

Provision of remote methods for estimating soil salinity on meliorated lands

Sabirjan Isaev¹, Gulom Bekmirzaev^{1,2*}, Mirkadir Usmanov¹, Elyor Malikov¹, Sunnat Tadjiev¹, and Abdukadir Butayarov²

¹Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Department of Irrigation and Melioration, 39, Kori-Niyoziy str., 100000 Tashkent, Uzbekistan.

²Termiz Institute of Engineering and Technology, 288a, Islom Karimov str., 190100 Termez, Uzbekistan

Abstract. The proposed methodological recommendation on the ground support of remote methods for assessing salinization of soil in reclaimed lands is devoted to the operational monitoring of salinity of reclaimed lands. The assessment and forecasting of cotton yield in the Hungry Steppe and the lower reaches of the Amu Darya, by direct signs of determining salinity at farms, a separate irrigated plot, based on remote information (aerial and space photography - APS and KFS). The task of the under investigations study is visual assessment of soil salinity level by indirect signs: condition of crops, fall of plants, salt bloom, etc. The results of the established check are recorded in the field journal. Salinity map with salinity contours; slightly saline, moderately saline and strongly saline soils are created based on the studied research materials. Number and location of the main sites for determination of soil salinity features are determined on the basis of analysis of the research materials determined with involvement of other available materials on the soil cover characteristics. Classification of soils according to the degree of salinity is carried out according to the formula $WP = PVU + VJp$; $WP = 51.42 - 96.28 Jp \pm 1.12 \text{ g ha}^{-1}$. It is presented in Table 2 for Amu-Darya lower reaches (Khorezm province and the Republic of Karakalpakstan), where + Y - yield calculation; PVU - maximum yield. This program is designed for use in the educational process during practical lessons on agricultural reclamation directions. Keywords: Remote methods; salinization; reclaimed lands; monitoring of salinity; salinity map.

1 Introduction

Salinization of soils is a well-known problem often associated with anthropogenic factors as well as climate changes. Salinity seriously threatens the provision of high-quality agricultural products [1, 2].

Today there are 220.4 million tons of wheat per hectare in the world, with an average grain yield of 34.0 cwt/ha. According to the International Food and Agriculture Organization, in 2021, the world has grown 777.0 million tons of wheat grain, and in the next decade, this figure will increase by 9.6% or 74 to meet the needs of flour products with population growth,

* Corresponding author: gulombek@gmail.com

which requires 6 million tons more crops. For 2022, more than 1 million 30 thousand hectares of winter cereals will be sown in Uzbekistan, including 273.6 thousand hectares in the open field and 756.8 thousand hectares in the inter-row cotton. One of the topical issues is the development and implementation of modern technologies that save land, water, fertilizers and resources, taking into account changes in the natural climate, especially winter wheat from lands with different levels of salinity [3, 4].

Worldwide efforts are being made for integrated management of land, water, fertilizers and resources in the processes of ensuring high and high quality yields, with optimal crop nutrition on saline lands. According to the Food and Agriculture Organization of the United Nations (FAO), more than 833 million hectares of agricultural land in the world is saline, representing 8.7% of the planet's area. In particular, in the context of global climate change, research on the development of irrigation and cultivation efficiency in sowing and maintaining winter wheat on soils with different degrees of salinity (non-saline, weak and moderate) is important [5].

The irrigated area is 4 273 700 hectares in the Republic of Uzbekistan, of which 50.1% of the land is reclamation-unsatisfactory; 19.6% are slightly saline; 25.1% are moderately saline; 5.4% of the land is highly salinized. In connection with the above, in irrigated agriculture it is necessary to obtain regular and objective information about the soil and vegetation cover: their properties, areas of distribution of spotting salinization of the land, as well as an assessment of the yield of a particular field. Without timely objective information, it is impossible to assess, manage and forecast the further development of the main reclamation indicators of reclaimed land (soil salinity and crop yields), as well as informed decision-making on the dynamic processes of reclamation of these soils [6, 7].

2 Materials and Methods

2.1 Using remote information for operational control of productivity losses of irrigated land of farms

An important direction in the implementation of the country's land legislation is the creation of a state land cadaster and land monitoring in the country on a fundamentally new basis as a system of information support for land relations.

The results of recent years in our country and abroad in this field testify to the great importance and advisability of using aerospace imagery to assess the condition and mapping of vegetation, soil cover in large areas, determine salinity of soils, assess the biomass of crops and the productivity of natural forage lands.

There is some experience in solving the above problems in the system of the Ministry of Agriculture and Water Resources and at SANIGMI Uzhydromet. In the scientific and experimental plan, a number of technological solutions have been worked out: assessment of the state of vegetation, natural fodder land using aircraft scanner information and its processing in an automated mode, [8, 9].

A system of information support for land relations between the state and farmers does not exist to fill this gap; a cheap and efficient method of obtaining information on the state of an individual irrigation field that meets the requirements of a market economy is needed. Space geography meets exactly these requirements.

The contractor has a computer complex and special programs for processing remote information and for creating an agro-reclamation passport for a separate irrigation field of a farm.

Technical and economic comparison of the traditional method of obtaining information about the state of an individual irrigation field and space geography methods [10] (in

comparable prices in 1986) at a scale of 1: 10000 for salt surveys. In the traditional method, 2 dollars are spent per ha; and when using the method of space geography, 18-30 sends are spent on ha.

2.2 Scope of work on ground support

The composition and scope of work on ground support is determined by the scale of the APS and CFS and the area of interpretation. Territories of various sizes can be taken as ground control objects: the area of one farm, the area of a group of farms, the area of an administrative region, the area of an irrigation system, etc.

In this case, aerospace photographs of the following scales can be used (tentatively):

- farm area - 1: 10000-1: 25000
- area of the district - 1: 50000-1: 100000
- area of the district - 1: 200000

Work on ground control includes the following types:

- Collection and analysis of stock materials;
- Reconnaissance survey of the territory of the studied object and the selection of key areas;

- The complex of work in key areas;
- Office data processing and assessment of soil salinization.

Collection and analysis of stock materials: To increase the reliability of assessing the degree of soil salinity from aerospace photographs at the first stage of research, we study in detail the natural reclamation conditions of the study area and data on the agricultural use of irrigated lands, based on:

- soil and agricultural maps;
- maps of salt surveys performed in previous years;

on these maps all points of salt testing and the salt content at the time of recording (the sum of toxic salts, the predominant anions and cations) should be taken out;

- cartograms of nutrients;
- Information on the reclamation state of the studied objects by species composition and productivity of the main crops.

All collected stock materials should characterize the object of research over the past 3-5 years. The most representative in the seasonal aspect are materials corresponding to the subsequent period of the AFS and KFS.

2.3 Reconnaissance survey of the territory of the studied object and the selection of key sites

The task of evaluation studies is to visually assess the level of soil salinity by indirect signs: the condition of crops, the presence of spots on the plants, reduction of salinity, etc. For an indicative assessment of salinity by the state of cotton, Table 1 can be used.

Each area of crop rotation is considered as the basic unit for study, if it is necessary to study several farms, area of district or region, a route survey of the area is given, only the area of crop rotation is considered as the unit of study.

Plans of economic and agricultural maps of the area at a scale of 1:10.000 or 1:25.000 are used as the basis for evaluation studies.

In the fall (August-September), an appraisal survey will be conducted for remote sensing the following year.

Table 1. Reconnaissance survey of the study area Estimates of soil salinization by cotton.

Degree of salinization of soil	State of plants	Yield, % of stable on saline soils
Non-saline	Good	100
Slightly salt effected	Slightly suppressed	80
Moderately salt effected	Oppressed	50
Highly salt effected	Highly suppressed	30
Very highly salt effected	Very severely suppressed or almost complete death	0-10

The results of the assessment are recorded in a field log. Salinity cartogram is made by drawing salinity contours according to the materials of the assessment surveys; slightly saline, moderately saline and strongly saline soils.

Based on the analysis of the materials of reconnaissance surveys using other available materials, the quantity and location of key sites are determined by the characteristics of the soil cover to identify deciphering signs of soil salinization [11, 12].

The classification of soils by salinity is based on the formula $RU = PVU + VJp$; $RU = 51.42-96.28 Jp \pm 1.12 \text{ kg ha}^{-1}$. For the lower Amu Darya is given in table-2 (Khorezm region and the Republic of Karakalpakstan), where + Y - calculation of productivity; PVU - maximum productivity [13].

Table 2. Assessment of soil salinization by spotting irrigation field.

Name of soil by salinity	Productivity% of sustainable on saline soils	Irrigation Field Spot Index	The amount of toxic salts% of air-dry soil
Non-saline	100	$0.00 \div 0.050$	$0.0 \div 0.15$
Slightly salt effected	90	$0.051 \div 0.100$	$0.151 \div 0.30$
Moderately salt effected	70	$0.110 \div 0.38$	$0.301 \div 0.60$
Highly salt effected	10	$0.381 \div 0.480$	$0.601 \div 1.4$
Very highly salt effected	Less than 10	$0.481 \div 1.000$	1.401 and more

Note: When the ratio of soil anions and cations is $SO_{4tox} > Na > Mg > Cl > HCO_3Ca$.

$$J = \frac{\text{area without plants}}{\text{total sown area}} - \text{spot index of irrigation field} \quad (1)$$

Classification of soils by salinity based on the formula $WP = PVU (e - BJp)$; $WP = 39.6 e (-5.0 Jp) \pm 1.7 \text{ qha}^{-1}$; for the Hungry steppe, where e is the base of the natural logarithm (Table 3).

Table 3. Classification of soils by degree of salinity.

Name of soil by salinity	Productivity % of sustainable on saline soils	Irrigation Field Spot Index	The amount of toxic salts % of air-dry soil
Nonsaline	100	$0.00 \div 0.020$	$0.0 \div 0.15$
Slightly salt effected	90	$0.201 \div 0.0711$	$0.151 \div 0.30$
Moderately salt effected	70	$0.0712 \div 0.24$	$0.301 \div 0.60$
Highly salt effected	10	$0.241 \div 0.46$	$0.601 \div 1.4$
Very highly salt effected	Less than 10	0.461 and more	1.401 and more

Note: WP - working productivity.

When the ratio of soil anions and cations is $SO_4^{2-} > Na > Mg > Cl > HCO_3Ca$

Work package at key sites: Studies at a key site are aimed at identifying deciphering features for a qualitative and quantitative assessment of soil salinity.

Studies in key areas are carried out synchronously with the AFS and KFS, while advancing or lagging behind the work by one week in relation to the date of shooting is allowed.

At key sites, they are determined - a map of the relative elevations of the earth's surface of the key sites is Appendix 1:

- Type and degree of salinization of the soil;
- Characteristics of the soil cover;
- Land cover parameters (crop yield);
- Depth and salinity of groundwater.

Requirements for key plots: A key plot should be representative of the study area: by the nature of soil salinization, agrotechnical conditions of soil treatment, plant conditions, and other indicators.

3 Results and Discussion

Over the past three years, the same crop (cotton) should be sown on a key plot. The size of the key site and the amount of work on it are determined by the degree of complexity of the soil-salt conditions, reflected on the materials of the APS and KFS [14, 15, 16].

If the key site characterizes the same type of photocontour, then the detail of the work on it can correspond to the activity of the general soil-salt survey of the massif at a given scale, and the size of the key site will depend on the accepted shooting scale (Table 4).

Table 4. The number of cotton bush subject to phenological observations for farms to justify decoding signs depending on the survey scale.

Scale	The amount of cotton bush to be measured per 100 hectares
1: 10000	50 - 60
1: 5000	100 - 120
1: 2000	250 - 300

Note: The area of the key plot is established in the farm.

The number of key plots is determined by the number of accepted gradations of salinity of soil. If all the requirements are met at key sites, decryption features should be obtained to recognize the contours of different gradations of salinity.

Determination of parameters of the vegetation cover. To obtain the parameters of the vegetation cover, phenological observations are carried out table No. 4:

Measurements of the height of the main stem and the number of tiers;

- Accounting for the number of fruit elements in tiers;
- Accounting for the density of plant standing;
- Accounting for the total area of photosynthesis (leaf surface) per plant;
- Measurement of the thickness of the sheet plate;
- Total weight of raw and dry biomass;
- Diameter of the head stem near the root neck during the selection of a plant sample;
- Projective coverage area.

Phenological observations are carried out at points located uniformly over the area of the key site. The number of points should be at least 50 according to the conditions of reliability of statistical processing. At each point, one plant is selected (typical for development). At the same points, soil samples should be taken for analysis of salinity - the height of the main

stem is measured from the surface of the ground to the point of growth to the nearest whole centimetre. The number of tiers for the main stem is calculated.

The number of fruit elements by tiers is calculated.

Plant density is counted on one running meter in two parallel beds.

To determine the total leaf surface area, all leaves are cut off and the total leaf area is determined.

To measure the thickness of the sheet plate from each tier, a middle sheet (a total of 8-10 leaves) is selected and its thickness is measured. When measuring the thickness of the sheet, it must not be allowed to deform (flatten) at the time of measurement.

To determine the raw biomass, the plant immediately after cutting is weighed on a technical scale. Dry mass is determined after drying to an air-dry state.

The area of the projective cover is determined by measuring the width of the bushes on two parallel rows along the length of several meters and the width of the gap between the rows. More accurate results can be obtained by photographing bushes from a small height.

It is confirmed that for farms specializing in grain production. As a result, this recommendation serves as a guide for the use of mineral fertilizers in multi-branch farms and agro-clusters of winter wheat on soils with different levels of salinity in the conditions of Syrdarya province [11 - 13].

Soil moisture before irrigation on the order of 70-70-60% according to PDNS, seasonal irrigation norm on the open plot of 3200 m³/ha and in inter-row cotton, winter wheat variety Andijan-4 nitrogen-160, phosphorus-100, potassium-70 kg/ha per hectare in norm, Soil moisture before irrigation is about 70-70-60% as compared to PDNS, seasonal irrigation norm of 2850 m³/ha watering technology under irrigated light grey soils of Syrdarya province, changing to grassy, Gulistan 20.0 ha, Saykhunabad 20.0 ha and Khavos 18.0 ha by district, total 58.0 ha. As a result, high yields of winter wheat varieties Andijan-2 and Andijan-4 at all levels of salinity were achieved [3, 4].

To obtain high and high quality grain yield of winter wheat varieties Andijan-2 and Andijan-4 on light sierozem soils of Syrdarya province under grazing, soil moisture before irrigation is 70-70- 60% in relation to PDNS on irrigated background. The technology of field level application was implemented on the area of 20.0 ha in the farm "Nurly zamin tukhfasi" of Gulistan district of Syrdarya province, 20.0 ha in the farm "Shoruzak Nurly Nakak" of Saykhunabad district and 18.0 ha in the farm "Ahmad Khojaev" of Khavos district. As a result, economic efficiency increased owing to saving of mineral fertilizers, profitability level made up 15-20%, additional grain yield reached 1,8-2,4 centners per hectare (Figure 1).



Fig. 1. Soils with different levels of salinity in the conditions of Syr Darya province (the working window of the program (model) created result of experience and research).

4 Conclusions

Calculations for the management of water, thermal and nutrient regimes in irrigated fields is a very important component in solving practical problems. Such calculations, based on the methods of static or mathematical modeling, can be applied only if the laws governing the movement of nutrients in salts, water, and heat from the medium to the plant are known.

To study these processes in different soil-reclamation conditions, we have laid down field experiments on cotton fields at selected reference sites in the Republic of Karakalpakstan, Khorezm and Syrdarya regions.

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