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Brackish Water Consumption to Sustain Nutrients Concentration in Berseem (*Trifolium alexandrinum* L.) Through a Leaching Fraction Stratagem

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Abstract

This study determines the nutrients composition of berseem, irrigated with brackish water through different leaching fractions. In this study, five saline waters of different types (canal water, EC= 2dSm $^{-1}$, EC= 3dSm $^{-1}$, EC= 4dSm $^{-1}$, EC= 5dSm $^{-1}$) were used with leaching fraction of <15% and >15%. For layout of the experiment, randomized complete block design (RCBD) was used. The experiment comprised of 5 treatments and replicated three times; W1= Control (canal water + <15% LF and >15% LF; W2= EC 2.0 water with normal irrigation + <15% LF and >15% LF; W3= EC 3.0 water with normal irrigation + <15% LF and >15% LF; W4= EC 4.0 water with normal irrigation + <15% LF and >15% LF; W5= EC 5.0 water with normal irrigation + <15% LF and >15% LF. From every pot, the samples of berseem plants were taken for analysis from the laboratory. The maximum nutrient concentration of nitrogen, phosphorous, potassium, calcium and magnesium contents were obtained in harvested berseem from pots with W1 + <15% LF. However, the treatment W5 resulted the high sodium contents in the berseem plants. Leaching fraction showed to be suitable to stun harmful effect of salty water on contents of several nutrients existing in berseem fodder crop.

Keywords: Brackish and Canal Water; Berseem; Electricial Conductivity; Leaching Fraction, Nutrients

1. Introduction:

In the 21st century, there are many complications that are associated with agroecosystems. These complications contain environmental degradation, water scarcity, and soil and water salinization. There are two dangers to the continuity of agriculture: the first is the exponential growth of the human population, and the second is the shrinking amount of land available for crop production due to less availability of good quality water. One of the most distressing environmental stresses is high salinity in the soil making underneath water saline/ sodic, which leads to large lessening in the amount of farmed land, the amount of crop output, and the quality of the produce. Therefore, enlarged salinity of the soil and water in various agricultural areas around the globe has created significant hindrances for the

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cultivation of crops that are used for human consumption (Velmurugan *et al.,* 2020). Dry areas conquer approximately 45% of the earth's land surface (Prăvălie, 2016; Plaza *et al.,* 2018). In this zone, agricultural activity is inadequate by lack of water. These arid regions experience increased evapotranspiration (Plaza *et al.,* 2018) coupled with little precipitation, leading to serious water scarcity and affecting performance of most agricultural crops. Irrigation water usage in a proper way is an alternative to lessen these restrictions related to agriculture. Though, water salinity is regularly the topical issue (FAO 2020). Brackish water usage for irrigation can be an alternative for few crops (Haman & Negim, 2014; Mosaffa & Sepaskhah, 2019); but, it needs continual checking of soil features and crops variations towards saline conditions.

Accumulation of salts in the root area is one of the key reasons of less of yield with the use of brackish water. Different methods are used to protect water for more crop production on sustainable basis in major agricultural nations (Shahid *et al.,* 2012). In arid and semi-arid areas, agriculture is mostly dependent upon irrigation water. Good worth irrigation water volume is inadequate in the Indus plains areas to support agriculture (Minhas *et al.,* 2012; Murtaza *et al.,* 2013). Water scarcity is the major challenge facing in the arid regions which had adverse impact on crop production (Latif and Beg, 2004: Murtaza *et al.,* 2009). Due to deficiency of freshwater resources, this is the need of time to use the current irrigation water resources in an outstanding mode to improve the efficiency of water use to produce more food and fodder. The expanded exchangeable sodium percentage (ESP) and soil pH resulting from the prolonged sodic water usage leads to breakdown of soil structure due to dispersion of clay particles and swelling (Bello *et al.,* 2021). Therefore, water management practices are necessary in a suitable way. (Anonymous, 2009; Pawlowski *et al.,* 2009).

Saline water and salt affected soil drops the crop development and produce of several agricultural harvests (Teshika *et al.,* 2019; Syed *et al.,* 2021). Secondary salinization of soil is usually triggered by an imbalance between water and transpiration input from irrigation and rainfall. Additional factors include the unlined waterways and pools usage, and vegetation clearance, in combination with insufficient drainage that sieves salts into ground waters (Ritzema, 2016). From where the mixed salts can be re-mobilized to upper layers of soil by ways of upward water movements in desiccated areas (Crescimanno & Garofalo, 2006; Bhutta & Smedema, 2007). Incorrect irrigation practices with bad planning including temporal over irrigation are main causes of salinization related to soil (Wichelns & Qadir, 2015). The quality of the irrigation water and balanced fertilizer application are also imperative to evade secondary salinization. Due to the use of brackish water, soils are becoming salt-affected and there are many approaches to reclaim this affected soil, comprising leaching of salts, amendments adding up, ripping of salt affected soil, revegetation by use of halophytes and scrapping of salts.

Fodder crops moreover act as bio-remediator in soils affected by salts which are developed by use of saline-sodic water as irrigation. Production of salt-tolerant fodder varieties for speculative making suggests a key chance to utilize water and soil sources which are excessively saline for traditional crops and fodders (Malcolm *et al.,* 1996; Swingle *et al.,* 1996). Berseem (*Trifolium alexandrinum* L.) is the most common fodder crop for farmers to feed their animals being the cheapest source of livestock feed in region of Pakistan. Being the most loving feed of livestock, berseem is known as king of fodder crops due to its high forage nutritive value and a greater number of cuts. It has become very popular Rabi fodder crop in aggregated area of the country (Roy *et al.,* 2009). As the cheapest source, it provides feed before the occurrence of winter. In Pakistan poor farmers prefer to grow fodder crops on salt affected soil and non-availability of good quality water. Berseem is the most sensitive fodder crop in legume family but different amendments including leaching could enhance the soil characteristics and plant growth as well (Maas and Hoffman, 1977; Murtaza *et al.,* 2013). Salinity stress can damage the plant at cellular and whole plant stage and decrease in plant progress and production. Salt loving plants can preserve growth by causing osmotic adjustment within the cells and by excluding salts from exchange sites. All major functions in a plant body critically affected under saline condition according to study by Parida and Das, 2005. In salt stress condition plant growth affected with saline water which causes osmotic effects and reactive oxygen species (Pakar *et al.,* 2016). Soil sodicity is more unfavorable than salinity for quinoa (Abbas *et al.,* 2021). Continual use of this water deteriorates soil's physical and chemical features with a subsequent decline in growth and yields of plant (Ravikumar & Somashekar, 2017; Abdel Hafez *et al.,* 2020; Singh, 2020). Former research experiments proved that different amendments including leaching fractions could improve soil characteristics and growth of plants. Naturally, it was due to the upgrading of the soil environment, such as by improving macro-nutrient and water availability, which also could raise the plant resistance to salt stress. That happens as salts destructively influence plants by bringing physical scarcity by osmotic effects that hamper water transport in plants and ion toxicity.

A previous study was likewise described by (Sarwar *et al.,* 2009; Litardo *et al.,* 2022).

Shaygan & Baumgartl (2022) revealed that identifying an appropriate reclamation tactic for salt-affected soil by brackish water demands knowing the plant, soil and climate interaction. Therefore, knowing this interface is suggested before choosing any reclamation practice. Sustainable reclamation implementable approach ought to be under concern because certain methods of reclamation are for little time just. Salt leaching is a highly valuable technique among the above-mentioned approaches. But its usefulness is dependent on soil physio-chemical and the climatical situations (Halwatura *et al.,* 2015).

1.1. Objectives:

- To evaluate the efficiency of leaching fraction in dropping the negative irrigation impacts with brackish water on absorption of many nutrients in berseem.
- To effects of brackish water irrigation on the contents of different nutrients/ essential elements in berseem crop.

2. Materials and Methods:

2.1. Study Area:

This study was done under pot conditions during winter season to observe the saline water usage on nutrient maintenance concentration of berseem by using different leaching fractions in the outside study zone of Soil and Environmental Sciences Department, CA, University of Sargodha, Pakistan, sited 32.0740^{o} N and 72.6861^{o} E (Siddiqui *et al.,* 2021) under environmental conditions. Its elevation is 193 meters above sea level.

2.2. Experimental Design:

This research trial was done with RCBD design with five treatments which were replicated three times by sowing berseem cultivar "Hisar Berseem 1". The treatments were as; W1 = Control (canal water + < 15% LF and >15% LF; W2= EC 2.0 water with normal irrigation + <15% LF and >15% LF; W3= EC 3.0 water with normal irrigation + <15% LF and >15% LF; W4= EC 4.0 water with normal irrigation + <15% LF and >15% LF; W5= EC 5.0 water with normal irrigation + <15% LF and >15% LF.

2.3. Soil Sampling and Analysis:

A compound soil sample was carried from agricultural area, air-dried, crushed, sieved (2 mm 10 mesh cm^{-1}) and was examined for physicochemical properties of soil. The analysis was done according to Handbook 60 of U.S. Laboratory Staff (1954). The texture of soil was clay loam with pH= 7.87 and EC= 11.39 dSm^{-1} (Table 1).

Table 1: Physio-chemical properties of soil used for experiment.

Properties of Soil	Pot	References
Physical properties		
Textural class	Clay loam	Bouyoucos, (1962)
Chemical properties		
pH	7.87 ± 0.06	US Salinity Laboratory Staff, (1954)
Electrical conductivity (µS cm^{1})	1139 ± 17.61	
Total organic-C (g kg^{-1})	5.84 ± 0.13	Walkley & Black, (1934)
Total nitrogen (mg kg^{-1})	263.08 ± 9.43	Jackson, (1958)
Available P (mg kg^{-1})	6.90 ± 0.65	Watanabe & Olsen (1965)
Extractable K (mg kg^{-1})	184.90 ± 9.23	US Salinity Laboratory Staff, (1954)

Values are mean of three replicates trailed by (±) standard error of means.

2.4. Seed Growing:

The uniform sizes pots were filled with field soil containing 12 kg in each pot. All pots were settled using RCBD design that was replicated three times. To maintain ideal moisture for development and seedling growth, distilled water was used for irrigation. Seeds of berseem cultivar "Hisar Berseem 1" were sterilized in sodium hypochlorite solution (5%) and then 96% for ethanol for 30 sec. Ten seeds of berseem were sown at 2-3 cm depth in each pot, and after seedling emergence, they were thinned to five in each pot after one week of germination and watered daily. After 10 days of germination the first irrigation was done. Other irrigation was applied to the crop according to the season and condition of the crop.

2.5. Preparation of Poor-Quality Water Level:

Using a quadratic equation, the salt required to build the poor-quality water (brackish water) levels was calculated (Abid, 2002) and mixed in distilled water. The salt $NaHCO_3$ @ 4.29 gL^{-1} was used to produce the sodic water level in the research laboratory. Then at the 2-3 leaves seedling phase, this poor-quality water (sodic) level was used in this pot experiment as the plant growth medium for all treatments except control.

2.6. Fertilization:

NPK recommended doses for Berseem fodder (100-80-50 kg ha^{-1}) were utilized in this study. Urea, SSP (Single Superphosphate), and SOP (Sulphate of Potash) were applied for supply of N (Nitrogen), P (Phosphorous) and K (Potassium) correspondingly. Nitrogen in half quantity and all phosphorous and potassium were utilized at sowing time whereas left-over nitrogen (half) was applied by following 30 days of sprouting. The berseem plants were mowed at maturity and crop samples were gathered to examine many factors/ parameters.

2.7. Measurement of Mineral Nutrients Attributes:

Berseem shoot samples were dried at 70ºC in an oven and later grinded. The dried-up ground plant material of 0.5 gm was shifted into digestion tubes and was digested with acid for the nutrients analysis including Nitrogen, Phosphorous, Potassium, Calcium, Magnesium and Sodium. Nitrogen and phosphorus determination in plant samples is determined by the method of Jackson (1958). Potassium and Sodium contents in plant samples were verified on a flame photometer (Jenway PFP-7). An atomic absorption spectrophotometer was used to examine calcium and magnesium.

2.8. Meteorological Data:

The meteorological data for the experimental crop development duration was obtained from the Pakistan meteorological department and are presented in Table 2. The mean rainfall, temperature and humidity from October to November months were obtained in 2019-2020.

Table 2: Meteorological data of mean temperature, relative humidity and rainfall through berseem growth period from October to November during 2019-20.

Month	**Temperature**			**RH**	**Rainfall**	**Pan**	**Sunshine**	**ETo**	**Wind speed**
	Maximum	Minimum	Average			Evaporation			
	ºC	ºC	ºC	%	mm	mm	Hours	mm	km h^{-1}
Berseem									
October	36.21	28.68	32.44	57.67	32.67	6.13	10.97	5.89	7.76
November	34.72	24.37	29.54	56.52	22.20	5.76	10.40	4.45	672

ETo: Evapotranspiration, **RH:** Relative humidity

2.9. Statistical Analysis:

RCBD was done for said test. The collected data was statistically analyzed using Fisher's study of variance, and the significance of treatments was determined using CRD (Steel *et al.,* 1997). Statistical evaluation and correlations among variables were also assessed by use of Statistic 8.1 package.

3. Results:

3.1. Nitrogen (%):

Nitrogen (N) is the chemical element and chlorophyll component which is consequently vital for the photosynthesis. The data concerning the nitrogen % in berseem is showed in Fig. 1 which displayed that canal and different level of brackish water meaningfully affected on content of nitrogen in berseem. The highest nitrogen contents in berseem were attained from the pots which were irrigated by canal irrigation water with leaching fraction >15% as shown in the Figure 1. Within the treatments, parallel effect of leaching fraction was detected and in sub treatments. Contents of nitrogen in pots having <15% leaching fraction was observed to be lower than >15% leaching fraction. The T1 treatment confirmed domination over all other treatments due to usage of canal water with <15% leaching fraction. As the electrical conductivity of irrigation water enhanced and the leaching fraction reduced contents of nitrogen. The minimum nitrogen % was noted in treatment T4 plots which were irrigated with EC 4.0 dSm^{-1} water trailed by treatment 5 having EC 5.0 dSm^{-1}.

3.2. Phosphorous (%):

Phosphorous (P) is a vital component of ATP and the utmost crucial nutrients for health of plants. It performs a significant and vital role in photosynthesis and various other process (chemical and bio-chemical) of crops. Results exposed that canal water usage and different level of brackish water with and without leaching fraction exaggerated P content in berseem pointedly. The highest contents of P in berseem plants were attained from those pots which were under the canal irrigation among all other treatments with leaching fraction >15% as exposed in the Fig. 1. Same impact of leaching fraction was noted within the treatments and sub treatments. Contents of Phosphorous in pots having < 15% leaching fraction were observed to be lower than >15% leaching fraction. The treatment W1 (canal water) confirmed dominance over all the other treatments. As the level of saline water enhanced and the leaching fraction lessened phosphorous contents were also decreased. The least phosphorous concentrations were detected in the plots of W4 treatment which were irrigated with EC 4.0 dSm^{-1} water trailed by treatment W5 having EC 5.0 dSm^{-1}.

3.3. Potassium (%):

Potassium (K) is vital for movement of water, nutrients and carbohydrates. Potassium also synthesizing plant sugar use as a food. Result about K in berseem crop is shown in Fig. 1 which exposes that different level of brackish water had major effect on K content in berseem. The maximum contents of K in berseem plants were attained from pots which were irrigated by canal irrigation as shown in the Figure 3. Parallel leaching fraction effect was seen within the treatments and sub treatments. Concentration of K in pots with <15% leaching fraction was distinguished to be lower than >15% leaching fraction. The treatment W1 (canal water) confirmed supremacy over all the other treatments due to canal irrigation usage with leaching fraction >15%. Irrigation water with high EC reduced potassium contents in berseem. The lowest potassium contents in berseem were noted in W4 treatment plots which were watered with EC 4.0 dSm^{-1} water trailed by treatment W5 having EC 5.0 dSm^{-1}.

3.4. Calcium (%):

Calcium (Ca) plays an important role in cell walls and cell membrane of plants and also contribute cell elongation and cell division. Calcium play an important role in cell membrane stability and uptake of ions and different metabolic process. Data concerning calcium content in berseem is presented in Fig. 1 which exposes that when canal water applied for irrigation, calcium content in berseem crop reported significantly. The highest concentrations of calcium in berseem were recorded from those pots where canal irrigation water trailed by plots irrigated with EC 2.0 dSm^{-1} and 3.0 dSm^{-1} water as shown in Fig. 1. Alike leaching fraction effect was noted within other treatments. Concentrations of calcium in berseem of pot with leaching fraction <15% was observed to be lower than leaching fraction >15%. The treatment W1 confirmed supremacy over all other treatments due to canal irrigation usage having >15% leaching fraction. As EC of irrigation water amplified and leaching fraction reduced amount of Ca also decreased. Minimum concentrations of Ca were recorded in W4 which were irrigated with saline irrigation having EC 4.0 dSm^{-1} in the pots trailed by W5 treatment with EC 5.0 dSm^{-1}.

3.5. Magnesium (%):

Magnesium (Mg) is the central core chlorophyll molecule which plays significant role in plant photosynthesis. Mg is an activator for many enzymes required in growth processes. It is also synthesis of oil in plants. Data discovered that canal water irrigation and brackish water had a significant influence on the concentrations of magnesium in berseem fodder crop. Result showed in Fig. 1 that canal irrigation usage was well than that of irrigation with EC 2.0 dSm^{-1} and 3.0 dSm^{-1} saline water alone and with different leaching fraction. Highest contents of magnesium in berseem plants were attained in pots which were irrigated by canal irrigation trailed by pots irrigated with EC 2.0 dSm^{-1} and 3.0 dSm^{-1} saline water. Same result of leaching fraction was noted within the sub- treatments and treatments. Concentrations of Mg in berseem plant of pots having >15% leaching fraction was observed to be more than leaching fraction <15%. The treatment W1 confirmed supremacy over all other treatments due to canal irrigation usage with >15% leaching fraction. As the electrical conductivity enhanced and the leaching fraction reduced, contents of Mg were also compacted. The lowest contents of Mg were noted in treatment W4 which were irrigated with EC 4.0 dSm^{-1} saline water trailed by W5 EC 5.0 dSm^{-1}. Magnesium contents in berseem plant were statistically alike with each other in case of W2 and W3.

3.6. Sodium (%):

In plants sodium (Na) is an inorganic, essential element presents in small amount. Mostly cations like sodium, calcium and magnesium are the major elements in saline irrigation waters. The canal irrigation with different levels of saline water significantly affected the Na contents in berseem (Fig. 1). Among all the treatments, saline water irrigation with EC 5.0 dSm-1 (W5) made maximum Na contents in berseem which were trailed by saline water of W4 (>15 % LF). The normally sodium contents in berseem were noted in W3 (EC 3.0). However, these treatments of W4, W5 and W1 were verified statistically nonsignificant with each other. The treatments W1 (canal irrigation water with <15% leaching fraction) verified minimum concentrations of Na in berseem plant which was trailed by saline water with W2 having EC 2.0 dSm^{-1} and W3 having EC 3.0 dSm^{-1} as shown in Fig. 1.

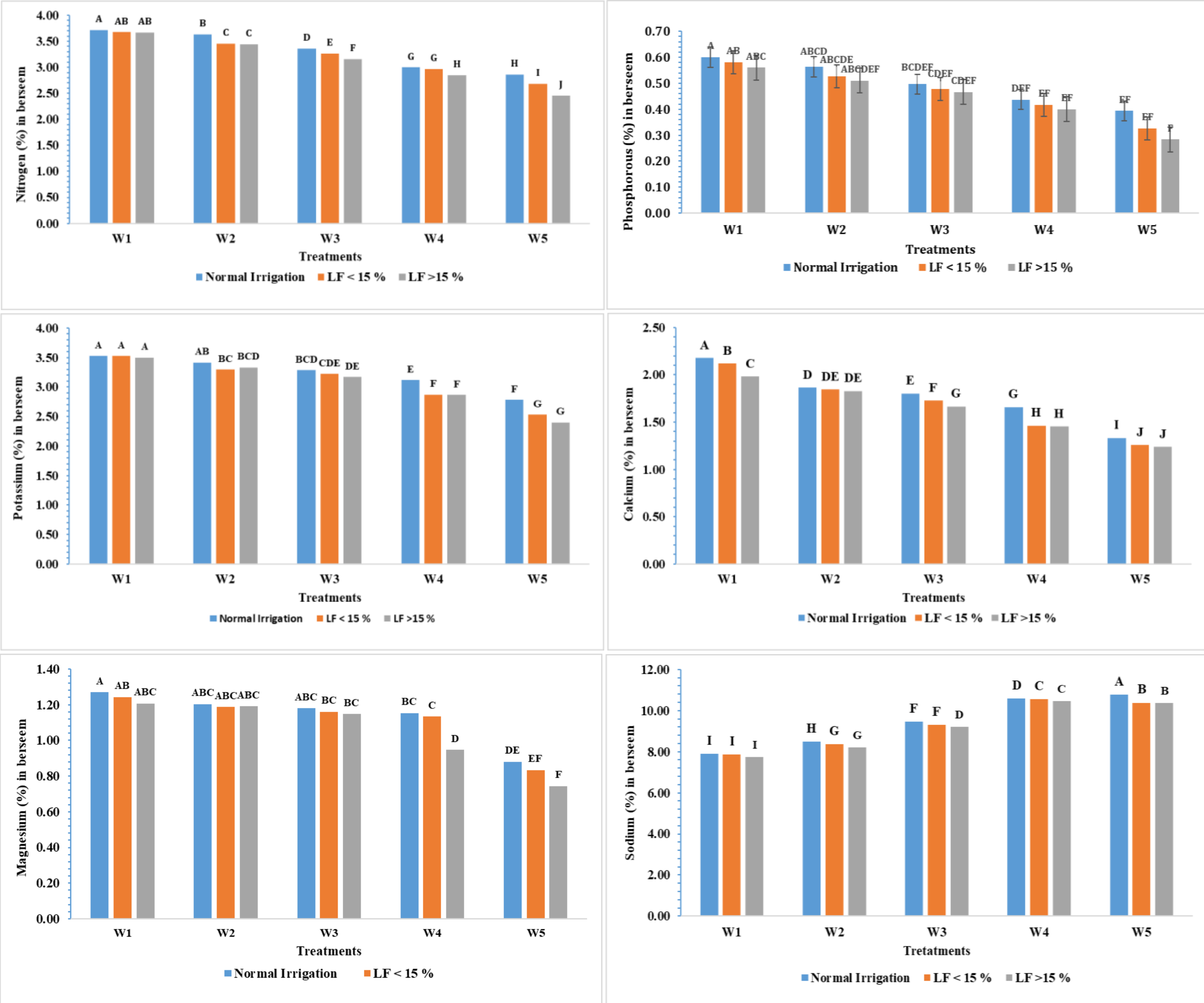

Figure 1: Nitrogen (%), Phosphorous (%), Potassium (%), Calcium (%), Magnesium (%) and Sodium (%) of berseem under different amendments of brackish water

4. Discussion:

Chemical composition of plants refers to the distribution of different elements in plant tissues. Therefore, a plant's chemical makeup reflects the soil and other environmental factors that influence how it begins or ends its life cycle. One may argue that a plant's chemical makeup serves as a signal of all good or bad changes that it experiences throughout its life cycle. Similar to this, there are numerous internal and external factors that influence on different nutrients uptakes from the soil in one way or another, including soil characteristics, climatic conditions, water availability, development procedure including phase of roots, absorption and nutrients accessibility, and aeration. In addition to all of these factors, the most vital and essential thought is the kind and concentration of available elements, which is crucial to its uptake (Sarwar, 2005). Pakistan's soils have a high salt content as a result of low rain fall and its arid environment, which is one of the causes of its poor soil fertility. By adding quick available forms of particular nutrients to the soil, the accessibility of all types of nutrients can be enhanced. But inopportunely, because of the high pH and salt stress environment, neither the plants nor the soil eternally holds any of these nutrients in a usable form. As a result, an ample portion of applied nutrients are quickly converted into forms that are not available due to a constant, ongoing natural dynamic process. Under irrigation with saline water, a portion of it is permanently fixed in the soil.

The goal of the current study was to assess the potential for leaching fraction when saline water was used for irrigation. The current study found that berseem plants' nitrogen absorption was negatively impacted by irrigation with saline water (Sarwar *et al.,* 2009: Anonymous, 2012). The use of saline water as a source of irrigation has a major impact on the intake and amount of nutrients like N, P, K, Ca, and Mg. When using canal water for irrigation, the highest concentration of these nutrients was found, as opposed to using saline water with 3.0 dS m^{-1} EC. When combined with a leaching portion of <15%. However, the volume of canal water irrigation is insufficient in Indus plain. The usage of this saline water improved the nutrients concentration in berseem crop. Though, below these circumstances, irrigation with saline water had a relatively high sodium (Na^{+2}) concentration. The intake of sodium finally reduced when Ca & Mg were taken up more and vice versa. This was because the root area of soil was made free from salts using the leaching fraction process, which eliminates salts from the soil's root zone. In this way, increased nutrient availability led to increased nutrient uptake by plants. Excessive salts are leached down the soil root zone as a result of the leaching fraction method, which increases the solubility and availability of nutrients and increases nutrient uptakes. These improvements make the physical characteristics of the soil and many others more favorable for the growth of fodder plants. As a result, root growth is encouraged, which increases the rate at which nutrients are taken up from the soil root zone (Sarwar *et al.,* 2003).

Numerous studies have confirmed our findings, showing that salt accumulation impair the soil properties and difficult to replenish the water supply in the root zone by irrigation. Accumulation and crucial nutrients movement was noted including N^{+}, K^{+}, and Ca^{+2}, in a variety of crops, including sunflower, cabbage, and canola (Jamil *et al.,* 2007; Akram *et al.,* 2007). The saline water application for irrigation purpose intensely reduced the uptake of macro and micronutrients from soil root zone. According to El-Nour *et al.,* (2005), the recent outcomes concur with that of Carden *et al.,* (2003), who asserted that potassium concentrations in plant cells were maintained by employing the leaching fraction approach under saline conditions. As per Akram *et al.,* (2007) salt pressure dramatically lessened the micronutrient levels in plants, similar findings to ours were previously reported by Carter *et al.,* (2005), who found that increased salt accumulation in the soil root zone decreased Calcium ion activity in exterior situation, which likewise decreased calcium accessibility in crops. Under salinity environment our outcomes are retained by El-Nour *et al.,* (2005) that plants cannot absorb nutrients from the soil. Another study also claimed that watering with saline water increased sodium content in plants significantly, increasing soil salinity by Acosta-Motos *et al.,* (2017).

5. Conclusion:

Saline water irrigation proved to be beneficial in reducing the negative impact on plants along with leaching fraction which is a modern management technique. In berseem fodder crop, it improved the content of macronutrient and micronutrients by the use of saline irrigation water which was combined with different levels of leaching fractions. Canal water use was found to be superior to all other treatments in this experiment. However, the saline water usage demonstrated to be inferior to all further different treatments.

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