СЕЛЬСКОЕ И ЛЕСНОЕ ХОЗЯЙСТВО

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SPACE MONITORING OF EFFECTIVENESS OF DIFFERENT METHODS OF GLYPHOSATE APPLICATION IN CENTRAL KAZAKHSTAN

Abstract. Effectiveness of different methods of glyphosate application can be showed Earth remote sensing technology, satellites imagery and special software. In scientific research were applied experimental field method (AmaSpot differentiated spraying technology), satellite imagery (Sentinel-2), software data processing (ArcGIS). Processed and interpreted NDVI images confirm the effectiveness of different methods of glyphosate application in the conditions of Central Kazakhstan. The differentiated method of glyphosate application allows to reduce the total agroecological load and the cost of agricultural production while not reducing the biological effectiveness of glyphosate action on weeds.
Keywords: field trial, glyphosate, spraying rate, differentiated method, effectiveness, NDVI.

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Аннотация. Эффективность различных методов внесения глифосата возможно показать с использованием технологий дистанционного зондирования Земли, спутниковых снимков и специального программного обеспечения. В исследовании применены экспериментальный полевой метод (инновационная технология дифференцированного внесения средств защиты растений AmaSpot), спутниковые снимки (Sentinel-2), программная обработка данных (ArcGIS). Обработанные и интерпретированные снимки NDVI подтверждают эффективность различных методов применения глифосата в условиях Центрального Казахстана. Дифференцированный способ применения глифосата позволяет снизить общую агроэкологическую нагрузку и себестоимость производства, не снижая при этом биологическую эффективность действия глифосата на сорные растения.
Ключевые слова: полевые испытания, глифосат, норма внесения, дифференцированный метод, эффективность, NDVI

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Түйіндеме. Жерді қашықтықтан зондтау технологиясын, спутниктік суреттерді және арнайы бағдарламалық қамтамасыз етуді қолдана отырып, түрлі глифосатты қолдану әдістерінің тиімділігі керсетілген. Ғылыми зерттеуде экс-

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рименттік далалық әдіс (AmaSpot бүрку технологиясы), спутниктік кескіндер (Sentinel-2), бағдарламалық қамтамасыздандыру (ArcGIS) қолданылды. Өңделген және интерпретацияланған NDVI кескіндері Орталық Қазақстанда түрлі глифосатты қолдану әдістерінің тиімділігін растайды. Глифосатты қолданудың сараланған әдісі арамшептерде глифосаттың биологиялық тиімділігін төмендетпей, жалпы агроэкологиялық жүктемені және ауылшаруашылық өнімнің өзіндік құнын төмендетуге мүмкіндік береді.
Түйінді сөздер: далалық сынақтар, глифосат, қолдану жылдамдығы, сараланған әдіс, тиімділік, NDVI.

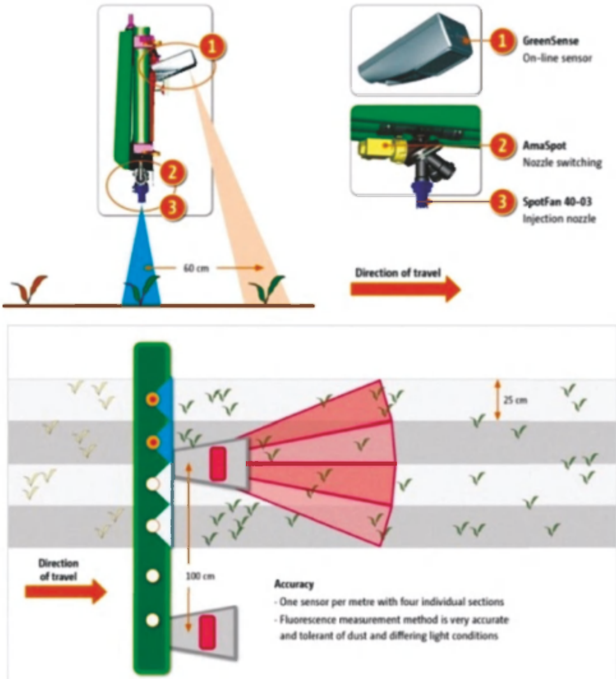
Introduction. Effectiveness of different methods of glyphosate application can be controlled using modern digital technology: for example, through space monitoring and normalized difference vegetation index (NDVI) images. The normalized difference vegetation index is a simple graphical indicator that can be used to analyze remote sensing measurements, typically, but not necessarily, from a space platform, and assess whether the target being observed contains live green vegetation or not.

Object of scientific work. The study of the effectiveness of different methods of glyphosate application through space monitoring technology.

Methods of research. In the growing season 2019, on the fallow field in Tselinograd district of Akmola region of Central Kazakhstan, by the field trial was used non-selective herbicide Roundup Extra (Water Solution, 540 g/l of glyphosate). For the field trial the average rate of 3,0 l/ha (1620 g/ha of glyphosate) and with all-round application the average spraying rate 70,0 l/ha of tank mix were applied (picture 1) [1].

Picture 1 – Geolocation of the fallow field

For spraying the Amazone UX5200 sprayer was used, equipped with an intelligent system of sensor nozzles AmaSpot (German innovation, AGRITECHNICA 2017). For detecting the targeted plants, the AmaSpot system features the GreenSense fluorescent sensors. Thanks to its chlorophyll detection ability, it can differentiate between green plants and bare ground. With a sensor spacing of 100 cm along the boom, and a resolution in 4 sectors within the sensor, strips with a width of 25 cm are scanned. This results a very high accuracy in the application of crop protection agents (picture 2).



Picture 2 – AmaSpot system configuration, top view schematic

When a GreenSense sensor detects a green plant, the relevant nozzle is switched on and off with centimeter precision, even at speeds of 20 km/h at night. In addition to the GreenSense sensors, the system features a special nozzle technology which can be controlled with the highest precision. In a split second the nozzles can open or close and thus only treat that specific area of weeds with the crop protection agent. This nozzle works according to the pulse width frequency modulation (PWFM) principle. Here, a valve regulates, within the high frequency range of 50 Hz (50 switches per second), the frequency of the closing and opening nozzle. By this high switching speed, the system can infinitely vary the spray rate from any individual nozzle from 100 % to 30 % or to switch off each nozzle individually. Due to this PWFM regulation, the spray pressure and thus also the size of droplet is always maintained.In addition, blanket coverage and a part-area site specific application can be combined. So, for example, 30% of the application rate can be sprayed across the total area and elsewhere, where the sensors detect areas with weeds, the rate can be increased to100%. This ensures that only areas with heavy weed populations receive the full application rate. The combination of the three components (Sensor–Nozzle Switching–Nozzle) on the Amazone sprayer allows a very precise application of glyphosate with the important objective of reducing the overall application rate (picture 3).

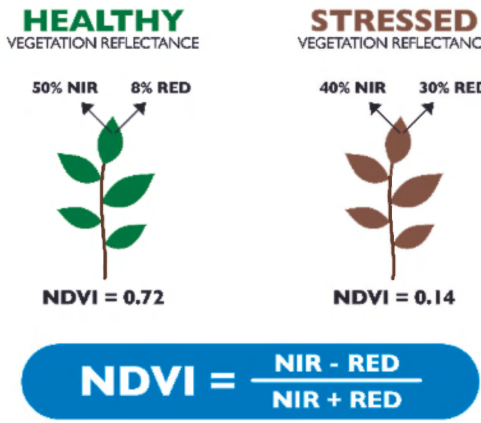
Picture 3 – AmaSpot technology in field conditions

For clarity, the effectiveness of all options for glyphosate application, the technology of remote sensing of the Earth using the Sentinel-2 satellite was applied [2]. The obtained NDVI images from August 8 and August 26 were processed and interpreted in the ArcGIS program [3].

The sun emits radiation with different wavelengths and frequencies. The electromagnetic spectrum (EM spectrum) indicates the totality of all possible frequencies of electromagnetic radiation. The whole spectrum is divided into the visible spectrum, which generates light and the parts of the non-visible spectrum at longer and shorter wavelengths of the visible spectrum.

Vegetation absorbs solar radiation in different bands, that is in different frequency ranges and wavelengths, and emits a different percentage of it back into them. The percentage of refracted radiation in specific bands, such as near infrared (NIR), red (RED), and short-wave infrared (SWIR), varies with plant health and water stress [4].

The most widely used vegetation index is undoubtedly the Normalized Difference Vegetation Index (NDVI): it is calculated as the ratio between the difference and the sum of the refracted radiations in the near infrared and in the red, that is as (NIR-RED) / (NIR + RED) (picture 4).



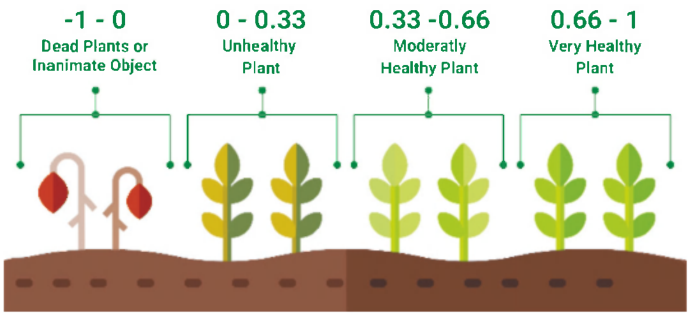
Picture 4 – Formula and calculation example of NDVI

The interpretation of the absolute value of the NDVI is highly informative, as it allows the immediate recognition of the areas of the farm or field that have problems. The NDVI is a simple index to interpret: its values vary between -1 and 1, and each value corresponds to a different agronomic situation, regardless of the plant (picture 5).

The average NDVI of a field varies according to the variety and phenological stage of the plant (crop, weed). In a field, where a crop tends to be at the same phenological stage, areas with a significantly lower than average NDVI value present problems in vegetative development, for example: necrosis due to the action of the herbicide, nutritional stress, parasitic attacks, hail damage or frost and others.

Monitoring the status of farmland based on satellite imagery. This is an important and promising area of application of remote sensing technology in the agricultural sector. Typical tasks for monitoring the status of farmland are:

- ensuring current monitoring of the state of crops;
- early prediction of crop yields;
- simultaneous monitoring of harvesting in large regions and others.



Picture 5 – NDVI interpretation

Solving these problems provides the user with the opportunity to create real field boundaries, evaluate their characteristics according to remote sensing data, check the availability of crops on a given set of fields, and identify discrepancies between the data. These data are due to systematic repeated surveys that meet the requirements of frequency and sufficient resolution, which provide monitoring of the dynamics of crop development and yield forecasting. When decrypting usually use information about the change in spectral brightness of vegetation during the growing season and NDVI index. It is easy to calculate, has a wide range and good sensitivity to changes in vegetation. This makes it possible to obtain an assessment of the state of plants. The tone of the field image allows you to judge state of plants and make decisions appropriate to the state [5].

Main results. During the field trial, a comparison of 3 methods of spraying glyphosate was carried out and the following results were obtained: in the western weediest part of the field, the 1st spraying method was used as a control variant, in which 100% all-round application of spraying was applied. In the middle of the field, less overgrown with weeds, a combined spraying method was used (2nd method), in which 30% of the tank mix was applied by the all-round application, and the remaining 70% by the differentiated application. In the eastern part of the field, the least overgrown with weeds, a totally differentiated method of glyphosate spraying was used (3rd method).

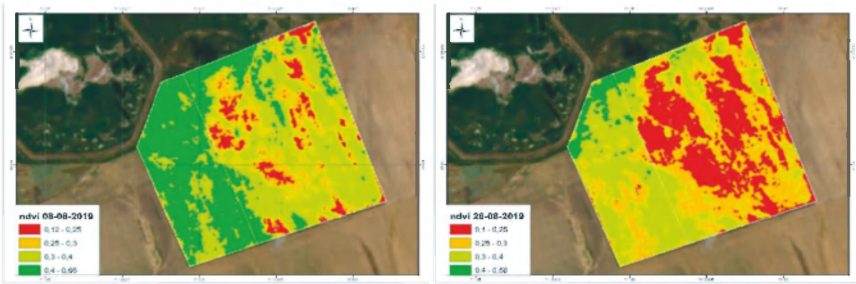
In the field trial scheme, 3 replications of all 3 methods were provided, in which a sufficient correlation of target values was observed. In the 2nd method, the average spray rate of the glyphosate tank mix was 25,3 l/ha, which is 44,7 l/ha or 63,9% less compared to the control value 70,0 l/ha of the spraying rate. In the 3rd method, a saving of the glyphosate spraying rate of 52,7 l/ha or 75,3% was obtained (table 1).

Table 1 - Scheme and results of the field trial

№	Glyphosate spraying rate, method of application	Tank mix spraying rate (3 replications), l/ha				Deviation (-/+)	
		1	2	3	average	l/ha	%
1	Roundup Extra, WS 3 l/ha (1620 g a.e./ha), totally all-round application	70,0	70,0	70,0	70,0	-	-
2	Roundup Extra, WS up to 3 l/ha (1620 g a.e./ha), combined application: 30% of all-round and 70% of differentiated	25,0	23,0	26,0	25,3	-44,7	-63,9
3	Roundup Extra, WS up to 3 l/ha (1620 g a.e./ha), totally differentiated application	17,0	16,0	19,0	17,3	-52,7	-75,3

Thus, the following data were obtained on the effectiveness of glyphosate: the 1st traditional method carried out in the western part of the field, mainly has initial NDVI values in the range 0,4-0,68, which confirms the normal vegetation of weeds. After 18 days, the value of NDVI in this area is in the range of 0,3-0,4, which indicates the inhibition of weeds and confirms the effectiveness of glyphosate (picture 6).

In the middle part of the field, where the 2nd method was carried out, the following NDVI values were: the initial prevailing ones were 0,3-0,4, the final ones showed mainly the range 0,1-0,25, that confirms the chlorosis phase, which turns into necrosis phase of weeds. On the 3rd method in the eastern part of the field, the situation regarding the NDVI dynamics is similar to the 2nd method, which also confirms the effectiveness of glyphosate.



Picture 6 – Processed and interpreted NDVI images

Conclusion. The traditional all-round method of glyphosate spraying is more important for fields with widespread weed overgrowth in a fallow field. The combined method is most suitable for pre-sowing spraying of glyphosate, because with optimal spraying rate, the relative purity of future crops is achieved. This is explained by the fact that 30% of the all-round application of glyphosate is sufficient for very young weeds, in their initial phase of vegetation (1-2 true leaves), which the sprayer sensors may not scan on the soil surface. The rest of the tank mix spraying rate (up to 70%) is applied to adult weeds, which are quite successfully scanned by sensors. And the totally differentiated method of glyphosate spraying is most recommended for partial weed overgrowth that requires the highest spraying rate, but at the same time the maximum environmental and economic effects will be obtained. Precision farming tools and technologies such as space monitoring help farmers identify early exactly which crops in the field are being impacted by problematic weeds. This enables them to quickly and precisely act to protect their harvests. In the face of weeds, this can mean applying herbicides, using just the right amount, in the right place, at the right time.

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