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NOTE

The impact of meteorological parameters on the biological productivity of mycorrhizal mushrooms in Eastern Siberia

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The correlation coefficient (r) between the meteorological parameters and the gross biological productivity of the most common mycorrhizal mushrooms was determined. The results can be both of theoretical and practical importance.

Keywords: correlation, meteorological parameters, mycorrhizal mushrooms, periodicity

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INTRODUCTION

The influence of meteorological factors on development of macromycetes is reflected in many papers. It was found that the main criteria determining the intensity of occurrence of carpophores (sporocarps) are the temperature and humidity of air and soil. The combination of weather conditions determines the fruiting period and the productivity of macromycetes. The humidity and the thermic regime of substrate effect on the development of mycelium only in relations with each other like other meteorological parameters (Danilov, 1949; Nanai, 1964; Matveev, 1972; Davydenko, 1974; Matveev, 1976; Sennikova, 1984; Burova, 1986; Shubin, 1990; Burova, 1991; Talley *et al*., 2002; Ratova, 2014). Despite the forecast for the beginning of the fruiting period of certain species of mushrooms according to the total sum of temperatures (Matveev, 1972), for the most part it has little effect on the yield of mushrooms without regard to precipitation. M. R. Ratova (2014) pointed out the most significant indicators of weather conditions by correlation analysis.

The aim of our study is to identify the degree of relation between the productivity of macromycetes and a wide range of meteorological parameters by correlation analysis.

MATERIALS AND METHODS

The time-consuming long-term observations and accumulation of significant statistical data are required to perform studies for determination of the correlation between the individual meteorological parameters and mushrooms productivity. Studies on the biological productivity of mushrooms for 27 years (1985-2012) on two plots in the north of the Sayan region were used as the statistical processing basis. The harvesting of the mushrooms took place in the period of their mass occurrence (August-September). The record of biomass was carried out only for 7 well-known edible mushrooms (*Suillus luteus*, *Suillus granulatus*, *Suillus variegatus*, *Lactarius deliciosus*, *Lactarius resimus*, *Lactarius representaneus*, *Boletus edulis*). We measured the total quantity of carpophores biomass of these species for the entire harvesting period.

To assess the degree of influence of various meteorological parameters on the mushrooms productivity we conducted paired correlation analysis between the annual data of meteorological observations for 27 years and the gross biological productivity of the above mentioned species of mushrooms. Taking into consideration that many meteorological parameters have close correlation with each other, we chose only the most significant parameters.

The linear Pearson correlation coefficient was calculated using the special function of MS Excel. In the course of calculations there were used the formula:

$$r_{XY} = \frac{cov_{XY}}{\sigma_X \sigma_Y}$$

where: X and Y are the sample mean values (meteorological parameters and biological productivity respectively), cov-covariance; σ-standard deviation.

Table 1. Correlation (r) of meteorological parameters with mushrooms productivity on the plots (# 1 and # 2)

Meteorological parameters	July		August		September	
	#1	#2	#1	#2	#1	#2
Average monthly temperature:						
- of the air, °C	0.2	0.21	0.04	0.01	0.23	0.19
- of the soil cover, °C	0.1	0.16	(–)0.01	(–)0.06	0.27	0.19
- of the soil under natural cover at a depth: - 20 cm, °C	0.13	0.14	0.16	0.21	0.19	0.24
- 40 cm, °C	0.2	0.24	0.47	0.44	0.27	0.24
- 80 cm, °C	0.22	0.47	0.12	0.36	0.2	0.41
- of the soil under bare soil cover at a depth - 5 cm, °C	0.14	0.27	0.04	0.09	0.19	0.14
Total precipitation, mm	0.14	0.19	0.42	0.49	0.23	0.14
Air humidity, %	0.18	0.09	0.34	0.43	0.11	0.26
Partial vapor pressure, mb	0.29	0.16	0.25	0.3	0.23	0.3
Quantity of overcast days	0.04	(–)0.12	0.54	0.31	0.08	0.14

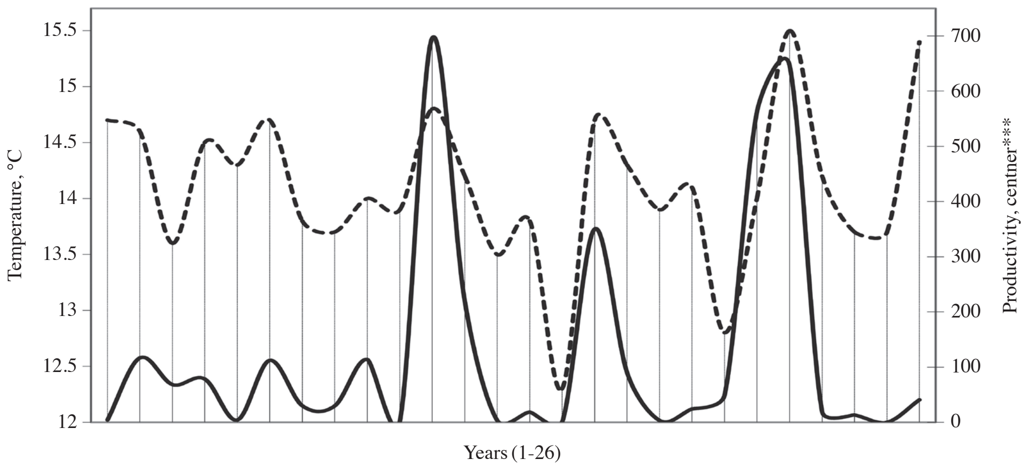

Fig. 1. The variation of average month temperature * of soil at a depth of 40 cm below the natural cover in August and biological productivity** of mushrooms in different years. ---* - variation of average month temperature, —** - biological productivity, *** - 1 centner = 100 kilograms (a centner is a metric unit of mass equal to one hundred kilograms).

RESULTS

The results of correlation analysis are presented in Table 1. With all the variety of meteorological parameters it is quite difficult to recognize their leading role in the mushrooms productivity. The influence of different factors can be aimed at both increasing and decreasing of the productivity of mushrooms. Maximum correlation (r) was determined with soil temperature at a depth of 40 cm below the natural cover in August (plot No. 1 - $r=0.47$, and accordingly, plot No. 2 - $r=0.44$) and precipitation in August ($r=0.42$ and $r=0.49$). Graphics of curve of soil temperature and the amount of August precipitation often coincide with the schedules of the mushroom harvesting (Fig. 1 and 2). The relationship between precipitation and soil temperature in July and September are less pronounced. Humidity and partial pressure of water vapor also have the highest value in August (Table 1). With the number of frost days in September there is an inverse relationship ($r=-0.26$ and $r=-0.39$ in). There is a relationship between September precipitation and productivity of mushrooms in the following year ($r=0.29$ and $r=0.28$). The relationship between the productivity of mushrooms and meteorological parameters in June is not observed. With the amount of precipitation in May there is a weak inverse relationship ($r=-0{,}33$ and $r=-0{,}31$).

The inverse relationship ($r=-0.38$, и$r=-0.29$) between the precipitation and the soil temperature is also observed. Minimum biological productivity coincides with the period of maximum solar activity.

The autocorrelation showed that the highest relationship in productivity is observed after 5 year- ($r=0.32$ and $r=0.41$) and 11 year- ($r=0.42$ and $r=0.54$) periods.

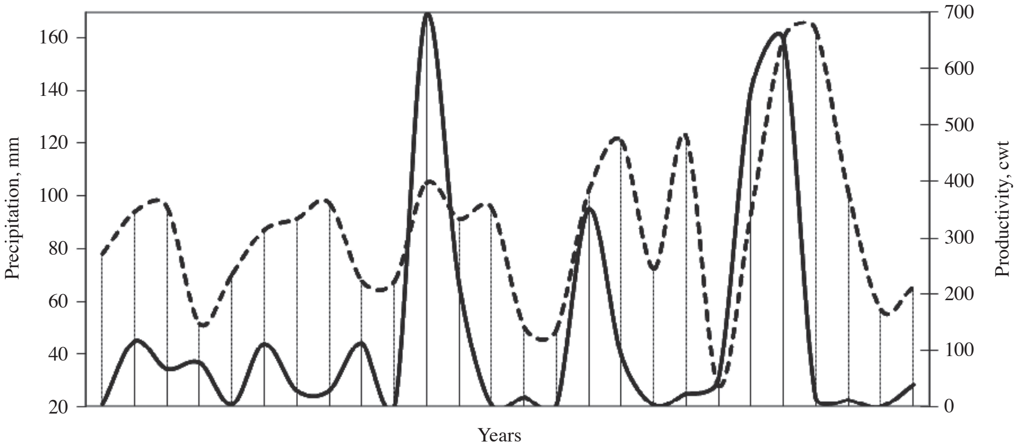

Fig. 2. The variation of total amount of month precipitations *** in August and biological productivity**** of mushrooms in different years. ---*** - variation of total amount of month precipitations, ━**** - biological productivity

Discussion

The analysis of the biological productivity dynamics showed that two years of high, four years of average, and four years of low biological productivity of carpophores (sporocarps) can be expected within 10 years in Eastern Siberia. High productivity of mushrooms is observed for two years in succession, followed by a sharp decline. Equal mushroom productivity may be expected in 5 and 11 years.

On the basis of the correlation analysis there is reason to believe that: 1) the main factor determining high productivity of mushrooms is an increased amount of precipitation in August; 2) the closest relationship with mushroom productivity is connected with the temperature at a depth of about 40 cm under the natural cover; 3) high air temperature in July and September with sufficient precipitation has a positive effect on the mushroom productivity; 4) high temperature in August and autumn frosts adversely affect the productivity of mushrooms; 5) the increased amount of precipitations in September has a positive effect on the productivity of mushrooms next year.

Conclusion

The following weather conditions are typical for the years of high mushrooms productivity: rainy September of previous year, dry winter, dry May, hot subhumid July, chilly rainy August, and warm humid September with a few frosty days.

Despite the fact that the conclusion about the dependence of biological productivity of mushrooms on meteorological parameters may be questionable, it presents scientific interest and may have practical importance for forecasting of mushrooms productivity. The results obtained can be extrapolated to other areas with similar climatic conditions and applied in commercial mushroom industry.

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