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THE ESTIMATION OF THE ECONOMIC EFFICIENCY OF REMOTE MONITORING WITH UAV USAGE IN AGRARIAN SECTOR

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Abstract: *The features remote monitoring of plant nitrogen nutrition using unmanned aerial vehicles. Shown the possibility to use for monitoring the nitrogen the additive color model RGB, including the standard board optical equipment. Modern UAVs are able to quickly receive spectral information about the state of the whole field, as well as its individual parts with appropriate positioning. This makes it possible to use techniques for fertilizing equipment equipped only with positioning equipment, which is fundamentally cheaper than additional touch equipment for leaf diagnostics. Has been made the calculation of economy affectivity of differential inputting fertilize. Has been proposed the use of UAV in crop plants for inputting the fertilizer is possible with the use of agricultural equipment equipped with positioning systems. Delineated for UAV it is expedient to develop vegetation indices adapted exactly for such equipment. Has been shown the possibility of using for monitoring the state of nitrogen nutrition may use red and green components of the visible spectrum, which can be provided at standard optical UAVs equipment.*

Key words: ***UAV, nitrogen nutrition, profitability, fertilize, economy affectivity***

Relevance. Monitoring of agricultural plantations using unmanned aerial vehicles (hereinafter UAVs) is widely advertised both in mass media and in specialized publications and is presented as a universal tool for agricultural producers. Unlike satellites, UAVs are able not only to evaluate expected yields, but also to provide information on the state of mineral nutrition needed for crop programming. That is, to help obtain the maximum profit by choosing the optimal dosage of fertilizers. However, in practice, there is some distrust of these technologies and even disappointment, as the received information needs to be further interpreted and implemented. Recognition of the state of plants by its spectral characteristics, the so-called leaf spot diagnostics, requires specialized algorithms and related software with a simple and understandable interface. Equipment that is capable of carrying out spot-testing and differential fertilizer application also requires appropriate investment, and therefore affects the profitability of production. Therefore, the estimation of economic prospects for farmers in monitoring plant plots with the use of UAVs for differential fertilizer application is the goal of our work.

Analysis of recent research and publications. Since the 70s of the previous century, technologies of satellite monitoring of planting have been developed, based on the use of so-called vegetation indices (VI), which made it possible to evaluate certain parameters of plantings [1,2]. The successful experience of these technologies was realized in serial ground equipment based on sensors such as Greenseeker (USA), CropSpec and Raptor (Japan), N-sensor (Norway) [3,4,5], used for differential fertilizer application. It should be noted that the use of such equipment, along with the benefits of the rational use of fertilizers, is limited by its significant cost and the ability to provide only such an optimality criterion as maximum yield, since it is not known before the start of the work, in which state are crops. Available ground equipment for assessing the state of nitrogen feeds uses such VI as NDVI, NDRE, which are determined by the intensity of the radiation for the channels NIR, RED, red edge. The near-infrared radiation fixation results in the use of specialized touch-sensitive equipment, which also limits the implementation of technologies.

The purpose of the research is find possibility to use for monitoring the nitrogen the additive color model RGB, including the standard optical equipment of UAVs.

Materials and research methodology. UAVs began to be massively introduced into the agrarian sector since 2008, after the emergence of powerful and small-sized lithium polymer batteries, which enabled relatively easy control in manual and automatic modes. Such a short term of production exploitation, to a certain extent, explains the relatively limited distribution of these technologies in the domestic market. Compared to satellite platforms, UAVs are the latest equipment with fundamentally new features, which allows it to be used for operational tasks. Modern UAVs are able to quickly receive spectral information about the state of the whole field, as well as its individual sites with appropriate positioning. This makes it possible to use techniques for fertilizing equipment equipped only with positioning equipment, which is fundamentally cheaper than additional touch equipment for leaf diagnostics. In the Ukrainian market there are firms offering modernization of existing equipment for fertilizing by means of positioning with the corresponding computer equipment at a cost about 1000-2000 USD. Also, unlike Greenseeker, positioning tools can be used continuously for any particular needs of the farm. Creation of VI for satellite platforms was associated with certain physical constraints such as: the presence of transparency windows of the atmosphere, the complexity of radio frequency correction, which affected the structure of the VI [6]. The most common NDVI index was constructed based on the fact that the radiation in the red region of the spectrum is well absorbed by plants and is well reflected in the near infrared spectral region. It should be noted that the optical range of the spectrum, which due to the clouds is limitedly used in satellite monitoring, is also informative about the state of nitrogen supply [7,8].

Research results. Accordingly, when placing sensors on the UAV platform, monitoring of the state of nitrogen can be carried out also by standard optical sensors. The most commonly used UAV sensors use the optical range, namely additive color models of RGB formation. Of the channels available in the RGB model for most crops, the greatest reflection of the radiation occurs for the green channel. Figure 1 shows a plot of the dependence of the vegetation index constructed for the optical region of the spectrum by analogy with NDVI on the amount of nitrogen. When the results are approximated, the coefficient of determination in the form of exponential dependence is 0.94. As can be seen from the data presented, with the amount of nitrogen less than 2.5% (areas requiring nutrition), the proposed VI can be used with high precision to make a decision on the differential application of nitrogen fertilizers.

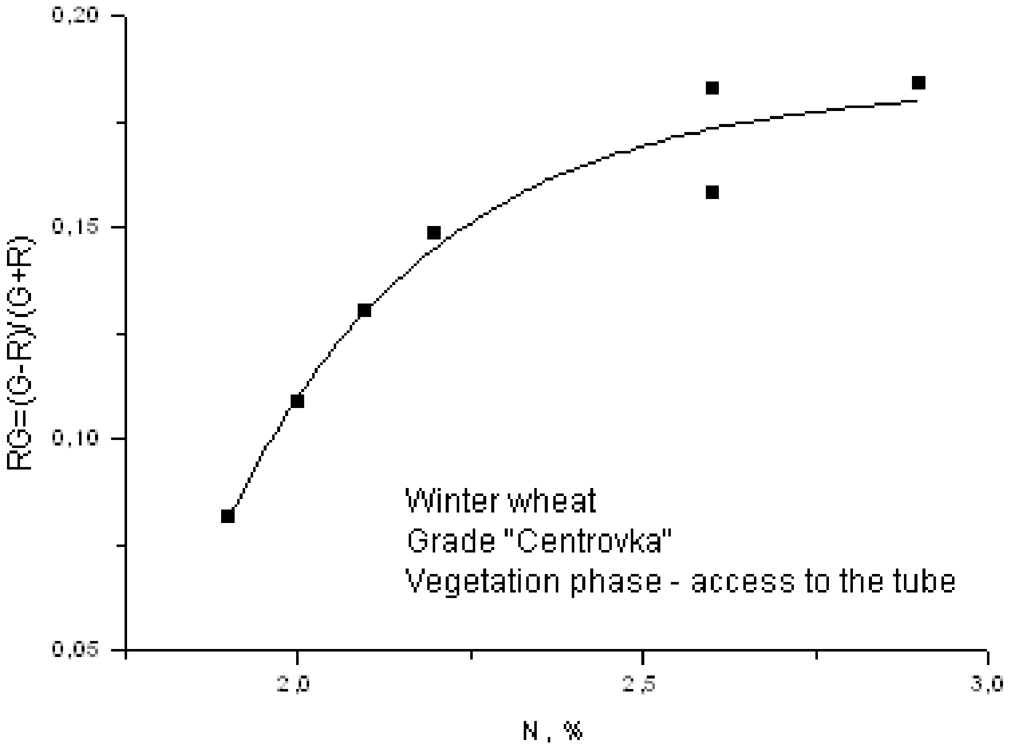

Fig. 1 Dependence VI created at the R and G channels on the amount of nitrogen

An economic component due to the rational use of fertilizers. Table shows the calculations for spring cereal wheat carbamide rejuvenation.

So, even for 1 year on a field of 100 hectares, it is possible to save (8-30) thousand UAH at differentiated inputting the fertilizer. That is, using the indicated technology, it is possible for one season to recoup the modernization of equipment for differential fertilizer application. In addition to the operational benefits of saving fertilizers when fed, the emergence of electronic field maps in the future will help to apply differentiated technological techniques for improving soil fertility (cultivation, melioration, fertilization).

Spring inputting of fertilizer

Feeding to the beginning of the bloom phase	
The rate of fertilization per 1 hectare	**22 kgDR.(N) / 48 kg fertilizer 16% solution, 300 l**
Amount / cost of fertilizers per 100 hectares	**4 800 kg / 51 360 UAH**
Saving fertilizers	**10-40% / 5 136 - 20 544 UAH**
Feeding to the output phase of the handset	
The rate of applying is 1 hectare of fertilizer	**11 kgDR.(N) / 24 kg fertilizer 8% solution, 300 l**
Amount / cost of fertilizers per 100 hectares	**2 400 kg / 25 680 UAH**
Saving fertilizers	**10-40% / 2 568 - 10 272 hryvnas.**

Conclusions and perspectives.

1. The use of UAV in crop plants for inputting the fertilizer is possible with the use of agricultural equipment equipped with positioning systems.

2. For UAV it is expedient to develop vegetation indices adapted exactly for such equipment.

3. For monitoring the state of nitrogen nutrition may use red and green components of the visible spectrum, as an example VI RG = (G - R) / (R + G), which can be provided at standard optical UAVs equipment.

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ОЦІНКА ЕКОНОМІЧНОЇ ЕФЕКТИВНОСТІ ДИСТАНЦІЙНОГО МОНІТОРИНГУ ЗЕРНОВИХ НАСАДЖЕНЬ ІЗ ВИКОРИСТАННЯМ БПЛА

В. П. Лисенко, Н. А. Пасічник, Д. С. Комарчук, О. О. Опришко

Анотація. Показано аспекти дистанційного моніторингу стану забезпеченості рослин азотом за допомогою безпілотних літальних апаратів. Представлено можливість використання додаткової RGB моделі, для моніторингу стану забезпеченості азотом рослинних насаджень з використанням стандартного оптичного обладнання. Сучасні БПЛА мають можливість швидко отримувати спектральні дані про стан всього поля, а також про окремі його частини з відповідним координатним позиціонуванням. Це дає можливість використовувати технології для калібрування стандартного фото обладнання, що є значно дешевше, ніж спеціальне обладнання з додатковими спектрами для діагностики листя. У роботі було проведено розрахунок економічної ефективності диференційованого внесення добрив. Було запропоновано використовувати БПЛА для визначення необхідної кількості внесення мінеральних добрив для сільськогосподарських рослин за допомогою техніки оснащеної системами позиціонування. Обґрунтовано, що для БПЛА доцільно розробляти окремі вегетаційні індекси, адаптовані саме для такого типу обладнання. Показана можливість використання для моніторингу стану азотного живлення, червоних та зелених компонентів видимого спектру, які можуть бути отримані з допомогою стандартного оптичного обладнання.

Ключові слова: ***БПЛА, забезпеченість азотом, рентабельність, мінеральні добрива, економічна ефективність***.

ОЦЕНКА ЭКОНОМИЧЕСКОЙ ЭФФЕКТИВНОСТИ ДИСТАНЦИОННОГО МОНИТОРИНГА ЗЕРНОВЫХ НАСАЖДЕНИЙ С ИСПОЛЬЗОВАНИЕМ БПЛА

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Аннотация: *Показано аспекты дистанционного мониторинга состояния обеспеченности растений азотом с помощью беспилотных летательных аппаратов. Представлена возможность использования дополнительной RGB модели, для мониторинга состояния обеспеченности азотом растительных насаждений с использованием стандартного оптического оборудования. Современные БПЛА имеют возможность быстро получать спектральные данные о состоянии всего поля, а также об отдельных его частях с соответствующими координатами позиционирования. Это дает возможность использовать технологии для калибровки стандартного фотооборудования, которое значительно дешевле, чем специальное оборудование с дополнительными спектрами для диагностики листьев. В работе был проведен расчет экономической эффективности дифференцированного внесения удобрений. Было предложено использовать БПЛА для определения необходимого количества внесения минеральных удобрений для сельскохозяйственных растений с помощью техники, оснащенной системами позиционирования. Обосновано, что для БПЛА целесообразно разрабатывать отдельные вегетационные индексы, адаптированные именно для такого типа оборудования. Показана возможность использования для мониторинга состояния азотного питания, красных и зеленых компонентов видимого спектра, которые могут быть получены с помощью стандартного оптического оборудования.*

Ключевые слова: ***БПЛА, обеспеченность азотом, рентабельность, минеральные удобрения, экономическая эффективность***