in traditional ones, as well as to assess the phytomelioration ability of green crops grown in Southern black soil of the Volga-region and subsequent crop yield.

Materials and methods

The research was carried out on the practice ground of Saratov State Agrarian University named after N.I. Vavilov, Russia, in the crop years 2008–2011 and aimed to evaluate perennial grasses as previous crops in rotation 2008–2010. Spring wheat followed three-year-cultivated grasses in 2011.

The area under cultivation was 50 м^2. Four replications were made. Plots had a systematical disposition. Spring wheat cultivar Favorite was used

The experiments were conducted on Southern black soil with moderate, slightly humic and mid-loamy granulometric composition.

Our field experiment included overviews and researches according to standard methodology instructions (Dospehov, 1985).

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In order to investigate soil nutrient dynamics, nitrogen was calculated using Lounge-Griss test (Phenol Disulfonic Acid Method) while exchangeable potassium was determined by Maslova method using plasma photometer.

Labile phosphorus determination was assessed by means of Machigin method in CINAO modification, State Standard 26205-84, humus content was calculated with the help of Turin method in CINAO modification, State Standard 26213-84, soil nitrification properties were analyzed considering «Standard systematic directions in determining soil nitrification properties», whereas exchangeable sodium content was determined according to State Standard 26950-86.

Finally, the quantity of stubble remains was determined with the help of frame soil cut by N.Z. Stankov.

Results and Discussion

Penetration of organic matter into the soil is the main factor affecting fecundity. In contrast to natural biocenosis, it's more than a half of organic matter produced by plants during yield formation process that is wasted in agrocoenosis. Therefore, the supply of organic matter accumulated in roots and stubble remains is found to be significant for retaining soil fertility.

The data (Table 1) revealed the highest percent of root residues allotted in soil bulk after alfalfa harvesting.

The comparison between previous crops showed that root supply left after sainfoin was 6.4% less compared to alfalfa, whereas after bird's-foot trefoil this amount was 3.6% less than after alfalfa and it was 18.2% less after awnless brome. One of the lowest parameters was observed after hill mustard, thus, on the control it was 38.2% less than after alfalfa.

There were no significant differences in amount of stubble and root residues after blue and yellow alfalfa and it quantified 0.3 t ha^{-1} or 2.7%, that was within experimental error.

Feed sorrel showed the amount of stubble remains by 22.7% less compared to alfalfa characteristics. The lowest amount of soil organic matter was marked after cicer milkvetch that made 6.3 t or 68.2% less than after alfalfa.

Permanent grasses influenced nutrients content in the soil, first of all involving humus content changes in topsoil (Table 2). The extreme humus content from 3.27 to 3.29% was registered in the first year after ploughing up alfalfa and bird's-foot trefoil. Although the supply of stubble residues was significant after nonlegume crops, humus content went 0.11–0.12% down.

As it was seen from the experiment's versions, the most significant differences concerned nitrogen content. While under alfalfa, bird's-foot trefoil and sainfoin soil nitrogen amount made 4.0–4.9 mg per 100 g, after nonlegume crops its amount didn't exceed 2.5–2.8 mg per 100 g, that meant it was 1.75–2.0 times lower.

Similar results were obtained in determining the content of available phosphorus and exchangeable potassium. In spring available phosphorus ranged from 8.0 to 9.9 mg per 100 g of soil after legume crops compared to 6.0–7.0 mg after nonlegumes.

Under legumes exchangeable potassium amount varied from 35.9 to 38.0 mg per 100 g at 0–30 sm soil layer, under nonlegume it made 33.0–34.8 mg.

Table 1. Root remains amount in repeated experiments in 0–60 sm soil layer on average for three years.

Grasses	Roots mass, t ha^{-1}	Deviation from alfalfa	
		t ha^{-1}	%
Blue alfalfa *(Medicago sativa)*	11.0	–	–
Yellow alfalfa *(Medicago falcata)*	11.3	0.3	2.7
Sainfoin *(Onobrychis)*	10.3	–1.0	–6.4
Bird's-foot trefoil *(Lotus corniculatus)*	10.6	–0.7	–3.6
Cicer milkvetch *(Astragalus cicer L.)*	3.5	–7.5	–68.2
Feed sorrel *(Rumex)*	8.5	–2.5	–22.7
Awnless brome *(Bromus inermis Leyss)*	9.0	–2.0	–18.2
Hill mustard *(Bunias orientalis)*	6.8	–4.2	–38.2
LSD_{05}	0.7		

Table 2. Nitrogen and nutrient content in the soil after perennials tillage at 0–30 sm layer, crop year 2011.

Grasses	Humus, %	Nitrogen, mg per 100 g	Available phosphorus, mg per 100 g	Exchangeable potassium, mg per 100 g
Blue alfalfa *(Medicago sativa)*	3.29	4.9	9.9	37.5
Yellow alfalfa *(Medicago falcata)*	3.28	4.8	8.0	38.0
Bird's-foot trefoil *(Lotus corniculatus)*	3.27	4.0	8.0	35.9
Sainfoin *(Onobrychis)*	3.25	4.3	9.7	36.7
Feed sorrel *(Rumex)*	3.18	2.5	7.0	33.0
Hill mustard *(Bunias orientalis)*	3.17	2.8	6.9	34.8
Awnless brome *(Bromus inermis Leyss)*	3.17	2.7	6.0	34.1

Coefficients of nitrogen variation made 8.6% after legume crops in comparison to 5.4% after nonlegumes, while this parameter for available phosphorus was 11.7% and 10.1%, respectively. At the same time coefficient of changeable potassium equaled 4.5% after legume crops and 4.8% after nonlegume. Legume crops increased soil storage of nitrogen by 1.8 g, of available phosphorus by 1.9 mg and of changeable potassium by 3.0 mg in comparison with nonlegumes.

Ultimately, agrophysical and especially agrochemical soil traits have been changed due to perennial grasses influencing, and in their turn affected crop yield of spring wheat planted in the first year after perennial tillage (Table 3).

After blue and yellow alfalfa differences of spring wheat grain yield stayed within experiment error. Similar crop yield was observed after bird's-foot trefoil and amounted to 2.95 t ha^{-1}. In the case spring wheat followed sainfoin the crop yield decreased to 2.84 t ha^{-1} or by 9.6%.

It has been observed that feed sorrel, hill mustard, awnless brome as the previous crops decreased spring wheat yield by 1.32; 1.07; 1.63 t ha^{-1}, respectively, in comparison to alfalfa. In essence, it can be explained by weakening feeding schedule of wheat after nonlegumes.

The data received during the experiment correspond to the results of Chernyshov (2006) who reported that four-year-cultivation of alfalfa leaded to

Table 3. Yield of spring wheat grain in the first year after perennial tillage.

Grasses	Yield, t ha^{-1}	Deviation from alfalfa	
		t ha^{-1}	%
Blue alfalfa *(Medicago sativa)*	3.14	–	–
Yellow alfalfa *(Medicago falcata)*	3.02	–0.12	3.8
Bird's-foot trefoil *(Lotus corniculatus)*	2.95	–0.19	6.1
Sainfoin *(Onobrychis)*	2.84	–0.30	9.6
Feed sorrel *(Rumex)*	1.82	–1.32	42.0
Hill mustard *(Bunias orientalis)*	2.07	–1.07	34.1
Awnless brome *(Bromus inermis Leyss)*	1.63	–1.51	48.1
LSD_{05}	0.22		

0.20% humus content increasing in a plough-layer, whereas cultivation of awnless brome increased humus content only by 0.10%.

Tuktarov *et al.* (2009) noted that grass cultivation on irrigation base for four years increased humus content in dark chestnut soil from 2.7% to 2.9%.

Denisov *et al.* (2008) in their previous researches indicated that the third-year-cultivated alfalfa increased nitrogen content in the soil by 1.4 mg per 100 g than that of the first year.

Furthermore, under Low Volga-region conditions stubble remains kept in the soil under the second year alfalfa up to 76.1 kg ha^{-1} of nitrogen, 17.0 kg ha^{-1} of phosphorus, and up to 26.3 kg ha^{-1} of potassium, under sainfoin 80.3 kg ha^{-1}, 19.8 kg ha^{-1} and 23.8 kg ha^{-1}, respectively (Kirchakhova, 2009).

Conclusions

1. The benefits of perennial grasses cultivation for three years resulted in enriching soil with new organic matter accumulated in stubble remains. After legume crops the amount of stubble remains varied from 10.3 to 11.3 t ha^{-1} and after nonlegumes from 6.8 to 9.0 t ha^{-1}. Postlegume stubble remains delivered from 131.0 to 237.0 kg ha^{-1} of nitrogen into the soil, whereas after nonlegumes this parameter decreased to 30.0–54.0 kg ha^{-1}.

2. The results showed that wheat yield following bird's-foot trefoil was higher than after sainfoin and not lower than after alfalfa.

3. Such nonlegume previous crops as hill mustard and feed sorrel were at a disadvantage in respect of legumes, but promoted increasing of wheat yields by 11.6–26.9% over awnless brome.

References

Chernyshov E.V., 2006. Alteration of agromeliorative conditions of chernozem leached by phytomeliorators and liming under the Volga-region conditions. PhD thesis, Penza, Russia.

Denisov E.P., Solodovnikov A.P., Panasov M.N., 2008. Effect of perennials on chestnut soils fertility in trans-Volga-region. Niva Povolzhiya. 1:4–8.

Dospehov B.A., 1985. Field experiment procedure (including statistic analysis of investigation results). Agropromizdat, Moscow.

Kirchakhova I.V., 2009. Techniques of productivity improvement of perennials and their effect on soils fertility under Low Volga-region conditions. PhD thesis, Kinel, Russia.

Tuktarov B.I., Potapenko V.M., Chadin D.V., 2009. Biological reclamation of degraded irrigated Volga-region soils. Bul. of Sar. State Agr. Univ. n. af. N.I. Vavilov. 6:39–42.

Zhuchenko A.A., 1990. Adaptive crop agriculture. Shtiinca, Kishinev.