东北高寒地区土壤动物和微生物的生态特征研究

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摘要：东北高寒地区农田在作物生长期内土壤动物具有明显的季节特征。土壤微生物季节变化具有单一的峰值，其中细菌和放线菌的高峰值在 7 月份，真菌的高峰值在 6 月份。从土壤酶及理化性质对土壤动物和微生物影响的灰色分析表明，对土壤动物和微生物影响最大的是脲酶、pH 值、含水量和速效磷，并建立了 8 个灰色数学模型[GM(0,5)]，最小的为土壤水解氮。这表明了土壤中水和速效磷是该地区土壤生态稳定的主要因素，因此调整土壤水分供应状况和土壤磷肥输入对改善土壤质量和作物生产将是一个重要的策略。同时加强对脲酶及土壤氮素状况等相关因素的分析。

关键词：高寒地区；土壤动物；微生物；生态特征；灰色分析

Ecology characters of soil faunas and microorganisms in the northeast heavy frigid region of China

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Abstract: Field investigation was carried out in the experimental station, Institute of Wheat and Potato in Heilongjiang, 124°50′E, 48°2′N. The experiment soil belongs to the classification of chernozem. The located site is of a typically heavy frigid climate, an annual mean temperature of 1.3℃, ranging from −42.0 to 38.0℃, an annual mean precipitation of 508.2mm, with 52.6% falling in July and August, and an mean annual evaporation of 1189.7mm. The sample of soil was taken from long-term fields rotating with wheat and soybean. The field productivity is of middle level (9 t/hm^2. grain yield in spring wheat).

Five zigzagging plots were allocated to different slopes and sunny fields (10hm^2 scope). The plot size is 10m by 10m, 6 sub-plots from each plot were chosen to take soil samples one very month from April to September 1993. The soil depths were divided into three layers, 0～5, 5～10, 10～15cm. The macro-faunas were hand-sorted by digging out 100×100cm^2 soil. The soil samples with 100cm^3 and 25cm^3 were taken by circle knives respectively for separating the middle and micro-faunas by methods of Tullgren and Baermann before they were brought back to the lab in nags. Then followed counted and classified faunas. Soil baceria, fungus and actinomycete from the same soil samples were determined with dilution-plate method, separately.

At the same time, the soil enzyme activities and physicochemical properties of the same samples were determined. A cellulase activity was detected with the anthrone colorimetric method, urease activity with the diffusion plate, invertase activity with reducing sugar determination method, catalase activity with

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oxidation-reduction titration technique and dehydrogenase with common method. The soil activer organic matter was determined by H_2SO_4 dilution method, the pH-value was determined with electrical potential method, the soil available P was determined with 0.5mol/L $NaHCO_3$ extraction and Mo-Sb resistance colorimetry method, the determination of soil moisture, soil temperature and hydrolysable N with the conventional methods.

Total soil faunas within the layer of 0～15cm exhibited two high peaks during the investigating periods. Acarina, just as the total soil faunas, were abundant in June and August; Collembola, Nematode and scarce group exhibited a single peak in June, July and August, respectively. Among three layers, the distributions of soil faunas were different. In 0～5cm layer soil faunas decreased from April to July, and then increased from July to September. In 5～10cm layer, two lower peaks of soil faunas were shown in May and August. In 10～15cm layer, the number of soil faunas fluctuated with a maximum of 6886/m^2 in August.

Judging from the seasonal change of the dominant group, Acarina in influenced greatly on the changes of total soil faunas. The 0～5cm layer showed one clear lower peak in Acarina, while two lower peaks appeared in May and August in both 5～10cm and 10～15cm layers. The distributions of Collembola in the upper layer showed less changes, ranging from 1600 to 2000/m^2 and two significantly high peaks of Collembola in soil of 5～10cm layer in June and August and of 10～15cm layer in June and September. As to Nematode, there was one higher peak from the upper layer to the deeper one in May and June, in August, and in July respectively. The scarce group showed one high peak in August. Three types of microorganisms exhibited single peak, with bacteria and actinomycete in July and fungus in June.

The study showed changes of eleven factors including soil enzymatic activities and physicochemical properties during the growing season of wheat. The performances of three hydrolytic enzymes were remarkably different. There was one high peaks of cellulase in July, two high peaks in urease in May and August, two lower peaks of invertase in July and August. All these suggested that the catabolism capability of the soil is stronger in July and August. The activities of two kinds of oxidoreductase exhibited different behavior. The peaks of catalase activity were in April and August. The activity of dehydrogenase was strongest in May, then decreased till July and increased slowly again. Such behavior of oxidoreductase revealed that the capability of oxidation-reduction in the soil was weakened in July. Among three layers, the lowest soil moisture was shown in May, the highest in August. Similarly, soil temperatures in three layers were low in the early months, then rose till August.

Relationships among quantity of soil faunas, soil microorganisms and ecology parameters were analyzed by grey correlation analysis. The output results were shown in a correlation matrix(R), wich was useful to define the primary ($r \geqslant 0.80000$) and secondary ($r < 0.80000$) factors. The primary factor influencing on Acarina and Total faunas were Urease, Invertase, Catalase, Dethydrogenase, active organic matter, pH-value, soil moisture, hydrolysable N and available P. All factors except soil cellulase, temperature and hydrolysable N were primary factor for collembola. And soil temperature was only one primary factor to Nematode. All factors showed secondary factors for the scarce group. The soil cellulase, urease, pH-value and moisture were primary factor for Bacteria, others were secondary factors. All factors were secondary factors for Fungus. Urease, Invertase, Catalase, Dehydrogenase, soil active organic matter, pH-value, soil moisture and available P were primary factors for Actinomycete.

The calculated weights (r'), which reflect the general influence on soil fauna and microorganisms exerted by ecological factors, were 9.47, 10.61, 7.77, 9.66, 8.90, 7.95, 12.12, 11.93, 5.49, 4.73 and 11.36% from x_1 to x_{11}, respectively. With regard to weights of soil ecology factors, they can be divided into

three groups: the top group ($r' \geqslant 10.00$) including urease, pH-value, moisture and available P; the middle group ($10.00 > r' \geqslant 5.00$) including cellulase, Invertase, Catalase, Dehydrogenase, soil active organic matter and temperature; the lower group ($r' < 5.00$) comprises hydrolysable N. These demonstrated that soil moisture and available P were "bottleneck" factors in this region. Therefore, regulating soil moisture and phosphate input should be an important strategy to improve soil quality and crop productivity.

The eight grey model [GM(0,5)] was developed to detect the relationship among soil urease, pH-value, moisture and available P to soil faunas and soil microorganisms depand on the four ecology factors ($r' \geqslant 10.00$), five soil fauna and three microorganisms, which showed biological characters of that region.

Key words: heavy frigid region; soil fauna; soil microorganism; ecological character; grey analysis
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在土壤生态系统中,主要的生物因子是动物、微生物和植物根系。各因子间相互作用和互相依赖，并进行着物质循环和能量流动过程,维持一种相对的生态平衡。在农田土壤生态系统中,人们都力求保持一个稳定的生态平衡,从而保证农业的可持续发展。稳定的农作物生产依靠一定的土壤结构、有机质和营养物质的循环,这与土壤的理化特征和生物因素的互相作用有关系。农业本身就是一个最大的压力源和干扰源，例如侵蚀和营养损失[1]。所以要对各种环境因素及其互相作用进行深入的研究。土壤的自然能力是能够形成和维持一种有利的结构,为作物提供合理的营养物质。在土壤生态特征的各环节中土壤动物和微生物起着重要作用。对土壤动物和微生物及各种环境因素之间的关系进行分析,为土壤质量评价,合理利用土地资源和农业的可持续发展提供重要科学依据。

1 研究方法

1.1 试验基地

试验在黑龙江省小麦、马铃薯研究所实验站的小麦田内进行。位于东经124°50′,北纬48°2′。海拔381.7～198.7m。属黑钙土区。气候条件属寒温带大陆性季风气候区。年平均气温1.3℃,高于10℃的年积温为2462.2℃,地表年均温3.0℃,无霜期122 d。年平均降雨量为508.2mm,其中7～8月份占全年降雨量的52.6%。年蒸发量为1189.7mm。以小麦和大豆轮作为主,上一年秋翻地一次,春播施用含多种成份的小麦专用肥。试验地为中产田。小麦1993年4月5日播种,4月20日出苗,6月5日抽穗，8月13日收割。

1.2 研究方法

在10hm^{2}地内蛇形分布5个小区。小区面积为10×10m^2,在每个小区内进行多点采样。挖掘土壤剖面,用100cm^{3}和25cm^{3}土壤环刀按0～5cm、5～10cm、10～15cm 3层取土样,放入土壤袋内于室内分离提取土壤动物。大型土壤动物在小区内挖掘100×100cm^{2}土壤采用手捡法。中、小型土壤动物采用Tullgren法(干漏斗法)和Baermann法(湿漏斗法)分离[2],进行计数分类[3,4],一般鉴定到纲、目或科。同时取样采用平板稀释法测定土壤细菌、真菌和放线菌[5]。并同步测定土壤酶及理化性质等11种因素。

土壤酶活性测定　纤维素酶采用蒽酮比色法,脲酶采用康维扩散法,转化酶采用还原糖测定法,过氧化氢酶采用氧化还原滴定法,脱氢酶采用常规测定法[5,6]。土壤活性有机质测定:采用稀释热法,土壤pH值测定:采用电位法,土壤速效磷测定:采用0.5M$NaHCO_3$侵提-钼锑抗比色法,土壤含水量、温度和水解氮等均采用常规分析方法[7]。4～9月份每月中旬调查1次。其它月份为封冻期,未调查。

2 结果

2.1 土壤动物的季节动态特征

已有学者研究了土壤动物的区系组成及季节变化[8],在土壤0～15cm层中土壤动物总数和蜱螨类的季节变化有两个高峰值,分别在6和8月份。弹尾类、线虫类和稀有动物类群都具有单一的高峰值,依次在6、7和8月份。在各土层中，土壤动物的季节变化也有差异（见图1)。在0～5cm土层中土壤动物总数,4～7月份逐渐减少,9月份又逐渐增多；在5～10cm土层中有两个低谷值,分别在5和8月份。在10～15cm层中土壤动物总数出现波动性变化,其中8月份最多为6886个/m^2。从优势类群数量的季节动态看,

蜱螨类动物在各土层中季节变化趋势与土壤动物总数的季节变化是一致的。弹尾类动物在 0～5cm 土层中季节变化不大,在 1600～2000 个/m^2 之间,在 5～10cm 土层中弹尾类动物有两个明显的高峰值,分别在 6 和 8 月份。在 10～15cm 土层中的也有两个高峰值,分别在 6 和 9 月份。线虫类动物季节变化在 3 个土壤层中均具有一个明显的高峰值。0～5cm 土层中高峰在 5～6 月份,5 ～10cm 层中高峰值在 8 月份,10～15cm 土层中高峰值在 7 月份。

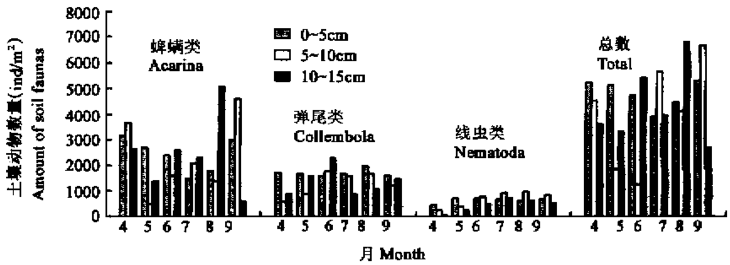

图 1 土壤动物类群数量季节变化

Fig. 1 Seasonal quantitative changes in various groups'faunas

2.2 土壤微生物的季节特征

在 0～15cm 土层中,3 类土壤微生物数量的季节变化均具有单一的高峰值,细菌和放线菌的高峰值在 7 月份,真菌高峰值在 6 月份(见图 2)。

2.3 土壤酶及理化性质的季节动态

在作物生长季节,同时测定土壤酶及理化性质等 11 种因素的季节变化(见表 1)。其中 5 种土壤酶活性具有明显的季节变化,纤维素酶活性在 4～7 月份逐渐增加,7～9 月份逐渐减少;脲酶活性有两个高峰值分别在 5 和 8 月份;转化酶活性有两个低谷值分别在 5 和 8 月份。从以上 3 种土壤水解酶活性的季节变化可以看出,在 7～8 月份土壤的分解代谢能力比较强。两种氧化还原酶中过氧化氢酶活性有两个高峰值分别在 4 和 8 月份,脱氢酶活性 5 月份最高 ,5～7 月份逐渐降低,7～9 月份又逐渐升高。可见 7 月份土壤的氧化还原能力比较弱。土壤含水量 5 月份最低,8 月份最高。土壤温度 6～8 月份较高。总之土壤含水量和土壤温度控制着其它环境因素,如活性有机质、pH 值、水解氮和速效磷等的季节动态变化。同时对土壤动物和微生物也产生很大的影响。

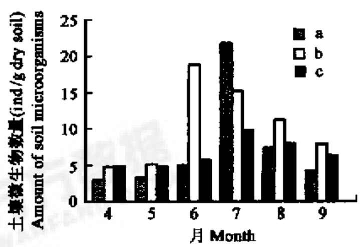

图 2 土壤微生物数量的季节变化

Fig. 2 Seasonal quantitative changes of soil microorganisms

a 细菌 Bacteria($\times 10^6$) b 真菌 Fungus($\times 10^3$) c 放线菌 Actinomyces($\times 10^5$)

3 分析与讨论

本文以土壤动物和微生物作为土壤生物学指标对农田土壤生态状况进行评价。土壤动物和微生物数量的季节变化主要取决于自身的生殖特性,它们的繁殖周期和分布特征又与生存环境密切相关。因而环境因素与土壤动物和微生物之间的关系非常复杂,介于确知和不确知之间,因此是一个灰色关系。本文采用灰色系统理论与方法对土壤动物和微生物与土壤酶及理化性质的关系进行评价[8]。将土壤动物和微生物定义为参考因素$\otimes y_j(j=1,2,...,8)$,$y_1 \sim y_8$ 依次为蜱螨类、弹尾类、线虫类、稀有动物类群、土壤动物总数、细菌、真菌和放线菌,在 0～15cm 土层中其数量的季节变化组成的数列定义为参考数列$[\otimes y_i(aK)]$。其他 11 种因素定义为比较因素 $\otimes x_i(i=1,2,...,11)$,$x_1 \sim x_{11}$ 依次纤维素酶、脲酶、转化酶、过氧化酶、脱氢酶、活性有机质、pH 值、含水量、温度、水解氮、速效磷的季节变化组成的数列定义为比较数列$[\otimes x_i(bK)]$。

计算过程采用初值化处理，得到新数列(表略)。取 $\rho=0.5$，差序列最小值 ΔK_{min} 均为 0，最大值 ΔK_{max} 分别

表 1 土壤酶活性及理化性质的季节变化(1999)

Table 1 Seasonal variation of soil enzymatic activity and physicochemical properties

指标 Index		4 月 April	5 月 May	6 月 June	7 月 July	8 月 August	9 月 September
纤维素酶活性 Activity of cellulase (Glucose mg/g. dry soil)		2.852	3.923	5.534	15.582	8.484	4.711
脲酶活性 Activity of urease (NH_3-N mg/g. dry soil)		0.128	0.160	0.105	0.198	0.341	0.097
转化酶活性 Activity of invertase (0.05mol $Na_2S_2O_3$ml/g. dry soil 24h)		1.559	1.442	1.600	1.621	1.299	1.496
过氧化氢酶活性 Activity of catalase (0.1mol $KMnO_4$ml/g. dry soil)		10.053	9.429	9.614	10.061	10.219	9.199
脱氢酶活性 Activity of dehydrogenase (H^+ μmol/g. dry soil)		31.175	40.624	33.219	25.372	29.531	34.111
活性有机质 Active O. M. (%)		4.33	3.86	4.11	4.71	4.09	4.14
pH 值 pH value		6.63	6.70	7.60	7.59	7.53	8.26
含水量 Moisture (%)	0～5cm	26.00	15.88	27.96	34.65	50.15	41.60
	5～10cm	33.20	28.53	30.22	43.51	52.18	40.65
	10～15cm	36.10	31.35	33.02	37.91	48.60	39.93
	平均 Mean	31.80	25.25	30.40	38.69	50.31	40.73
温度 Temperature (℃)	0～5cm	10.5	13.1	24.48	22.3	22.3	16.8
	5～10cm	6.5	9.9	20.7	20.6	21.4	16.2
	10～15cm	2.7	8.5	19.1	19.4	20.5	17.5
	平均 Mean	6.57	10.50	21.43	20.77	21.40	16.83
水解氮 Hydrolyted N(mg/100g. dry soil)		29.09	28.04	16.91	18.31	23.70	20.76
速效磷 Available P(mg/100g. dry soil)		2.1	2.5	2.3	2.4	2.2	2.3

为：4.83919，3.85113，2.79686，3.20956，4.46324，6.52847，3.34146，3.41363。按一定程序[9]运算得关联矩阵如下：

$$R=\begin{bmatrix} 0.66963 & 0.82769 & 0.92133 & 0.92346 & 0.90531 & 0.92370 & 0.87652 & 0.87082 & 0.62536 & 0.94994 & 0.88463 \\ 0.77429 & 0.83244 & 0.81737 & 0.82001 & 0.85000 & 0.81990 & 0.86999 & 0.87332 & 0.68672 & 0.77031 & 0.86409 \\ 0.73056 & 0.70072 & 0.59752 & 0.59836 & 0.62393 & 0.59735 & 0.62653 & 0.62844 & 0.80309 & 0.57088 & 0.62775 \\ 0.73848 & 0.75876 & 0.69544 & 0.69377 & 0.72079 & 0.69597 & 0.72337 & 0.72605 & 0.69100 & 0.65159 & 0.73075 \\ 0.69718 & 0.83201 & 0.95407 & 0.95967 & 0.94082 & 0.95400 & 0.95598 & 0.93432 & 0.64251 & 0.88791 & 0.95371 \\ 0.88041 & 0.81620 & 0.78200 & 0.78249 & 0.78896 & 0.78054 & 0.81101 & 0.80926 & 0.75354 & 0.75739 & 0.79983 \\ 0.74189 & 0.70826 & 0.65877 & 0.66128 & 0.65954 & 0.65883 & 0.69530 & 0.69654 & 0.79327 & 0.63791 & 0.67846 \\ 0.70920 & 0.80741 & 0.83169 & 0.83178 & 0.82358 & 0.82957 & 0.88939 & 0.89467 & 0.64935 & 0.77718 & 0.85182 \end{bmatrix}$$

关联序为：

$$x_{10} > x_6 > x_4 > x_3 > x_5 > x_{11} > x_7 > x_8 > x_2 > x_1 > x_9$$

$$x_8 > x_7 > x_{11} > x_5 > x_2 > x_4 > x_6 > x_3 > x_1 > x_{10} > x_9$$

$$x_9 > x_1 > x_2 > x_8 > x_{11} > x_7 > x_5 > x_4 > x_3 > x_6 > x_{10}$$

$$x_2 > x_1 > x_{11} > x_8 > x_7 > x_5 > x_6 > x_3 > x_4 > x_9 > x_{10}$$

$$x_4 > x_7 > x_3 > x_6 > x_{11} > x_5 > x_8 > x_{10} > x_2 > x_1 > x_9$$

$$x_1 > x_2 > x_7 > x_8 > x_{11} > x_5 > x_4 > x_3 > x_6 > x_{10} > x_9$$

$$x_9 > x_1 > x_2 > x_8 > x_7 > x_{11} > x_4 > x_5 > x_6 > x_3 > x_{10}$$

$$x_8 > x_7 > x_{11} > x_4 > x_3 > x_6 > x_5 > x_2 > x_{10} > x_1 > x_9$$

本文将关联度划分为主要因素（$r \geqslant 0.80000$）和次要因素（$r < 0.80000$）（见表 2）结果是影响蜱螨类动物和动物总数的主要因素是脲酶、转化酶、过氧化氢酶、脱氢酶、活性有机质、pH 值、含水量、水解氮和速效磷，其中水解氮关联度最高，纤维素酶和土壤温度为次要因素。影响弹尾类动物数量主要因素是脲酶、转化酶、过氧化氢酶、脱氢酶、活性有机质、pH 值、含水量和速效磷，其中含水量关联度最高，纤维素酶、土壤温度和水解氮为次要因素。影响线虫类动物数量主要因素是土壤温度，其它因素均为次要因素。影响稀有动物类群数量的因素均为次要因素，其中脲酶的关联度最高为 0.75876。

表 2 土壤酶及理化性质对土壤生物数量的影响

Table 2 Effect of soil enzymaic and physicochemicalproperties on quantity of soil biology

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}
y_1	−	+	+	+	+	+	+	+	−	+	+
y_2	−	+	+	+	+	+	+	+	−	−	+
y_3	−	−	−	−	−	−	−	−	+	−	−
y_4	−	−	−	−	−	−	−	−	−	−	−
y_5	−	+	+	+	+	+	+	+	−	+	+
y_6	+	+	−	−	−	−	+	+	−	−	−
y_7	−	−	−	−	−	−	−	−	−	−	−
y_8	−	+	+	+	+	+	+	+	−	−	+

* + 为主要因素（$r \geqslant 0.80000$）；− 为次要因素（$r < 0.80000$）

影响细菌数量的主要因素是纤维素酶、脲酶、pH 值和含水量，其中纤维素酶关联度最高，转化酶、过氧化氢酶、脱氢酶、活性有机质、土壤温度、水解氮和速效磷为次要因素。影响真菌数量的环境因素均为次要因素，其中土壤温度最高为 0.78327。影响放线菌数量的主要因素是脲酶、转化酶、过氧化氢酶、脱氢酶、活性有机质、pH 值、含水量和速效磷，其中含水量关联度最高，纤维素酶、土壤温度和水解氮为次要因素。

从关联矩阵中可以看出，关联度的差别不是很大。为强化在灰色分析过程中的各种信息，根据关联序来计算土壤动物和微生物总数与 11 种因素之间关系权重系数（r'）。计算方法是根据关联序依次赋值 11～1，然后将各因素赋值数相加求对土壤动物和微生物总数影响的权重系数（r'）。结果从 x_1～x_{11} 依次为：9.47，10.61，7.77，9.66，8.90，7.95，12.12，11.93，5.49，4.73，11.36。影响土壤生物的 11 种因素分为 3 组：最高的一组（$r' \geqslant 10.00$）包括脲酶、pH 值、含水量和速效磷；其次一组（$10 > r' \geqslant 5$）包括纤维素酶、转化酶、过氧化酶、脱氢酶、活性有机质和温度；最低一组（$r' < 5$）为水解氮。

权重系数最大的 4 种因素中，脲酶存在于大多数细菌、真菌和高等植物体内，它可水解尿素，在中性土壤中活性高，它可以表征土壤的氮素状况。pH 值是土壤综合作用的结果。土壤含水量对土壤动物和微生物的生态特性具有重要的调节作用。土壤动物具有趋湿性，同时含水量较高的土壤中有利于真菌的繁殖。速效磷决定磷酸酶活性，是土壤矿化有机磷的主要产物。因此这四种因素是重要的农田土壤生态因子。本文对权重系数（r'）$\geqslant 10.00$ 的 4 种因素分别和各类土壤动物和微生物数量共组成 8 组，每组 5 种因子构成因子集做进一步分析。

将原始数据 y_1 y_2 y_3 y_4 y_5 y_6 y_7 y_8 x_2 x_7 x_8 x_{11} 依次重新定义为：Y_1 Y_2 Y_3 Y_4 Y_5 Y_6 Y_7 Y_8 X_1 X_2 X_3 X_4，分别构造原始数列矩阵。并对其每个数列作一次累加生成数列（1-AGO）。按一定程序[9]建立静态模型[GM(0，5)]，即 0 阶 5 个变量的灰色数学模型（见表 4）。

表 3 灰色数学模型[GM(0,5)]及误差

Table 3 GM(0,5)for soil Urease(X_1),pH-value(X_2),Moisture(X_3) and Available P(X_4)

模型 Model	平均相对误差 Error(%)
$Y_1(K)=12825.62X_1(K)+4178.532X_2(K)-99.21215X_3(K)-10180.5X_4(K)+7297.815$	1.15940
$Y_2(K)=15115.81X_1(K)+1575.36X_2(K)-217.7476X_3(K)-547.1508X4(K)-2991.409$	0.11108
$Y_3(K)=62.44495X_1(K)-278.9414X_2(K)+17.54424X_3(K)+1592.367X_4(K)-2243.125$	0.58517
$Y_4(K)=625.4785X_1(K)+15.67786X_2(K)-6.14269X_3(K)+57.20653X_4(K)-107.6317$	0.12329
$Y_5(K)=28806.26X_1(K)+5511.339X_2(K)-306.2987X_3(K)-9093.156X_4(K)+1967.15$	1.46149
$Y_6(K)=11.73642X_1(K)+16.22719X_2(K)-1.056068X_3(K)-31.23877X_4(K)+1273.949$	0.63013
$Y_7(K)=90.82198X_1(K)+7.026786X_2(K)-1.437502X_3(K)-0.2242663X_4(K)-26.9739$	0.87794
$Y_8(K)=-28.3859X_1(K)-7.853356X_2(K)+0.538853X_3(K)+22.60959X_4(K)-12.28894$	0.24187

* 平均相对误差(%)= $\sum |[Y_j(t) - Y_j^{(1)}(t)]/Y_j(t)|$, $j = 1,2,\ldots,8$, t 为时间

模型检验表明,模型值与原始值平均相对误差很小,模型拟合很好。此模型显示了东北高寒地区麦田土壤动物和微生物及对其影响的几种重要生态因子之间的数量关系。它是农田土壤生态系统中生态特征的综合评价和概括。为农业的可持续发展和合理利用土壤资源提供了科学依据。

4 小结

4.1 在作物生长季节内土壤动物具有明显的分布差异和数量季节动态特征。

4.2 土壤微生物数量季节变化均具有单一的峰值,其中细菌和放线菌的高峰值在 7 月份,真菌的高峰值在 6 月份。

4.3 从土壤酶活性及土壤理化性质对土壤动物和微生物数量影响的灰色分析表明,对土壤生物影响最大的是脲酶、pH 值、含水量和速效磷,并建立了灰色数学模型[GM(0,5)]。最小的为土壤水解氮。这表明了土壤中水分状况和速效磷输入是该地区土壤生态稳定的主要因素。因此调整土壤水分供应状况和土壤磷肥输入对改善土壤质量和作物生产将是一个重要的策略。同时加强对脲酶及土壤氮素等相关因素进行分析。关于土壤温度和水解氮对土壤生物数量的影响还需做进一步研究。

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