Ways to restore the fertility of Mirzachul soils

Muhammad Umarov 1*, Bekzod Inomov2

1Tashkent State Agrarian University, University str., 2, 100140, Tashkent, Uzbekistan
2“Ozdaverloyiha” state scientific-design institute, Chopon ota str., 100170, Tashkent, Uzbekistan

Abstract. The soil is a vital and valuable public resource that forms the foundation of a country's prosperity and supports its productivity. Its importance primarily derives from its essential role in agriculture, which is a key factor in a nation's economic growth and stability. In order to assess the effectiveness of corn as a protective crop in increasing resistance to soil erosion, a field experiment was conducted involving four treatment options for cotton crops. The first option served as a control, using the typical fertilizer rates found in local farming practices (N250 P150 K80), and growing cotton without any additional measures. The results depicted that Corn strips that were 20-25 meters wide were effective in shielding cotton crops from wind. The width of the cotton crop, however, varied from 130-135 meters, contingent upon the mechanical composition of the soil. Our observations suggested that the bulk of wind-borne dust (also known as "dust") traveled at a height of 0-50 cm, which could enter the cotton plants and harm them.

1 Introduction

The soil is an invaluable and vital public asset that constitutes the cornerstone of a nation’s wealth and underpins its productive capacities. Its significance primarily stems from its crucial role in the agricultural sector, which is a crucial component of a country’s economic stability and development. The judicious and efficient utilization of soil is thus a matter of utmost national importance, as it serves as a vital means of meeting the food demands of the populace and promoting agricultural growth.

The agricultural sector of Uzbekistan has entered a new phase of structural changes following the introduction of the Strategy of Actions under the guidance of President Shavkat Mirziyoyev [1]. Despite the advancements in science and technology globally, the depletion of natural resources for economic gains has led to significant environmental degradation, including soil depletion, quarrying, deforestation, and indiscriminate soil usage to increase crop yields. Additionally, the use of heavy machinery in crop fields has resulted in the violation of granularity [3]. According to the Food and Agriculture Organization (FAO), a third of the global soil cover has been degraded to varying degrees, and desertification is currently observed on 23 hectares of land every minute [2].

In Uzbekistan, the efficient utilization of land resources, particularly irrigated soils, is crucial for sustaining and increasing their productivity. Identifying the limiting factors that hamper soil productivity and developing a scientific basis to address them are paramount.

*Corresponding author: umarov.7878@mail.ru

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Currently, various forms of erosion, including soil deflation, are prevalent, affecting over 2 million hectares of irrigated land. Evaluating and studying the condition of these deflation-prone lands and implementing anti-erosion measures are pressing issues in the agricultural sector.

Organizational-economic, agro-technical, and forest-reclamation activities are necessary to combat wind erosion and other forms of erosion. Properly organizing anti-erosion measures based on the unique topography of the soil and the cultivation of crops is essential. In 2003-2006, 11 key areas, including Mirzachul (Jizzakh and Syrdarya regions), were identified as research objects for addressing these issues. In addition, a 2-hectare pilot plot was selected for field experiments from “Chilonzor” AHM in Zomin district of Jizzakh region.

2 Materials and methods

The research was conducted using established methods in the field of soil science, as referenced in several academic sources [1-6]. In order to assess the effectiveness of corn as a protective crop in increasing resistance to soil erosion, a field experiment was conducted involving four treatment options for cotton crops.

The first option served as a control, using the typical fertilizer rates found in local farming practices \( (N_{250} P_{150} K_{80}) \), and growing cotton without any additional measures [1-7, 11-13]. The other three options involved planting corn alongside the cotton using the same fertilizer rates, but in varying quantities of corn rows: 3, 6, and 12 rows. The aim of the experiment was to evaluate the impact of these agrotechnical measures on soil erosion resistance [1-4, 13].

In the conducted field experiment, corn (Zea mays) was planted as a cover crop perpendicular to the wind direction with 90 cm spacing between rows. The soil’s mechanical composition, volume weight, soil moisture before and after irrigation, and NPK levels were measured before the experiment and at the end of the growing season across four experimental options. Soil samples were collected from 0-30, 30-50, 50-70, and 70-100 cm depths to determine the amount of mobile forms of NPK.

Water-resistant aggregates were analyzed in samples collected from 0-5, 5-15, and 15-30 cm layers seven days after irrigation. Additionally, the growth and development of cotton were monitored on June 1, July 1, and August 1 [1-7]. These measures were taken to assess the impact of planting corn as a protective crop on soil erosion resistance and the biological performance of cotton [11-13].

3 Results and discussion

Mirzachul region’s soils exhibit varying mechanical compositions that are linked to both soil-forming rocks and human irrigation-economic activities. The region’s primary soil-forming rocks include alluvial, proluvial-alluvial, lake-alluvial, loess, loess-like sands, alluvial-proluvial, and deluvial-proluvial deposits. The mechanical structure of the soils ranges from heavy sands to sandy loams, with distinct differences in mechanical composition observed at the boundary of each soil section. Our study focused on the meadow and gray-meadow soils of Mirzachul and found that these soils are rich in large dust fractions (0.05-0.01 mm particles), with their quantity ranging from 41 to 63% in the upper one-meter layer, except for section 19. Notably, section 19, located in the central part of Mirzachul (Mehnatabad district, “Pakhtakor” company), which characterizes newly irrigated gray-meadow soils, has a high content of fine sand particles (0.25-0.05 mm) ranging from 47 to 67% and uniformly distributed [9, 12] (Fig. 1).
Fig. 1. Deflation risk map of the soils of “Galaba” farm (Zomin district) Scale 1:5,000.

The mechanical composition of gray-meadow soils is characterized by the significant presence of fine sand fractions in the upper layers, surpassing the sum of medium and fine dust fractions in the one-meter layer of the soil. Analysis of irrigated gray-meadow soils showed that the upper layer contains 30-55% of large dust fractions, while the lower layer has 45-68%. The percentage of medium and fine dust fractions ranged from 3-15% in different regions. Microaggregates of 0.25-0.01 mm particles accounted for 80-95% of the soil, with 0.25-0.05 mm microaggregates observed in 30-45% of samples. Microaggregates smaller than 0.01 mm were present in 0.5-3% of samples, and were mainly found in particles of 0.1-0.05 and 0.05-0.01 mm. Large dust particles were the primary constituent of microaggregates in the soil-forming rock of the area. According to N.A. Kachinsky’s method, the percentage of microaggregates in old and newly irrigated light-medium sandy meadow soils, old and newly irrigated light sandy gray-meadow soils was found to be low, ranging from 27-46% and 54-86%, respectively (Fig. 2).

Fig. 2. Deflation risk map of the soils of the “Mirzachul” company farm (Mirza Abad district) Scale 1:5,000

Based on statistical analysis, the aggregate composition of non-deflated soils with heavy mechanical composition in key areas can be explained as follows: The coefficient of wind resistance K, which is the ratio of <1 mm aggregate mass to >1 mm aggregate mass sum, is large and ranges from 3.6-5.0 in both old and newly irrigated meadow soils. In deflated soils, K decreases significantly to 1.7-1.9. The amount of eroded aggregates in the upper layer of pollinated soils increases by 2-3 times compared to non-deflated soils. Mirzachul, a region in Uzbekistan, is vulnerable to wind erosion, particularly in soils with a light mechanical composition. This erosion causes a decline in soil productivity and fertility, leading to a 30-40% loss of cotton crops in some farms during years of increased dust storms.
The pollination of irrigation fields creates pits in the upper layer of the soil, which are then covered with a new layer of soil. Repeated replanting of crops in these areas results in a slight reduction in average yield and mostly low-quality cotton harvests. To mitigate the risk of deflation on irrigated land, it is advisable to create large, medium, and small-scale maps of deflation risk. This is particularly useful in agriculture, as compacted working maps can make it difficult to identify soil types and classify them according to hazard levels.

In order to create an accurate soil map of the key points studied in our research in this regard, a map of small and medium-scale deflation risk of irrigated soils was created and the levels were classified based on the methods of Q.M. Mirzajonov [8, 9] and S.M. Elyuboev [2]:

- **Level I** – 100% no risk of deflation;
- **Level II** – 95% weak deflation risk, 5% no deflation risk;
- **Level III** – 55% moderate risk of deflation, 30% weak, 15% no risk;
- **Level IV** – 70% strong deflation risk, 20% weak, 10% no risk;
- **Level V** – 80% very strong risk of deflation, 15% weak, 5% no risk [7];

The soils under investigation, namely semi-hydromorphic (gray-meadow) and hydromorphic (meadow, meadow-swamp) soils, were categorized into four groups based on deflation risk. To combat wind erosion, field protective (backdrop) crop strips are crucial. Changes in wind regimes, temperature, air humidity, moisture evaporation from soil and plants, snow distribution, water regime of the soil, and ground water level are felt due to these measures. Protective crop strips absorb wind resistance, reduce horizontal wind speed, and separate eddies from the surface of the earth. They also have a positive impact on the water balance of crops by weakening drought in the summer and enabling efficient use of accumulated moisture in the soil. Windbreak crop strips also dramatically decrease the force of the wind, dust storms, and their effects on crops such as cotton. The width of fields with wind erosion should not exceed 150-160 meters, and their length can be 100 meters or more. It is necessary to support agrotechnical or chemical measures against wind erosion until crop strips reach a certain height to protect the soil from wind erosion. These measures have low cost and high efficiency and are directly linked to agricultural production, representing a critical component of agrotechnics for growing crops on eroded soils.

Protective crops were used to safeguard irrigated soils against wind erosion. Corn strips that were 20-25 meters wide were effective in shielding cotton crops from wind. The width of the cotton crop, however, varied from 130-135 meters, contingent upon the mechanical composition of the soil. Our observations suggested that the bulk of wind-borne dust (also known as "dust") traveled at a height of 0-50 cm, which could enter the cotton plants and harm them. A 2-meter-high protective barrier, such as corn, could trap this dust and prevent it from infiltrating the cotton field. Practical research had demonstrated that alfalfa, grown under wheat or rye, could effectively control dust and safeguard the soil from deflation. During the cotton planting season (early April), the height of alfalfa and wheat reached 40-50 cm, and by May, it had reached 90-100 cm. Planted alfalfa not only protected the soil from wind erosion but also enhanced the fertility of deflated soils. Cotton-alfalfa rotations were also studied and introduced as an erosion control measure.

The tall stems of cover crops offered excellent protection against pollination of the soil. The spacing of protective planting bushes, consisting of plants in 3, 6, and 12 rows, was 8-10 cm and was oriented perpendicular to the wind direction [9, 12]. Cover crops were a powerful tool in defending the soil from wind erosion, reducing the wind speed in the surface air layer and distributing it uniformly across the field.
4 Conclusion

To protect soil from erosion, cover crops such as winter wheat, sorghum, corn, and sudan grass can be used. These fast-growing crops can be spaced 15-25 meters apart, with a maximum width of 2-2.5 meters for each protective crop. Sowing of winter wheat and rye is carried out in autumn, with the row spacing pre-softened to a depth of 7-9 cm using a softener device. Adequate watering of wheat should be provided 2-3 times before the end of the growing season, and ammonium nitrate should be applied at a recommended rate of 100 kg/ha of pure nitrogen in the spring.

In order to prevent soil deflation in forest strips and horticultural crops, chemical preparations such as K-9, TNM-1, and bentonites can be used for 1-3 years during the period of activity. These preparations increase the productivity of humus and enhance nutrient availability in deflated soils.

It was found that cover crops with tall stems provide effective protection against soil erosion caused by wind. Planting bushes for protection are spaced at 8-10 cm intervals and oriented perpendicular to the direction of the wind. These protective measures reduce wind speed in the surface air layer and promote even distribution of wind over the entire field.

References

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