Effect of soil properties on yield, quality and soil quality score of food crops

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Abstract

The article presents the properties and characteristics of irrigated soils distributed in the Mirzachol oasis. Correlative relationships between soil properties, such as soil mechanical composition, humus content and salinity level, and yield of winter wheat, soybean, and its technological indicators have been determined. Based on the obtained yield indicators, the soil quality assessment for these crops was calculated. Calculation of crop yield based on soil quality scores, calculation of average soil quality score on the example of one array is also covered.

Keywords: Soil, Salinity, Mechanical composition, Physical clay, Dry residue, Winter wheat, Soy, Gluten, Protein, Correlation, Main scale validation coefficient.

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Introduction

To ensure a secure and stable food supply is, arguably, the world's most critical challenge in the present (Nair and Reddy, 2024). To achieve this, however, is not merely a matter of correct selection and growing of crops but an understanding of the overall environmental and economic factors influencing agricultural output. Among these, soil conditions and climatic factors are fundamental in establishing crop yields and quality. Soil fertility, water-holding capacity, soil organic matter content, and salinity content immediately affect plant growth, nutrient acquisition, and total yield. Grain and legume crops are particularly dependent on soil characteristics, as they have precise demands for optimal growth (Balavandi, 2017).

Poor soil management, soil degradation, and salinization can significantly decrease agricultural production and crop quality, worsening food security and economic stability in the agri-food sector (Aseeva, 2009). Therefore, the research on soil characteristics and agricultural productivity is theoretically and practically significant. Better understanding of these relationships facilitates scientists and farmers to use more efficient soil management, optimize land use, and enhance sustainable agriculture (Bosco, 2016). By means of scientific research and practical application, improvement of soil can lead to increased agricultural efficiency and sustainable food security (Karimov and Bobur, 2024).

Literature review

Oldfield and others studied the effect of soil organic matter content on the yield and quality of maize and wheat crops (Oldfield *et al*. 2019). It was found that there is a strong correlation between the amount of organic matter and humus in the soil and the yield of these crops. Based on the data obtained, it was possible to predict the yield of these crops.

Zotikov, Sidorenko, Matveichuk conducted special experiments to study the effect of soil properties on the yield and quality indicators of winter wheat and soybeans (Zotikov, Sidorenko and Matveichuk, 2020). It was found that the gluten and protein content in winter wheat grains and the dry protein content in soybeans are directly related to the quality score of the soil9 (Tehulie and Tola, 2020).

Shogenov and Kishev determined the effect of soil agrophysical properties on wheat productivity (Shogenov and Kishev, 2023). It is noted that it gives high yields in well-cultivated soils with a fine-grained structure, free from various diseases, pests and weeds.

Aseeva distinguished the factors affecting the productivity of grain crops and soybeans, identified correlational relationships between them (Aseeva, 2009). Principles of soil quality assessment were developed based on the obtained data. It is noted that the mechanical composition of the soil is the main factor affecting the productivity of crops.

Nuru Seid and Tarikua Shumi recognized that the amount of organic matter in the soil is one of the main factors shaping wheat yield (Nuru Seid *et* *al.* 2020). There are many factors that affect the yield and quality of crops, and they depend on the natural and climatic conditions of each region.

Bisht, Sah, Satyawali, Tewari, Kandpal studied the effect of soil quality assessment on wheat yield (Bisht *et al*. 2018). In addition to soil nutrients, crop productivity is also influenced by agroecological conditions.

Osipov, Khatkov, Mamsirov, Makarov, Laura L. Van Eerd, Katelyn A. Congreves, Adam Hayes, Anne Verhallen, David C. Hooker provided general information on the properties of soils. They studied the influence of soil properties on the productivity of agricultural crops, and determined the correlation between them. The high productivity of crops also affects its quality indicators. They emphasized that it depends on biological characteristics of crops, soil conditions and variety (Osipov, 2018; Khatkov, Mamsirov and Makarov, 2021).

Information on the soils of Mirzachol oasis, their properties and quality assessment was obtained and analyzed (Turdimetov and Esonboyeva, 2023; Turdimetov, 2024; Turdimetov and Khudoyberdiyeva, 2023; Turdimetov and Khudoyberdiyeva, 2024; Turdimetov, 2024; Arabov *et al.* 2021). The soil quality assessment data is based on the example of the cotton crop, and the main assessment scale and assessment coefficients were calculated according to the method developed for this crop (Sh, 2023). It is known that different crops have different requirements for soil fertility. Therefore, this work, devoted to the development of soil quality assessments for winter wheat and soybean crops used as food, can be considered to be relevant (Narayan & Balasubramanian 2024).

Research Object and Methods

As a research object, irrigated meadow-gray and meadow soils were used in the old developed part of the Mirzachol oasis. When placing the soil cross-sections, the areas that are typical for the soils of this region were selected. Researches were carried out in fields planted with winter wheat and soybean crops in Gulistan district and Saykhunabad district of Syrdarya region. The reference points were selected, the productivity of wheat and soybean crops was determined (Sh, Urazalieva and Esonboeva, 2023). Correlations between soil properties and crop yield and quality were determined. To determine the base grading score and grading coefficients, the property with the highest yield was considered to be 100 points (1.00 coefficient), and the remaining coefficients were calculated as percentages of this yield (Sh, Khudoyberdiyeva and Tadjibayev, 2023).

Research results

The soil of the research site consists of irrigated gray-meadow soils and belongs to semi-hydromorphic soils. The mechanical composition of the soil directly depends on the parent rocks. Long-term irrigation significantly affects the mechanical composition of gray soils. There is a law of increasing the amount of clay both in the arable layer and in the sub-arable layer.

Typical for gray soils, these soils are also dominated by “large dust” (0.05-

0.01 mm) particles (Table 1). The amount of particles larger than 0.25 mm is high in sections 2 and 10, reaching 10 percent. The amount of particles 0.25-0.1 mm is high in section 2, around 20 percent. In the remaining soil sections, it is 1.0-5.0 percent.

Table 1: Mechanical composition of the soil of the research object, %.

Incision No	Depth, cm	>0,25	0,25-0,1	0,1-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	Physical clay
2	0-30	8,3	20,7	19,4	19,1	1,6	16,7	14,3	32,6
	30-50	9,1	21,8	14,3	19,1	9,5	13,5	12,7	35,8
	50-70	8,1	22,7	10,4	19,1	8,7	19,1	11,9	39,8
8	0-30	1,1	1,2	13,4	43,3	8,3	19,9	12,7	40,9
	30-50	0,4	0,6	14,0	44,5	8,7	19,9	11,9	40,5
	50-70	0,3	0,5	12,5	44,9	13,9	15,1	12,7	41,7
10	0-30	5,3	5,6	20,8	35,8	9,5	17,5	5,6	32,6
	30-50	11,6	5,5	23,3	31,0	8,0	16,7	4,0	28,6
	50-70	9,6	5,9	24,9	33,8	6,8	14,3	4,8	25,8
13	0-30	2,1	6,3	17,8	40,1	9,1	13,5	11,1	33,8
	30-50	1,0	1,7	10,0	46,9	15,9	13,5	11,1	40,5
	50-70	0,6	1,4	8,2	47,7	16,7	13,5	11,9	42,1

One of the main indicators of soil quality is the level of nutrient supply. The amount of nitrogen in the soil is distributed depending on the amount of humus, and is relatively higher in the upper layers (Table 2). In the topsoil of both plots, its content was 0.43-0.44 percent. Towards the bottom, its content decreased to 0.065 percent.

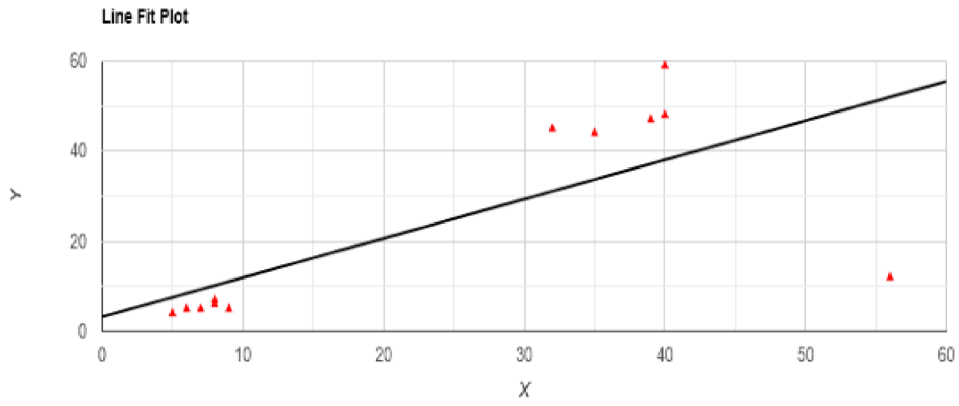
Table 2: Agrochemical properties of irrigated gray-meadow soils

No	Depth, cm	N, %	Plenary, %		Active, mg/kg	
			P2O5	K2O	P2O5	K2O
1-22	0-31	0,130	0,195	1,320	52,6	210,0
	31-52	0,120	0,124	1,290	32,6	110,0
	52-89	0,104	0,107	1,280	-	-
	89-100	0,080	0,096	1,160		
	100-150	0,065	0,088	1,070		
2-22	0-30	0,140	0,165	1,410	35,0	190,0
	30-70	0,136	0,265	1,480	20,2	100,0
	70-91	0,122	0,180	1,300		
	91-102	0,100	0,105	1,248		
	102-160	0,076	0,122	1,117		

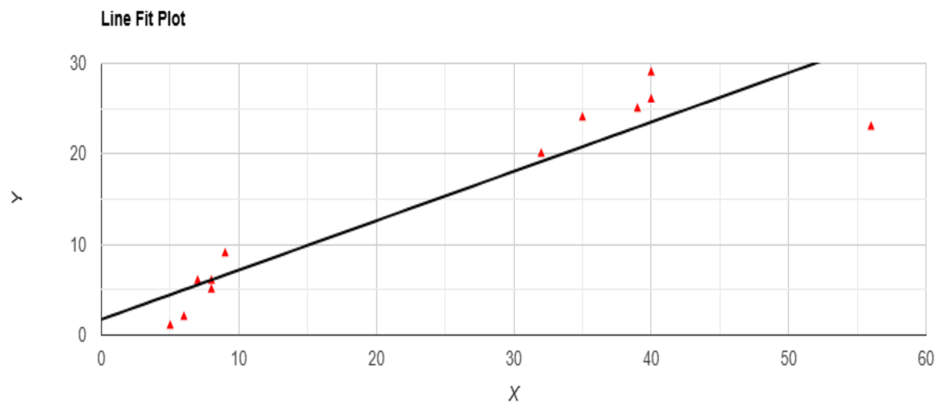
The amount of mobile phosphorus in the topsoil is 52.6 mg/kg, and the soil's level of supply of this element belongs to the "moderate" supply group. In other cases, it belongs to the "low supply" group. Because gray soils are rich in calcium carbonates, there is a high probability of formation of calcium phosphates in the soils, therefore, the amount of mobile phosphorus in these soils is low compared to other soils.

In terms of the amount of exchangeable potassium, these soils belong to the groups of "poorly supplied" and "moderately supplied soils". Both soils have a relatively high index in the topsoil layer of the cross-section. In the subsoil layer, it is slightly lower.

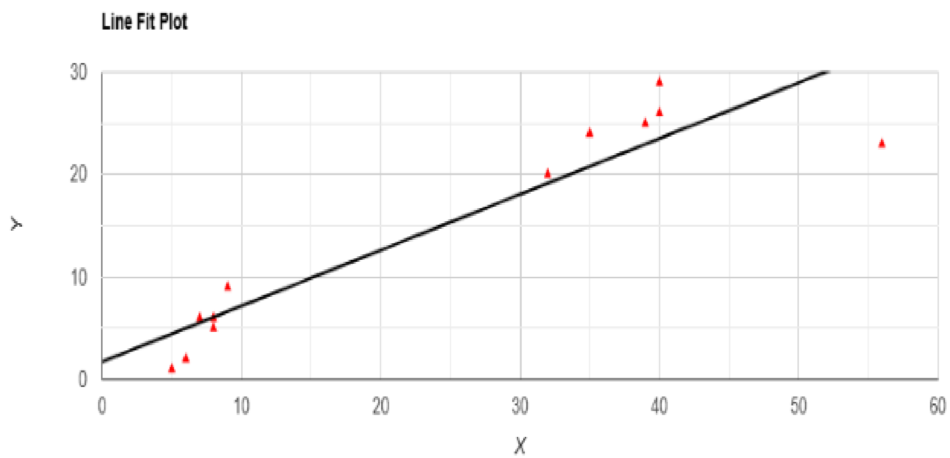
Below is information on correlations between soil mechanical composition, soil salinity, and wheat and soybean crop yields and crop quality (Figure 1).



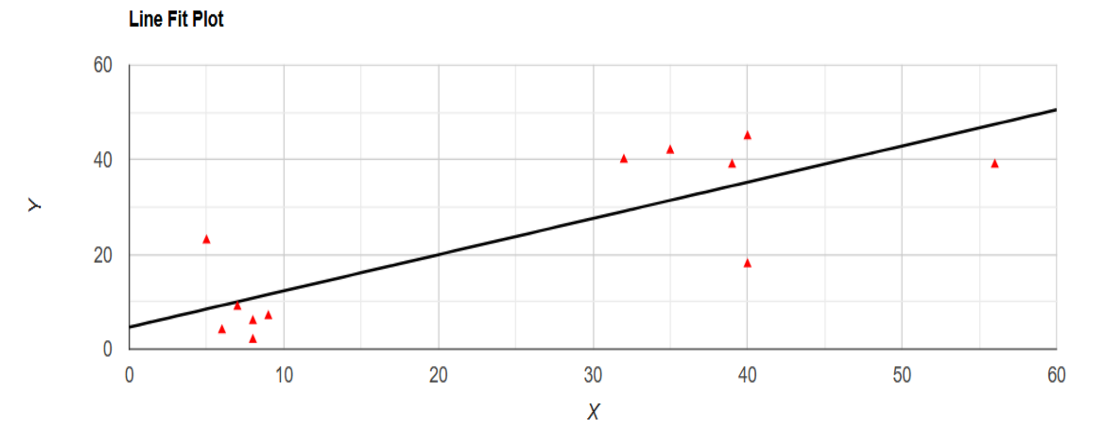
Correlation between the amount of “physical mud” and winter wheat yield r=0.71



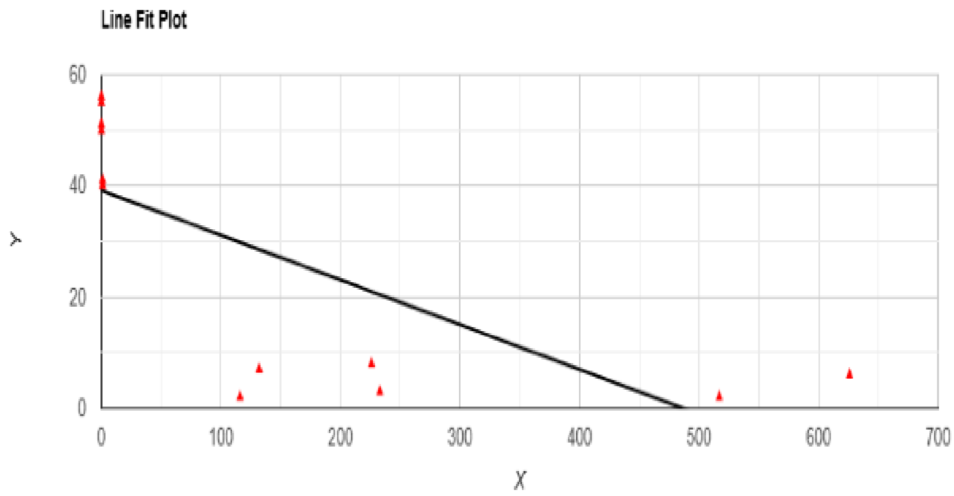
Correlation between the amount of “physical mud” and the gluten yield of winter wheat r=0.93



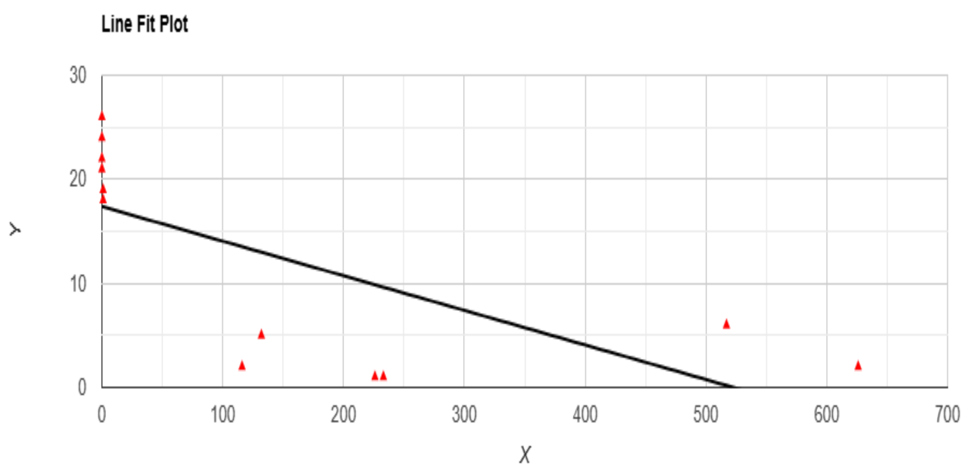
Correlation between the amount of “physical mud” and soybean yield r=0.78



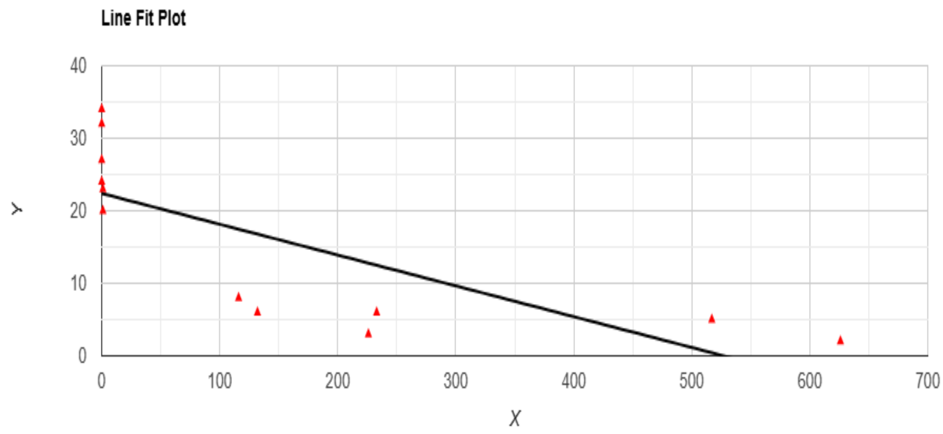
Correlation between the amount of “physical mud” and soybean yield protein r=0.81



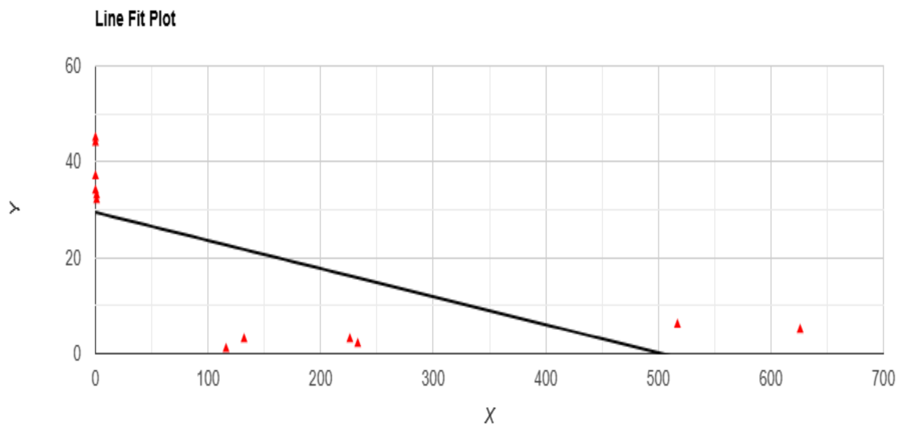
Correlation between soil salinity level and winter wheat yield r=-0.73



Correlation between soil salinity level and winter wheat gluten yield r=-0.71



Correlation between soil salinity level and soybean yield r=-0.76



Correlation between soil salinity level and soybean yield protein r=-0.68

Figure 1. Dependence of soil properties and indicators of yield and quality of food crops.

The amount of "physical mud" in the soil was taken as the basis for studying the correlation between the mechanical composition of the soil and crop yield and quality indicators. The correlation coefficient between the amount of "physical mud" and winter wheat yield was 0.71.

One of the main indicators of wheat yield is the amount of gluten in its grain. The correlation between this indicator and the amount of "physical mud" showed a correlation of 0.93, which indicates the existence of an organic relationship. Also, it was found that there is a sufficient relationship between the productivity and quality of the soybean crop.

Soil mechanical composition is one of the important indicators of soil productivity. Soils with a heavy mechanical structure contain a lot of nutrients, water, and have a high holding capacity. However, it is poorly permeable to water and air, and has a lot of resistance during processing. Light soils have low nutrient and water content, low holding capacity, high filtration capacity, high aeration, and low tillage resistance.

When creating a basic scale for qualitative assessment of irrigated soils, it is advisable to take the genetic dependence and mechanical composition of soils as a basis. It is necessary to take into account the genetic dependence of soils because almost all properties of soils are, to one degree or another, related to their genesis. For example, the humus content or mineralogical composition of soils is directly related to their genetic makeup.

One of the factors affecting the quantity and quality of agricultural crop yields is soil salinity. The relationship between the quantity and quality of salt in the soil and crop yields is very complex and has not yet been sufficiently studied. This is one of the reasons why plants have different levels of salt tolerance during different phases of growth and development. For the normal growth and development of cultivated plants, not only the total amount of salts in the soil, but also their chemical composition (qualitative composition) plays an important role. Therefore, it is very important to determine salinity levels based on the chemical composition of the salts.

Our experiments show that there are correlations between winter wheat yield and quality indicators and soil salinity levels (r=-0.71-0.73). The correlation between soybean yield and soil salinity levels was -0.76. There is also a correlation between soybean yield protein and salinity levels, i.e. r=-0.68.

On the basis of the obtained mathematical statistics data, it was possible to calculate the basic scale of soil evaluation and the evaluation coefficients. The soil base grading scale for irrigated pasture-gray and gray pasture soils is light loam-90 points, medium loam-100 points, and light loam-85 points for winter wheat crops, and light loam-85, medium loam-100 points, and light loam-85 points for soybean crops.

Validation coefficients for soil salinity are presented in Table 3.

Table 3: Weighting coefficients according to the degree of soil salinity.

No	Salinity level	For wheat crop	For soybean crop
1	Unsalted	1,00	1,00
2	Lightly salted	0,85	0,80
3	Moderately salty	0,70	0,60

Looking at the data in the table, comparing the two crops, it can be observed that the wheat crop is more salt tolerant than the soybean crop. Soybean yield was reduced by up to 20% in weakly saline soils and up to 40% in moderately saline soils compared to non-saline soils.

Discussion

The study is in line with the observation that soil properties play an enormous role in controlling winter wheat and soybean yield and quality. The results suggest that mechanical structure, organic matter, and salinity are of prime significance in regulating crop yields. Physical clay content in the soil increases positively with winter wheat yield (r = 0.71) and gluten content (r = 0.93), as supported by observations by Oldfield *et al*. (2019). Their research confirmed that soil organic matter improves nutrient retention and plant growth. Similarly, Zotikov *et al.* (2020) confirmed that wheat grain quality depends on soil fertility, highlighting the importance of well-structured soils to obtain better yields. Crop productivity is adversely affected by soil salinity.

The correlation between soil salinity and wheat yield is -0.73, and for gluten content, it is -0.71, which means that increased salinity reduces both quantity and quality. Soybeans are more susceptible, with yield and protein content showing negative correlations of -0.76 and -0.68, respectively. This is supported by Arabov *et al.* (2021), who discovered that salinization of soil in irrigated land is unfavorable to crop production. Turdimetov *et al.* (2023) also emphasized the need to reclaim soil in order to offset salinity and promote crop performance. The study establishes a scale of soil quality evaluation of winter wheat and soybean crops. Soil texture and salinity analysis were utilized to grade coefficients in determining land suitability for assessment.

Osipov *et al.* (2018) previously mentioned the importance of such assessments in crop yield estimation and soil management improvement. Similarly, Turdimetov *et al.* (2024) studied gypsum and hydromorphic soils in Mirzachol and concluded that soil composition affects crop potential directly. This study bases its findings on those conclusions by creating more sophisticated methods of soil evaluation and yielding valuable suggestions for land use. The research emphasizes the necessity for sustainable soil management. Organic matter enhancement, lowering salinity, and optimizing the mechanical structure all have the capacity to greatly raise crop yield. These results also concur with Van Eerd *et al.* (2014), which provided evidence that tillage in the long term coupled with crop rotation maintains healthy soils. Aseeva (2009) similarly emphasized fertility and soil structure to be important components of the viability of agriculture. This research provides scientific basis for optimizing soil management practices and agricultural yields. Monitoring soil health for the long term, integrated soil fertility management, and expansion of the research to other areas and crops can be done in subsequent studies. Soil properties will be understood, and proper agricultural planning and sustainable food production will be achieved.

Conclusion

By learning about the relationship between crop yield and soil properties, scientists and farmers can make informed choices about optimal location of crops, such that each crop is placed in the most suitable soil condition. By understanding how factors such as soil texture, organic content, water-holding capacity, and salinity influence plant growth, agricultural scientists can optimize productivity and sustainability.

Mathematical and statistical use in soil science significantly increases the reliability of data and measurement accuracy of soil fertility and agricultural yield. Novel and more accurate methods of analytical studies form a solid basis for precise measurement of agricultural productivity versus soil properties with reduced uncertainty levels. Advanced statistics facilitate easier formation of patterns, establishment of forecasting models, and identification of resource management, ultimately leading to effective agricultural farming.

The development of a standard scale of assessment and grading coefficients is a handy tool for quantifying soil quality and predicting crop yields. With the application of these models of assessment, it is likely to classify soils based on their suitability for use with specific crops taking into consideration fertility, nutrient availability, and water holding capacity. This planned approach, besides aiding in land-use planning, also assists in more productive decisions in the agricultural policy and investment, promoting sustainable agriculture as well as longer-term food security.

References

Arabov, S., Abdurakhmonov, N., Bakhodirov, Z. and Sobitov, U., 2021. Salinization processes in irrigated soils of Mirzachul. In: *Halt Soil Salinization, Boost Soil Productivity – Global Symposium on Salt-Affected Soils*, 20–22 October 2021. Proceedings, pp. 4–5.

Aseeva, T.A. 2009. Agroecological bases of formation of productivity of grain crops and soybeans in conditions of the Middle Amur region. *Abstract of dissertation for the degree of Doctor of Agricultural Sciences.* Settlement Timiryazevsky.

Balavandi, S., 2017. Further study industrial production in hemp crops agriculture. *International Academic Journal of Science and Engineering*, *4*(1), pp.123-127.

Bisht, N., Sah, V.K., Satyawali, K., Tewari, S. and Kandpal, G., 2018. Assessment of soil quality and wheat yield under open and poplar based farming system in Tarai region of Uttarakhand. *Indian J. Agric. Res*, *52*(1), pp.101-103. https://doi.org/10.18805/IJARe.A-4799

Bosco, N.J., 2016. Farmers' Perceptions on Maize Varieties in Rwanda: A Case Study of Smallholder Farmers in Rwimbogo Sector in Gatsibo District. *International Academic Journal of Innovative Research*, *3*(9), pp.1-8.

Karimov, Z. and Bobur, R., 2024. Development of a food safety monitoring system using IoT sensors and data analytics. *Clinical Journal for Medicine, Health and Pharmacy*, *2*(1), pp.19-29.

Khatkov, K.Kh., Mamsirov, N.I. and Makarov, A.A. 2021. Evaluation of the effectiveness of the crop rotation link "soybean-winter wheat" and its impact on soil properties. *New Technologies*, 17, pp. 134–135.

Nair, R. and Reddy, D., 2024. Sustainable Food Systems for Reducing Food Waste and Loss. *International Journal of SDG's Prospects and Breakthroughs*, pp.18-23.

Narayan, A., and Balasubramanian, K. (2024). Modeling Fouling Behavior in Membrane Filtration of High-Fat Food Emulsions. *Engineering Perspectives in Filtration and Separation*, *2*(1), 9-12.

Oldfield, E.E., Bradford, M.A. and Wood, S.A., 2019. Global meta-analysis of the relationship between soil organic matter and crop yields. *Soil*, *5*(1), pp.15-32. https://doi.org/10.5194/soil-5-15-2019

Osipov, A.A. 2018. Influence of elements of cultivation technologies on the yield and quality of winter wheat grain in the southwest of the central region of Russia. *Abstract of the dissertation for the degree of Candidate of Agricultural Sciences. Bryansk.*

Sh, T., 2023. Esonboyeva N. Mirzaobod tumani gidromorf tuproqlarinig xossalari. *Eurasian Journal of Technology and Innovation*, *1*(5), pp.81-85.

Sh, T., Khudoyberdiyeva, Z. and Tadjibayev, A., 2023. Quality Assessment of Gypsum Soils of Mirzachol Oasis. *Journal of Population Therapeutics and Clinical Pharmacology*, *30*(12), pp.295-301.

Sh, T., Urazalieva, M. and Esonboeva, N., 2023. Properties and Quality Assessment of Hydromorphic Soils of Mirzachol Oasis. *Eur. Chem. Bull*, *12*, pp.3992-4000.

Shogenov, Yu.M. and Kishev, A.Yu., 2023. Influence of predecessors on winter wheat yield by zones of the Kabardino-Balkarian Republic. *Bulletin of the Kabardino-Balkarian State Agrarian University named after V.M. Kokov*, 1(39), pp. 38–44.

Tehulie, N.S. and Tola, T.S., 2020. The effect of organic and inorganic fertilizers on growth and yield of bread wheat (Triticum aestivum L.). *Curr Investig Agric Curr Res*, *9*(1), pp.1161-1166.https://doi.org/10.32474/CIACR.2020.09.000302

Tiwari, G., Tuteja, G., Jadhav, Y. and Selvarajan, S., 2025. Performance of Biodegradable Packaging Films Containing Essential Oils for Food Quality Maintenance. *Natural and Engineering Sciences*, *10*(1), pp.468-478. https://doi.org/10.28978/nesciences.1660349

Turdimetov, S.M., Musurmanova, M.M., Urazalieva, M.D., Khudayberdieva, Z.A., Esanbayeva, N.Y. and Xo'jabekova, D.E., 2024. Morphological features of mirzachol oasis soils and their changes. *Acta Innovations*, *52*, pp.1-8. https://doi.org/10.62441/ActaInnovations.52.1

Turdimetov, Sh.and Esonboyeva, N. 2023. Reclamation status of soils of Mirzaabad district. *International Scientific and Educational Electronic Journal "Education and Science in the 21st Century"*, 37(3), pp. 67–73.

Turdimetov, Sh.M. & Khudoyberdiyeva, Z.A., 2023. Agrochemical characteristics of irrigated meadow and pasture soils planted with winter wheat. *GulSU Newsletter*, (2), pp. 73–76.

Turdimetov, Sh.M. & Khudoyberdiyeva, Z.A., 2024. Properties of irrigated soils planted with wheat crops. *Bulletin of the Khorezm Mamun Academy*, (8/1), pp. 159–162.

Turdimetov, Sh.M., 2024. Soil quality assessment. Tashkent: Uzbekistan Publishing House.

Van Eerd, L.L., Congreves, K.A., Hayes, A., Verhallen, A. and Hooker, D.C., 2014. Long-term tillage and crop rotation effects on soil quality, organic carbon, and total nitrogen. *Canadian Journal of Soil Science*, *94*(3), pp.303-315. https://doi.org/10.4141/cjss2013-093

Zotikov, V.I., Sidorenko, V.S. and Matveichuk, P.V. 2020. Productivity and grain quality of winter wheat and soybean varieties at LLC "Dubovitskoe". *Leguminous and Cereal Crops*, 1(33), p. 98.