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Research Article

Effect of NaCl Toxicity on Development and Anatomical Structure of Varieties of *Sorghum saccharatum* (L.) in Kazakhstan

[1]Yerlan Kirshibayev and [2]Danagul Mukasheva

[1]Al-Farabi Kazakh National University, Almaty, Kazakhstan
[2]Department of Biology, Kazakh National Women's Pedagogical University, Almaty, Kazakhstan

Abstract

Background and Objective: Salinity is a major factor limiting agricultural productivity and strongly affects sorghum (*Sorghum saccharatum* L.) yield. This plant has many varieties with different responses to environmental toxicity. The present study aimed to evaluate the toxic effects of salt (NaCl) in the nutrient medium of seedlings of sorghum crops. **Materials and Methods:** In the present study, the salt tolerance properties of selected sorghum varieties (Kazakhstan-20 and Porumben-7 varieties). Seeds of sorghum varieties were placed in containers with different concentrations of saline solution 15 pieces in three replications. Concentrations of NaCl salt solution was 0.1, 0.3 and 0.6%. Within 3 days from the day of setting the seeds of sorghum varieties, germination indicators of sorghum were counted. The anatomical structure of the roots of the varieties was determined using an electron microscope. Alcohol, glycerol and distilled water were taken for fixation in the same ratio and they were prepared by stirring. **Results:** Findings showed that salinity toxic effect is varied based on variety, Porumben-7 during the growth and development showed significant resistance compared to the control (Kazakhstan-20). This effect was associated with the number of mature metaxylem in root in the Kazakhstan-20 variant and in the Porumben-7 variant, with salinity, the metaxylem number was decreased. In Porumben-7, the root vessels were shortened and vessels number decreased. **Conclusion:** Based on findings, it was concluded that salt tolerance is considerably affected due to a variety of sorghum. the variety of Kazakhstan-20 (domestic variety) is more effective than the foreign variety (Porumben-7) in productivity and saccharinity of stems.

Key words: *Sorghum saccharatum*, NaCl, xylem, resistance, root vessels, metaxylem, salt stress, phosphorylation

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Corresponding Author: Danagul Mukasheva, Department of Biology, Kazakh National Women's Pedagogical University, Almaty, Kazakhstan

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Salinity is a major factor limiting agricultural productivity and affects nearly 80 million hectares of cropland worldwide (20% of cropland and 50% of irrigated land) in arid and coastal areas[1]. Soil is considered saline when its electrical conductivity is 4 dS m^{-1}, approximately 40 mM NaCl[2]. Salt stress is caused by a wide range of dissolved salts but NaCl is the most common, which is explained by the intensive studies[3-5]. Salinization is an increasing threat to agriculture due to poor soil quality and inefficient management of irrigated land, which prevents the use of drainage facilities and land clearing for agricultural development and livestock grazing. Soil salinization is a global problem and leads to reduced plant growth, lower yields and, in severe cases, complete crop failure[6-10]. Among all the ions in physiological solution or sodium-salt medium, Na+ can have a detrimental effect on the availability of water in the root medium, depending on the growth period and the concentration in the root medium. The source of the sodium ion also plays an important role in plant response to salinity[11]. Sodium sulfate is less toxic than sodium chloride for wheat growth provided that potassium and calcium are available in the nutrient medium[11]. Chlorine is an important biogenic element, which in small doses promotes plant growth and development and participates in energy metabolism in plants by activating oxidative phosphorylation. It is necessary for oxygen formation during photosynthesis and stimulates auxiliary processes of photosynthesis, especially those related to energy storage[12]. Chlorine positively affects the uptake of oxygen, potassium, calcium, magnesium compounds by roots[13]. In plants, sodium can replace the nonspecific functions of potassium[14,15]. Plants can assimilate sodium in varying amounts[14]. Major crops are divided into groups with high (fodder, sugar and table beets, chard, celery, spinach, tomatoes), medium (lupine, oats, cabbage, potatoes, field turnip), low (wheat, barley, millet, flax, turnip) and very low (buckwheat, corn, rice, soybean, turnip cabbage) sodium absorption. Pasture grasses need an increased supply of sodium[16]. The application of sodium fertilizers in pastures increases the supply of magnesium to plants, normalizes the sodium-potassium ratio in them, which generally improves the quality of grass feed and its absorption by animals[9,16]. Excessive concentrations of water-soluble salts of sodium and chlorine in the soil harm the ability of plants to absorb moisture from the soil solution, necessary for growth processes, affect various physiological processes in plants. Excess of exchangeable sodium can lead to soil swelling and (or) atomization, which creates several difficulties for water infiltration into the soil, aeration and root penetration[17].

Salinity is one of the important abiotic factors of the environment, the sensitivity to which varies in cultivated plant species and varieties[18,19]. At the initial stages of ontogenesis, plant tolerance to salinity is determined by the activity of growth function. The most important criterion of salt tolerance is the yield of plants on saline soils. However, the selection of salt-tolerant forms under field conditions is complicated by the uneven distribution of saline areas. Therefore, the search for ways to assess plant tolerance to salinity does not stop under controlled laboratory conditions. To improve the efficiency of selection, it is necessary to have a good understanding of how salt tolerance is formed. Two factors are distinguished in the effect of salinity on plants: A toxic component associated with the accumulation of ions in the cytoplasm and water deficit due to the presence of excess ions in the soil. The main attention of researchers is attracted by the study of the mechanisms that ensure ion homeostasis during salinization[20].

The problem of soil salinization refers to 7% of the earth's surface, 30% of agricultural land and almost 27% of irrigated arable land[21].

The increased concentration of Cl^- and Na^+ ions in the soil causes undesirable changes in the metabolism of ions such as K^+, Ca^{2+}, Mg^{2+} and NO_3 and therefore plays a role in altering the course of metabolic and enzymatic processes[22]. Osmotic stress occurs due to Na^+ and Cl^- uptake, which provokes water deficit inside the cell. The accumulation of Na^+ and Cl^- reduces the water gradient between the root and the soil solution, impeding the movement of water across the root surface[23]. In turn, when water absorption decreases and the osmotic effect spreads from the root surface to the inner tissues, the accumulation of ions inside the plant changes the solute balance[23]. Salinity stress mainly reduces germination percentage and delays germination initiation, its effects are modified by interactions with other environmental factors such as temperature and light. Salinity can affect germination by affecting the osmotic component, which is an ionic component, i.e., Na and Cl accumulation[24,25].

According to Kalifa *et al.*[26], plant tolerance to high concentrations of NaCl is partly related to the presence of inorganic P. High NaCl content caused decreased P uptake in several crop species. Both root uptake and translocation of P to shoots were suppressed. All these processes lead to lower yields. According to Orcutt and Nielsen[27], the most interesting interaction between salinity and macronutrient uptake is salinity and N accumulation. Bensalem *et al.*[28] reported that NaCl reduces nitrate and ammonium accumulation when taken together on a plant. On the other hand, P limitations can occur in glycophytes such as strawberries exposed to high salinity[24,25]. *Sorghum saccharatum* (L.) has many varieties with different responses to environmental stress and toxicity. Am initial study was conducted on the effect of saline stress on physiological indices of local varieties of sorghum in Pakistan and Iran[29,30].

The present study aimed to evaluate the toxic effects of sodium chloride salt (NaCl) in the nutrient medium on the seedlings of *Sorghum saccharatum* (L.) Pers crop. As well as, the salt tolerance properties of different sorghum crop varieties was determined with a focus on locally available varieties.

MATERIALS AND METHODS

Study area: The study was carried out at the Department of Biology of the Kazakh National Women's Pedagogical University of Almaty, Kazakhstan from March, 2019-October, 2020.

Methodology: Before starting the study, first of all, the necessary equipment was decontaminated. In addition, to clean the grain from harmful microbes, the plant grains were placed in potassium permanganate solution ($KMnO_4$) for 15-20 min and rinsed with distilled water. Seeds of *Sorghum saccharatum* varieties were placed in containers with different concentrations of saline solution (sowing into petri dishes causes discomfort) 15 pieces in three replications.

Concentrations of NaCl salt solution was 0.1, 0.3 and 0.6%. Within 3 days from the day of setting the seeds of *Sorghum saccharatum* varieties, germination indicators of sorghum were counted. The amount of heat and light intake was monitored and distilled water was supplied according to daily intake. The growth rate of sorghum that was grown under saline conditions was monitored.

Bioparameters of varieties: Elongated growth of aboveground and root organs (cm) of varieties, accumulation of dry biomass (g), were calculated after 15 days. The anatomical structure of the roots of the varieties was determined using an electron microscope Micros Austria MCX-100. Since it was time-consuming to accurately determine the anatomical structure, the plant fixation was done first. Alcohol, glycerol and distilled water were taken for fixation in the ratio of 1/1/1 and they were prepared by stirring.

RESULTS

It was found that the studied sorghum crop has several specific features of resistance to salinity. For example, it was observed in indicators of plant growth and dry biomass accumulation. These results are shown in the tables below.

The table shows that the growth of *Sorghum saccharatum* varieties is negatively affected by different salt concentrations. However, 0.1% salt concentration had a significant positive effect on stems and roots of the variety Porumben-7 (stems 12.6 cm, roots 11.6 cm). In the variety Kazakhstan-20, on the contrary, stem growth decreased by 17%, having a positive impact only on the growth of the vessels, increasing it by 33%. And with increasing salt concentration, plant growth decreased (Table 1).

Elongated stem growth of a variety Porumben-7 at 0.3% salt concentration decreased by 54% than stem growth in the control variant. Compared with the stem of a plant grown in salt medium with a concentration (NaCl 0.6%) of 0.3%, elongated stem growth was reduced by 2.97 cm and from the control variants to 8.64 cm. And the roots were not formed under the toxic influence of salt. In the variety Kazakhstan-20 with an increase in salt concentration, also growth indicators are decreased. Compared with the control variant at a concentration of NaCl 0.3% stem growth rate of variety Kazakhstan-20 decreased by 72% and root growth by 57%. In the control variant variety Kazakhstan-20 grown in 0.6% concentration of salt, there is a significant decrease (1.2 cm) of elongated stem growth. Elongated stem growth of the variety Porumben-7 grown in 0.6% salt concentration decreased by 7% compared to 0.3% concentration and roots were not formed at all. The experiment revealed that of the two varieties, the Porumben-7 variety was more tolerant than the Kazakhstan-20 variety in terms of salt tolerance. Despite the high saccharinity of the variety Kazakhstan-20, this is one of the proofs that it is inferior to Porumben-7 in salt tolerance.

Attention shall be paid to the fact that the saline environment, which influenced the growth and development of the plant, further affects the accumulation of dry biomass by its organs.

The dry weight of stems and roots depends on the indicators of plant growth. That is, it was found that at the lowest salt concentration (NaCl 0.1%) stem and root mass of the Porumben-7 variety are higher than other indicators (Table 2). For example, at a NaCl concentration of 0.1% the dry weight of the stem compared with the control increased by 5% (105%) and the dry weight of the root by 169% (269%). And when the salt concentration was increased, the dry weight indicators decreased dependently. At a concentration

Table 1: Effect of different salt concentrations on growth indicators of *Sorghum saccharatum* varieties Porumben-7 and Kazakhstan-20

Name of sorghum varieties	Porumben-7				Kazakhstan-20			
	Stem (cm)		Root (cm)		Stem (cm)		Root (cm)	
Variants								
Control	10.4±0.9	100%	4.13±0.2	100%	11.2±0.5	100%	3.92±0.1	100%
NaCl 0.1%	12.6±0.5	121%	11.6±0.3	281%	9.3±0.3	83%	5.2±0.01	133%
NaCl 0.3%	4.73±0.2	46%	2.53±0.01	61%	2.0±0.001	18%	1.7±0.01	43%
NaCl 0.6%	1.76±0.01	17%	-	-	1.2±0.01	11%	-	-

Table 2: Accumulation of dry biomass by individual organs of *Sorghum saccharatum* varieties with different concentrations of salt (mg)

Name of sorghum varieties	Porumben-7				Kazakhstan-20			
	Stem (cm)		Root (cm)		Stem (cm)		Root (cm)	
Variants								
Control	7.5±0.05	100%	1.3±0.01	100%	6.0±0.03	100%	1.1±0.01	100%
NaCl 0.1%	7.9±0.06	105%	3.5±0.02	269%	5.0±0.004	83%	1.8±0.01	164%
NaCl 0.3%	5.6±0.03	74.6%	1.0±0.01	77%	2.4±0.02	40%	0.8±0.01	73%
NaCl 0.6%	3.3±0.02	44%	-	-	0.17±0.001	3%	-	-

Table 3: Effect of different concentrations of salt on the consumption of the stored substance of grain sorghum Porumben-7 and Kazakhstan-20 varieties (mg)

Name of varieties of sorghum	Porumben-7			Kazakhstan-20		
	Initial mass of grain (mg)	Dry mass of grain (mg)		Initial mass of grain (mg)	Dry mass of grain (mg)	
Variants						
Control	25.9±0.8	8.0±0.5	100%	20.1±0.9	4.4±0.1	100%
NaCl 0.1%		6.8±0.2	85%		5.3±0.3	120%
NaCl 0.3%		10.0±0.6	125%		10.0±0.4	227%
NaCl 0.6%		14.0±0.9	175%		11.0±0.3	250%

of 0.3%, NaCl compared with the control dry weight of the stem decreased by 25.4% (74.6%), dry weight of the roots by 23% (77%). When comparing the indicators of the variety Kazakhstan-20 with the variety Porumben-7 differences were revealed. This proves the indicators, i.e., that at a concentration of NaCl 0.1% grade Kazakhstan-20, compared with the control variant, the dry weight of the stem decreased by 17% (5 mg) And the dry weight of the root increased by 64%. When the salt concentration was increased by 0.3%, the dry weight of the stem decreased by 60% and the dry weight of the root decreased by 27%. Since at the maximum salt concentration (NaCl 0.6%), the roots did not grow at all, respectively, their dry weight was also not formed. And the variety Kazakhstan-20 had the same indicators as in Table 2. As the concentration increased, these indicators of dry weight decreased.

In the next part of the work, the salinity of the medium is directed to the consumption of the reserve substance of the grain of the plant. First, the initial weight of the grain (25.9 mg) was measured. The dry weight of a grain of Porumben-7 variety in the control variant was taken as 100% (8 mg). Since at NaCl concentration of 0.1% the stem and root of the plant were well developed, the nutrients in the endosperm were used to the full extent. Compared with the control variant only 15% of the dry weight of the grain (6.8 mg) was not consumed.

Thus, at NaCl concentration of 0.3% due to a decrease in the degree of consumption of nutrients in the endosperm because of the toxic effect of salt on growth indicators, the dry weight of grain shows 10 mg (Table 3). The dry weight of a grain of the variety Porumben-7 increased by 25 and 40% (10 mg) compared with control and NaCl concentration of 0.1% and, conversely, the growth of the stem and root decreased. At the maximum concentration (NaCl 0.6%), plant stem growth was low and because the roots did not grow completely, the degree of reserve substance consumption was low. Therefore, the dry weight of the grain was also high. That is, the dry mass of grain was used by 75% less compared with the control variant and by 50% compared with NaCl 0.3%. And the fact that the second tested variety of Kazakhstan-20 is sensitive to salt, we were convinced once again. That is, the greater the salt concentration in this variety, the lower the growth rate and thus reduced consumption of nutrients in the endosperm but increased indicators of the dry weight of grain. Thus, compared with the NaCl concentration of 0.1% of the control variant, the consumption of dry weight of grain in the variety Kazakhstan-20 decreased by 20% (5.3 mg). And if the consumption of the nutrient in the endosperm at a concentration of 0.3% NaCl decreased by 127% (10 mg), at a concentration of 0.6% they were not consumed up to 150%. As it is clear in these Figures, the effect of salts had a significant effect on growth rates and since no stored nutrients were consumed as the concentration increased, the dry weight increased.

Peculiarities of the anatomical structure of sorghum varieties roots: Depending on the biological properties of varieties there are some features of the anatomical structure of the root. As a result of studies, it was found that the variety Kazakhstan-20 features of root tubes and the number of metaxylem-one and the variety Porumben-7-three. In addition, a change in the number of metaxylem was observed in the salt medium. Features of the study of plant anatomical structure are shown in the Figures below (Fig. 1). As shown in the Figure, there was a good growth of root tubes (Fig. 1a) in the anatomical structure of the root of the control variant of the variety Kazakhstan-20. In addition, the number of metaxylem (mature xylem) showed one depending on the variety property (Fig. 1b).

The anatomical structure of the root of the variety Kazakhstan-20 grown in NaCl 0.3%. Using an electron microscope the anatomical structure of the root of Kazakhstan-20 variety was considered, the names were indicated in the drawings. These are root tubes (vessels), epiblema, the exoderm, parenchyma tissue, endoderm, xylem, metaxylem, phloem. The peculiarities of the anatomical structure of the root when the plant is exposed to different concentrations of salt have been studied and shown in the drawings.

Regarding the peculiarities of the anatomical structure of the root of variety Kazakhstan-20 grown in NaCl 0.1%, revealed in the study by electron microscope. They were primarily observed on the root tubes (Fig. 2a). Slower elongated growth of root tubes compared to the root tubes of the control variant was detected. And the number of metaxylem located in the central cylinder increased by two (Fig. 2b). The reason for the manifestation of such indicators may be caused by the toxic effects of salt. As can be seen in Fig. 3 and the root of the variety Kazakhstan-20, grown in NaCl 0.3% has featured in the anatomical structure. Compared with the anatomical structure of the root grown in 0.1% salt, the elongated growth of the root furs (tubules) was strongly impaired (Fig. 3a). The number of metaxylem located in the central cylinder increased by three (Fig. 3b). That is, the number of metaxylem is three times the original number. This may be due to the toxic effect of salt on the anatomical structure of the plant root. As shown in Fig. 4a elongated growth of root furs is much better. The number of metaxylem located in the central cylinder is three Study of the anatomical structure of the root when exposed to different concentrations of salt in the variety Porumben-7 (Fig. 4b and 5-6).

In the anatomical structure of the root of the control variant of variety Porumben-7, in comparison with variety Kazakhstan-20, the growth of root furs (tubes) is high. And the elongated growth of root furs in 0.1% -salt concentration is significantly better than the growth of root furs grown in the control variant (Fig. 5a). It was found that the number of metaxylem grew from three to four (Fig. 5b). This indicated that a lower concentration of salt may positively affect the anatomical structure of the root. As shown in Fig. 6a features of the anatomical structure of the root of the Porumben-7 variety grown in 0.3% salt medium are primarily seen in the

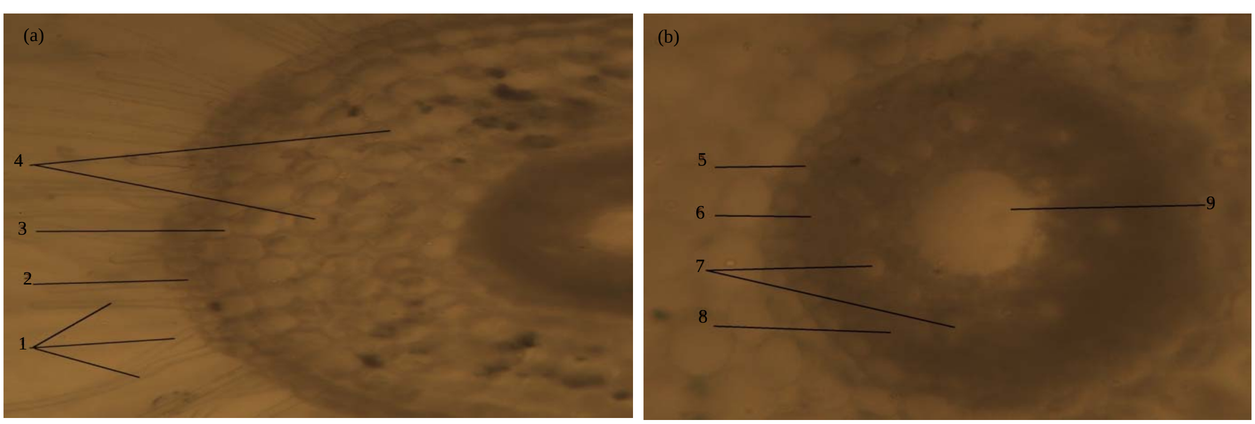

Fig. 1(a-b): Anatomical features of Kazakhstan-20 variety of sorghum, (a) Anatomical structure of root cross-section of Kazakhstan-20 variety and (b) Enlarged view of the central cylinder of the cross-section

1: Root tubes (vessels), 2: Epiblema, 3: Exoderm, 4: Parenchyma tissue, 5: Endoderm, 6: Pericycle, 7: Xylem, 8: Floem and 9: Metaxylem

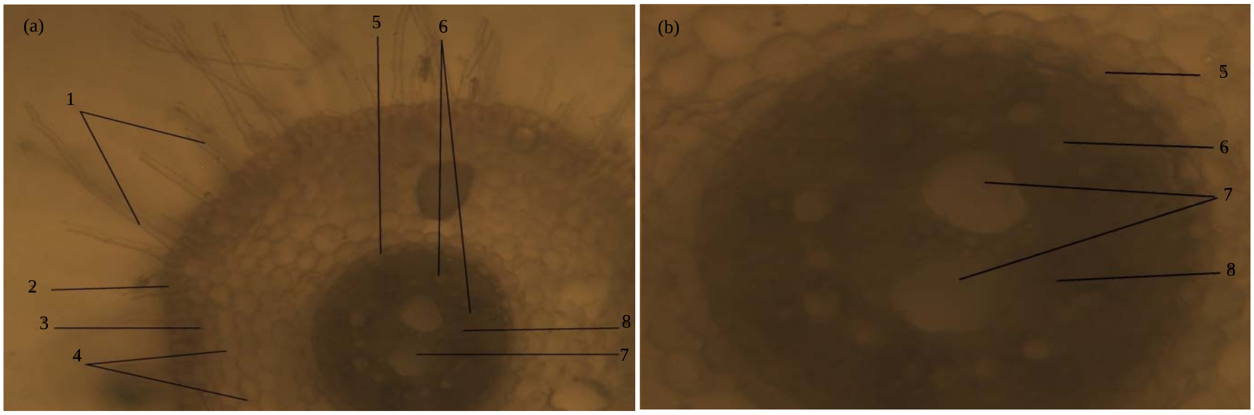

Fig. 2(a-b): Root features of Kazakhstan-20 variety of sorghum, (a) Anatomical structure of the root of Kazakhstan-20 variety in horizontal section and (b) Enlarged view of the central cylinder cross-section

1: Root tubes (vessels), 2: Epiblema, 3: Exoderm, 4: Parenchyma tissue, 5: Endoderm, 6: Xylem, 7: Metaxylem and 8: Floem

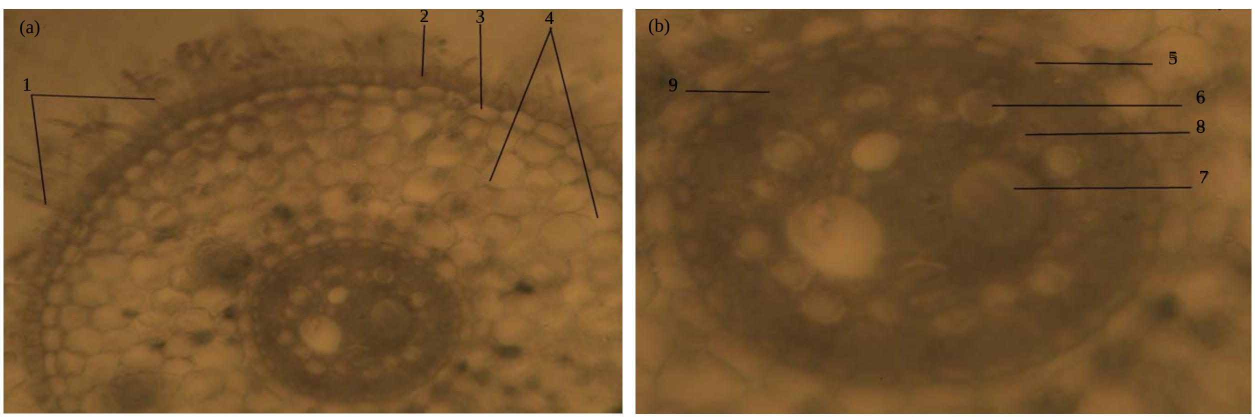

Fig. 3(a-b): Root of the variety Kazakhstan-20 grown in NaCl 0.3%, (a) An anatomical structure of root cross-section of Kazakhstan-20 variety and (b) Enlarged view of the central cylinder of the cross-section

1: Root tubes (vessels), 2: Epiblema, 3: Exoderm, 4: Parenchyma tissue, 5: Endoderm, 6: Xylem, 7: Metaxylem, 8: Floem and 9: Periculum

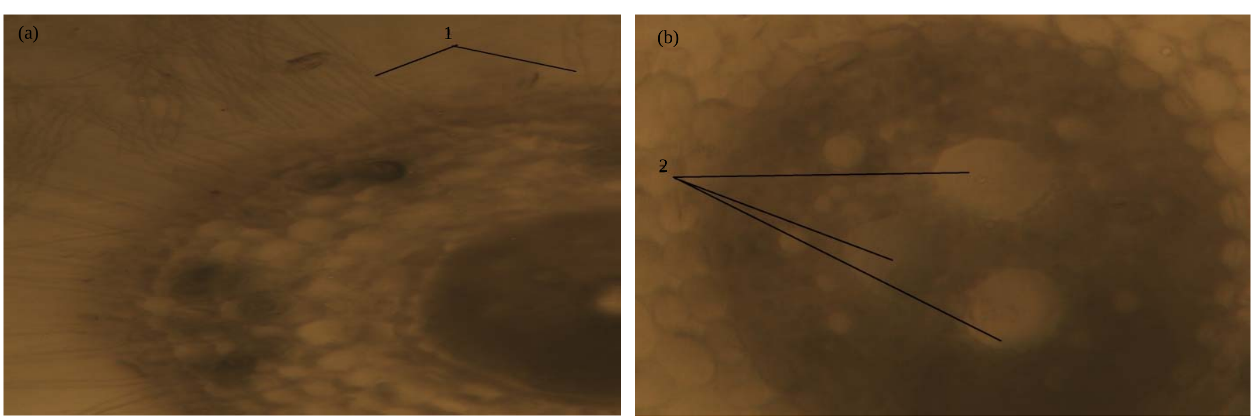

Fig. 4(a-b): Structure of root of porumben-7 variety, (a) An anatomical structure of root cross-section of porumben-7 variety and (b) Enlarged view of central cylinder of cross-section

1: Root tubes (vessels) and 2: Metaxylem

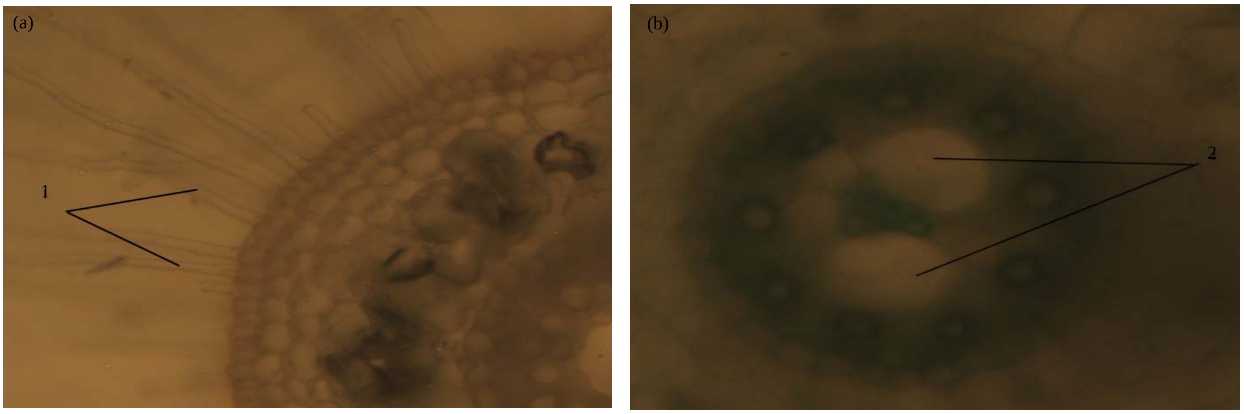

Fig. 5(a-b): Anatomical structure of porumben-7 variety grown in NaCl 0.1%, (a) Anatomical structure of root cross-section of porumben-7 variety and (b) Enlarged view of the central cylinder of the cross-section
1: Root tubes (vessels) and 2: Metaxylem

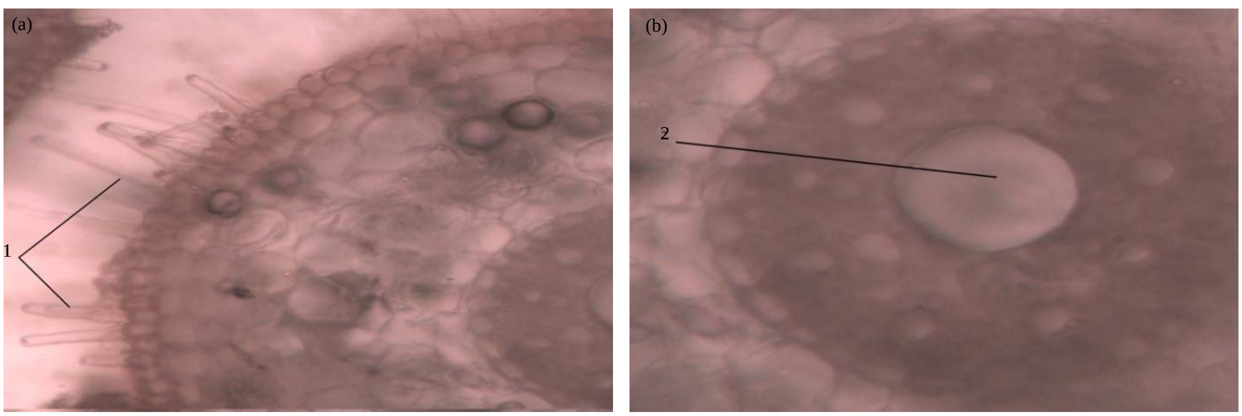

Fig. 6(a-b): Anatomical structure of the root of the porumben-7 variety of sorghum grown in 0.3%, (a) An anatomical structure of root cross-section of porumben-7 variety and (b) Enlarged view of the central cylinder of the cross-section
1: Root furs (tubes) and 2: Metaxylem

root furs. That is, there was a decrease in the growth of root furs compared to the control and root furs grown in 0.1% salt concentration. The number of metaxylem Fig. 6b located in the central cylinder or mature xylem, is one. The initial number of metaxylem decreased by a factor of three. It was found that the decrease in the number of metaxylem, reduction and stopping the growth of root furs is due to the toxic effects of salt.

DISCUSSION

In the scientific literature, the problem of soil salinity is increasingly beginning and recognized as a factor limiting the productivity of crops. The damage to plants from soil salinization is complex. Salinity decreases the activity of nucleic acids, disrupts nitrogen metabolism, which leads to the proteins' breakdown, suppresses their synthesis associated with synthetic processes' violation and hormonal balance in the roots. For example, for the entire Republic of Kazakhstan, the increasing saline problem, unsuitable for agricultural soils, is extremely urgent[31].

In agricultural practice, the method of soil leaching from salinization has long been entrenched. This agro-technique, depending on climatic conditions, is carried out in the winter-spring period and requires significant investment and water resources. This soil leaching practice not only increases the cost of producing agricultural goods but also leads to a shortage of water resources in the Central Asia region[32].

Moreover, rinsing water through drainage systems enters subterranean waters and rivers, poisoning and polluting them.

In most cases, drainage systems are clogged and poorly functioning and on some saline soils, agricultural plants are irrigated with mineralized water. In addition, annual soil leaching and irrigated agriculture contribute to the rise of groundwater, which again carries salt into the fertile arable horizon. It turns out that the problem of soil salinization is anthropogenic. In the region, located in arid and semi-arid zones, there are many problems associated with irrigation and reclamation[33].

Irrigated agriculture is the basis of agriculture in the region (Volga region of Russia, Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, Tajikistan and Azerbaijan). Against the background of a wide variety in natural conditions on the irrigated zone, unsatisfactory water management at various functional levels of irrigation systems creates many problems, deteriorating soil fertility and the quality of agricultural lands as well as aggravate environmental problems, expressed in salinization and pollution in irrigated soils, groundwater and water sources[34].

The salts accumulation in areas that could potentially be used in agriculture is a worldwide problem, covering 340 million hectares worldwide[35]. Moreover, territories subject to natural salinization occupy much more area than salinized because of irrigated agriculture.

The plain territory of Central Asia has, for the most part, naturally saline and potentially dangerous secondary soil salinization process. Over the past twenty thousand years, extensive transgressions have repeatedly occurred, during which huge areas of wind-blown salt marshes were released. In the Caspian basin, vast areas of salt marshes after regressions were observed nine thousand years ago, when the entire northern part of the Caspian Sea, up to the mouth of the Terek, was drained. The same processes have been observed in modern times. For the Caspian basin alone, the area of salt marshes several times during the Pleistocene and Holocene reached a million square kilometres. So, salts blown by the wind entered the formed loess and formed salt reserves[36,37]. The question arises of regulating negative soil processes and, first of all, salinization, since this problem is difficult to regulate in irrigated agriculture, the history of which dates back more than eight thousand years in Central Asia[38].

The most typical depressions, in the steppe and desert zones, have significant areas of salt marshes, include the Shuruzyak and Arnasai depressions in the Hungry Steppe, the Charagyl and Dengizkul depressions in the Karshi steppe as well as the Tudakul, Shorsai and Shorkul depressions in the Bukhara oasis. A typical example of zones of salt marshes' formation on the periphery of the foothill plains is a rather extended territory at the contact of the Dzhizak and Golodnaya steppe. The processes of soil degradation and secondary salinization continue in Azerbaijan as well. Based on the materials of numerous field surveys and mass surveys of farms located on saline soils, a decrease in the yield of crops has been established, which is approximate: With low salinity from 0-33%, with an average salinity 50%, with strong salinity from 67-83%, with very strong salinity, yield losses are almost 100%[39].

The Central Asian irrigated lands are suitable for agricultural production development. In Kazakhstan and Central Asia, there are approximately 50-60 million hectares of land suitable for irrigation. At the same time, water resources are only enough for irrigation of 8-10 million hectares[39]. In such conditions, it is necessary to choose the right ways for the development of irrigated agriculture, to prevent the irreversible process of ecosystem destruction. The total area of agricultural land in the republics of Central Asia is 294.2 million hectares, of which arable land is 43.4 million hectares. The irrigated land area is more than 9.39 million hectares[40].

Over 93% of the territory in Tajikistan is occupied by mountains, separated by intermountain basins and valleys-Fergana, Zaravshan, Vakhsh, Gissar, etc., more than 44% of the estimated runoff of the Aral Sea basin is formed. In Turkmenistan, land suitable for irrigation is 7 million hectares. Currently, about 2 million hectares are irrigated, 70% of the territory is sand, 7% is rocky mountains, 5% is salt marshes, 5% is clay surface. In Turkmenistan, more than 60% of the irrigated area is salinized to a medium, strong and very strong degree, about 53% of the territory is subject to erosion and deflation, 87% is eroded, about 60% of the territory in the irrigated zone is in conditions of critical depth (1-2.5 m) groundwater. When groundwater is shallow, the likelihood of salt accumulation increases as a result of increased salt flow into the soil. A general idea of this problem is given in the works. For comparison, a large area of irrigated agriculture in Russia is the Volga region. From 1966-1996, the irrigated area of semi-arid and arid zones of the Volga region increased from 0.1-1.2 million hectares and in the 2000s it decreased by 20%. In the Lower Volga region, it is impossible to obtain crop products without irrigation. The irrigated area of the Volga region is 30% located in the chernozem zone, 58% in the chestnut, 12% in the semi-desert. On the terraces of the Volga River, about 400 thousand hectares of chernozems and chestnut soils are irrigated, on the territory of the Syrtova Plain 200 thousand hectares, in the Caspian lowland about

250 thousand hectares. Irrigation of chernozem, chestnut, brown semi-desert soils can lead to their salinization and alkalinization if natural and anthropogenic sources of salinization are not taken into account when using irrigation water[41,42].

In an arid climate, readily soluble salts in river waters are the most powerful and permanent source of salinization in irrigated soils[43,44]. The river waters' salinity has increased eightfold over the past fifty years. At the same time, with an increase in the degree of surface river runoff, used for irrigation, the accumulation of salts in soils and underlying sediments also increases. Thus, the main massifs of saline soils were confined to the delta sections of rivers and local relief depressions, where the formation of salt marshes took place. Examples of zones of salt marshes' distribution in the delta areas of large and small rivers are the delta part of the Zarafshan river (Karakul oasis) and the Amu Darya river (Khorezm oasis and Karakalpakia) as well as soda-saline soils of the Tartar river cone[45].

In the context of an increase in fertilizer application rates, an increase in the imbalance of the soil microbial community and elements of mineral nutrition of plants, observed in recent years in agro-ecosystems, the function of improving soil regimes, preserving their fertility is called upon to perform resource-saving soil cultivation technologies in combination with effective methods of using funds that combine ecological and economic feasibility[46]. For all the republics of Central Asia, the problem of increasing saline unsuitable for agricultural soils is extremely urgent. Effective microorganisms play an extremely productive life-giving role when introduced into any biological environment, be it soil, human or animal organism[22]. As shown in the results, it was found that depending on the specific characteristics of the variety Kazakhstan-20 the number of metaxylem-one and when exposed to different concentrations of salt the number of metaxylem increases. Conversely, depending on its biological characteristics in the variety Porumben-7 the number of metaxylem is three and when exposed to salt at a lower concentration the number of metaxylem increases and at the maximum concentration the number of metaxylem decreases also, variety Porumben-7 was superior in salt tolerance than the variety Kazakhstan-20 and there is a great opportunity to include this variety in the production in the saline areas of Kazakhstan. Present findings indicate a climate of farm and also local soil composition may be close with local varieties of plants especially this is strongly suggested for Sorghum.

When the salinity problem has widely occurred in the farm, farmers should choose local breeds and varieties of plant seed, especially for Sorghum.

CONCLUSION

It was concluded that the variety of domestic selection Kazakhstan-20 is more effective than the Moldovan variety Porumben-7 in productivity and saccharinity of stems. It was found that the variety Porumben-7 belongs to the medium-ripening crop and Kazakhstan-20 to the late-ripening crop. In another word, salt tolerance is differed by verity in sorghum, in general terms. So, farmers should know about verities specify for salt tolerance, when they have salinity problems in the field.

SIGNIFICANCE STATEMENT

The study states the importance of variety selection in fields with salinity problems. This study is shown the toxicity of NaCl salt for sorghum and also indicates local varieties of sorghum can be resistant to this toxicity in comparison with other varieties. This study will help central Asian farmers with attention to the geographical, climate and soil properties of the region.

REFERENCES

1. Yamaguchi, T. and E. Blumwald, 2005. Developing salt-tolerant crop plants: Challenges and opportunities. Trends Plant Sci., 10: 615-620.
2. Munns, R. and M. Tester, 2008. Mechanisms of salinity tolerance. Annu. Rev. Plant Biol., 59: 651-681.
3. Hasegawa, P.M., R.A. Bressan, J.K. Zhu and H.J. Bohnert, 2000. Plant cellular and molecular responses to high salinity. Annu. Rev. Plant Physiol. Plant Mol. Biol., 51: 463-499.
4. Cherifi, K., B.E. Houssein, B. Hassan and M. Fouad, 2016. Comparative salt tolerance study of some *Acacia* species at seed germination stage. Asian J. Plant Sci., 15: 66-74.
5. Alwan, A.H., K.A. Hussein and K.A. Jaddoa, 2015. Effect of sodium chloride on response of two wheat cultivars (*Triticum aestivum* L.) at germination and early seedling stages. Int. J. Appl. Agric. Sci., 1: 60-65.
6. Ivushkin, K., H. Bartholomeus, A.K. Bregt, A. Pulatov, B. Kempen and L. de Sousa, 2019. Global mapping of soil salinity change. Remote Sens. Environ., Vol. 231. 10.1016/j.rse.2019.111260.
7. Safdar, H., A. Amin, Y. Shafiq, A. Ali and R. Yasin *et al*., 2019. A review: Impact of salinity on plant growth. Nat. Sci., 17: 34-40.
8. Corwin, D.L., 2021. Climate change impacts on soil salinity in agricultural areas. Eur. J. Soil Sci., 72: 842-862.
9. Woldemariam, G.A., 2021. Efforts, successes and challenges of green feed production in Ethiopia. Online J. Anim. Feed Res., 11: 13-17.

10. Qadir, M., A. Ghafoor and G. Murtaza, 2000. Amelioration strategies for saline soils: A review. Land Degrad. Dev., 11: 501-521.
11. Badr-uz-Zaman, A. Ali, M. Salim and K. Hussain, 2002. Growth of wheat as affected by sodium chloride and sodium sulphate salinity. Pak. J. Biol. Sci., 5: 1313-1315.
12. Franco Navarro, J.D., M.A. Rosales, P. Cubero Font, P. Calvo, R. Álvarez, A. Diaz Espejo and J.M. Colmenero Flores, 2019. Chloride as macronutrient increases water use efficiency by anatomically driven reduced stomatal conductance and increased mesophyll diffusion to CO_2. Plant J., 99: 815-831.
13. Ahmadi, M. and M.K. Souri, 2019. Nutrient uptake, proline content and antioxidant enzymes activity of pepper (*Capsicum annuum* L.) under higher electrical conductivity of nutrient solution created by nitrate or chloride salts of potassium and calcium. Acta Sci. Polonorum Hortorum Cultus, 18: 113-122.
14. de Souza Mateus, N., E.V. de Oliveira Ferreira, J.C.A. Junior, J.C. Domec, L. Jordan-Meille, J.L. de Moraes Gonçalves and J. Lavres, 2019. The ideal percentage of K substitution by Na in eucalyptus seedlings: Evidences from leaf carbon isotopic composition, leaf gas exchanges and plant growth. Plant Physiol. Biochem., 137: 102-112.
15. Ievinsh, G., S. Ieviņa, U. Andersone-Ozola and I. Samsone, 2021. Leaf sodium, potassium and electrolyte accumulation capacity of plant species from salt-affected coastal habitats of the baltic sea: Towards a definition of Na hyperaccumulation. Flora, Vol. 274. 10.1016/j.flora.2020.151748.
16. Masters, D.G., H.C. Norman and D.T. Thomas, 2019. Minerals in pastures-are we meeting the needs of livestock? Crop Pasture Sci., 70: 1184-1195.
17. Wakeel, A., M. Farooq, M. Qadir and S. Schubert, 2011. Potassium substitution by sodium in plants. Crit. Rev. Plant Sci., 30: 401-413.
18. Paul, D. and H. Lade, 2014. Plant-growth-promoting rhizobacteria to improve crop growth in saline soils: A review. Agron. Sustainable Dev., 34: 737-752.
19. Shahbaz, M. and M. Ashraf, 2013. Improving salinity tolerance in cereals. Crit. Rev. Plant Sci., 32: 237-249.
20. Yu, Y., T. Xu, X. Li, J. Tang, D. Ma, Z. Li and J. Sun, 2016. NaCl-induced changes of ion homeostasis and nitrogen metabolism in two sweet potato (*Ipomoea batatas* L.) cultivars exhibit different salt tolerance at adventitious root stage. Environ. Exp. Bot., 129: 23-36.
21. Tester, M. and R. Davenport, 2003. Na^+ tolerance and Na^+ transport in higher plants. Ann. Bot., 91: 503-527.
22. Shrivastava, P. and R. Kumar, 2015. Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi J. Biol. Sci., 22: 123-131.
23. Khan, M.A., I.A. Ungar and A.M. Showalter, 2000. Effects of salinity on growth, water relations and ion accumulation of the subtropical perennial halophyte, *Atriplex griffithii* var. stocksii. Ann. Bot., 85: 225-232.
24. Gul, B., R. Ansari, T.J. Flowers and M.A. Khan, 2013. Germination strategies of halophyte seeds under salinity. Environ. Exp. Bot., 92: 4-18.
25. Zivkovic, S., M. Devic, B. Filipovic, Z. Giba and D. Grubisic, 2007. Effect of NaCl on seed germination in some Centaurium Hill. species (Gentianaceae). Arch. Biol. Sci., 59: 227-231.
26. Kalifa, A., N.N. Barthakur and D.J. Donnelly, 2000. Phosphorus reduces salinity stress in micropropated potato. Am. J. Potato Res., 77: 179-182.
27. Orcutt, D.M. and E.T. Nilsen, 2000. Physiology of Plants under Stress: Soil and Biotic Factors. Vol. 2, John Wiley and Sons, New York, ISBN-13: 9780471170082, Pages: 696.
28. Bensalem, N., S.M.R. Helali, M. Chebbi, T. Ghnaya and Z. Ouerghi, 2020. The interactive effect of nitrate/ammonium ratio and sodium chloride on tunisian medicinal plant (*Nigella sativa* L). J. Plant Nutr., 43: 987-999.
29. Dehnavi, A.R., M. Zahedi, A. Ludwiczak, S.C. Perez and A. Piernik, 2020. Effect of salinity on seed germination and seedling development of sorghum (*Sorghum bicolor* (L.) Moench) genotypes. Agronomy, Vol. 10. 10.3390/agronomy 10060859.
30. Kausar, A., M.Y. Ashraf, I. Ali, M. Niaz and Q. Abbass, 2012. Evaluation of sorghum varieties/lines for salt tolerance using physiological indices as screening tool. Pak. J. Bot., 44: 47-52.
31. Laiskhanov, S.U., A. Otarov, I.Y. Savin, S.I. Tanirbergenov, Z.U. Mamutov, S.N. Duisekov and A. Zhogolev, 2016. Dynamics of soil salinity in irrigation areas in South Kazakhstan. Pol. J. Environ. Stud., 25: 2469-2475.
32. Mostafazadeh-Fard, B., M. Heidarpour, A. Aghakhani, M. Feizi 2008. Effects of leaching on soil desalinization for wheat crop in an arid region. Plant Soil Environ., 54: 20-29.
33. Podkówka, Z. and L. Podkówka, 2016. Use of sugar sorghum (*Sorghum saccharatum*) for biogas production. Nauka Przyroda Technologie, Vol. 10. 10.17306/j.npt.2016.1.14.
34. Sharma, D.P. and N.K. Tyagi, 2004. On-farm management of saline drainage water in arid and semi-arid regions. Irrig. Drain., 53: 87-103.
35. Mossi, I., E.S. Adjou, C.P.A. Doosa, G. Nonviho, M.M.C. Adda, B.B Yehouenou and D.C.K. Sohounhloue, 2018. Production of bioethanol from stems of *Sorghum saccharatum* monitoring kinetic parameters of fermentation. J. Chem. Eng. Mater. Sci., 9: 9-16.
36. Hopmans, J.W., A.S. Qureshi, I. Kisekka, R. Munns and S.R. Grattan *et al*., 2021. Critical knowledge gaps and research priorities in global soil salinity. Adv. Agron., 169: 1-191.

37. Grygorenko, N., S. Danylenko and N. Stangeeva, 2018. Research of change of technological quality of *Sorghum saccharatum* juice in the process of storage of stems. Food Resour., 6: 48-55.
38. Storozhyk, L.I., V.I. Voitovska, L.V. Vyshnevska and L.M. Kononenko, 2019. Callus formation of sugar sorghum (*Sorghum saccharatum)* as affected by type and size of explantand level of ploidy. Adv. Agritechnologies, 10.47414/na.7.2019.204784.
39. Rakhmetov, D., O. Vergun, Y. Blum, S. Rakhmetova and V. Fishchenko, 2018. Biochemical composition of plant raw material of sweet sorghum (*Sorghum saccharatum* (L.) moench) genotype. Plant Introduction, 7: 22-37.
40. Kozlowski S., W. Zielewicz, R. Oliwa and M. Jakubowski, 2006. Biological and chemical properties of *Sorghum saccharatum* from the point of view of possibilities of its cultivation in Poland. Poznan Univ. Life Sci., Vol. 9: 112.
41. Lipińska, A., J. Wyszkowska and J. Kucharski, 2015. Diversity of organotrophic bacteria, activity of dehydrogenases and urease as well as seed germination and root growth *Lepidium sativum*, *Sorghum saccharatum* and *Sinapis alba* under the influence of polycyclic aromatic hydrocarbons. Environ. Sci. Pollut. Res., 22: 18519-18530.
42. Gondek, K., M. Mierzwa-Hersztek, W. Grzymała, T. Głąb and T. Bajda, 2021. Cavitated charcoal-an innovative method for affecting the biochemical properties of soil. Materials, Vol. 14. 10.3390/ma14092466.
43. Minhas, P.S., T.B. Ramos, A. Ben-Gal and L.S. Pereira, 2020. Coping with salinity in irrigated agriculture: Crop evapotranspiration and water management issues. Agric. Water Manage., Vol. 227. 10.1016/j.agwat.2019.105832.
44. Okur, B. and N. Örçen, 2020. Soil Salinization and Climate Change. In: Climate Change and Soil Interactions, Prasad, M.N.V. and M. Pietrzykowski (Eds.)., Elsevier, Amsterdam, Netherlands, pp: 331-350.
45. Tuymurodovna, A.H. and S.M. Muhiddinnovna, 2021. Assessment of irrigated lands in the soil climate of the Bukhara oasis. Eur. J. Mol. Clin. Med., 8: 1890-1901.
46. Singh, B., 2018. Are nitrogen fertilizers deleterious to soil health? Agronomy, Vol. 8.