EFFECT OF DIFFERENT PLANTING DATES AND DEFOLIATION ON THE PROPERTIES OF SUGAR BEET (*Beta vulgaris* L.)

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KEYWORDS

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Sugar Percentage of Root
Root Yield
White Sugar Yield

ABSTRACT

The experiment was conducted in spring 2014 to evaluate the effect of defoliation on the quantitative and qualitative characteristics of sugar beet in Motahari research station located in the Kamal Shahr region in Karaj, Iran. The study was conducted in split plot factorial with completely randomized block design with four replications. The main factors included two planting dates viz 23 April, 2014 (suitable planting time) and 18 May, 2014 (Late planting) and the sub-factors included five levels of defoliation including stage of early cotyledon growth to two true leaves (2 leaves), the stage of plant deployment (about 12 leaves), mid-growth (about 32 leaves) and late season of growth (about 54 leaves) and another sub-factors included five levels of defoliation intensity of leaves included 25%, 50%, 75% and 100% of defoliation and non-defoliation stage (control) as randomized and factorial were considered. Result of study revealed that different planting dates have significant effect on the sugar percentage of root. In addition, the treatment of defoliation stage could have a significant effect on root yield and white sugar yield ($p>0.01$). The treatment of defoliation intensity had a significant effect on all three traits ($p>0.01$). In general, increase in the defoliation intensity negatively affects the root yield and significantly reduced the white sugar yield (compared to control). Among the various stages of defoliation, middle stages of the defoliation have least effect on the evaluated traits which indicated more sensitivity of this treatment during the growing season of plant.

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1 Introduction

There are several biotic and abiotic factors which able to damage the leaves of sugar beet plants and subsequently reduce the yield. Among these, some of the already noted factors are cold and frost, drought, hail, wind, pests and diseases which can effectively reducing the leaf area (Jadidi et al., 2010). Sugar beet production under semi-arid conditions of growth has been mainly decreased due to the limited access to water (Morillo-Velarde & Ober, 2006). Water shortage may be a significant limiting factor and can reduce the quality of sugar beet root in the future due to climate changes (Jones et al., 2003). In the Middle East, low rainfall during the months of July and August, when water demand is maximum, supplemental irrigation is necessary to avoid lowering the quality of sugar beet root. Further, sugar beet is a drought tolerant species (François & Maas, 1994) and part of the plant foliage (defoliation) limited the water demand and respond to the environmental stress (Vesk & Westoby, 2003).

Since the leaves of plants are the main area of receiving sunlight and photosynthetic. Therefore, any reduction in the surface of leaves or their low efficiency can be considered as main factors in reducing the ability of plant to assimilate carbon dioxide and on the other hand decrease the translocation of assimilates into the storage or vegetative organs and subsequently impairs the plant yield. For this reason, the estimation of yield loss caused by defoliation has an important role in farm management (Muro et al., 2001; Ashley et al., 2002; Abdi et al., 2007). Data obtained from the simulated hail damages as defoliation in the United States, Canada, England, India and Spain suggest that damages resulted from hail on the quantity and quality of sugar beet depend on the severity of the damage in stage and period of development (Alimoradi, 2001). Every year pests, diseases and hail caused considerable damage to sugar beet farms in the country. Further, there are no scientific patterns to estimate the damages caused by hail and other factors reducing leaf area in sugar beet farms. Though some effort has been carried out for the estimation of these damages but these are often not accurate. That's why this study was conducted to estimate the damages caused by hail factors. With this effect of leaf area reduction via defoliation on qualitative and quantitative yield of sugar beet was also determined. The effects of time and intensity of defoliation on root yield and other quantitative and qualitative characteristics of root were also studied. In Montana, Morris (1950) found that complete defoliation in late June or early July in sugar beet reduced yield to a quarter of the normal conditions and 50% defoliation can reduce yield to one sixth of normal conditions (Morris, 1950). Under similar conditions, Afanasiev et al. (1960) reported that more than 75% defoliation caused reduction in root yield to less than 6% and the yield of the plant to less than 20%.

According to the results of the research, complete defoliation caused 80% reduction in weight of the leaves between 23% to 27% decline in the yield of root. In fact, when sugar beet is

confronted with semi-arid conditions, high temperature, light and salinity stress is not easily separable and more complex situation is created (Munns, 2002; Chaves et al., 2002). According to the reports of Jones et al. (1955) in the UK on sugar beet, 50%, 75% and 100% defoliation at 4 or 8- leaf stages decreased the root yield to 5%, 10% and 27% , respectively. The results of artificial defoliation at 120 and 144 days after planting in India showed that defoliation treatments of 25%, 50%, or 75% did not reduce the root yield of sugar beet, but 100% defoliation at 120 days after planting significantly decreased the root yield (Singh et al., 1980). Defoliation to 100% in late June or early July or middle of September or the middle of October decreased the average root yield in the 3-year period to 23, 27, 20 and 10%, respectively (Stallknecht & Gilbertson, 2000).

2 Materials and Methods

The experiment was conducted in Motahari research station located in Kamalshahr of Karaj during 2014. The station is located at Latitude 35° 15' N and longitude 50°51' E with an altitude of about 1300 meters above sea level. This area with 180-150 dry days is considered of the hot and dry Mediterranean climate zones. Split plot factorial experiments were carried out in a randomized complete block design with four replications. Treatments of planting dates as main plots were placed on two levels, including 23 April, (appropriate time of planting) and 18 May, (at late planting). Treatments of defoliation as sub plots were the early growth of cotyledon to two true leaves (2 leaves), establishment stage (about 12 leaves), middle of growth (about 32 leaves) and the end of the growing season (about 54 leaves) along with five levels of defoliation intensity factors including the removal of 25, 50, 75 and 100 percent of leaves and non-defoliation (control) as factorial and random. Row to spacing was 50 cm and the length of the rows was 8 m and each sub-plots had four lines and the final harvest took place taking into consideration marginal effects. The amount and time of use from nutrient elements were imposed based on soil test results. During the growing season, pests and weeds were controlled at critical times. Irrigations time was also determined based on the amount of evaporation between 80 and 90 ml from class A pan. Plant density on the farm was considered about 100 thousand plants per hectare.

Defoliation per plot was treated on the green leaves with at least 75 per cent healthy leaves. Defoliation was imposed using scissors and its intensity was based on experimental treatments on each leaf, independently. During the growing season, the process of light absorption was performed using a radiometer in intervals of 20 days, since the beginning of the treatment. The total numbers of leaves were counted every 15 days to determine the time of treatment in the control plot. The final harvest was simultaneously carried out in all the plots in late October or early November, 2014. In the running time of each treatment, dry weights of leaf, petiole, stem and storage root as well as leaf area were determined at a level of about 1 square

meter after 4 weeks and at harvest time; and the trend of changes was examined in different treatments. Also root yield, sugar content of root and white sugar yield were measured at the end of the growing season. Sugar content of roots was measured by polarimetry (Kunz et al., 2002). Also, according to the results, the reduction in sugar yield caused by leaf damage was determined in each growth stage. Data obtained from this study was analyzed using SPSS software and ANOVA analysis method and LSD test was used for mean comparison ($P < 0.05$).

3 Results and Discussion

3.1 Root yield

According to the results of variance analysis, the root yield of sugar beet was not affected by different planting dates. The main effects of defoliation treatments, defoliation intensity and interaction between planting date and the defoliation was reported on the root yield and these were significantly different ($P > 0.01$) to each other (Table 1). Among these, lowest root yield was obtained in the middle stage of growth with an average of 48.10 tons per hectare which showed significant differences compared with other treatments. The highest root yield (57.40 tons per hectare) was also achieved in the early stages of growth (Figure 1). This factor can be attributed to the fact that at the beginning of growth, the pace of growth in many plants is directly associated with the amount of light received by their leaf area (Monteith, 1977; Gallagher & Biscoe, 1978). In fact, when the plant encounters in the early stages with a treatment of defoliation has more time for the next leaf production and capture more light, resulting in increased yield so that plant is almost associated with higher levels of leaves until the middle stages of growth. Compare the average interaction between planting date and defoliation showed that the highest ratio of root yield was observed in the treatment of early planting date and the initial defoliation stage (64.72 tons per hectare) and the lowest root yield was in the treatment of late planting date and in the middle of the defoliation stage (42.27 tons per hectare) (Figure 3). It is also

remarkable that the ratio of root yield was reduced by increasing the intensity of defoliation. So that the highest root yield (61.89 tons per hectare) was obtained in control and the lowest rate (51.05 tons per hectare) was in treatment of 100% defoliation (Figure 2); it could be due to reduced ability to absorb light by plant with increasing the intensity of defoliation. Result of the present study are in agreement with the findings of Morris (1950,) also found that with increasing the intensity of defoliation, the root yield will be greatly reduced. Further, Afanasiev et al. (1960) reported that complete defoliation led to a reduction of 23 to 27 percent of yield in sugar beet. Similar types of results was obtained by Singh et al. (1980), they suggested that complete defoliation at 120 days after planting can severely reduce root yield; but unlike the results of this study, Singh and colleagues did not observe any reduction in root yield in the treatments of 25%, 50% and 75% defoliation. Jones et al. (1955) in their research on sugar beet in the United Kingdom reported that 50%, 75% and 100% defoliation in the 4 and 8-leaf stages decreased root yield, respectively, to 5%, 10% and 27%.

3.2 Sugar content of root

According to the results of Table 1, plants that were planted at late planting date had higher sugar content, so that the ratio of these traits showed significant differences compared to the early planting which the ratio in late May planting was 15.16% while in early planting it was 14.03% (Figure 4). This can be attributed to the fact that, unlike the earlier planted plants, plants that were planted later have spent most of their energy for storage of sugar in the root. In fact, early planting has probably led to more opportunities for more suitable vegetative growth. According to present research, there is a negative correlation between root weight and sugar content in sugar beet was reported by various researchers (Abdollahian Noghabi, 1992; Ashraf Mansouri, 2000; Ebrahimian, 1993; Habibi, 1993; Beigy, 2007;). Also in the studies of Bazrafshan et al. (2008) highest percentage of sugar in late planting date (25th June) was 14.98% and 17.72% on 20th May (Sarmast-Garusi, 2011).

Table 1 Analysis of variance for treatments of planting date, defoliation stage and intensity of defoliation on physiological traits in sugar beet.

Source of variations (S.O.V.)	Degree of Freedom (d.f.)	Root yield	Sugar content of root	White sugar yield
Replication	3	439.01	1.85	4.50
Planting dates(Pd)	1	4058.45 ^{ns}	51.05 [*]	15.13 ^{ns}
Error Pd	3	697.07	3.03	16.62
Defoliation(D)	3	788.96 ^{**}	1.47 ^{ns}	13.21 ^{**}
Defoliation intensity(Di)	4	714.76 ^{**}	2.31 ^{**}	14.84 ^{**}
Pd×D	3	198.56 [*]	0.44 ^{ns}	2.29 ^{ns}
Pd×Di	4	49.53 ^{ns}	0.91 ^{ns}	0.31 ^{ns}
D×Di	12	96.21 ^{ns}	1.02 ^{ns}	1.23 ^{ns}
Pd×D×Di	12	65.75 ^{ns}	1.00 ^{ns}	0.96 ^{ns}
Error	114	66.61	0.6	1.15
C.V. (%)		14.92	5.31	16.79

n.s: not significant. *, **: Statistically significant at $P < 0.05$, 0.01, respectively.

Figure 1 The effect of defoliation stages on root yield of sugar beet

In this regard, have stated that on April planting, the sugar content of root was more compared to late planting date due to the production of larger roots (Chaves et al., 2002). The intensity of defoliation had a significant effect ($P>0.01$) on sugar content in roots (Table 1). The most sugar content (15.04%) was related to the control and the lowest percentage (14.35%) was observed in treatments of 100% defoliation (Figure 5). According to the table of mean comparisons, there was a significant difference among treatments of control and defoliation. This means that defoliation, reduced sugar content in sugar beet root, but the intensity of defoliation had no significant effect on reducing the traits. The results of these experiments were in agreement with the reports of Kamandi et al. (2008). Also in accordance with the results of Sarmast-Garusi (2011) in the maximum reduction of sugar content was found in complete defoliation treatment. In this study, sugar content was not affected by the mean defoliation stage. These

Figure 2 The effect of the intensity of defoliation treatment on root yield of sugar beet

results indicate that plant leaves for their development use the large amount of sugar stored without recycling opportunities.

3.3 White sugar yield

According to the results, it can be stated that unlike planting date which had no significant effect on the yield of white sugar, some factors, such as intensity and stages of defoliation caused significant difference ($P>0.01$) on this trait (Table 1). Among the intensity of defoliation treatments, the highest yield of white sugar (6.57 tons per hectare) was belonged to 25% defoliation and the lowest rate (5.88 tons per hectare) was obtained in 100% defoliation (Figure 7); but generally complete defoliation treatments caused a significant decrease in yield of white sugar compared to the control. In fact, there was an inverse relationship between high intensity of defoliation and white sugar yield that can be attributed due to less absorption of light by leaves.

Figure 3 The effect of interaction between treatments of planting date and defoliation stage on root yield of sugar beet

Figure 4- The effect of planting date on the sugar content in sugar beet root

Figure 5- The effect of the intensity of defoliation on the sugar content in sugar beet root

Figure 6- The effect of defoliation stages on the yield of white sugar in sugar beet

Figure 7- The effect of the intensity of defoliation on the yield of white sugar in sugar beet.

According to Stallknecht & Gilbertson (2000) 100% defoliation leads substantially to decrease in the amount of sugar yield. Further, according to the results of Kamandi et al. (2008), white sugar yield was declined with increasing of defoliation compared with the control (non- defoliation). In this study, it was observed that the least amount of white sugar yield was achieved in the middle stage of growth, which this decrease can be expected due to the lowest of produced root yield. The greatest amount of white sugar yield was belonged to the early stage treatments with 6.79 tons per hectare and the lowest rate was observed in the middle stage treatments with 5.55 tons per hectare (Figure 6). According to the results of Muro et al. (1998) in defoliation treatments in the middle of growth had the greatest impact on reducing of root yield and consequently the yield of white sugar.

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Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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