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# Effects of bio-fertilizers (*Bacillus lentus – Pseudomonas putida*) and different rates of Triple Superphosphate fertilizers on some attributes of sugar beet (*Beta Vulgaris* L.)

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**Abstract**

The aim of this study was to determine both combined and individual effects of phosphorus bio-fertilizers (*Bacillus lentus – Pseudomonas putida*). Additionally, the study also monitored the different effects of triple superphosphate fertilizers on agronomic and quantitative characteristics of sugar beet. The factorial experiment approach (RCB design) was used to conduct this experiment. Furthermore, cultivars 7233 and $BR_1$ were used as experimental materials to enhance the evaluation of the different fertilizer treatment. An evaluation of the experiments result showed minimal adverse effect, of application of phosphorous fertilizers to phosphorous rich soils. In particular, continued application of phosphorous fertilizer despite its improved values, will results into plant nutritional stress. In conclusion, this experiment results indicated that $BR_1$ cultivar in comparison to 7233 cultivar $BR_1$ had improved qualitative and quantitative characteristics like dry weight, leaf area, high sugar content and better tolerance to increased application of phosphorus fertilizer. Consequently, increased application of phosphorus fertilizers to phosphorus rich soils resulted to decreased yield output. However, biological fertilizer in comparison to its mineral counterpart had reduced impacts on the traits

**Keywords:** Bio-fertilizer, Seed, Sugar beet, Triple superphosphate

## Introduction

It is important to note that various agricultural soils in the world, in one way or another lack the key nutrients required to support the growth of healthy plants. Consequently, this necessitates application of fertilizers to promote sufficient fertilizer supply and boost yield output. Efficient use of chemical fertilizers is arguably lowers the base on the reduced ratio uptake by plants (Adesemoye et al., 2009). The heavy use of chemical fertilizers over a long period of time results into adverse structural defects on both plant and soil. These adverse impacts on both plant and soil by chemical fertilizers have encouraged the alternative use of organic fertilizers in the recent years (Nur et al., 2016). It is noteworthy that fertilizer used efficiently, can be an improvement and by fertilizer management where application rate, time and place are carefully considered for both organic and conventional farming. Research has indicated that for efficient crop production to be achieved a balance between nutrient use efficiency and optimal crop production must be undertaken (Roberts, 2008). Intensive farming results into high demand for chemical fertilizers which then result into adverse environmental impacts. Additional, these adverse impacts are associated with negatively altered biogeochemical cycles. Therefore, attention has shifted to organic fertilizers which are cost effective, environmental friendly (Ehteshamiet al., 2007). In an attempt to manage negative environmental impacts from chemical fertilizers, inoculation with plant growth promoting rhizobacteria (PGPR) has been encouraged. One of the advantages of the bacteria is that they assist plants in bet-

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ter growth and development thus making them suitable to be used as bio-fertilizers (Adesemoye et al., 2009). Many tests have proved that plant rhizosphere have boosted crop quality, yield output and general plant growth. Ideally, this study was conducted to determine the individual and combined effect of phosphorous bio-fertilizer (*Bacillus lentus – Pseudomonas putida*) and different rates of triple superphosphate fertilizers on agronomic, quantitative traits of sugar beet. Cultivars 7233 and $BR_1$ were used as experimental materials in this study to evaluate the effects of different fertilizers.

**Materials and Methods**

**Experimental Details and Treatments**

The experiment was carried out in sandy loam soils with EC of 0.72 dS $m^{-1}$ and pH of 7.8 at the Agriculture Research Station of the Islamic Azad University, Tabriz Branch, Iran. Tabriz is located at 38º5'N and Long 46º17'E about 1360 m above sea level and its annual mean temperature is 13.04ºC. The region is classified as cold and semi-arid. Its annual precipitation is 271.3 mm (physical and chemical properties of soil in experimental field were presented in table 1).

**Seed material:**

Two sugar beet varieties ($BR_1$-7233) were used in the experiment. The seed material was obtained from the Sugar Beet Seed Institute Research Center at Karaj, Iran.

Table 1. Soil analysis result for physical and chemical characteristics

| Characteristic | Soil depth (cm) | Soil texture | pH | P | K | N |
|---|---|---|---|---|---|---|
| Value | 0-30 | Sandy-loam | 7.8-8.9 | 8/39 | 513 | 059/0 % |

The study was performed as a factorial experiment based on randomized complete block design with three replications and 16 treatments. The fertilizer levels were presented in Table 2.

Table 2. The levels of fertilizers

| |
|---|
| Control |
| Only impregnated seed with organic biological phosphorus (phosphorous biofertilizer) |
| 50kg/ha triple super phosphate |
| 100kg/ha triple super phosphate |
| 150kg/ha triple super phosphate |
| 25kg/ha triple super phosphate + impregnated seed with organic biological phosphorus |
| 50kg/ha triple super phosphate + impregnated seed with organic biological phosphorus |
| 75kg/ha triple super phosphate + impregnated seed with organic biological phosphorus |

After measuring the shoot fresh weight and LAI (leaf area index), 20 kg sample from each plot was obtained randomly. About 150 g of pulp from each plot was prepared by Venema apparatus and kept in a freezer until analysis. Frozen sugar beet pulp samples were analyzed in sugar technology laboratory in Sugar Beet Seed Preparing and Breeding Center at Karaj of Iran for purity parameters with Betalyser (model OR-KERNCHEN). Betalyser is a computer controlled system for automated routine analysis of sugar beet on sugar content and impurities including $Na^+$, $K^+$ and $NH_4^+$-N. Sugar content (SC) was measured by polarimetr, $Na^+$and $K^+$by flame bemission photometry and $NH_4^+$-N by double beam filter photometry using the blue number method (Sheikh-Aleslami, 1997). The combined effect of $Na^+$, $K^+$and $NH_4^+$-N on the amount of sugar lost to molasses in the factory process was determined following the Reinfeld et al.(1974) method.

**Molasses sugar (MS) = 0.343 * ($K^{\pm}$ + $Na^{\pm}$) + 0.094 * $NH_4^+$ -N 0.31.**

[$Na^+$, $K^+$ and $NH_4^+$-N in meq (100 $g^{-1}$ beet).

Standard factory loss (SFL = 0.6).

White sugar contents (recovered sugar content) were calculated using the formula of Reinefeld et al. (1974):

**WSC = SC– MS– SFL**

White sugar yield (WSY) = root yield (RY) * WSC.

An alkalinity coefficient (AC) was determined from the major non-sugars $K^{\pm}$, $Na^{\pm}$ and $NH_4^+$ -N, as follows (Sheikh-Aleslami, 1997):

**AC = ($K^+$+ $Na^+$)/ $NH_4^+$ - N**

Gross sugar yield and white sugar yield were obtained multiplying sugar content (SC) and white sugar content (WSC) by root yield. Statistical data analysis was done by using SAS software. The ANOVA test was used to determine significant ($p \leq 0.01$ or $p \leq 0.05$) treatment effect and Duncan Multiple Range Test to determine significant difference between individual means.

**Results and Discussion**

Variance analysis revealed that differences in leaf area index (LAI), total dry weight, shoot fresh weigh, shoot dry weight, single root weight, Na (%), Molasses sugar (%) and harvest index values of the cultivars were found to be significant at 1% level and the differences in root fresh weight, white sugar content and extraction sugar content (%) of the cultivars were found to be significant at 5% level. Effects of different fertilizers on LAI, total dry weight and Na contents were found to be significant at 1% level and the effects on shoot dry weight were found to be significant at 5% level. On the other hand, effects of cultivar x fertilizer interactions were on LAI, Na and Molasses Sugar Content (MS) were found to be significant at 1% level and the effects of interactions on N (%) and extraction sugar content (%) were found to be significant at 5% level (Table 4 and 5).

Table 3. Technical terms of sugar beet yield and quality (Abdollahi Noghabi et al., 2005)

| No | Title: English | Title: Symbol | Definition | | English |
|---|---|---|---|---|---|
| 1 | Root yield | RY | Root yield of sugar beet per area unit (root wet weight | Weight of harvested roots in area unit after rinsing (net weight) | $t.ha^{-1}$ |
| 2 | Sugar content | SC or (Pol) | Sugar content in wet root of sugar beet | Polarimetric method | % in beet or g sugar.100g beet-1 |
| 3 | - Potassium - Sodium - Amino-nitrogen | K Na α-N | Amount of health threatening potassium, sodium, amino nitrogen | Potassium and sodium were measured through photometric film Nitrogen was measured using chromometry (blue number) | meq.100g beet-1 or mmol. 100g beet-1 |
| 4 | Molasses sugar | MS | Amount of extractable sugar from root of sugar beet (molasses/sugar beet rate) | Based on volume of health threatening potassium, sodium, and nitrogen and using a standard experimental formula | % in beet or g sugar.100g beet |
| 5 | White sugar content or - Recoverable white sugar | WSC RWS | Amount of extractable white sugar content of sugar beet in mill Among of extractable sugar | WSC = SC - (MS + 0.6*) Sugar waste in the mill (set to 0.6)* | % in beet |
| 6 | Sugar yield | SY | Amount of produced sugar in area unit (sucrose content of sugar beet root) | SY = SC × RY | $t. ha^{-1}$ |
| 7 | White sugar yield | WSY | Extractable while sugar content of white beet per area unit | WSY = WSC × RY | $t. ha^{-1}$ |
| 8 | Extraction coefficient of sugar (Purity) | ECS (Yield) | Content of extractable white sugar from sucrose content in sugar beet root | ECS = (WSC ÷ SC) ×100 | % in sugar |
| 9 | Alkalinity coefficient | Alc or AC | Health threatening sodium/potassium to nitrogen ratio in sugar beet | Alc=(K+Na) ÷ (α-N) | - |
| 10 | Brix | Brix | Density of roughage in extract of sugar beet root | Refrectometry method | % in extract |

* Terms in the parentheses are wrong commonly used terms which are not recommended.

Table 4. Anova of effect of fertilizer and cultivar on different characters of sugar beet

| ANOVA | df | Mean squares | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LAI (leaf area index) | Total Dry Weight $Kg/m^2$ | Shoot Dry Weight $Kg/m^2$ | Root Fresh Weight $Kg/m^2$ | Shoot Dry Weight $Kg/m^2$ | Root Dry Weight $Kg/m^2$ | Single Root Weight $Kg/m^2$ | LAR ( leaf are ratio) | Sugar Contents % | Na (%) |
| Replication | 2 | 0.557** | 1.058** | 23.689** | 2.036** | 0.551** | $0.056^{ns}$ | 0.752* | 0.373** | 5.000** | 2.067** |
| Cultivar | 1 | 2.460** | 1.026** | 35.432** | 1.922* | 0.707** | $0.058^{ns}$ | 1.245** | $0.028^{ns}$ | $1.505^{ns}$ | 4.332** |
| Fertilizer | 7 | 0.122** | 0.112** | $1.518^{ns}$ | $0.362^{ns}$ | 0.052* | $0.009^{ns}$ | $0.112^{ns}$ | $0.042^{ns}$ | $0.521^{ns}$ | 0.797** |
| Cultivar x Fertilizer | 7 | 0.134** | $0.039^{ns}$ | $1.266^{ns}$ | $0.219^{ns}$ | $0.014^{ns}$ | $0.008^{ns}$ | $0.003^{ns}$ | $0.016^{ns}$ | $0.783^{ns}$ | 0.834** |
| Error | 7 | 0.030 | 0.026 | 0.827 | 0.346 | 0.020 | 0.0022 | 0.164 | $0.025^{ns}$ | 0.461 | 0.228 |
| CV | 30 | 4.05 | 7.14 | 32.07 | 8.14 | 30.23 | 8.41 | 32.33 | 8.23 | 4.03 | 26.39 |

ns = Non significant, ** = $p < 0.01$ and * = $p < 0.05$

Table5. Anova of effect of fertilizer and cultivar on different characters of sugar beet

| ANOVA | df | Mean squares | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | K (%) | N(%) | Alc | White Sugar Content (WSC) | Ex-traction Sugar Content (ESC) | Mollase Sugar (MS) % | Quality | Brix | Harvest Index | Sugar Con-tents Yield | White Sugar Yield (ton/ ha) |
| Replication | 2 | 1.772** | 1.307* | 2.718$^{ns}$ | 10.470** | 85.088** | 1.055** | 2.8723$^{ns}$ | 6.772** | 0.059** | 28.834$^{ns}$ | 29.031$^{ns}$ |
| Cultivar | 1 | 0.018$^{ns}$ | 0.517$^{ns}$ | 0.780$^{ns}$ | 4.219* | 47.661* | 0.684** | 0.0008$^{ns}$ | 3.101* | 0.082** | 0.450$^{ns}$ | 0.838$^{ns}$ |
| Fertilizer | 7 | 0.164$^{ns}$ | 0.441$^{ns}$ | 1.0774$^{ns}$ | 0.950$^{ns}$ | 8/894$^{ns}$ | 0.148$^{ns}$ | 0.0006$^{ns}$ | 0.945$^{ns}$ | 0.005$^{ns}$ | 9.325$^{ns}$ | 6.081$^{ns}$ |
| Cultivar x Fertilizer | 7 | 0.389$^{ns}$ | 0.668* | 0.953$^{ns}$ | 1.864$^{ns}$ | 18.685* | 0.317** | 0.0002$^{ns}$ | 1.261$^{ns}$ | 0.002$^{ns}$ | 7.822$^{ns}$ | 9.169$^{ns}$ |
| Error | 7 | 0.247 | 0.255 | 0.940 | 0.829 | 6.852 | 0.083 | 0.017 | 0.585 | 0.003 | 11.023 | 9.614 |
| CV | 30 | 5.95 | 23.02 | 19.82 | 7.09 | 3.44 | 8.53 | 3.36 | 3.24 | 6.57 | 11.18 | 13.65 |

ns = Non significant, ** = p < 0.01 and * = p < 0.05

Table 6. Mean comparison of effect of biological and chemical phosphorus fertilizer on total dry weight and shoot dry weight of sugar beet

| | Total dry weight | Shoot dry weight |
|---|---|---|
| Control | 2.488 a | 0.5866 ab |
| Only impregnated seed with organic biological phosphorus (phosphorous bio fertilizer) | 2.362 ab | 0.6188 a |
| 50kg/ha triple super phosphate | 2.297 ab | 0.4943 abc |
| 100kg/ha triple super phosphate | 2.101 b | 0.3908 c |
| 150kg/ha triple super phosphate | 2.102 b | 0.3625 c |
| 25kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 2.195 b | 0.4648 abc |
| 50kg/ha triple super phosphate + impregnated seed withorganic biological phosphorus | 2.151 b | 0.4093 bc |
| 75kg/ha triple super phosphate + impregnated seed withorganic biological phosphorus | 2.189 b | 0.4213 bc |

Columns means followed by the same letter are not significantly different at 0.05 probability level.or 0.01 probability level.

Table 7. Means comparison of effects of biological and chemical phosphorus fertilizer on LAI, Na, N (%), ECS and MS (%) of sugar beet

| Cultivar | Fertilizers | LAI | Na | N (%) | ECS | MS (%) |
|---|---|---|---|---|---|---|
| $BR_1$ | Control | 4.401ab | 1.930 bc | 1.700 abcd | 77.29 abc | 3.220 abcd |
| $BR_1$ | Only impregnated seed with organic biological phosphorus (phosphorous bio fertilizer) | 4.593 ab | 2.707 ab | 2.703 a | 73.26 c | 3.727 abc |
| $BR_1$ | 50kg/ha triple super phosphate | 4.682 a | 2.250 bc | 2.080 abc | 75.61 abc | 3.490 abcd |
| $BR_1$ | 100kg/ha triple super phosphate | 4.448 ab | 2.020 bc | 1.633 abcd | 76.31 abc | 3.353 abcd |
| $BR_1$ | 150kg/ha triple super phosphate | 4.376 abc | 2.600 abc | 2.627 ab | 74.70 bc | 3.627 abcd |
| $BR_1$ | 25kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 4.269 abcd | 2.213 bc | 1.470 abcd | 77.31 abc | 3.313 abcd |
| $BR_1$ | 50kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 4.555 ab | 2.417 abc | 2.660 ab | 73.11 c | 3.763 ab |
| $BR_1$ | 75kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 4.622 ab | 2.250 bc | 1.993 abcd | 73.86 bc | 3.517 abcd |
| 7233 | Control | 4.451 ab | 3.273 a | 2.360 abc | 72,87 c | 3.930 a |
| 7233 | Only impregnated seed with organic biological phosphorus (phosphorous biofertilizer) | 4.323 abc | 2.527 abc | 2.313 abc | 74.45 bc | 3.583 abcd |
| 7233 | 50kg/ha triple super phosphate | 3.879 de | 1.943 bc | 1.227 cd | 78.66 ab | 3.100 bcd |
| 7233 | 100kg/ha triple super phosphate | 3.879de | 1.730 bc | 1.387 cd | 76.99 abc | 3.253 abcd |
| 7233 | 150kg/ha triple super phosphate | 3.837 de | 1.663 c | 0.8367 d | 80.41 a | 2.900 d |
| 7233 | 25kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 3.959 cde | 1.877bc | 1.327 cd | 76.54 abc | 3.243 abcd |
| 7233 | 50kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 4.227 bcd | 1.930 bc | 1.427 bcd | 78.53 ab | 3.117 bc |
| 7233 | 75kg/ha triple super phosphate + impregnated seed with organic biological phosphorus | 3.769 e | 1.783 bc | 1.183 cd | 78.93 ab | 2.973 cd |

Columns means followed by the same letter are not significantly different at 0.05 or 0.01 probability level.

Table 8. Means comparison of effects of cultivar on Brix, Harvest Single root weight (Kg/m$^2$) index, Total dry weight (Kg/m$^2$), Shoot fresh weight (Kg/m$^2$), Root fresh weight (Kg/m$^2$), Shoot dry weight (Kg/m$^2$), Single root weight (Kg/m$^2$) and WSC

| Cultivar | Brix | Harvest index | Total dry weight(Kg/m$^2$) | Shoot fresh weight(Kg/m$^2$) | Root fresh weight (Kg/m$^2$) | Shoot dry weight (Kg/m$^2$) | Single root weight (Kg/m$^2$) | WSC |
|---|---|---|---|---|---|---|---|---|
| $BR_1$ | 23.376 | 0.795 | 2.382 | 3.696 | 7.423 | 0.590 | 1.387 | 12.551 |
| 7233 | 23.884 | 0.841 | 2.090 | 1.977 | 7.023 | 0/374 | 1.056 | 13.144 |

Columns means followed by the same letter are not significantly different at 0.05 or 0.01 probability level.

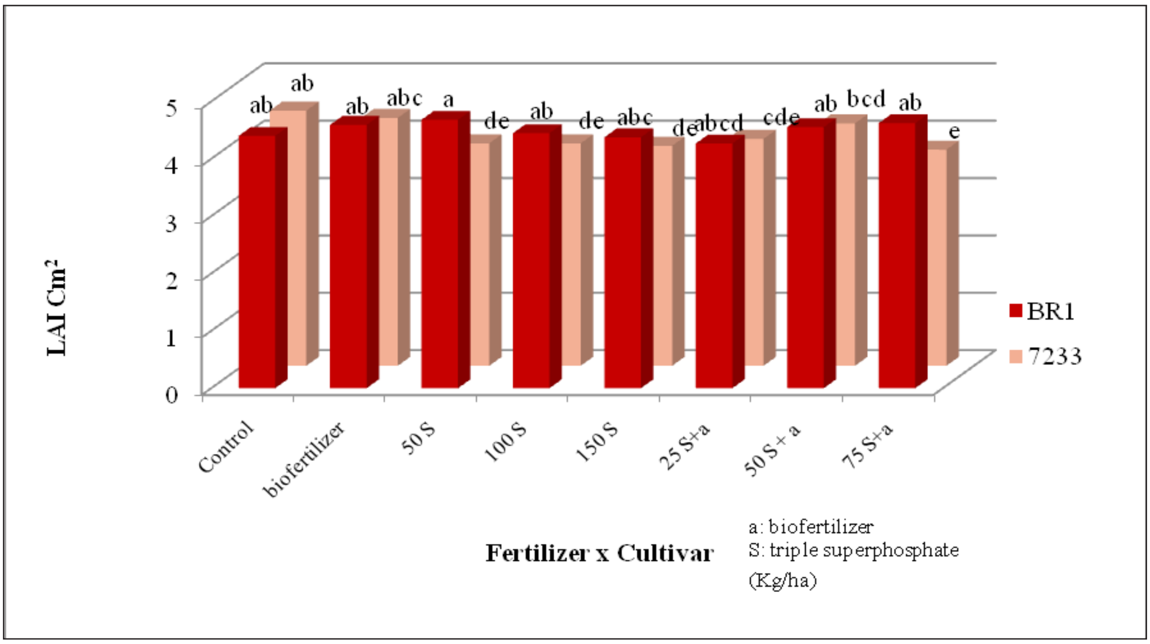


Figure 1. LAI of sugar beet due to the combined effect of cultivars and fertilizers.

**LAI (Leaf Area Index):** With regard to LAI, cultivar x fertilizer interaction was found to be significant at 1% level (Table 4). Considering the effects of fertilizers on cultivars, the greatest LAI (4.682 cm$^2$) was obtained from 50 kg/ha triple super phosphate treatments of $BR_1$cultivar. As compared to 7233 cultivar, $BR_1$ exhibited more constant respond to different fertilizer doses and placed within the same statistical group with the control plants. Except for the control and biological fertilizer treatments, other fertilizers had negative effects on LAI of 7233 cultivar and decreased LAI values. Biological fertilizers reduced the negative effects of excessive soil phosphorus levels in 7233 cultivar. As compared to 7233 cultivar, biological fertilizers yielded more positive outcomes in $BR_1$cultivar. In other words, cultivar x fertilizer interaction was found to be significant since the cultivars had different responds to biological fertilizers and doses (Table 7). Excessive soil phosphorus levels reduced LAI values of sugar beet plants in different ways. Excess phosphorus resulted in Fe and Zn deficiency, thus restricted leaf growth and development and decreased LAI values (Marschner, 1995). Burnett et al. (2008) carried out a study with Fan flower plants and indicated that soil phosphorus levels over 40 mg/l reduced LAI values. Similarly, Zhang et al. (2004) also worked with Fan flower plants, but indicated this time that soil phosphorus levels over 14.5 mg/l reduced LAI values.

**Total dry weight (kg/m$^2$)**: Effects of cultivars and fertilizers on total dry weights were found to be significant at 1% level (Table 4). In general, $BR_1$cultivar (2.382 kg/m$^2$) had greater total dry weights than 7233 cultivar (2.090 kg/m$^2$). Since $BR_1$ cultivar had greater LAI (leaf area index) values, it produced greater quantities of dry matter (Table 8). Effects of different fertilizers (bio-fertilizers and chemical) on total dry weights are presented in Figure 2. Although phosphorous bio-fertilizers and 50 kg/ha triple super phosphate treatments were placed in the same statistical group with the control plants, the greatest total dry weight was obtained from the control plants. In other words, in case of sufficient soil phosphorus levels, supplementary phosphorus fertilizers (either biological or chemical) had negative effects on plant total dry weights. Over-treatments may alleviate toxic impacts of phosphorus in soils, imbalance soil Fe, Cu, Zn, Mn and B microelements and ultimately result in yield losses. Excessive phosphorus in soil also result in toxic accumulation of B, alleviated Cd pollution in soil, thus reduced quality and dry matter yields (Marschner, 1995). Excessive phosphorus reduce Fe ratio and thus decrease dry matter and LAI values. Excess phosphorus resulted in Mn deficiency in spinach plants and thus reduced photosynthesis rate by 28% and dry mater yield by 20%.

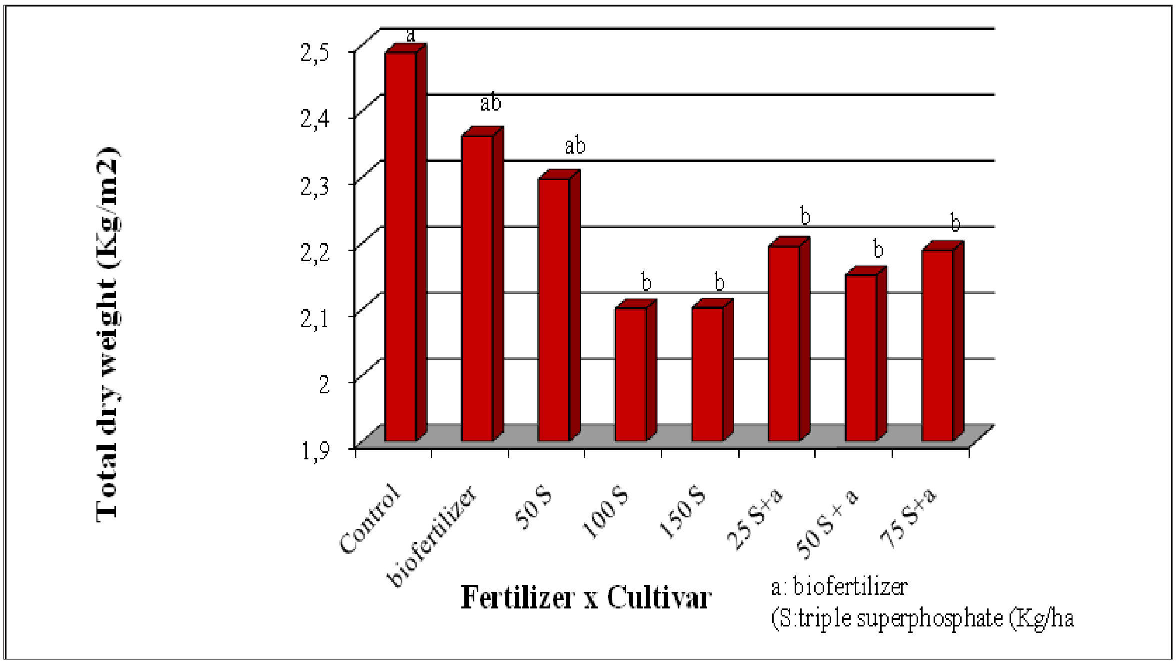


Figure 2. Total dry weight (Kg/m$^2$) of sugar beet due to the effect of fertilizers.

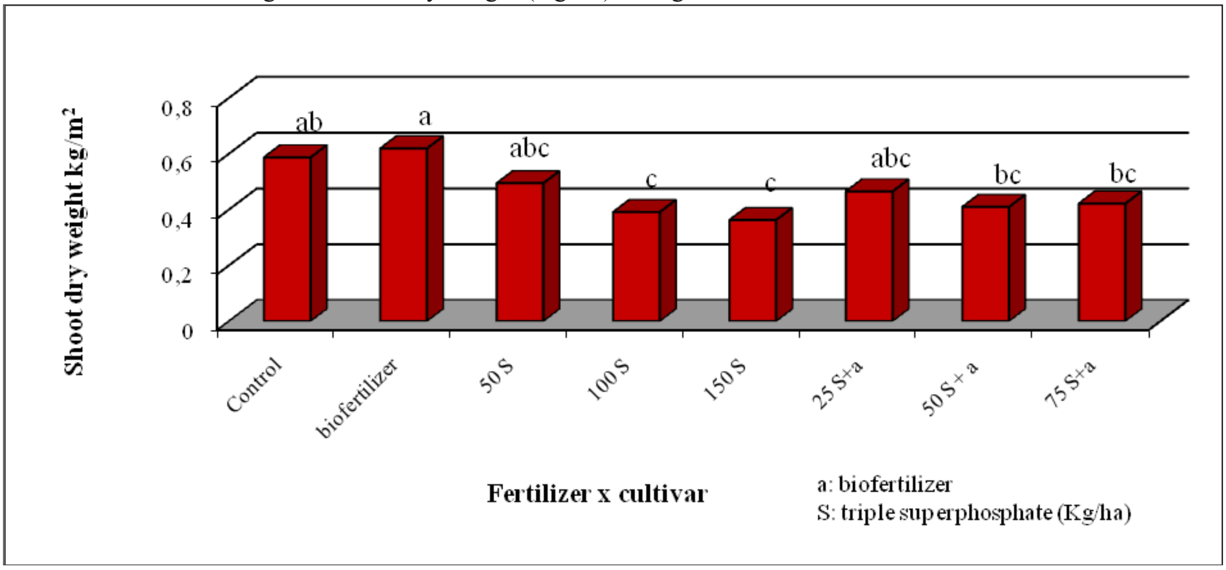


Figure3. Shoot dry weight (Kg/m$^2$) of sugar beet due to the combined effect of cultivars and fertilizers.

**Shoot Dry Weight:** According to variance analysis, fertilizers had significant effects on shoot dry weights at 5% level (Table 4). As can be seen in Figure 3, cultivars had different responds to different fertilizer treatments. Considering shoot dry weight and total dry weight data together, it was observed that plants had similar responds. The greatest shoot dry weight was obtained from single biological fertilizer treatments. Such a case indicated that the difference in total dry weight was resulted from shoot dry weight. As can be seen in Table 4, fertilizer factor did not have significant effects on root fresh and dry weights. Again, according to variance analysis, there were significant differences in shoot dry weights of the cultivars at 1% level. $BR_1$cultivar (0.590 kg/m$^2$) had about 41% greater shoot dry weight than 7233 cultivar (0.347 kg/m$^2$). High soil phosphorus levels indirectly influence soil microelements and thus reduce shoot dry weights. Rumheld and Marschner (1991) indicated that excessive soil phosphorus negatively influenced manganese (Mn) quantities absorbed by the soils and reduced shoot dry weight. According to Marschner (1995), high soil phosphorus levels decreased plant IAA (Indole acetic acid) contents, increased tryptophan quantities and such a case then decreased leaf dimensions and thus leaf areas. Burnett et al. (2008) indicated that increasing soil phosphorus levels to a certain level resulted in increased shoot dry weights, but further increases resulted in decreasing shoot dry weights. Zhang et al. (2004) reported for fan flower plants that soil phosphorus levels over 14.5 mg/l reduced shoot dry weights, Shan et al. (2004) indicated for *Hakea prostrata* plants that phosphorus quantities over 30 µmol reduced leaf dry weights.

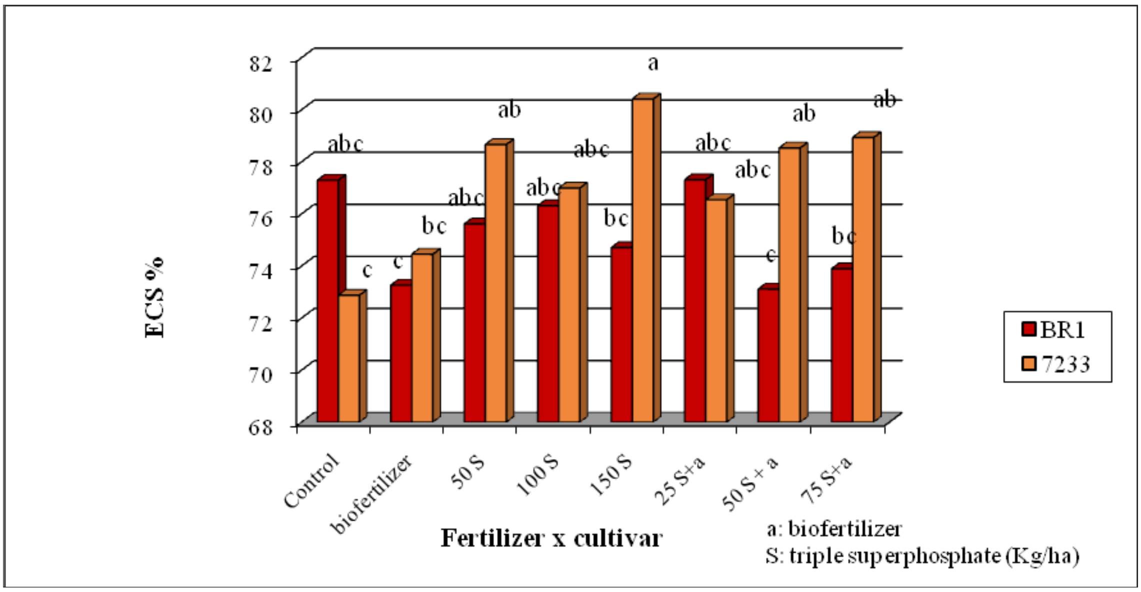


Figure4. Extraction sugar (ESC) of sugar beet due to the combined effect of cultivars and fertilizers.

**Extraction coefficient of sugar (ECS):** As can be seen in Table 5, fertilizer x cultivar interactions was found to be significant at 1% level with regard to extraction coefficient of sugar (ECS). The greatest ECS was obtained from 150 kg/ha phosphorus treatment of 7233 cultivar and the lowest value was obtained from the control plants. In $BR_1$ cultivar, the greatest ECS value was obtained from the control plants (Table 7). Draycott and Christenson (2003) carried out a research in Minnesota of the USA and reported that high soil phosphorus levels had greater impacts on sugar content (%) than on ECS ratio of sugar beet plants. It was indicated in another research that increasing phosphorus contents of phosphorus-deficient soils increased ECS ratios, but increasing phosphorus quantities did not have significant effects on ECS ratios. In other words, phosphorus fertilizer did not have significant effects on ECS.

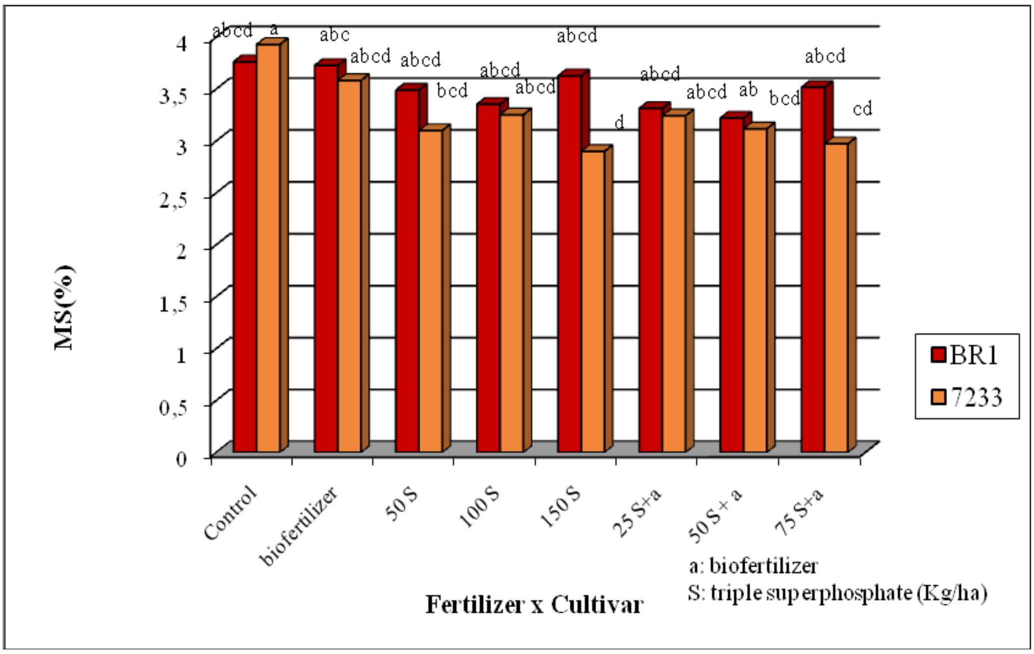


Figure 5. Molasses sugar of sugar beet due to the combined effect of cultivars and fertilizers.

**Molasses sugar (MS):** In sugar production from sugar beet, the economically non-valuable portion of the sugar, so called as molasses, is used as a byproduct of the sugar facility. Since the molasses sugar is not able to be converted into white sugar, there is a loss in sugar content. With regard to molasses sugar, cultivar x fertilizer interactions was found to be significant at 1% level (Table 5). As can be seen in Table 7, the greatest molasses sugar in 7233 cultivar was obtained from the control group and the other fertilizer treatments reduced molasses sugar ratios. In $BR_1$cultivar, different fertilizer doses did not created significant differences in molasses sugar and fertilizer treatments yielded similar results with the control plants. As it was in 7233 cultivar, the greatest molasses sugar in $BR_1$ cultivar was also obtained from the control plants.

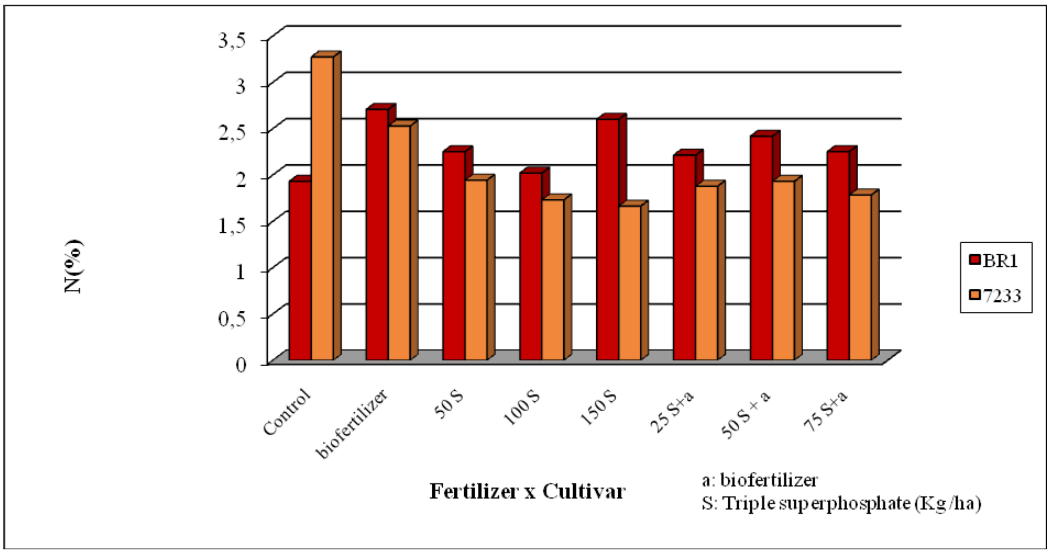


Figure 6. N (%) of sugar beet due to the combined effect of cultivars and fertilizers.

***Alpha-amino nitrogen*** **(N):** As can be seen in Table 4, cultivar x fertilizer interactions was found to be significant at 5% level with regard to N (%) content. Present findings revealed that with regard to N (%), cultivars had different responses to phosphorus fertilizer. In 7233 cultivar, the greatest N (%) content was obtained from the control and bio-fertilizertreatments. Although different phosphorus treatments did not have significant differences, N (%) contents decreased with increasing phosphorus contents. In $BR_1$ cultivar, control and fertilizer treatments yielded similar results and the greatest N (%) content was obtained from phosphorus bio-fertilizer treatments. In general, 7233 cultivar was found to be more sensitive to fertilizer quantities than $BR_1$cultivar. Kuang et al. (2005) reported increasing N quantities in soybean plants with increasing phosphorus quantities. Groot et al. (2003) also indicated increasing plant N quantities with increasing soil phosphorus quantities.

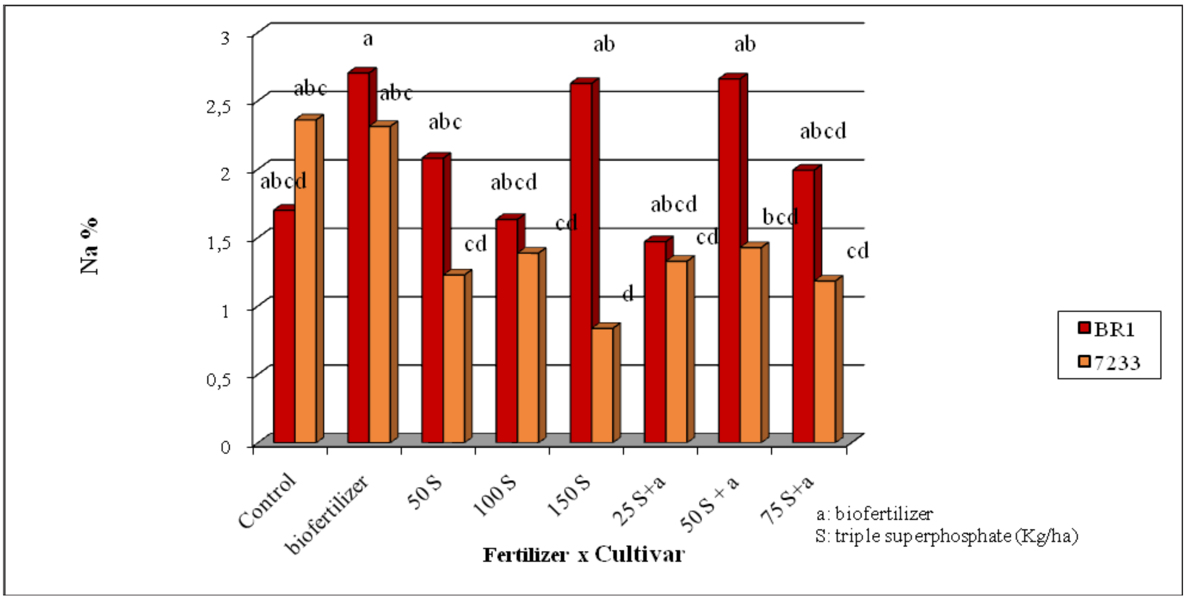


Figure7. Na (%) of sugar beet due to the combined effect of cultivars and fertilizers.

**Na (%):** Na, K and*alpha-amino nitrogen* (N) substances increase molasses sugar, thus reduce white sugar content of sugar beet. Variance analysis revealed that cultivar x fertilizer interactions was significant for Na (%) factor at 1% level. In 7233 cultivar, the lowest Na ratios (1.663%) was obtained from 150 kg/ha triple super phosphate treatments and the greatest Na (%) ratio was obtained from control plots and bio-fertilizertreatments. Increasing phosphorus quantities reduced Na (%)

ratio and positively influenced sugar quality. In $BR_1$ cultivar, the lowest Na ratio (1.930%) was obtained from the control plots and the greatest Na ratios were obtained from biological fertilizer, 50 kg/ha triple super phosphate and 50 kg/ha triple super phosphate + impregnated seed with organic biological phosphorus treatments. Different responds of two cultivars with regard to Na (%) may be resulted from own characteristics of the cultivars. It was reported in a previous study carried out with chickpeas that decreasing soil phosphorus levels increased plant NA (%) contents (Das and Sen, 1981).

## Conclusions

Excess soil phosphorus may have indirect negative impacts on sugar beet yield and quality. Excess phosphorus fertilizer treatments reduce plant Fe, Zn and Mn uptake from the soils, thus negatively influence plant growth and development. Such negative impacts are not solely attributed to chemical phosphorus fertilizers. In case of excessive soil phosphorus contents, even biological phosphorus fertilizers do not have positive impacts on sugar beet quality. Present findings revealed decreasing LAI and dry weight values with increasing phosphorus fertilizer quantities. While biological phosphorus fertilizer did not have any significant effects on shoot dry weight, chemical phosphorus fertilizer significantly decreased shoot dry weights even with the lowest dose. Sugar beet cultivars had different responses to phosphorus quantities. In present study, $BR_1$has better quality than 7233 cultivar and exhibited more stable respond to excess phosphorus fertilizers. In other words, $BR_1$ was found to be more tolerant to negative conditions than 7233 cultivar, thus it is recommended to be cultivated under adverse conditions.

## Compliance with Ethical Standards

**Conflict of interest**

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Author contribution**

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

**Ethical approval**

Not applicable.

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**Data availability**

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**Consent for publication**

Not applicable.

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