***INT. J. BIOL. BIOTECH.*, 20 (1): 145-155, 2023.**

YIELD AND NITROGEN USE EFFICIENCY OF SOME BIOSALINE AGRICULTURE FORAGE PLANT SPECIES UNDER DIFFERENT TREATED SEWAGE EFFLUENT (TSE) IRRIGATION LEVELS

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ABSTRACT

The aim of this investigation was to determine effects of applying N fertilizer and the optimal irrigation amount on enhancing forage production on excessively saline soils (Sabkha) utilizing treated sewage effluent (TSE) irrigation. Experiments were carried out on saline-proven forage plant species. N15-fortified urea fertilizer was used to track the fertilizer-sourced nitrogen in the biomass yields. Effects of irrigation and nitrogen rate were examined on fodder biomass output, nitrogen content, and nitrogen use efficiency. A split plot design was adopted with three main factor drip-irrigation flow rates and four sub-factor nitrogen (N) application rates. The level of irrigation water significantly affected the amount of biomass produced but the effect of fertilizer application rate and its interaction with the TSE irrigation level were insignificant. No association was there between the two variables (correlation coefficients = 0.28 and 0.01). Variations in nitrogen derived from fertilizer (% Ndff), total nitrogen (% TN), and fertilizer nitrogen use efficiency (FNUE) although affected by the two tested factors but did not appear to be connected to changes in yield. The agronomic approach of growing a combination of fodder beet and legumes appeared as another potential technique besides breeding for achieving high nitrogen (TN) content and nitrogen use efficiency (FNUE).

Keywords: Sabkha land, Excessive salinity, Biosaline agriculture, Forage plant species, N15 fortified urea; N-tracing. , Fertilizer nitrogen use efficiency.

INTRODUCTION

In the 21st century, there are several problems that are associated with agroecosystems. These problems include environmental degradation, water scarcity, and soil and water salinization. There are two threats 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. Because of this scenario, there is a greater need for land that can be cultivated. However, natural factors such as irregular precipitation, severe temperatures, drought and floods, high winds, and soil salinity have had an influence on crop yield and cultivation, which in turn has led to a decrease in overall food production. One of the most devastating environmental stresses is high salinity in the soil, which leads to large reduction in the amount of farmed land, the amount of crop output, and the quality of the produce. The salinity of the soil has significant consequences on the general population, particularly on farmers, because of the influence it has on agricultural practices. Given the growing cost of farming, it is of the utmost importance to determine the causes of soil salinity as well as the impacts of soil salinity (both economically and environmentally) on the yield of crops grown in saline soils. Thus, increased salinity of the soil and water in many agricultural regions around the globe has created significant obstacles for the cultivation of crops that are used for human consumption. (Velmurugan *et al.,* 2020). However, it has provided fresh possibilities for animal rearing. There are certain plants that can survive in salty conditions, and these plants have historically been employed as grazing animal fodder or as roughage replacements in more varied diets. Few attempts have been made to improve the plant's suitability for animals, either by agronomic or genetic modification of the plant itself, or by identifying both the animal species and group that is best suited to the plants. An explanation is that few humans have tried to adapt these plants so that they are more palatable to animals. (Kewan *et al*., 2019)

On extremely saline soils, little is known about the effects of applying N fertilizer and the optimal irrigation level to determine the yield potential and nitrogen utilization efficiency. Utilizing treated wastewater for agriculture gains a global importance (Oki and Kanae, 2006). Increased urea application strongly acidifies soil by enhanced plant uptake of base cations. Thus, it can alleviate salt stress within a specific salinity range (Du *et al*., 2022). Experiments were conducted between 2017 and 2019. As a tracer for the N fate, N15-enriched urea fertilizer was utilized. The objective was to determine the effect of irrigation and nitrogen application rate on the yield, nitrogen content, and nitrogen use efficiency of forage biomass. There were three experiments undertaken. Each consisted of a factorial combination of three main factor drip-irrigation flow rates (2, 4, and 8 liters/hour) and four sub-factor nitrogen rates (0, 110, 220, and 330 kg N/ha for fodder beet and Brassica, and 0, 25, 50, and 75 kg N/ha for Sesbania).

BIO-SALINE AGRICULTURAL FORAGE

Some animals may use salt-tolerant plants as a food source or a fiber source. There is a dearth of quantitative data on the use of these plants as cattle feed (e.g., Semple *et al*., 2003). The resilience of these plants is one of their most distinguishing features. It is not hard to find plants that have potential for use in Biosaline agriculture; what is challenging is growing such plants and getting them to market. What we call "Biosaline agriculture" is really farming in environments where the salinity of the groundwater, soil, or both varies. Salinity covers a lot of ground. Some examples of salty habitats include the Eastern Mediterranean, which has saline groundwater but non-saline, highly transmissive, permeable soils; Central Asia and Australia, which have saline and/or sodic soils; and saline irrigation fluids. According to a recent study (Corwin and Scudiero, 2019), the salinity, availability, and ionic composition of salty water, as well as the responsiveness of soil, are very varied even under these extreme conditions. While no plant is ideal for every environment, even a little patch of salty soil may support a rich diversity of plant life. The high plant variety at this location may indicate that no one species is well-suited to fill all the available ecological niches (Norman *et al.*, 2003). Despite the extreme saltiness of two regions in Australia, thirty-five species managed to flourish there. Several types of niches and species interactions, such competition and complementarity, need to be thought through before making decisions concerning saltwater environments.

The amount of edible biomass that is generated on a Biosaline farm will determine the maximum number of times that animals may be grown there. In addition to the specific ion functions it has; salt also has osmotic effects on the growth of plants. A diet that is heavy in salt may lead to cellular dehydration as well as a loss of turgor in the tissue. It is possible that an overabundance of salt and chloride may throw plants' metabolic processes off-kilter as well, mostly since they are both cations. Osmotic stress has a more direct influence on the germination of seeds, the sprouting of young plants, and the initial stages of plant development. In contrast to the effects that ions have, the impacts of osmotic stress may be seen very immediately. Plants that can tolerate high amounts of salt may be able to rid themselves of excess salt in one of four ways: they may be able to either reject salt at the root level, limit its transport to the shoot, move salt ions into vacuoles, or expel excess salt through the leaves. Plants that can survive in very salty environments could be able to expel excess salt via their leaves. Plants that can withstand high levels of salt may actually release salt via their leaves. It is to be anticipated that the bulk of actions conducted daily in the plant would have large energy needs (Barrett-Lennard *et al.*, 2003). As a result of the inability of plants to transfer the energy they would have spent reacting to salt stress toward growth, the potential that they possess is hampered.

The presence of salt in either the water or the soil may slow the development of vegetation. Plants that are salt-sensitive have a growth rate that is 50% slower at 4-5 dS.m^{-1}, which is equivalent to 7-9% saltwater. Once they are established, halophytes can develop in surroundings with a salt concentration as low as 4-5 dS.m^{-1}, and their growth rate does not begin to decrease by 50% until the salt concentration reaches 40 dS m^{-1} (87% of which is in saltwater). It is possible that increases in salinity will slow down the rate of reproduction in salt-tolerant non-halophytes (Barrett-Lennard *et al.*, 2003).

It is possible to cultivate puccinellia (*Puccinnelia stricta*), tall wheatgrass (*Thinopyrum ponticum*), balansa clover (*Trifolium michelianum),* Italian ryegrass (Lolium *multiflorum*), saltwater couch (*Paspalum vaginatum*), and sweet clover (*Melilotus alba*) in areas with low to moderate salinity. These plants collectively produce four to ten tons of dry matter per hectare (Warren et al., 1996; Evans and Kearney, 2003). At ECe: 13.1 dS m^{-1}, creeping wild rye (*Leymus triticoides* cv. Rio) produced an extraordinary amount of dry matter (10–13.8 t DM ha^{-1} year^{-1}), but tall wheatgrass only produced a moderate amount (5.9–8.2 t DM ha^{-1}.year^{-1}) of dry matter (5.9–8.2 t DM ha-1 year^{-1}). Alkali sacaton with *Sporortula airioides* alone with tall wheatgrass (Suyama *et al.*, 2006). This amount of biomass is sufficient to support a subsistence level of animal production; however, there is room for expansion if grazing is managed to improve plant nutrition.

Indoor sand tank cultivation of Bermuda grass (*Cynodon dactylon* cv. Tifton), Paspalum (*Paspalum vaginatum* cv. Duncan and cv. Polo), and forages resulted in yields of 9.4, 10.5, 7.8, 8.8, 6.6, 5.9, 5.6, 5.6, and 4.6 t dry matter per hectare. This was accomplished by employing synthetic drainage water with ads m-1 concentration of (Robinson *et al.,* 2004; Grattan *et al.,* 2004). Sulfates were the predominant component of the salty drainage water that was used in these investigations. Earlier, consideration of this topic was given. Other research has shown that sulfates, not chlorides, are the most effective way to increase a plant's salt tolerance. Research conducted in greenhouses has led to the discovery of certain grasses and legumes that can withstand high levels of salt. These plants have reached their full maturity and are in good health. It is necessary to do more field study to determine whether these plants can produce an economically feasible amount of biomass when grazed. If you do so, you will be better able to evaluate the potential of the plants.

When irrigated with salty drainage water, saltbush (*Atriplex* spp.) has the potential to produce anywhere from 2.2 to 5.3 tons of dry matter per hectare and per year. According to the findings of a research carried out in Australia. In hypersaline conditions, the halophytes *Atriplex, Salicornia, Distichlis crenata,* and Batis can potentially create significant amounts of biomass. In any case, this is what the study indicates (about 70 dS.m-^{1}). Once they were established, all these plants produced more than ten tons per hectare on a yearly basis, even though a few of them required more care when they were in the early phases of their growth. The International Center for Biosaline Agriculture has calculated that coastal couch and inland salt grass may provide hay yields of 45 t DM ha^{-1} year^{-1} when irrigated with 30 dS.m^{-1} of salty groundwater. This information comes from research that was conducted by Clifton *et al.,* (2019) on *Distichlis spicata*.

It was observed in the past that the optimal conditions for fodder production are either water and soil salinities that are low to moderate, or when saline water is easily accessible and soil penetration rates are high. In regions where there is both a high concentration of salty water and soil penetration, forage yields tend to be higher. These two components working together would be beneficial to the situation in many ways. The areas of the globe that tend to have the highest concentrations of salt are those that have arid or almost dry climates, according to research that was conducted by FAO and AGL (two thousand). The Chenopodiaceae halophytic plants are perfect for this environment since they are perennial, resistant to drought and can withstand being grazed on. They can successfully adjust to the varying climatic conditions. Plants such as saltbushes, small-leafed bluebush (*Maireana brevifolia),* Kochia spp., Tamarix spp., glassworts (*Salicornia* spp.), and Suaeda spp. have been utilized for grazing and the production of fodder in environments that are either salty or non-saline because of their resistance to salt and drought. There is a wide range of variation in the percentage of edible biomass to total biomass; in certain cases, it may be as low as 10%. (Barrett-Lennard *et al.*, 2003). Either the amount of edible biomass or the overall amount of biomass will rise or decrease depending on how the forest is maintained. When saltbush is chopped down or subjected to heavy grazing, the plant responds by producing new growth that is less woody and more edible. The adaptability of the plant is to fault for this situation. When it comes to harvesting plants, having knowledge of the optimal height at which to cut them will allow to get the most out of crop. Saltbush species in low-salinity environments, produces 5 to 10 kg DM ha^{-1} year^{-1} for each mm of precipitation (Le Houe'rou, 1992). In areas with a low salinity, this was a significant issue. This seems like a plausible forecast to make, considering the saltbush's resistance to dryness. This shows that yields of 2-4 tons of dry matter per hectare are possible, provided that the soil is adequate and there is a consistent amount of precipitation (200-400 millimeters per year). The annual production of dry matter in salty soil might vary from a half to a full ton per hectare. There is an increased potential for rotting (Warren *et al.,* 1994; Morecombe *et al.,* 1996).

The quantity of dry matter that is generated by an organism is dependent not just on its genetic make-up but also on the environment that it lives in. Whether or whether a plant is successful depends on a number of things, including the climate, the soil, the plant and animal life, and the animal life.

In regions with low to moderate amounts of salt, it is feasible to achieve high levels of forage and animal production. It is possible that the availability of salty groundwater or irrigation water at the location may determine whether feed will be available outside of the growing season. It is possible that this may help you feel better. The potential for agriculture in dry and semiarid settings is reduced when the soil and water are salty. Even in these areas, food surpluses and grain production might be increased with the help of salt-resistant plant species.

The plants that are cultivated for use as Biosaline fodder have not been developed to have the highest possible nutrient density. It is possible to increase the profitability of livestock systems by choosing and managing livestock systems in such a way as to maximize metabolizable energy and protein, as well as by finding plants that accumulate less salt and chemicals that are detrimental to nutritional value.

It is possible to enhance the amount of organic matter that is converted into livestock products by selecting animals that are more tolerant of high salt intakes across species, breeds, and classes. Discover types of animals that can adjust to higher salt concentrations.

Yield and Nitrogen for Biosaline Agriculture

Since most of our agricultural plants have been grown in cultivated soil throughout their lives, they are very vulnerable to salt. The term "glycophytes" is used to describe these agricultural plants because they are unable to complete their life cycle in an environment high in salt ions, in contrast to "halophytes," which can do so. While most other plant species perish under high salt concentrations, halophytes thrive. One of the most crucial aspects in determining the potential for agricultural plant production in arid and semiarid locations is the salinity of the soil. Lack of water and improper drainage in irrigated regions has detrimental effects on the economy, the environment, and society (Munroe and Gilliam, 2015). Salt buildup in the soil solution limits the availability of available water and nutrients. Results include osmotic stress, ion toxicity, nutritional imbalances, and dehydration. In addition, chlorosis and premature leaf senescence may be induced by exposure to high salt ion concentrations in leaves that retain their photosynthetic capabilities (Hanin *et al.* 2016). Presently, less than a third of the plant-based food we eat comes from the thirty crop plant species that have been domesticated. In moderately salty circumstances, yields of all major glycophytic crops are lowered by 50–80%. (EC: 4-8 dS.m^{-1}). It is anticipated that in certain places, salinity-related issues may grow more severe because of climate change. A variety of techniques, including as mitigation and adaptation, are required to deal with such consequences (Shrivastava and Kumar, 2015). By 2050, it is estimated that there will be 9.1 billion people in the globe. To feed everyone, food production would need to grow by 70 percent (Panta *et al.* 2014). Improving crop yields in salty areas requires a deeper understanding of the physiological, biochemical, molecular, and genetic underpinnings of salt tolerance. Research in these fields may help get the job done. This article details the mechanisms that, when present in high-salt environments, serve to restrict development and harvest success.

High yields and high-quality grain, fiber, sugar, oil, or protein can be obtained from crop plants if their optimal growth needs, such as those related to temperature, light, and nutrients, are met throughout the growth season. Whether the crops are cultivated inside or outdoors, this is true. During their development, plants are negatively affected by abiotic stressors like salt or drought, which may have a negative impact on yield-related properties. The yield, as well as the quality and quantity of the plant's products, will decrease if salt stress stops the plant from developing in the early stages of growth. While the negative impacts of salt on crops may not be immediately apparent, it is crucial to be aware that salinity may reduce crop yields. Whether or not a crop can absorb water and nutrients from salty soils and whether it can tolerate high concentrations of salt ions in its tissues are two of the main factors that determine how salt tolerant or sensitive a given crop will be (Kaleem *et al.* 2018; Kahn *et al.* 2017; Ahmad *et al.* 2017).

MATERIALS AND METHODS

The test plants selected represent three types of forage crops: forage beet - *Beta vulgaris* (shallow root forage), brassica - *Brassica napus (*oil seed forage) and *Sesbania aculeate* (seed-legume forage) where the first two are winter forages (October to March) meanwhile the last one is a summer forage (April to September). These plant species had proved suitable to grow on Sabkha (Elsharief Abdalla *et al.* 2015) and were chosen to manifest root (the beet), oil seed (Brassica) and legume (Sesbania) forages.

SITE, TREATMENTS AND EXPERIMENTAL DESIGN

Field experiments were conducted in the MM (Ministry of Municipality) Biosaline agriculture research station which exists in the Subkha of Dukhan (N25°26′24″, E50°52′12″), a salt-encrusted flat area resulting from evaporation of a former body of water, near the western coast of the State of Qatar. The marginality of the barren Sabkha is mainly due to soil salinity and waterlogging (water table at 80cm depth) which give way only to uneconomical yields of any hosted cropping system. Salinity in the non-cultivated control and cultivated soil expressed as average EC value in dSm^{-1} was 100 and 12.15, respectively. Cultivated soils in their top 60 cm had averages of 8 saturated extract pH, 0.70% organic matter and 30% $CaCO_3$. The soil texture in all experimental plots was loamy sand which averaged 81.88% sand, 6.35% silt and 11.72% clay). It was classified as *a typical aquisalid* (Soil Survey Staff. 1999). Three independent field trials were implemented in split plot experimental design on the above-mentioned selected plants as test crops during 2017 to 2020 years. Irrigation levels (First factor) were assigned to main plots, meanwhile fertilizer application rates (Second factor) were assigned to subplots. Each Fertilizer plot was divided into a yield-subplot (large) and an isotope-subplot (small) to accommodate ordinary and N15 enriched urea fertilizer applications, respectively. The three TSE irrigation levels were implemented by using appropriate drip irrigation networking method with flow rates of 2, 4 and 8 liters/hour dripping units. All these flow rates are maintained to automatically irrigate their assigned-to plots for 10 minutes once a day for 5 days a week.

DATA COLLECTION

The forage plants were harvested from N15 microplots to measure both %N15 excess and % total N. This harvest was chopped, oven-dried at 70 C, thoroughly mixed then subsamples of above or below ground biomass and/or leaf and seed were taken for each test crop, well-packed and mailed to IAEA laboratories for N mass absorption measuring. Macro-yield plots were harvested and both fresh and dry biomass weights were determined in kg ha^{-1}.

Statistical analysis

The crop biomass & seed yield data were analyzed using a Statistical Analysis System (Lowry, 1998) - Vassar Stats website). Following the analysis of variance procedures, differences among treatment means were determined using the Tukey' Honest Significant Difference (HSD) test. This test is a post hoc test commonly used to assess the significance of differences between pairs of group means.

Fertilizer Use efficiency (FUE):

The minimum data set for these N15 experiments for both isotope aided fertilizer and N fixation experiment will cover:

- Dry matter yields for the whole plant or sub divided into plant parts. This data will be derived from dry weight values.
- Total N concentration (%N) in dry matter.
- % N15 abundance of plant or plant parts
- %N15 abundance of the applied urea fertilizer.
- Rates and nature of labeled and unlabeled urea fertilizer which will be used.

Sources of N for N non-fixing crops are soils and fertilizer but for N fixing crops (such as legumes) these sources are soil, fertilizer, and atmosphere and this can be expressed as follows:

$\%Ndff_{NF} + \%Ndfs_{NF} = 100\% \quad NF \text{ or } Ndfs_{NF} = 100 - Ndff_{NF}$

$\%Ndff_{F} + \%Ndfs_{F} + Ndfa = 100\% \text{ or } Ndfa = 100 - (Ndff_{F} + Ndfs_{F})$

Estimations for these fractions and nitrogen recovery follow the following equations:

1. %2.28N atom excess = (%2.28N a.e.) = *% 2.28N abundance - 0.3663*
2. Percentage N in the plant derived from the fertilizer (% Ndff):

% Ndff = ((% N15 a.e. (crop) / (% N15 a.e. (fertilizer)) X 100

3. Percent of fixed N in the plant - derived from the atmosphere (% Ndfa):

% Ndfa = [1 - (% Ndff fixing) / (Ndff non-fixing)] X 100

4. Amount of N in crop derived from fertilizer= *(% Ndff/100) X total N in crop*
5. Fertilizer use efficiency FUE) = *(Amount of N in crop derived from fertilizer/Amount of N added as fertilizer) X100*

Where Ndff stands for nitrogen derived from fertilizer, Ndfs for nitrogen derived from soil, Ndfa for nitrogen derived from atmosphere, NF for N non-fixing crops and F for N fixing crops.

RESULTS AND DISCUSSION

Yield of Biosaline forages

The statistical analysis of the obtained data indicated that the effect of the TSE irrigation water levels on biomass dry weight (Table 1) was significant in each of fodder beet tuber (α = 1%), fodder beet leaf (α = %), Brassica biomass (α=1%) and *Sesbania* whole above ground biomass (α=1%), whereas effects of fertilizer application rates and the interaction between the two factors on biomass dry weight were found to be insignificant. The increase of TSE irrigation water level caused a distinct increase in biomass yield under the four fertilizer application rates (N0, N1, N2 & N3) in both fodder beet leaf and tuber, but to lesser extent in brassica biomass (Table1). The *Sesbania* whole above ground biomass exhibited a negative trend ,where not applying fertilizer under minimum irrigation manifested the best effect on biomass yield.

Table 1. Measured Dry Biomass yields of some Biosaline forage plants species.

	Fodder beet leaf				Fodder beet Tuber				Brassica Biomass				Sesbania-whole above ground			
Yield ton/ha																
T Time	N0	N1	N2	N3	N0	N1	N2	N3	N0	N1	N2	N3	N0	N1	N2	N3
2l/hr	0.91	1.75	1.82	1.8	1.72	3.1	3.69	3.08	1.09	1.19	1.04	1.22	5.44	3.42	3.57	3.41
4l/hr	2.07	2.49	2.29	2.91	3.43	4.9	5.09	5.69	2.85	1.94	2.01	2.75	5.04	2.92	3.2	3.59
8l/Hr	2.15	3.09	4.49	4.63	3.99	6.22	8.27	7.75	2.75	3.73	3.45	3.23	3.14	3.76	3.21	3.11

Total Nitrogen and N derived from fertilizer

Increasingly adding N in the form of urea fertilizer reduced largely dry biomass content of total nitrogen (TN) in the brassica, to a very minor extent in the fodder beet leaf but both the fodder beet tuber and the Sesbania whole above-ground biomass almost showed no effect (Fig. 1).

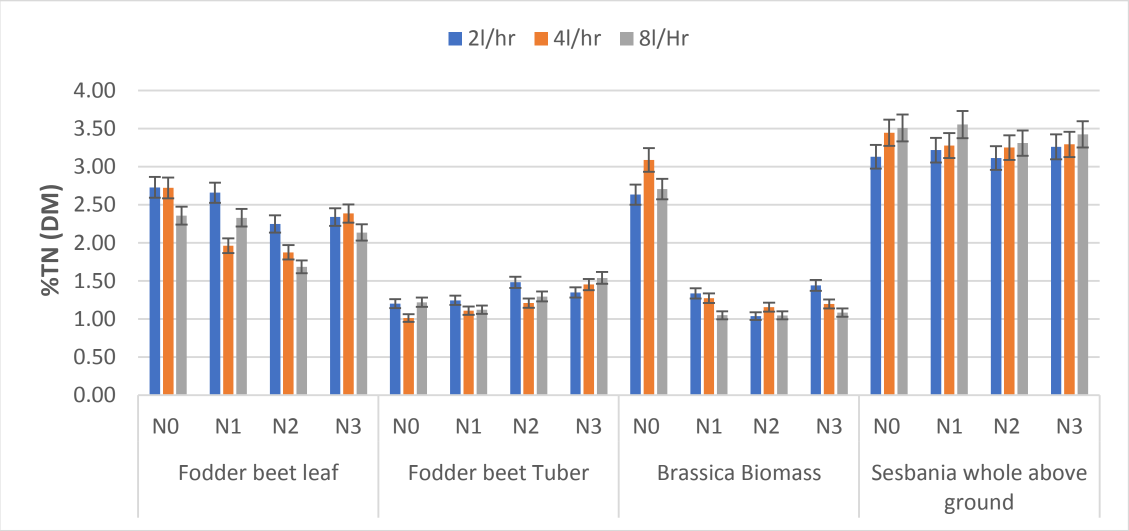

Fig. 1. Effect of Application Rate of N on Dry Biomass N Content Under different Irrigation Levels.

Percent nitrogen derived from fertilizer (% Ndff) was high for both fodder beet leaf and fodder beet tuber compared to the brassica and Sesbania legume crops (Fig. 2). Elevated fertilizer application rate under the three irrigation levels generally increased nitrogen derived from fertilizer (%Ndff) for fodder beet leaf and fodder beet tuber. A less increase in %Ndff due to the same, in Sesbania above-ground biomass, was noticed only with the highest irrigation level (8L/hour). In the same context, it is noticeable that the trend of %Ndff was uncertain in Brassica biomass compared to the other crops.

Fig. 3 showed, because of increased application rate of N fertilizer, a proportional behavior to %Ndff mentioned earlier. Fodder beet, the non-legume forage, produced the highest biomass leaf and tuber yields and obviously showed high amounts of N derived from fertilizer compared to those reached in the two other forages. It was obvious that Brassica and Sesbania were less reliant on artificial N (mineral fertilizer).

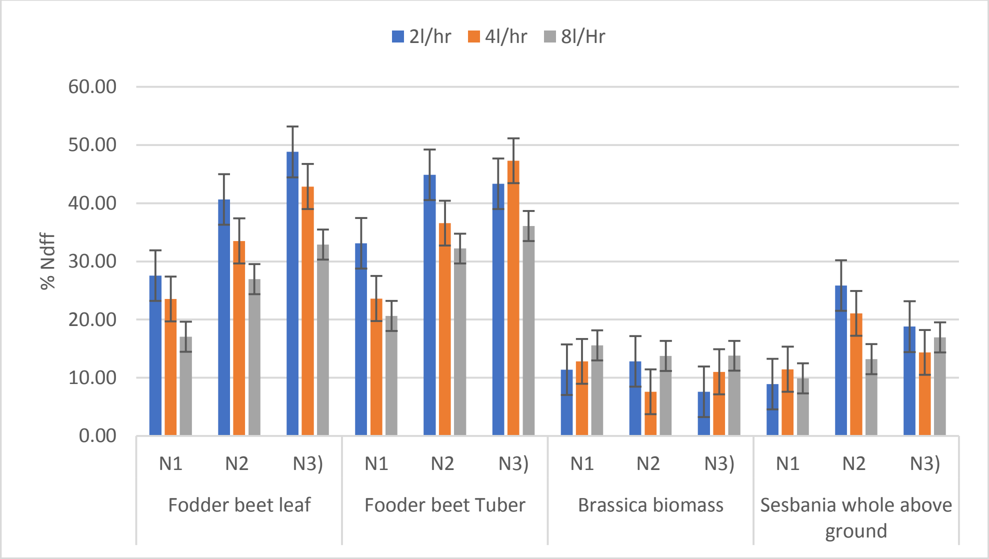

Fig. 2. Effect of Application Rate of N on Percent N derived from Fertilizer (%Ndff) Under different Irrigation Levels.

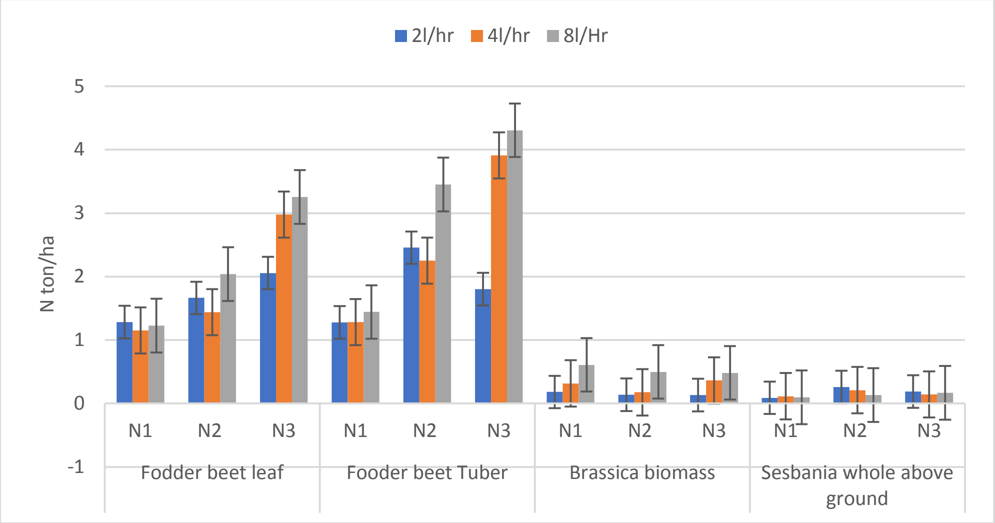

Fig.3. Effect of Application Rate of N on The Amount of N derived from fertilizer Under different Irrigation Levels.

Sesbania Amount of Nitrogen derived from fertlizer and biological nitrogen fixation

Despite to the extreme soil salinity conditions of the study site applying urea (N source) contributed higher percentage of N to Sesbania dry biomass than the N percent contributed through its symbiosis with soil bacteria (Fig. 4). This symbiotic N produced (1-18%) made Sesbania less reliant on artificial fertilizer (the same apply to brassica). It was revealed that the highest percent of both N derived from fertilizer (25.85%) and N derived from atmosphere (18.34%), together totaling 44.19%), for Sesbania were manifested under the lowest TSE irrigation level (2L/hour) and when N was applied at the N2 fertilizer application rate (50kg/ha). Under this optimum level of irrigation and rate of fertilizer application, calculated N derived from soil (Ndfs) would be the least (100%-44.19%=55.81%) compared to the expected highest %Ndfs (=87.26%) under the highest TSE irrigation level and lowest N1 fertilizer application (25kg/ha).

Fertilizer Nitrogen use efficiency

The following graph (Fig.5) show the effect of rate of N on fertilizer nitrogen use efficiency under different irrigation levels. The highest efficiency was observed in Fodder beet tuber which was nearly 16%. It showed most high efficiency values, the least efficient was among brassica biomass, meaning that they had less FUNE, which was less than 6%.

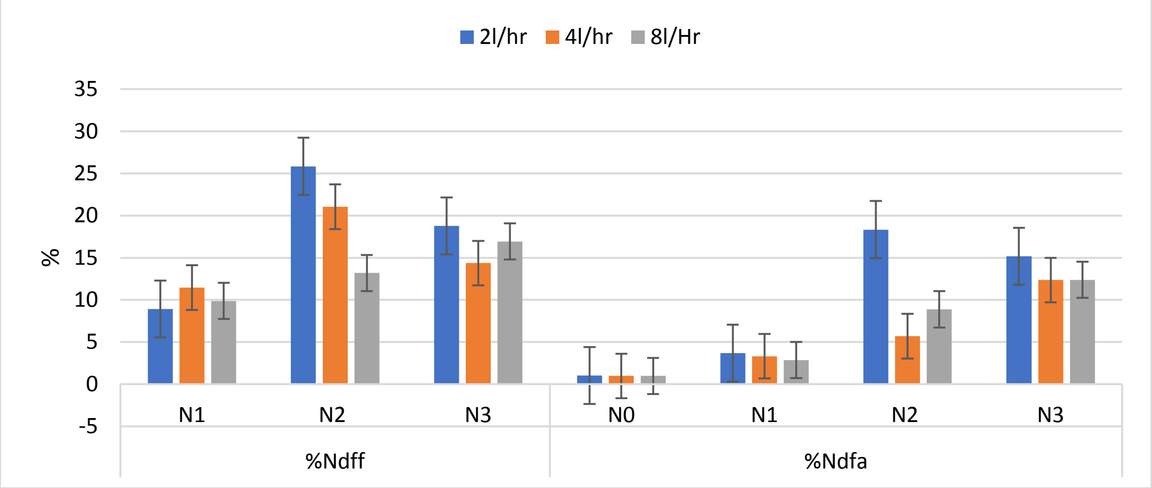

Fig. 4. *Sesbania*: Nitrogen Derived from Fertilizer (%Ndff) Compaired to Nitrogen Derived from Atmosphere (%Ndfa)

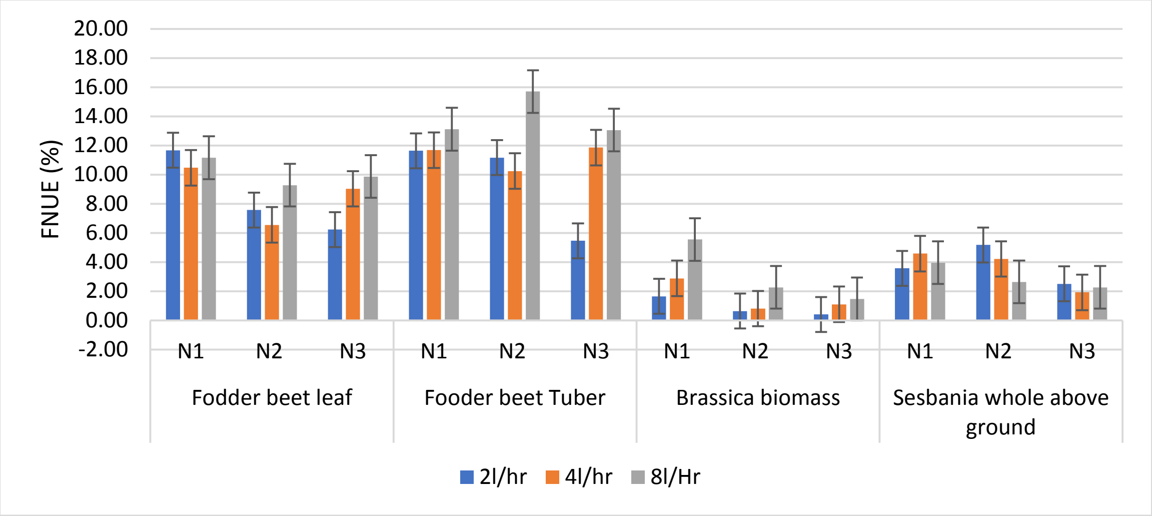

Fig. 5. Effect of Application Rate of N on Fertilizer Nitrogen Use Efficiency (FNUE)Under different Irrigation Levels.

DISCUSSION

The results suggest that at different levels of irrigation with different yield and nitrogen concentrations, there has been different growth pattern in all plants used as fodder. The difference in growth has been shown in detail in the previous section (Result section). In this section we still see how the results have been in correlation to previous studies of the topic.

According to the findings of the statistical analysis performed on the data that were collected, the effect of TSE irrigation water levels on biomass dry weight (Table 1) was significant for fodder beet tuber (=1%), fodder beet leaf (=5%), brassica biomass (=1%), and Sesbania whole above ground biomass (=1%). On the other hand, the effects of fertilizer application rates and the interaction between the two factors did not have a significant impact on biomass dry weight. Because of the rise in irrigation water level, there was a large increase in the quantity of biomass produced by fodder beet leaf and tuber at each of the four different fertilizer application rates (N0, N1, N2, and N3); however, the increase in brassica biomass was of a lower magnitude. The above-ground biomass of Sesbania as a whole exhibited a declining tendency, with the absence of any fertilizer application and the lowest irrigation having the biggest impact on the amount of biomass produced.

When more nitrogen was added to the soil in the form of urea fertilizer, the dry biomass content of total nitrogen (TN) in brassica decreased. However, the dry biomass content of TN in fodder beet leaf increased to a very small level. Meanwhile, increasing the amount of nitrogen added to the soil had almost no effect on fodder beet tuber and Sesbania whole above-ground biomass (Fig. 1).

Due to increasing N fertilizer application rates, the quantity of nitrogen acquired from fertilizer (ton/ha), which can be found in Figure 4, demonstrated a proportional connection to the previously reported %Ndff (Fig. 2). This was the case in both figures. In comparison to the other two forages, the non-leguminous forage (fodder beet) had the highest levels of nitrogen (N) derived from fertilizer, the biggest biomass leaf and tuber yields, and the greatest amount of biomass. Brassica and Sesbania, both of which are legumes, were obviously less reliant on nitrogen that was added artificially (mineral fertilizer).

The interaction between irrigation water and N had a positive effect on all other parameters, with the only exception of the uptake of N. It is probable that the relevance of different level of irrigation attributable, at least in part, to the fact that fertilizer N had the opposite effect on them as it did on the other examples. This is something that needs to be investigated further.

These variances in N response occurred independently of the nutrient, even though the yield level at N0 varied between habitats. This was the case even though the nutrient did not make a significant difference. There is a possibility that increasing the amount of nitrogen fertilizer will only minimally boost leaf development under the given irrigation conditions. It is abundantly obvious that increased soil-borne N release under different saturation circumstances enhanced leaf growth more than root elongation and sugar storage. Sugar beet harvests had comparable reactions according to research conducted by Gracia *et al.* (2019). The findings are in line with what we already know about the growth of root crops, namely those that develop vegetatively and have a high ability to absorb nitrogen throughout the growing season. We were able to do this by using FUNI levels of around 60%, which were unaffected by either the natural environment or the amount of nitrogen fertilizer that was applied.

In most development scenarios, the leaf and taproot components of beet crops have the capability to absorb the available nitrogen. Beets are a member of the Brassicaceae family. According to the data, changes in yield caused by environmental and fertilizer N effects do not appear to be related to variations in harvest indices or FNUE. This conclusion is drawn from the fact that there is no correlation between the two. This is the conclusion that one can reach after considering all the data. The small correlation coefficients of 0.28 and 0.01 that were calculated for the study provided support for this theory. According to the findings of studies, this does take place.

There has been research done on this subject that has been published in a variety of different years and in a variety of distinct locations. Researchers discovered that maize, wheat, barley, and oilseed rape, all of which have high N concentrations in their harvested product, had much more robust associations between the two variables than any of the other crops studied.

Plants having a high nitrogen use efficiency are good for agriculture. It has been defined in several separate ways, such as the shoot weight based on the nitrogen content of the shoots, the yield based on the availability of nitrogen, and the yield growth based on the application of nitrogen. It was decided to go with the first definition, which is regarded to be more appropriate for use with perennial cellulosic energy crops that get the least amount of fertilizer feasible, just in the first year after they are established. Sugarcane and sorghum had higher values than other crops when compared to the interspecific variations in nitrogen utilization efficiency at both high and normal densities. Sugarcane and sorghum were grown at higher densities. Despite the possible threats to food supply, sugarcane may be a viable option for the manufacture of ethanol due to its high nitrogen efficiency and its ability to produce ethanol by the straightforward direct fermentation of sugar. Sugarcane is now responsible for around sixty percent of the world's ethanol output. Because of its remarkable nitrogen utilization and high biomass output, sorghum has the potential to become a useful crop for producing alternate forms of energy. (Benderoff *et al.*, 2022)

Except for maize and sorghum, nitrogen use efficiency was significantly improved at significantly higher planting densities compared to significantly increased planting densities at normal planting densities. Because there are more plants competing for the same amount of nitrogen when there is a high planting density as opposed to when there is a standard planting density, the nitrogen environment for plants that are grown in an area with a high planting density is comparable to that of plants grown in an area with low nitrogen application. We propose that the greater nitrogen use efficiency of plants with a higher planting density is consistent with an earlier finding suggesting that nitrogen use efficiency improves as nitrogen application reduces. This finding suggests that nitrogen use efficiency improves when there is less nitrogen applied to the plant. For the formation of dry matter, it is also important to consider the dynamic relationship that exists between planting density and nitrogen. There is a suitable range of planting densities within which enough biomass output may be achieved while maintaining the same amount of nitrogen. We recommend selecting a larger planting density that is within the acceptable range for the nitrogen level to increase the efficiency with which nitrogen is used.

Multiple pieces of research have shown that breeding programs may be used to increase the amount of nitrogen that is used effectively in a variety of ecosystems. The results of our research indicate that crop management is a potential alternative to genetic techniques for achieving high nitrogen use efficiency. In conclusion, we propose that steps be taken toward the establishment of a sustainable agricultural system for forage crops via the use of a variety of methods, such as the distribution of plant waste from these plants to the farm as a way of preventing the exhaustion of soil resources.

ACKNOWLEDGEMENTS

Ministry of Municipality and Environment provided facilities and logistics which make this research possible. These trials are part of the regional project RAS 5080 supported by IAEA in Vienna for whom the authors are grateful.

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(*Accepted for publication January 2023*)