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# Physiological Characteristics of Fodderbeet Grown on Saline Sodic Soils of Pakistan

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## Abstract
During germination, cultivar Monoval tolerated the salinity as well as higher temperature better as compared to Majoral, Monored and Polygroeningia cultivars of fodderbeet *(Beta vulgaris).* Whereas, cultivar Majoral had the lowest salinity and temperature tolerance during germination. The number of leaves, leaf length and root girth was not affected in cvs. Monoval and Monored under same soil conditions. Fresh weight of leaves and beet in cv. Majoral increased significantly over control. Chlorophyll a and chlorophyll b in cv. Majoral increased significantly. Total protein of leaf and sugar content of beet were comparatively higher under saline conditions as compared to the non-saline soil.

## Introduction
Salinity and temperature stresses are primary limiting environmental conditions which significantly restrict the successful cultivation of crops in irrigated arid and semi-arid regions (Bergmeyer and Bernt, 1974). Salt affected non-arable land is increasing in canal irrigated areas in North West Frontier Province (N.W.F.P), Pakistan due to the rise in water table resulting from the seepage from canal beds. Currently, about 11.98 million hectare land is under moderate to high salinity/sodicity (Muhammad, 1990). Production of almost every conventional crop in this area is significantly reduced under saline soil conditions. Hence, the introduction of non-conventional salinity tolerant fodder crops could be a suitable option. Fodderbeet was reported to he highly salt tolerant during vegetative growth stage (Niazi *et al.,* 1997). It is extensively grown in the coastal areas in many European countries and New Zealand (Furunes, 1988; Goh and Magat, 1989). A substantial amount of NaCl is applied as fertilizer for better growth and biomass of the crop (Draycott and Bugg, 1982; Magat and Goh, 1988). Germination of seed may be adversely influenced by increasing the entry of certain ions into the seed which are toxic at high concentration (Khatib and Magsengale, 1966). A slight improvement of alfalfa seed germination at low osmotic potential (1 to -1 bar) under different temperatures (21 to 33°C) has been reported by Stone *et al.* (1979). Initially the studies were conducted to figure out the most appropriate conditions for germination of four cultivars of fodderbeet to ensure the appropriate crop stand in the field. Then the growth performance and physiological responses of these four cultivars of fodderbeet were studied in the field with and without salt stress.

## Materials and Methods
Four fodderbeet *(Beta vulgarls)* cultivars viz: Monored, Monoval, Majoral and Polygroeningia were received from Holland through the courtesy of Department of Ecology and Ecotoxicology, Free University, Amsterdam. Those were identified as salt tolerant by Rozema and his associates

Table 1: Physico-chemical characteristics of soil (soil saturation extract) used during fodderbeet experiment at AZRSS D.1. Khan (N.W.F.P.)

| Soil properties | Normal soil | Saline soil |
|---|---|---|
| pH | 7.92 | 8.15 |
| EC dS $m^1$ | 2.65 | 11.38 |
| $CO_3^{2-}$ mMol | - | - |
| $HCO_3$ mMol | 5.10 | 10.90 |
| $Cl^-$ mMol | 8.50 | 30.10 |
| $Ca^{2+}$ + $Mg^{2+}$ mMol | 3.00 | 9.40 |
| $Na^+$ mMol | 19.00 | 90.60 |
| $K^+$ mMol | 1.40 | 9.70 |
| ESP | 1.57 | 37.65 |
| Soil Texture | Silty clay | Silty clay |

ESP = Exchangeable Sodium Percentage

Seeds of these cultivars were tested for germination under saline conditions. Salt solutions were prepared in 1/4 strength Hoagland (1950) solution. One hundred selected seeds of each of the four fodderbeet cultivars were germinated in separate petri dishes in NaCl salt solutions with EC 4, 8, 12 and 16 dS $m^{-1}$ in triplicate in incubator maintained at three different temperatures (20, 25 and 30°C). Germination percentage was recorded after one week of sowing. A seed was considered germinated with at least 2 mm long radicle. For field experiment, two sites (a normal and a saline sodic field) were selected at Arid Zone Research Sub-station (AZRSS), D.I. Khan. Seeds were sown in black polyethylene bags to raise two week old nursery which were transplanted in the field. Characteristics of soil saturation extract of the experimental field are given in Table 1. Plots (6 x 4 m) were arranged in Complete Randomized Block Design (CRBD), with five replications per treatment. Experiments were conducted during November to May at both sites which were irrigated with canal water. Recommended doses of fertilizer for the sugarbeet (N 120 kg $ha^{-1}$ as urea and P 100 kg $ha^{-1}$ as single super phosphate) were applied. Two third of the N was added at the time of transplantation, while rest of the one third was applied after 6 weeks. Growth data were recorded at the time of harvest. Plant material was analyzed biochemically for chlorophyll, total proteins (Lowry *et al.,* 1951) and sugar (Bergmeyer and Bernt, 1974). Data obtained were subjected to analysis of variance (Little and Hills, 1978) test.

## Results and Discussion

Cultivar Monoval showed comparatively higher tolerance to salinity as well as to temperature increase (Table 2). Percent seed germination was significantly reduced ($p<0.05$) in all the cultivars with rising temperature as well as increasing NaCl concentration. More than 80 percent germination was recorded at EC 4 dS $m^{-1}$. Whereas, 50 percent reduction in germination was noted beyond EC 12 dS $m^{-1}$ at 20°C. Increase in temperature above 25°C significantly reduced the percent germination (Table 2). Order of performance of the cultivars tested was:

Monoval > Polygroeningia > Monored > Majoral

Qureshi *et al*. (1980) had reported an 80 percent wheat seed germination at 15 dS $m^{-1}$. The percent germination in wheat varied with the variety and the type of salt used during that experiment. A decline of 50 percent in tomato and carrot seed germination at root medium salinity of 12 and 18 dS $m^{-1}$ respectively has been reported by Miyamoto *et al*. (1985). The germination is presumably affected by the toxicity of ions present in the medium (Uvhits, 1946) and/or decreased water availability to seeds (Chapman, 1968) causing a water stress upset in the physiological germination process. Ryan *et al*. (1975) have noted that chloride ions in solution with Na restricts germination more severely than equivalent concentration of Ca. Salinity causes a low percentage of seed germination due to high osmotic pressure (Ryan *et al.,* 1975), however a rise in temperature from 20 to 25°C favoured the process upto 8 dS $m^{-1}$, above this, germination of the seed was supressed. A further rise in the temperature imposed a negative effect in this regard (Table 2).

The pH and EC of the saline soil were reduced significantly 'in the upper 0-15 cm of soil at the time of harvest (Table 3). Fresh weight of beet increased in cos. Monored and Majoral in the presence of high salts in the growth medium. The increase in fresh weight of leaves under saline conditions was highly significant (Table 4). Cultivar Majoral performed better than rest of the cultivars. For significant higher production of fodderbeet, 295 to 1195 kg $ha^{-1}$ NaCl has been recommended by Magat and Goh (1988). In contrast, application of various doses of K (0-60 mg 100 $g^{-1}$ soil) did not significatly improve the leaf and root growth of sugarbeet on an alluvial soil (Beringer *et al.*, 1986). It indicates the low K requirement of beet. Chlorophyll a and b content were increased significantly under saline conditions (Table 5). Increase in chlorophyll a under saline conditions was highly significant in Monoval, Polygroeningia and Majoral. Chlorophyll a/b ratio revealed that chlorophyll b increased under saline conditions in all the cultivars except in Monored (Table 5). It may be a reason for darker colour of the leaves under saline conditions. A decrease in the chlorophyll content has been reported in sugarbeet by Papp *et al*. (1983). They have related it to the increase in self shading of mesophyll cells due to leaf thickness of sugarbeet under saline conditions. Total sugar in beet was comparatively higher under saline conditions, while in leaves, the sugar content was comparatively low, showing a better downward movement and storage of sugar in the beet under saline conditions. Protein content of leaves was comparatively high under saline conditions. Similarly, proline content of beet and leaves was significantly increased by salinity (Fig. 1).

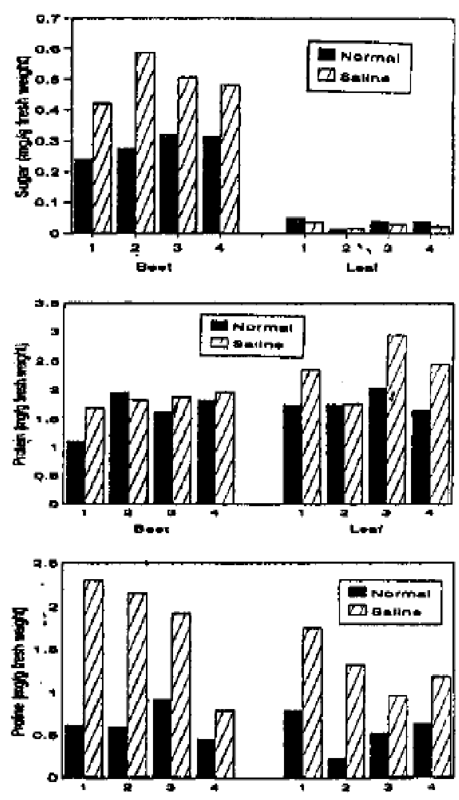


Fig. 1: Salinity induced changes in biochemical contituents of fodderbeet.
1 = Monoval, 2 = Monored, 3 = Polygreningia, 4 = Majoral

Table 2: Effect of different temperatures and salinity levels on germination percentage of fodderbeet seeds.

| | Salinity Levels ($dSm^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| Beet cultivars | 4 | 8 | 12 | 16 | 20 | Mean |
| | | | Temperature 20°C | | | |
| Monored | 84.3a | 56.0d | 38.0i | 38.7hi | 21.31 | 47.7b |
| Majoral | 82.3b | 51.0e | 40.3gh | 38.7hi | 19.0m | 46.3b |
| Polygroeningia | 82.0b | 59.7c | 40.3gh | 36.0j | 17.0n | 47.0b |
| Monoval | 82.7ab | 58.0c | 43.0f | 42.3fg | 29.7k | 51.1a |
| Means | 82.8a | 52.2b | 40.4c | 38.9d | 21.7e | |
| | | | Temperature 25°C | | | |
| Monored | 94.0a | 60.0d | 32.75j | 38.3hi | 32.0jk | 51.4b |
| Majoral | 92.3ab | 55.0e | 36.3i | 36.7i | 30.0kl | 50.1c |
| Polygroeningia | 90.7b | 58.7d | 41.0fg | 39.3gh | 28.7l | 51.7ab |
| Monoval | 87.7c | 53.7e | 42.0f | 39.7gh | 39.0gh | 52.4a |
| Means | 91.2a | 56.8b | 38.0c | 38,5c | 32.4d | |
| | | | Temperature 30°C | | | |
| Monored | 81.3a | 58.3c | 35.7c | 22.7j | 20.0k | 43.6c |
| Majoral | 80.7a | 55.3e | 44.3f | 34.7g | 14.7m | 45.9b |
| Polygroeningia | 76.3b | 58.0cd | 44.3f | 32.7h | 16.7l | 45.6b |
| Monoval | 76.0b | 56.3de | 45.3f | 36.0g | 29.3i | 48.6a |
| Means | 78.6a | 57.0b | 42.4c | 31.5d | 20.2e | |

Values sharing the ccommon letter do not differ significantly at $p<0.05$

Table 3: Analysis of soil saturation extract before sowing and after harvest of fodderbeet at Ratta Kulachi, D.I. Khan

| | Depth (cm) | pH | | EC dS $m^{-1}$ | |
|---|---|---|---|---|---|
| | | Normal | Saline | Normal | Saline |
| Before | 0-15 | 7.96 | 8.15 | 2.65 | 11.38 |
| sowing | 15-30 | 8.41 | 8.26 | 1.14 | 6.72 |
| After | 0-15 | 8.48 | 7.56 | 0.88 | 7.39 |
| harvest | 15-30 | 8.67 | 8.03 | 1.35 | 5.61 |

Table 4: Growth parameters as affected by the presence of salinity in the soil at AZRSS, Ratta Kulachi, D. 1. Khan

| | Monoval | Monored | Majoral | Polygroeningia |
|---|---|---|---|---|
| | Beet Fresh weight (g) | | | |
| Non Saline | 867g | 1142e | 933f | 1408b |
| Saline | 525h | 1492a | 1317d | 1367c |
| | 696d | 1317b | 1125c | 1387a |
| | Leaf Fresh weight (g) | | | |
| Non Saline | 317f | 400de | 375e | 417d |
| Saline | 400de | 1275b | 1392a | 1042c |
| | 358d | 837b | 883a | 729c |

Values sharing the common letter do not differ significantly at $p<0.05$

Table 5: Salinity induced changes in the chlorophyll content of fodderbeet grown under salt stress conditions at AZRSS, Ratta Kulachi, D.1. Khan

| | Monoval | Monored | Majoral | Polygroeningia |
|---|---|---|---|---|
| | Chlorophyll a (mg chlorophyll/g F. Wt.) | | | |
| Non Saline | 0.39g | 0.56e | 0.49f | 0.27h |
| Saline | 0.65c | 0.62d | 0.97b | 1.22a |
| | 0.52d | 0.59c | 0.73b | 0.75a |
| | Chlorophyll b (mg chlorophyll/g F. Wt.) | | | |
| Non saline | 0.29f | 0.27g | 0.60b | 0.21h |
| Saline | 0.42e | 0.56c | 0.67a | 0.50d |
| | 0.36c | 0.42b | 0.64a | 0.36c |
| | | Chlorophyll a/b | | |
| Non saline | 1.34 | 2.07 | 0.82 | 1.29 |
| Saline | 1.55 | 1.11 | 1.45 | 2.44 |

Values sharing the common letter do not differ significantly at $p<0.05$.

Salinity induced reduction in leaf weight was shown during earlier growth period in sugarbeet (Plaut and Heuer, 1985). A significant increase in root fresh weight compared to leaf has been noted in the present study which revealed a high salt tolerance and a quick adjustment of fodderbeet to salinity as a consequence of efficient transportation of net photosynthates from leaf to root. These results could be supported by the data regarding chlorophyll a and b content of the plants under normal and saline soil conditions (Table 4). A significant increase in chlorophyll a and b content considerably added to the fresh weight of the plant. It was helpful in determination of accumulation of plant structural and storage materials. Products of photosynthesis may also be important for osmoregulation and may help in the evaluation of degree of salt tolerance of the plant. A significant reduction in pH and EC of the saline soil may have improved the soil conditions, increased ion uptake and hence improved the physiological functions of the plant i.e. photosynthesis. Increase in protein and proline content may also indicate the improved physiological processes related to salt tolerance of fodderbeet. The plant seems to be halophilous. Sodium chloride is applied as fertilizer in some soils of 'New Zealand for its better growth (Magat and Goh, 1988). The normal soil field used for experiment was a reclaimed soil and still had a higher SAR and ESP. The halophilous nature of the plant might have helped the plant growth under saline soil conditions.

The saline areas at D.I. Khan (N.W.F.P) were found to be suitable for the cultivation of fodderbeet. The crop could solve the problem of utilization of saline soils and shortage of green fodder in this area to a certain extent.

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