SUGAR BEET PRODUCTIVITY AS AFFECTED BY FOLIAR SPRAYING WITH METHANOL AND BORON

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Abstract- Two field experiments were carried out at Kafr El-Garaya Village, Bialla Center, Kafr El-Sheikh Governorate, Egypt during 2010/2011 and 2011/2012 seasons to study the effect of methanol and boron foliar spraying on growth, yield and quality of sugar beet. This aimed to study four aqueous methanol solutions control without 0, 15, 30 and 45% (v/v) sprayed three times during growth stages which occupied the vertical plots and four boron concentrations control without 0, 40, 80 and 120 ppm as boric acid applied as foliar spraying at two times during growth season and assigned in the horizontal plots.

Results indicated that foliar application of 30% methanol solution significantly increased all studied characters i.e. total chlorophyll, leaf area/plant, foliage and root fresh weight, foliage and root length and root diameter, total soluble solids, sucrose and apparent purty percentages, root, top and sugar yields/ha, whereas harvest index was decreased. Moreover, increasing methanol concentration to 45% tended to decrease all above mentioned characters. Application of 80 ppm boron significantly improved root yield and its attributes and root quality, on contrarily harvest index was decreased. Maximum top, root, sugar yields/ha and root quality produced by foliar spraying of 30% methanol and 80 ppm boron.

Keywords- Sugar beet, (Beta vulgaris, L.), methanol, Boron, yield and quality

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Introduction
In Egypt, there is a gap between sugar consumption and production due to steady increases in population and average consumption of sugar beside limited cultivated area of both sugar beet (Beta vulgaris, L) and sugar cane. To increase sugar beet productivity per unit area sugar beet plants subjected to i.e. methanol and boron foliar fertilization since production of biomass by plants depends to great extent on environmental factors i.e. water supply, air temperature and carbon dioxide concentration in the canopy [24]. Increasing the dioxide carbon content in the air increase yield and plants accumulated more carbohydrates because almost 90% of plant dry matter weight is resulted from CO₂ assimilation during photosynthesis [1,12,15,17]. Photo respiration can be minimized with methanol spray, since 25% of carbon wastes during photorespiration [6]. Similar conclusions were reported by [2,18,23,25]. Moreover, Sadeghi-Shoae M., et al [20] concluded that foliar application of methanol at 14% increased root yield to 25% in comparison with the control.

Foliar spraying of boron increase root yield since roots absorbed boric acid and its uptake depends on soil pH and soil boron content [8] due to chloroplast formation and sink limitations [22] and changes in cell wall which effects of boron deficit and led to secondary effects in plant metabolism, development and growth [16]. Gobarah Mirvat E., et al [10] revealed that application of boron rates from zero up to 1.5 Kg/acre increased root length, diameter and root yield. Moreover, increasing boron fertilizer up to 2.0 Kg/acre resulting highest sugar yield (6.811 ton/acre). Sucrose and juice purity percentages were also increased by adding higher concentration of boron might be attributed to decrease Na and K uptake in root juice. Similar results were recorded by [7,9,13,14]. Armin M. and Asgharipour M.R. [3] indicated that highest root yield and sucrose concentration were obtained by spraying with 12% boric acid.

Therefore, this study was undertaken to study the response of sugar beet cv. Gloria to foliar application with methanol and boron to achieve maximum root productivity and its quality.

Materials and Methods
Two field experiments were conducted at Kafr El-Garaya Village, Bialla Center, Kafr El-Sheikh Governorate, Egypt during 2010/2011 and 2011/2012 seasons. The main objectives of this study were aimed to study the effect of foliar application with methanol and boron concentrations on sugar beet (Beta vulgaris L.) cv. Gloria productivity and quality.

Two field experiments were laid out in strip plot design with four
repllications. The vertical plots were occupied by four concentra-
tions of methanol i.e. control without 0, 15, 30 and 45% (v/v) metha-
ol and each solution contained 0.2% glycine to reduce the prob-
ability of methanol toxicity [19]. These solutions were sprayed on
sugar beet foliage three times every two week. The first foliar appli-
cation was applied at 80 days after planting. The horizontal plots
were assigned to four foliar application of boron in the form of boric
acid i.e. control without 0, 40, 80 and 120 ppm these solutions
were sprayed on foliage parts of sugar beet two times (50 and 70
days after planting). The foliar solutions volume was to 200 L/ha
conducted by hand sprayer. The soil of experimental site was clay-
ey with an electrical conductivity (EC) of 1.65 dS/m and a pH of
7.98.

Each plot consist 5 ridges, each of 60 cm apart and 3.5 m long,
comprising an area of 10.5 m² (1400 ha). The preceding summer
crop was rice (Oryza sativa L.) in both seasons. The experimental
soil was fertilized with 71.4 kg P₂O₅/ha in the form of calcium super-
phosphate (15.5% P₂O₅) during soil preparation, nitrogen in the
form of ammonium nitrate (33.0% N) at a rate of 297.5 kg N/ha
added at four equal doses before second, third, fourth and fifth
irrigations and potassium at the rate of 114.24 kg K₂O/ha in the
form of potassium sulphate (48% K₂O) in two equal portions added
before second and fourth irrigations. Sowing took place on Sep-
tember 15th and 18th in the first and second seasons, respectively.
Sugar beet balls were hand sown (3-5 balls/hill) using dry planting
method on one side of the ridge and hills 20 cm apart. Experi-
mental plots were irrigated immediately after planting, then irriga-
tion frequently every 10 days. Plants were thinned after 30 days
from planting to one plant/hill to produce 83300 plants/ha. Plants
were kept free from weeds, which were manually controlled by
hoeing two times before the second and third irrigations. In gen-
eral, the agricultural practices for growing sugar beet according
to Ministry of Agriculture recommendations were followed.

**Studied Characters**

**Growth, Yield Component and Quality Characters**

A representative samples were taken during the growth period (150
days from planting), i.e. five guarded plants were chosen at ran-
dom from second and fourth ridges of each plot to determinate the
following traits:

1. Total chlorophyll (SPAD): Leaf chlorophyll content was as-
   sessed by SPAD-502 (Minolta Co. Ltd., Osaka, Japan).
2. Leaf area/plant (cm²): It was determined using Field Portable
   Leaf Area Meter AM-300 (Bio-Scientific, Ltd., Great Amwell,
   Herfordshire, England).

At maturity (190 DAP) five guarded plants were chosen at random
from the second and fourth ridges of each plot to determine yield
components and quality characters as follows:

3. Foliage fresh weight (gm/plant).
4. Foliage length (cm).
5. Root fresh weight (gm/plant).
6. Root length (cm).
7. Root diameter (cm).
8. Total soluble solids (TSS %) in roots was measured in juice of

fresh roots by using Hand Refractometer

9. Sucrose percentage (%) was determined Polarimetrically on
leak acetate extract of fresh macerated roots according to the
method of Carruthers A. and Oldfield J.E.T. [5].

10. Apparent purity percentage (%): It was determined as a ratio
between sucrose % and TSS % of roots as the method outlined
by Carruthers A. and Oldfield J.E.T. [5].

Yield of three inner ridges of each plot were harvested and
cleaned. Roots and tops were separated and weighted to estimate:

11. Root yield (ton/ha).
12. Top yield (ton/ha).
13. Sugar yield (ton/ha); was calculated by multiplying root yield
   (ton/ha) by sucrose %.
14. Harvest index (HI): was calculated by using the following equa-
tion:

\[
HI = \frac{\text{Root yield (ton/ha)}}{\text{Top yield (ton/ha) + Root yield (ton/ha)}}
\]

All obtained data were statistically analyzed according to the tech-
nique of analysis of variance (ANOVA) for the strip plot design as
published by Gomez and Gomez [11] by using by using MSTAT-C
Statistical package MSTAT-C with (MGRAPH version 2.10). Least
Significant Difference (LSD) method was used to test the differ-
ences between treatment means at 5 and 1% level of probability
[21].

**Results and Discussion**

**A. Effect of Methanol Concentrations**

Results showed that all studied characters i.e. total chlorophyll, leaf
area/plant, foliage fresh weight, foliage length, root fresh weight,
root length, root diameter [Table-1], total soluble solids, sucrose,
apparent purity percentages, root yield, top yield, sugar yield and
harvest index [Table-2] were significantly affected by spraying 30%
methanol in both seasons and then decreased due to application of
45% methanol. It could be stated that foliar application of 30%
methanol solution significantly increased all studied growth, yield
and quality of sugar beet traits and consequently produced the
highest values. It could be noticed that applying 30% methanol
caused significant increases in total chlorophyll, leaf area/plant,
foliage fresh weight, foliage length, root fresh weight, root length,
root diameter, total soluble solids, sucrose (%), apparent purity
percentages, root yield/hd, top yield/hd and sugar yield/hd by
12.38, 8.95, 40.92, 10.53, 17.20, 18.32, 19.53, 5.17, 10.8, 7.76,
16.31, 30.53 and 25.5%, respectively as an average of both sea-
sons compared with control treatment. Harvest index was de-
creased by 4.04% as an average of both season compared to con-
trol treatment. Generally, foliar application of 45% methanol solu-
tion came in the second rank after 30% methanol and then fol-
lowed by foliar application of 15% methanol solution, whereas con-
trol treatment recorded the lowest values for all studied characters,
except (HI) was the higher one. The favorable effect of 30% metha-
ol might be due to the treating plants with methanol could be en-
hance their net photosynthesis, therefore improving the yield.
Nonomura and Benson [19] showed that methanol reduces the
plants photorespiration and the rapidly oxidized. Also methanol
causes to delay senescence in leaves and influences on ethylene production in plant which this causes to increase photo synthesis activity [25]. Moreover, Zbieć I., et al [24] observed that yield of roots increased by 10% using 20 or 30% methanol solutions. These results are in accordance with those reported by [17,18,20].

B. Effect of Boron Concentrations

A significant effect was detected due to boron concentrations application on total chlorophyll, leaf area/plant, foliage fresh weight, foliage length, root fresh weight, root length, root diameter [Table 1], total soluble solids, sucrose, apparent purity percentages, root yield, top yield, sugar yield and harvest index [Table 2] in both seasons. Increasing boron concentrations up to 80 ppm significantly increased all studied traits. While, application boron at 120 ppm came in the second rank with respect to these characters. Foliar spraying of boron at 80 ppm increased total chlorophyll, leaf area/plant, foliage fresh weight, foliage length, root fresh weight, root length, root diameter, total soluble solids, sucrose (%), apparent purity percentages, root yield/ha, top yield/ha and sugar yield/ha by 12.77, 9.53, 31.34, 10.83, 9.72, 16.68, 15.24, 2.48, 9.75, 7.39, 11.27, 19.01 and 20.14%, respectively as an average of two seasons compared with the control treatment. While harvest index decreased by 1.91% as an average of two seasons compared to the control treatment. The positive effect of boron may be due to the boron role in cell elongation where, in case of boron deficiency, plant leaves were smaller, stiff and thick [4]. Gobarah Mirvat E. and Mekki B.B. [10] indicated that root yield, sucrose and juice purity percentage increased by boron addition which may be attributed to decrease Na and K uptake in root juice. These results are in harmony with those obtained by [3,7,9,13].

### Table 1- Means of total chlorophyll, leaf area/plant, foliage fresh weight, foliage length, root fresh weight, root length and diameter as affected by methanol, boron concentrations and their interaction during 2010/2011 and 2011/2012 seasons

| Treatments | Total chlorophyll (SPAD) | Leaf area/plant (cm²) | Foliage fresh weight (g) | Foliage length (cm) | Root fresh weight (g) | Root length (cm) | Root diameter (cm) |
|-------------|-------------------------|-----------------------|-------------------------|--------------------|----------------------|------------------|--------------------|
| Seasons     | 2010/2011               | 2011/2012             | 2010/2011               | 2011/2012          | 2010/2011             | 2011/2012        | 2010/2011          | 2011/2012          |
| Control without 0 | 42.08                  | 42.86                 | 332.16                  | 337.29             | 229.91               | 238.33           | 41.02              | 41.8             |
| Methanol 15% | 44.47                  | 45.34                 | 347.59                  | 350.95             | 291.25               | 303.75           | 43.09              | 44.09           |
| Methanol 30% | 47.91                  | 49.04                 | 364.17                  | 367.68             | 370.85               | 387.91           | 46.12              | 47.57           |
| Methanol 45% | 45.16                  | 46.12                 | 353.48                  | 355.95             | 331.66               | 348.33           | 44.02              | 45.02           |
| F. test     | **                     | **                    | **                     | **                 | **                  | **              | **                | **              |
| LSD at 5%   | 0.4                     | 0.43                  | 0.39                    | 0.63               | 0.36                 | 0.42            | 0.86               | 0.85            |

### Table 2- Means of total soluble solids (TSS), sucrose and apparent purity percentages, root, top and sugar yields and harvest index (HI) as affected by methanol, boron concentrations and their interaction during 2010/2011 and 2011/2012 seasons

| Treatments | Total soluble solids (TSS) | Sucrose (%) | Apparent Purity (%) | Root yield (ton/ha) | Top yield (ton/ha) | Sugar yield (ton/ha) | Harvest index (HI) |
|------------|---------------------------|------------|---------------------|---------------------|-------------------|----------------------|--------------------|
| Seasons    | 2010/2011                 | 2011/2012  | 2010/2011            | 2011/2012           | 2010/2011          | 2011/2012            | 2010/2011          | 2011/2012          |
| Control without 0 | 21.67                  | 21.86                 | 16.45               | 16.73              | 75.86              | 76.5                 | 57.217             | 57.75            |
| Methanol 15% | 22.18                  | 22.6                 | 17.1                | 17.4               | 77.11              | 76.98               | 59.081             | 60.352           |
| Methanol 30% | 22.8                   | 23.11                | 18.45               | 18.75              | 80.87              | 81.12               | 67.882             | 69.595           |
| Methanol 45% | 22.7                    | 22.73                | 18.05               | 18.2               | 79.49              | 80.04               | 62.682             | 63.912           |
| F. test     | **                      | **                   | **                  | **                 | **               | **                 | **                | **             |
| LSD at 5%   | 0.23                     | 0.24                 | 0.34                | 0.33               | 1.39              | 1.55                | 0.381             | 0.376            |
| C-Interaction: NS | NS                      | NS                   | NS                 | NS               | NS                | NS                 | NS                | NS             |

C. Interactions Effect

Regarding the interaction effect between methanol and boron concentrations. The results clearly showed a significant effect on total chlorophyll [Fig-1], leaf area/plant [Fig-2], foliage fresh weight [Fig-3], foliage length [Fig-4], root fresh weight [Fig-5], root length [Fig-6], root diameter [Fig-7], root yield [Fig-8], top yield [Fig-9], sugar yield [Fig-10] and harvest index [Fig-11] in both season as well as sucrose [Fig-12] and apparent purity [Fig-13] in the second season only.
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Fig. 1 - Total chlorophyll (SPAD) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons

Fig. 2 - Leaf area (cm$^2$) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons

Fig. 3 - Foliage fresh weight (g) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons

Fig. 4 - Foliage length (cm) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons

Fig. 5 - Root fresh weight (g) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons

Fig. 6 - Root length (cm) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons
Fig. 7 - Root diameter (cm) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons.

Fig. 8 - Root yield (t/fed) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons.

Fig. 9 - Top yield (t/fed) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons.

Fig. 10 - Sugar yield (t/fed) of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons.

Fig. 11 - Harvest index of sugar beet as affected by the interaction between methanol and boron treatments during 2010/2011 and 2011/2012 seasons.

Fig. 12 - Sucrose % of sugar beet as affected by the interaction between methanol and boron treatments during 2011/2012 season.
It could be stated that highest averages of total chlorophyll, leaf area/plant, foliage and root fresh weight, foliage and root length, root diameter, sucrose (%), apparent purity percentages (%), top and root yield, sugar yield were obtained from foliar spraying of 30% methanol and 80 ppm boron. On the other hand, highest values of harvest index were recorded due to the interaction without methanol spraying.

It could be recommended that to maximize sugar beet yields and root quality achieved by foliar spraying 30% (v/v) methanol and 80 ppm boron.

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