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MONITORING OF BIOPRODUCTIVITY OF OILSEED SPRING RAPE ON THE BASIS OF REMOTE PROBING OF CROPS IN BAVLINSKY MUNICIPAL DISTRICT OF THE REPUBLIC OF TATARSTAN

Taisia Scherbinina [a], Faik Safiollin[b1], Genadiy Minnullin[c], Oleg Avvakumov [d]
[a d] Kazan federal university, Kremlevskaya,6/20, Kazan 420111, Russia.
[b c] Kazan state agricultural university, K.Marx,65, Kazan 420015, Russia.
Email: faik1948@mail.ru

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Abstract

In the Republic of Tatarstan (Russia) the issues of import substitution and providing the population with food are largely resolved. Agri-farms of Tatarstan have a positive dynamics of development and stably take its place among the first four constituents of the Russian Federation. Having cultivated 2.3% of agricultural lands in Russia, Tatarstan provides 4.7% of agricultural production, in the amount of 188.8 billion rubles.

Agricultural business becomes profitable, and begins to entice such a great investors as "Krasny Vostok Agro", "Kulonstroy", "Zolotoy Kolos", "Tatfondbank", "Agrosila Group", et al., who invest multi billions of dollars. So, just “Krasny Vostok Agro”, taking a responsibility for 56 thousand of peoples, living in 124 settlements of Alekseevsky, Alkeevsky, Verkhneuslonsky, Zelenodolsky, Nurlatsky and Spassky Districts, managed in a short time, radically change the actual position of affairs. During the implementation of the national project, the results of its activities became the following: tripling of the meat production, tenfold increase of milk production, which made it possible to provide all working population with paying job.

The Republic is gradually resolved the questions about supporting of young specialists in agriculture. New houses are built for them in accordance with the federal programs. The aim is to bring the level of country people income to the level of industrial workers.

Despite the gained progress, the agricultural sector has many unsolved problems. One of them is the production of vegetable oil. According to specialists’ calculations, each year our republic is required 47520 tons of vegetable oil (about 800 wagons with carrying capacity of 60 tons), not including the consumption of mayonnaise, margarine and other products. Taking into account the needs of domestic and foreign markets, it is necessary to increase the cultivated areas of spring rape (main cold-resistant oilseed of Tatarstan) at least up to 200 thousand hectares and to

bring gross output of oilseeds to 200-250 thousand tons per year, yielding per every hectare 20-25 quintals of commercial products, instead of 10-12 quintals at this time.

One of the reasons of low output of spring rape is the failure in optimal timing of crops treatment against numerous pests (more than 80 species of blasters can occupy this culture, and ruined all the crops during 8-10 days), and chemical weeding due to the lack of timely information.

In this regard, the definition of the current situation on the crops of the researched object, the methodology of which is presented in this Article, the assessment and forecasting of its productivity on the basis of space imagery data is the actual problem of modern agro-industrial complex, not only of the Republic of Tatarstan, but the Russian Federation in whole [1, 2].

Keywords: satellite imagery, the biomass of spring rape, yielding capacity, pests, weed infestation of crops, radiation and absorption of solar radiation, the NDVI index and others.

Introduction

In Russia the consumption of vegetable oil per head of population is only 8-9 kg, even with imports, that reaches up to 1 million tons per year. Meanwhile, in the USA, China and Japan, the consumption of vegetable fats per head of population increased to 24-26 kg per year, in Germany - 22, in England and Canada - 19, which allows them to reduce the number of cardiovascular diseases (the main cause of mortality in Russia). Moreover, according to calculations of specialists, for the production of 1 ton of oil it is required only 1 ha of arable land, while to produce 1 ton of butter it is necessary to occupy 3.5 hectares of land for managing 5.2 cows with milk yield 5200 kg of 3.7% fat content, therewith it is necessary to invest 23 thousand dollars of capital costs and 300 pers./hour of working time. In Russian context, the comparison of two oil sources will be more disadvantageous for animal fats, since even with an average milk yield of 3000 kg with fat content 3.5%, to obtain 1 ton of butter, it will need 9.5 cows and 10 hectares of land for its managing.

Moreover, under the conditions of transition to the market economy, it is necessary to determine the capacity of domestic and global market and only with this accounting, to cultivate those crops, that can provide high economic results. From this point of view, there is no alternative for oilseeds (320-350 euros per 1 ton).

In addition, while the processing of oilseeds, seed cake and oilseed meal are rested (35-40%), which contained 5.7% of fat, 32-35% of crude protein, 20% of carbohydrates,13-14% of pectin, 4.3% of phytin (biologically active

substances), a wide range of vitamins and minerals. One ton of seed cake allows to balance by the protein 8-10 tons of animal feed.

Vegetable oils are widely used in cooking, used for the manufacture of various types of margarine, mayonnaise, vegetable and fish canned food, confectionery and bakery products. Part of the oil, unsuitable for food, is used for the production of detergents, soap, linseed oil, linoleum and oilcloths. Vegetable oil in the developed countries is used as biofuels, motor oil, and the component for the manufacture of coolants.

However, in Russia the production of oilseeds reaches only 4-6 million tons per year and does not provide even the minimum needs of the economy. Under the operating conditions of restrictive sanctions, such a low level of oilseeds production, leads to great difficulties in providing the population with not only vegetable oil, margarine and mayonnaise, but also causes a significant decrease in livestock production, simultaneously increasing the over-expenditure of food grain for feeding purposes (18-20 million tons per year).

Therefore, the control of current situation over the affecting of the main oilseed of Tatarstan - spring rape – with the pests and weed infestation of crops; and forecasting of its productivity on the basis of interpretation of publicly available satellite imagery of the American system Landsat-4, can be the basis of increasing production of oilseeds.

2. Materials and Methods

The researches of specific situation on spring rape sowings, with the use of space scanner images of medium definition, were carried out on the fields of Agricultural Production Co-operative "Kolos" (economic center of Pokrovski-Urustamak) of Bavlinsky municipal district (Figure 1). It is located in the south-east of Tatarstan and sometimes Bavlinsky District called "the land of the rising sun" as its residents see the sunrise for 2 hours early than the residents of Kazan.

Fig. 1. The state of the crops on the 23 of June 2015.

The coordinates of the territory of Agricultural Production Co-operative "Kolos» are the following: 54º15' north latitude and 53º23' east longitude. In the physical and geographical terms, this location determines the significant severity and continentality of climate that has an impact to all the components of nature.

The total land area of farms is 8200 hectares, 6411 hectares from them – is arable land. The share of leached chernozem soils is 39.8%; typical soils – 134%; carbonate soils - 31.6% and meadow soils (the floodplain of Ik River) - 7.5%. The saturation of arable lands by oilseeds is 6-8 percent.

The farm monthly sells milk for amount of 2900-3100 thousand rubles, and meat – for amount of 1560 thousand rubles. Net profit from the sale of livestock products amounted to 9 million 225 thousand rubles, the profitability of livestock was 35% and crop production was 42 per cent in 2015.

Therefore, the Agricultural Production Co-operative "Kolos» is one of the most economically strong and dynamically developing economies of our republic. In this regard, it has the opportunity to change the methods of agricultural crops cultivation on high-tech methods, including the use of remote sounding of crops, for monitoring of pests and weeds.

Results

It is known that various methods of remote sounding of crops are widely used in the USA, Canada, EU countries, China and Japan [3, 4, 5]. Early identification of cultivated areas of crops and forecasting of its yields allows to set the target price and the intervention price [6]. Therewith the level of the target price enables the oilseeds manufacturers to cover the costs of production and to obtain a "fair" profit, regardless of supply and demand, even in years of overproduction. In dry lean years, the state intervention price supports the farmers of developed foreign countries. In the Russian Federation, including the Republic of Tatarstan, this practice is completely absent and the target price of oilseeds, as well as food grains and cereals, is determined and set only during the harvest, that is reflected on the cost of food products in retail trade (as a rule, upwards).

The basis of this kind of work is a reflection of solar radiation by agrocenosis, that is connected with the amount of chlorophyll in plant phytomass. Between these two factors, there is a close correlation - the larger is phytomass, the higher is the reflection of solar radiation.

On the other hand, the plants not only reflect, but also absorb solar radiation. Therefore, to assess the state of crops, the vegetation index NDVI [7-9, 10] is used, which is calculated by the following formula:

$$NDVI = NIR-RED / NIR + RED, \quad (1)$$

where NIR – is the reflection in the near infrared region of the spectrum;

RED – is the reflection in the red region of the spectrum.

With the help of this index, one can determine pest infestation of plants (dramatic thinning of grass) and weed infestation of crops [11, 12, 13]. In the latter case, on the contrary, there is excessive seeding density of spring rape crops (Table 1).

For the comparison, we note, that for open ground, the index value decreased to 0.025.

At the same time, the considerations of biological characteristics of spring rape, allows to exclude the daily control of pests and weeds infestation of this culture crops.

Table 1: NDVI index value depending on the state of crops.

The type of object	The reflection in the red region of spectrum, um	The reflection in the infrared region of spectrum, um	NDVI value
Thick vegetation	0,1	0,5	0,7
Thinned vegetation	0,1	0,3	0,5
Optimum density	0,1	0,4	0,6

So, among 80 types of pests, the most dangerous are the following: crucifer flea beetle (Phyllotreta cruciferae), diamondback moth (Plutella xylostella) and pollen beetle (Meligethes aeneus) [14,15]. The first of them appears in 10-12 days after sowing and eats cotyledonous leaves throughout (Figure 2). At this particular time, during the analysis of satellite imagery, it can be set thinning of grass.

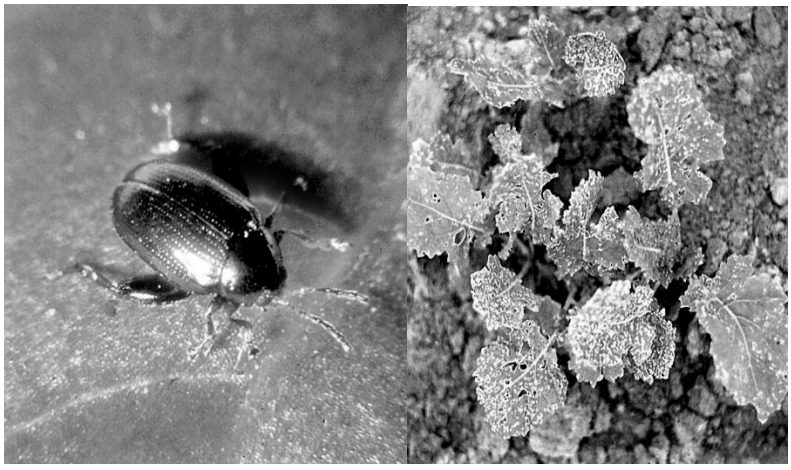

Fig. 2. Crucifer flea beetle and its action.

The second period of thinning spring rape crops is connected with a mass infestation of plants, especially if the spring is hot and dry, by diamondback moth (Figure 3), which feed on mesophyll on the downside. If we do not take prompt measures, the value of the analyzed index may decrease to 0.3-0.4.

Fig. 3. The leaves of spring rape, infested by diamondback moth.

Pollen beetle appears in the middle of June, in the early budding of spring rape (Figure 4). At first, it infests the stamens and pistils, and then begins to eat the young pods, thereby reducing the phytomass, which is easily detected by satellite imagery.

Conclusion

Thus, a threefold review of satellite imagery allows to establish infestation of spring rape by pests and to take prompt measures timely.

Fig. 4. The massive appearance of pollen beetle at the end of the spring rape budding.

The weediness of spring rape crops is tested in a stage of the second-third pair of true leaves of this culture. In case of exceeding the NDVI index 0.8, it is necessary to carry out a chemical weeding, taking into account the species composition of weeds.

Yield predicting is more complicated process, because it is necessary to have an average value (year - equivalent), with relation to which, the productivity of the studied culture of a particular year is compared. To do this, the values of farm vegetation index are averaged and the diagram of vegetation curve is built (Figure 5).

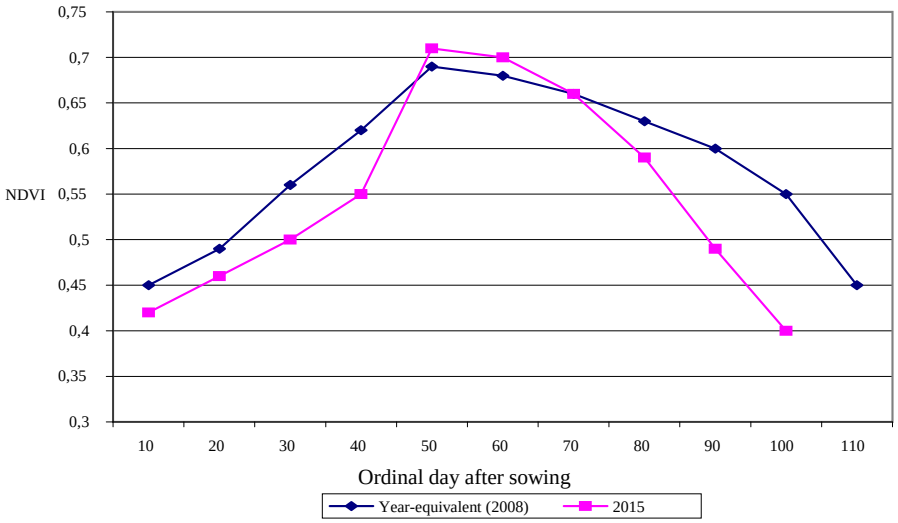

Fig. 5. The diagram of vegetation index.

In 2008, the biomass accumulation of spring rape was without abrupt jumps, as weather and climatic conditions were very favorable (the oilseeds yield was 24.4 centner/ha). Therefore, 2008 year we took as the year – equivalent (Figure 6).

Fig. 6. The state of the crops on the 14 of June 2008.

In 2015, hot and dry weather of May, caused the mass appearance of diamondback moth, and as a result the index NDVI was significantly lower than during the year-equivalent.

Discussion

On the other hand, "sabantuyskie" rains in the middle of June, initiated the growth and development not only cultural plants, but also weeds. So, there was marked an abrupt jump in the accumulation of biomass.

In addition, in 2015, the duration of the vegetation period decreased by 10 days, compared to 2008. As a result, the projected yield, according to NDVI index in 2015 was 21.8centner/ha of oilseeds, that is confirmed by the results of yield recording with the visit to Agricultural Production Co-operative "Kolos» of Bavlinsky municipal district of our republic (Table 2).

The objectivity of our prediction is proved by the selling price of oilseeds. For example, during 2008 crop year, grain reception centers bought the oilseeds of spring rape at the rate of 9-10 thousand rubles per ton, then in 2015 the selling price of spring rape oilseeds increase twice (18-20 thousand rubles per ton).

Table 2: The actual yield of spring rape in the Agricultural Production Co-operative "Kolos».

Year	Square, ha	The oilseeds yield, centner/ha	Gross output, centner
2008 (year-equivalent)	350	24,4	8540
2015	420	21,8	9156

So, the use in agricultural the high-tech methods of spring rape cultivation, on the basis of the satellite imagery and taking prompt measures to eliminate the negative phenomena, as well as forecasting the yield, has both economic and social value.

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