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Biogeochemistry of Irrigated Desert Soils and Vegetable Crops in Uzbekistan

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A B S T R A C T

Nowadays, owing to the increasing requirements for environmentally friendly products such as vegetable crops, it is necessary to study their macroelement and microelement compositions. In this regard, we studied the elemental composition of onion and fennel organs as well as newly irrigated and old-irrigated gray-brown soils. The study of soils was carried out according to the method of V.V.Dokuchaev, and determination of sodium, potassium, calcium, iron, strontium, nickel, barium, and chlorine in soils and plant organs was carried out using the neutron-activation method. Biogeochemical properties of soils and plants were determined according to the method of Perelman and Glazovskaya. It was determined that the highest chlorine content corresponds to the roots of onions grown on old-irrigated gray-brown soils, followed by the leaves and head. As for the content of other elements in onions, they are in decreasing order: potassium > sodium > iron > strontium > nickel > calcium > barium; the same pattern is repeated in dill. The sequence of changes in the amounts of chemical elements in the underground and aboveground parts of fennel (*Anethum graveolens L.*) differed slightly from those in the soil: potassium > sodium > iron > strontium > nickel > barium > calcium. This corresponds to the law of selective absorption of these plants.

Introduction

Scientific research on a number of priority directions is carried out worldwide aimed at determining the balance of chemical elements in irrigated soils under the influence of agriculture from the point of view of ecological safety, elimination of their negative consequences, issues of quantity, quality, and toxicology of chemical elements. In this regard, special attention is paid to scientific research related to the determination of ecological and ameliorative state, geochemical and biogeochemical properties of soils under the influence of anthropogenic factors, assessment of the importance of soil fertility and ecological state, and cultivation of ecologically clean vegetable products.

It is known that most chemical elements of the periodic system of D. I. Mendeleev, with the exception of elements obtained artificially, are present in various quantities and qualities in plant organs, including agricultural crops such as onions. White and red varieties of onions have antibacterial, antiviral, and antioxidant

effects and also serve as therapeutic agents for human cardiovascular diseases (Upadhyay, 2016). The above properties of onions, along with others, are related to their chemical elemental composition.

The essential oils of onions impart a specific odor, that is, a distinctive taste. The amount of essential oils in onions varies depending on soil and climatic conditions (Zafar *et al.,* 2023).

The onion leaves contained chemical elements in the following sequence: Fe>Mn>Zn>Zn>Cu>Ni>Pb>Cd. Scientists have determined that iron is present in excess in onions. It was also determined that there are differences in the content of Fe, Mn, and Pb in the onion head, with an average concentration of Fe and Mn in the leaves (Yahaya *et al.,* 2010; Ga *et al.,* 2024). In addition, the amount of heavy metals harmful to the human body has been determined in the onion head ("Communications in Soil Science and Plant Analysis," n.d.); (M *et al.,* 2017). The elements Cr and Fe in young growing onion leaves were studied, grown on soils of Mojo, Meki, and Ziwai regions, where the content of Cr-4.87 mg/kg, Fe-1090.40 mg/kg in leaves, Cr-4.13 mg/kg, and Fe-1836.47 mg/kg. In the Mojo region, Fe accumulation in leaves is up to 764.33 mg/kg.

In a study of steppe chernozem soils in the Nigerian region, researchers (Akinyele and Shokunbi, 2015) results show mean values of 1.67-32.00, 7.25-61.58, 1.59-10.56, 6.65-46.99, 0.02-0.58, <0.01-0.09, <0.08, and 0.06-0.14 mg/kg for Mn, Fe, Cu, Zn, Cr, Cd, Pb and Ni respectively. The levels of these metals in all the samples analysed were within the ranges reported for similar tubers, legumes and cereals from various parts of the world.

The geochemical nature of the environment, including soil, is inherently complex and changes in time and space. Therefore, the content of chemical elements changes in the onions. It is necessary to pay attention to the fact that the decrease or increase of certain chemical elements in the soil, especially biophilic elements, in turn, affects the quantity and quality of yield. Therefore, a chemical element or a group of elements can affect the yield of onions or other crops both positively and negatively.

A chemical element or group of elements accumulates differently in different plant varieties depending on the soil and climatic conditions and the properties of the chemical elements.In particular, an element or elements can accumulate in the stem, root, leaf, and seed. Elements, or groups of elements, play multifaceted physiological and biochemical roles.

For example, Mg, Mn, C, O, H, Fe, and Cu participate in the process of photosynthesis; C, O, H, N, Mn, Cu, and Zn in the metabolism of carbohydrates; and Fe, Mo, Mn, Cu, and Zn play the role of a catalyst in various biochemical processes (Noralievich and Gulom, 2023). The above provides reasons that the topic is relevant.

The aim of this study was to determine the quantity, quality, and differentiation of macro- and microelements in irrigated gray-brown soils and organs of onion (*Allium Cepa* L.) and dill (*Anethum graveolens* L.).

Materials and Methods

The pilot plots were located on the farms of Uzbekistan and Baghdad districts of the Fergana region of the Republic of Uzbekistan.In the Baghdad district, the soils are newly irrigated, and in the Uzbekistan district, old-irrigated gray-brown soils, and onions (*Allium Cepa* L.) and dill (*Anethum graveolens* L.) grown on these soils are selected.

Soil research methods include morphogenetic methods of V.V. Dokuchaev and physicochemical methods, as well as generally accepted standard agrochemical methods, are widely used in soil science. Dokuchaev's morphogenetic and physico-chemical methods, as well as standard agrochemical methods, are widely used in soil science.The elemental composition of the soil and plants was determined by the neutron activation method in the laboratory of ecology and biotechnology of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan. Biogeochemical studies were based on the method of A. I. Perelman and M.A. Glazovskaya and the onion and dill selection method described in were used.

Results and Discussion

The morphogenetic traits of transects of irrigated gray-brown soils on which vegetable crops common onion (*Allium Cepa* L.) and fragrant dill (*Anethum graveolens* L.) are grown have a unique two-layer structure.The topsoil has a light grey tone, light mechanical composition, and consists of loose arable and subaerial horizons.

The thickness of the arable horizon is 22-26 cm and is available depending on the duration of the development and irrigation period. The lower second horizon is noted as the subsoil horizon, which has a light brown and yellowish-brown color, dense, light, and medium loamy mechanical composition. It shows white carbonate spots, gypsum grains, and ochre iron compounds.

In irrigated gray-brown soils, gray-brown color is an indicator in the definition of these soils, and it is more developed on lower horizons in Neogene and Lower Quaternary rocks.The brown and gray-brown conglomerates, with a well-defined fine-grained structure of heavy mechanical composition, and the underlying gypsum layers are the products of weathering processes of the distant past. The brown upper subsoil layer is the result of modern development processes (Ball *et al.,* 2023).

In the distribution of the studied chemical elements by horizon of the soil section, there is a relative group differentiation, where there is a decrease in the amount of macro- and microelements in soil horizons compared to their parent rocks.

If the amount of chemical elements is accumulated in the aboveground organs, it is recommended to include them in the basipetal group, and if accumulated in the underground part, such plants are recommended to be included in the acropetal group. Taking this into account, let us familiarize ourselves with the data on the chemical element composition of onions grown on irrigated gray-brown soils (Table 1, Fig. 1-2).

From the given data, we can see that the onion head, leaves, and roots contain significantly more chemical elements: Na, K, Ca, Fe, and Cl compared to Sr, Ni, and Ba. This is despite the fact that the soils are not saline.The chlorine content in onion organs exceeded that of other studied elements. In newly irrigated gray-brown soils, the chlorine content in leaves is 1990 mg/kg, in onion head is 1620 mg/kg, and in roots is 3500 mg/kg.

This indicator in the leaves of onions grown on old-irrigated gray-brown soils was 3300 mg/kg, in the head 2000 mg/kg, and 3100 mg/kg in the roots. According to these indicators, onion is noted as a basipetal plant, that is, the amount of chlorine in leaves is significantly higher than in roots. From this point of view, basipetal accumulation is observed for the elements sodium, potassium, iron, barium, nickel, and strontium. The amount of sodium in roots and leaves of onions grown on old-irrigated gray-brown soils is practically the same as that in onions grown on new-irrigated gray-brown soils and varies in the range of 1300-1360 mg/kg. Similar situations were observed for other elements. The amount of potassium in onion leaves in old-irrigated gray-brown soils was 1200 mg/kg more than that in newly irrigated gray-brown soils. It was observed that the amount of potassium in other organs of the onion was almost the same.

The above analysis results show that onion heads grown on irrigated gray-brown soils contain 1530-5360 mg/kg Ca, 10400 mg/kg K, 540-1360 mg/kg Na, 34-73 mg/kg Fe.The contents of the same elements vary in relatively large values in the arable horizons of gray-brown soils, that is, calcium - 39900-55800 mg/kg, iron - 18700-28700 mg/kg, potassium - 22900-23000 mg/kg and sodium - 11600-12400 mg/kg.

Potassium in onion head on old-irrigated gray-brown soils is 10400 mg/kg and 1.6-2.1 times less than in leaves and roots. The difference in this indicator in the root is 11200 mg/kg in favor of roots.

The amount of sodium is distinguished by its abundance in onions grown on newly irrigated gray-brown soils. Such a situation is observed in the case of iron. A similar situation was observed for strontium. These situations are related to the agrobiological properties of onions and the amounts of elements in the soil. The composition and amount of chemical elements in aboveground and underground plant organs vary depending on several soil and plant factors. In particular, fennel (*Anethum graveolens* L.) grown in irrigated gray-brown soils depends on the chemical composition of the genetic horizons of gray-brown soils.

The biological uptake coefficient, which characterizes biogenic migration fluxes of chemical elements, is associated with the uptake of mobile elements, including heavy metals, which are involved in small biological cycles of elements and substances (Zafar *et al.,* 2023; Shokri *et al.,* 2022). The fennel plant (*Anethum graveolens* L.) absorbs chemical elements from the soil in different amounts from different organs in different ways (Table 2). Dill (*Anethum graveolens* L.) absorbs chemical elements contained in gray-brown soils during growth and development. The order of content of chemical elements in gray-brown soils was as follows: in old-irrigated Ca>Fe>K>Na>Ba>Sr=Cl>Ni; in newly irrigated Ca>K>Fe>Na>Ba>Cl>Sr>Ni.

The content of chemical elements in the aboveground parts of fragrant dill (*Anethum graveolens* L.) plants differs from that in the soil and is in the following sequence: K>Na>Fe>Sr>Ni>Ba>Ca. This corresponds to the law of selective absorption and other plant properties. All studied chemical elements contained in gray-brown soil were reflected in the dill organs. However, there are certain regularities in their quantity accumulation in vegetative organs. The organs of fennel (*Anethum graveolens* L.) contain Ca-0.60-1.55 µg/g, with an average of 0.92 µg/g, K-29900-36600 µg/g, with an average of 33300 µg/g, Na-365-2700 µg/g, with an average of 1905 µg/g, Sr-101-217 µg/g, averaging 143 µg/g, Fe-167-1210 µg/g, averaging 521 µg/g, Ni-3.34-39.5 µg/g, averaging 134.1 µg/g, Ba-1.0-27.5 µg/g, averaging 10.9 µg/g.

Table.1 Macronutrient content in irrigated gray-brown soils and onion (Allium cepa L.), mg/kg (n=5).

Elements	Soils	Onion			Soils	Onion		
	0-26 см	Leaves	Onion head	Roots	0-22 см	Leaves	Onion head	Roots
	Oldly tilled				Newly painted			
Na	12400	630	1360	13000	11600	1430	1360	15900
K	22900	17900	10400	21600	23000	16700	10400	21600
Ca	55800	11400	1530	9800	39900	11000	5360	14300
Sr	190	50	12	75	140	43	31	94
Fe	28700	290	34	1260	18700	330	73	690
Ni	36	1	1	2,6	19	1	1	1,8
Ba	1150	18	1	53	900	13	3,2	40
Cl	190	3300	2000	3100	201	1990	1620	3500

Table.2 Quantity of chemical elements in organs of fennel (*Anethum graveolens* L.), µg/g (n=5)

Plant organs	Na	K	Ca	Sr	Fe	Ni	Ba
Roots	2700	29900	0,60	111	1210	39,5	27,5
Stems	2650	36600	0,61	101	185	4,2	6,1
Flowers	365	33400	1,55	217	167	3,34	<1,0
On average	1905	33300	0,92	143	521	134,1	10,9

Figure.1 Contents of chemical elements in arable horizon of old-irrigated soils and onion organs

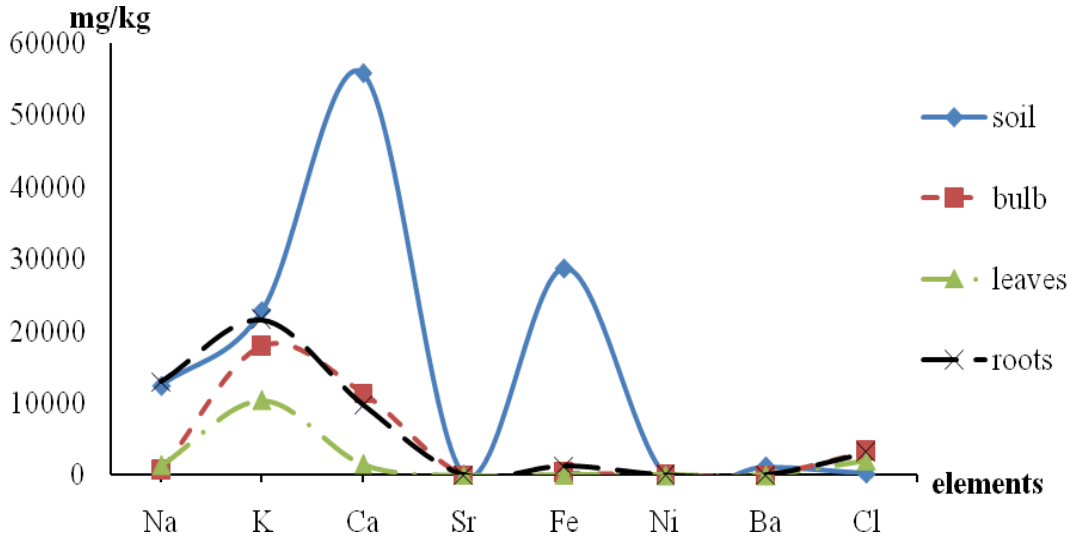
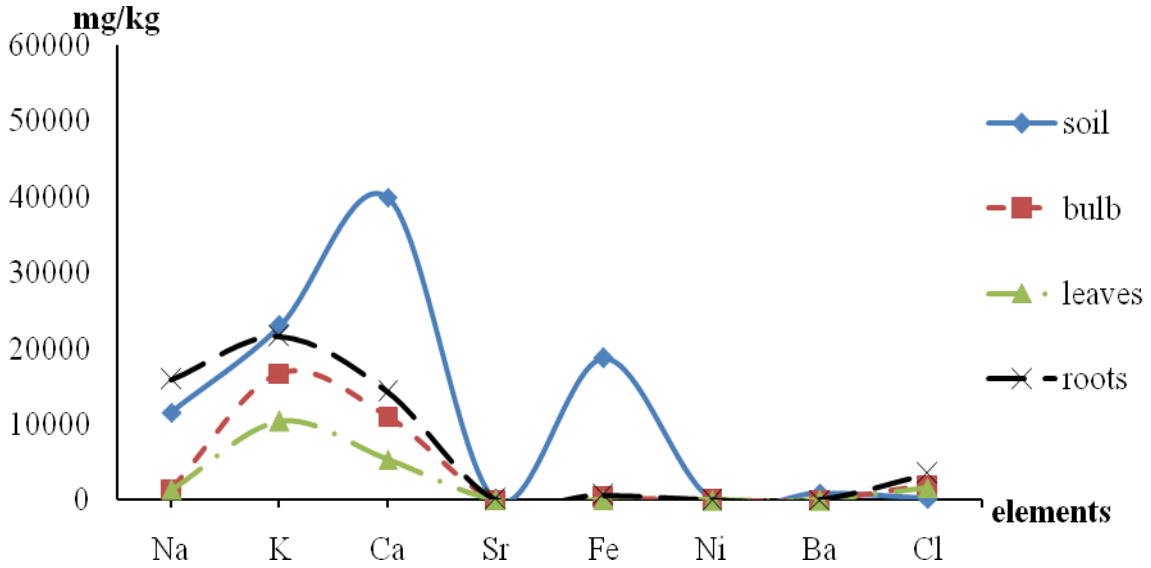


Figure.2 Contents of chemical elements in arable horizon of newly irrigated soils and onion organs



If the amount of sodium in the soil is 0.002-3.42%, this amount of Chamenu is the norm for crops (Zafar *et al.,* 2023). According to this indicator, the amount of Na in the studied soils varies within 1.2-1.63%. The lower limit of the highest permissible norm was above 1.5.

According to these indicators, the studied soils met the requirements for planting and sowing of onions and dill. These plants react to low and average amounts of calcium and iron. In gray-brown soils, their excessive amounts are identified. For nickel, only the standard, that is, the average, is at the level of demand, and in other cases deficiencies are identified. Vegetable crops rich in vitamins are widely used in all spheres of human economic activity, particularly in medicine, folk medicine, and industry.Further, the wide development of science makes it possible to study the chemical composition of many plants, isolate various substances from them, and study their physiological and biochemical properties, resulting in an increase in the number and level of utilization of medicinal plants over the years.

Onions grown on irrigated gray-brown soils are basipetal plants because of their biological absorption of chemical elements.

Odorous dill absorbed small amounts of macro-and microelements contained in the studied gray-brown soils.In the above-ground part of fragrant dill (*Anethum graveolens* L.), the change in the amount of chemical elements was significantly different from gray-brown soils, occupying the following row: K>Na>Fe>Sr>Ni>Ba>Ca.

This position corresponds to the regularity of its selective absorption.Abiotic and anthropogenic factors and some uptake patterns were retained. The correlation between the elemental composition of the plants and the composition of the soil where they grow was positive.Obtaining a quality and environmentally friendly crop of vegetables rich in healing vitamins and using them as food and medicine is promising.

Author Contributions

ZI and MI, GY contributed to the design and implementation of the research; MU analyzed the results and wrote the manuscript.

Data Availability

Not applicable.

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Declarations

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Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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