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RESEARCH ARTICLE

Modeling valerian roots yield depending on mineral fertilization rates

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Abstract

Valerian (*Valeriana officinalis* L.) is a prospective medicinal crop for Ukraine with stable high demand on the national and global phytopharmacological market. There is a need in the improvement of the crop's cultivation technology in order to obtain higher yields of qualitative roots to satisfy the needs of pharmaceutical branch. The prospective way of cultivation technology improvement is in engagement of modern modeling techniques including multiple linear regression analysis of effects of different agrotechnological factors on valerian productivity. The study revealed that in Ukraine valerian's reaction on different mineral fertilizers differ. The yield of roots depends mainly on Potassium fertilizer rates, the least effect on the crop productivity was fixed for Phosphorus. The model for valerian root yields depending on NPK fertilization provides new possibilities for planning and prediction of the crop yields based on the rates of mineral fertilization.

Keywords: *Valeriana officinalis* L., medicinal plant, regression analysis, fertilization, yield prediction

Introduction

Valeriana is a genus of flowering plants in the *Caprifoliaceae* family (Nandhini et al. 2018). *Valeriana officinalis* L. is a perennial medicinal plant, which is cultivated almost worldwide and used in the preparation of drugs for treatment of cardiological, neurological and psychiatric diseases due to spasmolytic, anxiolytic, antiarrhythmic, sedative, and sleep-inducing activities, which are related to the composition of the root (Becker and Chavadej 1985; Oshima et al. 1995; Jia and Zhang 1999; McCabe 2002). It contains nearly 150-200 constituent compounds, each of which has its specific effect on the systems of human body (Bissett 1994). The greatest share among them belongs to valerianic acid, which provides most psychotropic effects of the root extracts (Khom et al. 2007). Due to the increased interest in society to non-synthetic drugs for treatment of mild forms of various mental and cardiac diseases, the increase in the demand to natural raw materials increases each year. Valerian root is one of the major compounds of many sedative and sleep-inducing complex herbal medicines, therefore, the demand for qualitative valerian root is quite stable and high in the world pharmacological market. To satisfy the needs of modern phytopharmacology, it is necessary to increase the efficiency of the medicinal crop cultivation technologies. And one of the prospective instruments for the improvement of crops productivity in modern conditions is implementation of information technologies in agricultural production, one of which is yield prediction and planning using the agrotechnological prediction models (Lykhovyd 2018; Vozhehova et al. 2019). The goal of the study was to develop and test the model of valerian root yield estimation by the mineral (NPK) fertilization rates using simple multiple linear regression model.

Materials and Methods

The study of valerian root yields depending on different rates of mineral nutrition was performed using retrospective data on the crop yields obtained in the studies of Ukrainian domestic scientists in the period from 2008 to 2015 years in the Forest-Steppe and Polissia zones of Ukraine (Svitelskyi et al. 2012; Pryvedeniuk 2016). The data of the studies was generalized and processed by the standard algorithm of multiple linear regression analysis in Microsoft Excel 365 add-in BioStat v7 (Neter

et al. 1996). Evaluation of the created mathematical model was performed using the criterion of Mean Absolute Percentage Error (MAPE) (Khair et al. 2017).

Results

The results of the crop yield modeling revealed that there is a strong tendency to the root yield increase with the improvement of Phosphorus and Potassium nutrition. Surprisingly, Nitrogen fertilization is not essential, and can even result in the decrease of the crop productivity. The model for valerian root yield depending on NPK inputs is provided in the equation 1.

$$VRY = 2.8592 - 0.0211 * N + 0.0063 * P + 0.0280 * K$$

where, VRY is valerian root yield, t/ha; N, P, K– application rates for N, P, K fertilizers in kg/ha, respectively.

The MAPE for the model averaged to 24.13%. According to Caraka et al. (2019) this value testifies that the model is not acceptable for good yield prediction. However, another gradation provided by Moreno et al. (2013) suggests that the MAPE values within the range of 20%-50% is reasonable forecasting. The value of RSQ criterion for our model is 0.4799, while the forecasted RSQ drops to 0.3894.

We believe that such low values of the criterion could be put upon the fact that not only mineral nutrition determines the level of valerian productivity, and some other major natural and anthropogenic factors remained out of our sight in the study (for example, watering and tillage practices). That is why further developments will be performed to enhance valerian root productivity model with consideration of other agrotechnological factors. It is necessary to point on the fact that our findings have no analogues in Ukraine, and we are the first to settle this issue of medicinal plants production. Visual approximation of the model is provided in the Fig. 1.

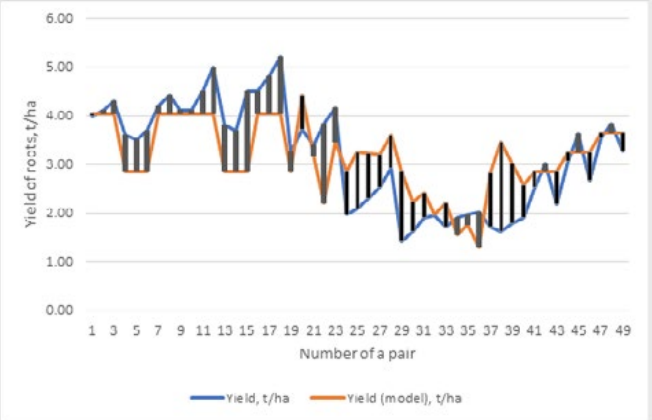

Figure 1. Approximation of the valerian root yield model.

Conclusion

As a result of multiple linear regression analysis, the model for valerian root yields depending on mineral fertilization was developed. The greatest impact on the crop productivity was fixed for Potassium fertilizers (1 kg/ha of applied fertilizer improves the yield by 28.0 kg/ha), while the slightest effect was observed for Phosphorus (1 kg/ha of applied fertilizer improves the yield by 6.3 kg/ha). Surprisingly, Nitrogen fertilizers can lead to the decrease in the crop yield by 21.1 kg/ha per 1 kg/ha of fertilizer used.

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