Review on sugar beet salt stress studies in Iran

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Abstract. Increase of saline lands in most regions of the world and Iran, limit of production increase based on land enhancement and also threat of saline water and soils for crop production make related researches and production of salt tolerant variety to be more serious. There have been many researches about salt stress in Sugar Beet Seed Institute of Iran (SBSI) during several years. Accordingly, the new screening methods for stress tolerance to be continued based on these researches. Previous researches in SBSI were reviewed and results concluded to this study which is presented in this article in three categories including: Agronomy, Breeding and Biotechnology. In agronomy researches, suitable planting medium, EC, growth stage and traits for salinity tolerance screening were determined and agronomic technique such as planting date, planting method and suitable nutrition for sugar beet under salt stress were introduced. Sand was salinizied by saline treatments two times more than Perlit so large sized Perlit is suitable medium for saline studies. Sugar beet genotypes screening for salt tolerance and should be conducted at EC=20 in laboratory and EC= 16 dS/M in greenhouse. Although sugar beet seed germination has been known as more susceptible stage to salinity, it seems establishment is more susceptible than germination in which salinity will cause 70-80% decrease in plant establishment. Measurements of leaves Na, K and total carbohydrate at establishment stage would be useful for faster screening of genotypes, based on high and significant correlation of these traits at establishment with yield at harvest time. In breeding section, SBSI genotypes with drought tolerance background would be useful for salinity stress studies and finally there is a need for more research in the field of biotechnology in Iran.

1. Introduction
Salt stress is one of the most important abiotic stresses, which decreases crop yields and limits the land use. Three hectares of agricultural land are being destroyed in each minute by salinity [1]. 53 million hectares of salt affected grounds in Asia and Middle East (Iran, Syria, Egypt and Tunisia) are caused by man-made activities in irrigated fields [1]. In Iran, salinity is one of the most important factors which limit the agriculture. Mean of yield loss is estimated more than 50% in saline lands of Iran [1] which causes more than one milliard dollars financial loss annually [2]. Saline lands are increased to 33 million hectares which is 20% of total irrigated lands in Iran [3]. Salt stress studies were very
important in the most sugar beet planting regions of Iran based on sugar beet experts and farmers opinions [4] Producing sugar beet salt tolerant varieties, improving planting methods, irrigation and fertilizer use are the most Sugar Beet Seed Institute (SBSI) strategies for optimizing the production in saline lands [5].

A lot of researches have been conducted in this institute, during several years which are categorized in Agronomy, Plant breeding and Biotechnology. In this article we reviewed these researches and summarized the most important factors.

2. Agronomy researches

2.1. Base agronomic research
There are different researches on medium of saline studies. Although sand is cheap and accessible medium [6], Seedling growth on Perlite, especially large size, was stronger and more suitable than sand because sand was salinized two times more than Perlite in salt treatment [7, 8].

Although seed germination in EC=16 was the same as EC=20 dS/m under laboratory conditions, 50% of seedling losses was observed at EC=16 dS/m in the greenhouse condition [7].

There are reports that salt stress didn’t affect sugar beet till 35 [9] and 50 days growth stages [10]. Also germination of Sugar beet seeds decreased to 35% and dead seedlings increased to 80% under salt stress (EC=16 dS/m) in greenhouse condition. So salinity decreased seed germination and by increasing dead seedlings, caused sugar beet establishment and final yield to be reduced. It is concluded that establishment stage in comparison to germination is more susceptible to salinity [11].

Breeding for salinity tolerance requires the study of different physiological mechanisms based on complexity of this stress [12]. Salt as the same as drought stress, has similar physiological acclimation mechanism. Thus development in drought resistance would be useful for plant adaptation to salinity, but it is important to pay attention that a salt tolerant plant should regulate toxic levels of NaCl by its uptake and compartmentalization [13]. The first important characteristic of seed quality is germination which shows significant correlations in laboratory with field tests [14]. Sugar beet seed germination and establishment are more affected by genetic effects than germination rate [15], so they could be used for genotype selection [16]. Root length and abnormal seedling in addition to the seed germination, are suitable traits for screening sugar beet salt tolerant genotypes at the first growth stages [11]. Crop production is the main trait for genotype selection in abiotic stress such as salinity but its inheritance is complicated and extremely influenced by environment [17]. There are various mechanisms in plants for adjusting to osmotic and ion stresses. Accumulation of important solutes such as poly amin (glycine betaine and proline), ions (K⁺) and carbohydrates are the main ways in crops [18, 19]. Leaf potassium, sodium, and their ratio, soluble carbohydrate, were more significant and related characteristics with yield under saline condition during whole growth stages [20, 21].

2.2. Practical Agronomic research
Practical agronomic methods such as suitable planting pattern, plant density, fertilization and crop protection are the most useful ways to increase yields under salinity stress. It is reported that yield of sugar beet transferred plants under salinity condition was more than direct planting [22]. Earlier and two-rows plantings were suitable methods in saline condition because of better irrigation and lack of accumulated salt on top of rows [22]. 25% more use of nitrogen fertilizer in saline land in comparison with normal condition [23] and also use of urea in comparison with ammonium sulfate were recommended for sugar beet growth in saline land of Iran [24]. As environmental conditions are very important, study on applied agronomic factors which affecting salinity stress would still be necessary for future.

3. Breeding researches
One of the most important strategies that will increase crop yields is breeding of new varieties. The complexity of improvement salt tolerant variety is because of multi-genic characteristic of salinity
tolerance [25] which is genetically complicated character [26]. Also traits such as epistasis, genotype-environment interaction and great environmental effects cause the complexity of breeding for salt tolerant variety. So the most important way for breeding is utilization of genetic mechanism [27]. Salt tolerance indicates dominance, heterosis and also additive effects [12]. Sugar beet genotypic variation in drought [28, 29] and salinity tolerance [22, 30] are high that would be used for improving salt tolerant varieties. Also applying *Beta vulgaris ssp. Maritima* as a wild relative of sugar beet will be useful for making its gene pool rich. Both sugar beet female and male parental plants must be tolerant but improving of tolerant female parents is long lasting, so the activity for development of tolerant male parent is more than the female one [22]. Fortunately, there are chances for improving sugar beet tolerant varieties because of variation in germplasm especially it is observed that sugar beet drought tolerant genotypes were also tolerant to salinity stress [21, 31]. This is because of same physiological mechanism between these two stresses [13], concluding germplasm with drought tolerance background could be used for salt tolerance improvement.

4. Biotechnology researches
Conventional breeding programs are time lasting and somehow expensive because of multi-genic tolerance of abiotic stress so, applying advanced molecular techniques show promising results in understanding molecular background of abiotic tolerance and enhancement of this tolerance in crops. Results show the importance of molecular, physiological and metabolic studies in future to assist crop improvement with an inherent tolerance capacity [12]. Some molecular markers, such as SSR markers or microsatellite are suitable methods for describing genetic variation at DNA level [32]. 23 SSR markers were used to analyze genetic diversity in 168 sugar beet lines and many SSR marker polymorphisms was seen in these breeding lines [31]. If this marker applied repeatedly, it will establish marker-assisted selection for tolerance of salinity in this crop and may be used to estimate the potential heterosis from the distance between parents in hybrid breeding programs [12].

Proteomics is a method which is used in assessment of plants under stress condition. Several proteins with various roles and candidate genes which respond to salinity are identified by proteome and transcriptome analysis in monosomic addition line of sugar beet which would be useful for more studies of salt tolerance functions in future [33]. Some candidate proteins in sugar beet were observed in related to drought [34] and salinity tolerance [35] with proteomics approach. Also there is some quantitative trait loci (QTLs), related with salt tolerance in crops but there isn’t any reports on sugar beet [12].

Molecular markers clarify quantitative genetic and use for facilitating selection effectively [36]. As told before, genetic of salt tolerance is complicated because of multiple genes and loci distributed at different locations through the genome of crops. The mixture of genes and alleles and their interactions would have great importance in comparison to gene expression [37]. After time, breeders should improve salt tolerance in plants through various biological methods [12].

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