Journal of Sugar Beet
http://jsb.sbsi.ir/
Journal of Sugar Beet 2013, 29(1)

Effect of nitrogen rates on growth characteristics, yield and quality of autumn -sown sugar beet

M. Hosseinpour(1)*, A. Paknezhad(2), A. Naderi(3), R. Eslamizadeh(1), V. Yousef Abadi(4), V. H. Sharifi(2)

(1) *Assistant Professor of Safi Abad Agricultural Research Center, Dezful, Iran.*
(2) *Instructor of Safi Abad Agricultural Research Center, Dezful, Iran.*
(3) *Assistant Professor of Khoozestan Agricultural and Natural Resources Research Center, Khoozestan, Iran.*
(4) *Instructor of Sugar Beet Seed Institute, Karaj, Iran.*

Hosseinpour M, Paknezhad A, Naderi A, Eslamizadeh R, Yousef Abadi V, Sharifi VH. Effect of N rates on growth characteristics, yield and quality of autumn-sown sugar beet. J. Sugar Beet. 2013; 29(1): 17-26.

Received May 03, 2009; Accepted August 21, 2013

ABSTRACT

In order to evaluate the effect of different N rates on yield components, the proportions of each part of the sugar beet plant such as leaf number, leaf area index, canopy expansion rate, and N uptake to total dry matter, were evaluated in autumn planting of 2004-2005 at Safiabad Agricultural Research Center, Dezful, Iran. Five rates of N fertilizer including 0, 60, 120, 180 and 240 kg/ha and two monogerm cultivars Shirin and Rasoul were evaluated in factorial experiment based on randomized complete block design with four replications. In terms of quantitative and qualitative characteristics, significant differences were observed between two years. In the first year of the experiment, N level had no significant effect on root yield, and both cultivars were placed in one group (average root yield of 93 t/ha), however, sugar percentage was influenced and the maximum value (13.7%) achieved in zero N rate. In the second year, root yield was influenced significantly by N rate and the maximum yield (80.9 t/ha) was achieved at 240 kg/ha N treatment, while sugar percentage was not influenced. In both years, no significant difference was observed among cultivars for quantitative and qualitative traits. With further N application, the proportion of total biomass increased in petiole and crown and decreased in root, with no influence on leaf dry matter. N rates showed no significant difference in terms of leaf number, leaf area index and complete canopy expansion in the first year of the experiment, whereas, in the second year, significant differences were observed among the treatments, so that increased N rate resulted in increaesed leaf number, leaf area index and the rate of complete canopy expansion. N treatments in the first year had no significant effect on N concentration in plant organs and the total rate of N taken up by the plant was 574 kg/ha. In the second year, N treatments influenced the rate of N uptake from the soil and the rate of N taken up at 0 and 240 kg/ha N fertilizer levels were 186 and 351 kg/ha, respectively.

Keywords: autumn sugar beet, biomass, nitrogen, quantitative and qualitative yield

INTRODUCTION

Nitrogen fertilizer application in agricultural production is 42 million tons throughout the world, and the huge amount of it is applied for producing crops such as wheat, rice, sugarcane, and cotton (Azam 2002). In sugar beet agronomy, among the elements which are supplied through fertilizer application, N is the most important element and in the soil with a low level of N, the yield drops sharply and may be less than half (Draycott 1993). Although compared with crops such as corn, the roots of sugar beet can penetrate into deeper layers of the soil to gain further N but most of the plant needs is dependent upon available N in soil rather than the N supplied by fertilizer (Hill et al. 1983). The contribution of soil N to sugar beet growth compared with N provided in fertilizer is 78 versus 22%, respectively (Abshahi 1988). By placing the labelled N (^{15}N) in 120 cm soil depth, it was shown that the N is taken up by sugar beet effectively from all soil depths, especially in the latter stages of the plant growth (Broeshart 1983). Studies on labelled N also illustrated that about 50% of the applied N was taken up by the plant, 20% remained in the soil and 30% was taken away from plant access through

*Corresponding author's email: Harm558@yahoo.com

Table 1. Physicochemical properties of the soil in two years (2003-2004)

Year	Depth (cm)	Electrical conductivity (dS m^{-1})	Acidity	Organic carbon (%)	Absorbable phosphorus (mg/kg)	Absorbable potassium (mg/kg)	Nitrate (mg/kg)	Ammonium (mg/kg)	Soil texture
2004	0-30	1	7.5	0.75	4.7	121	25.2	17.1	Silty-loam
2005	0-30	0.45	7.9	0.49	8.3	112.4	7.8	11.1	Silty-loam

leaching and denitrification (Draycott 1993). The proper amount of applied N depends on many factors such as the amount of residual nitrate in soil, N application timing, field management, rotation, and the details of contract between farmer and sugar factory (Blaylock 1995). Climate factors may also reduce the use of N through providing appropriate conditions for N mineralization, or may shorten the period of N application through creating unfavourable conditions (De-Koeijer 2003). Nearly all sugar beet crops require some N fertilizer unless there is a substantial N release from the soil organic matter. For achieving the maximum sugar yield, N should be provided to plant in sufficient amount in an early stage and it should be reduced later in the life-cycle of the crop to decrease root impurities (Mortvedt et al. 1996). Excessive or delayed N application increases the proportion of dry matter allocated to shoot and root and decreases root dry matter and sucrose percentage (Carter 1984; Halversonet al. 1975). Since the leaf expands for solar radiation interception, developing more shoots for the synthesis of sucrose may not be efficient (Anderson et al. 1988). In addition to improving the colour of the leaves, N increases the size and number of the leaves remarkably. Loomis and Nenins (1963) showed that with adequate N application, three to five new leaves appear each week and the leaf area also increases (Gohari 1994). In sugar beet, the proportion of N in beet tops is higher than root. The maximum and the minimum rates of N are in leaf (3%) and root (0.6%), respectively and in petiole it is about 1.2% (Draycott 1993). In a study by Sharifi (1992), the evaluation of N uptake in autumn sugar beet planting in Dezful region showed that maximum N level in leaf and petiole (88 and 30 kg/ha, respectively) is achieved about 126 days after emergence, whereas, in root and crown, it increases to 195 and 25 kg/ha, respectively, 126 days after emergence. Increasing N application not only decreases the proportion of root dry matter to total dry matter, but also increases N concentration in leaf, crown and root (Shock et al. 2000). Most studies illustrated that N application decreased sugar percentage and slightly increased root yield, sugar percentage and root impurities (Carter and traveler 1981; Lee et al. 1987; Bravo et al. 1989; Winter 1990; Sharifi and Orazi zadeh 1992; Mohammadkhani 1992; Hosseinpour 1993; Ebrahimian 1994; Gohari 1994). This indicates the complexity of N management in sugar beet cultivation for achieving high yield and quality because low N application will cause yield reduction and high N application will decrease the quality and will increase the cost of production. Thus, it is necessary to determine the proper amount of N fertilizer to take maximum advantage from the economic point of view. This study aimed at exploring the application of different N rates on the growth characteristics, quality and quantity of autumn sugar beet within two years at Safi Abad Agricultural Research Center.

MATERIALS AND METHODS

Field site

The experiment was conducted at Safi Abad Agricultural Research Center in Dezful (Latitude 32°16'N and Longitude 48°25'E), at altitude 82 meters above sea level in two years (2003-2004 and 2004-2005). The region has a warm semi-arid climate with mild winter. The average annual rainfall is 344.8 mm and maximum rain events occur in winter. Table 1 shows the results of the soil analysis of the site. The field used was cropped to wheat the previous two years and required 150 kg/ha K_2O from potassium solfate, 90 kg/ha P_2O_5 from triple super phosphate, and half of the N from urea source. Fertilizers were top-dressed and mixed with soil by disking (Table 1). Then ridges with a 120 cm distance were made and two rows of 60 cm distance were planted on each ridge. The experiment was laid out as factorial arrangement based on randomized complete block design with four replications. The two factors included five fertilizer levels (0, 60, 120, 180 and 240 kg/ha) and two cultivars, Rasoul and Shirin. Each plot consisted of three ridges (120 cm apart) with 6 rows (60 cm apart) of 13 m length and one unplanted ridge between plots. Drip irrigation tape was placed between two planted rows (with 30 m distance from the rows). First irrigation was on 17 October 2005 and on 18 October in the second year. Plants were thinned early November and the other half of the N fertilizer was dressed in both sides of the drip tape.

Measurement of the traits

About 64 days after emergence (early June) up to final harvest, every single month, sampling for the measurement of leaf area index, leaf number, fresh and dry weight of the leaves, petiole, crown, root and N content, was done monthly from 0.5 m^2 of each plot in two replications. Plants were harvested and separated into four plant parts: leaf, petiole, crown and root. Wet and dry weights were measured. The wet and dry weights of dead leaves were also considered at final harvest. The proportion of the dry matter in different plant parts compared with total dry weight was estimated. Leaves were counted on three plants per plot. Leaf area index was measured using weight method. Root brei was prepared in each root sampling and sugar percentage was determined. Total N was determined using Kjeldahl method (Bremner 1965).

Statistical analysis

Due to significant interaction between N treatment and year, in addition to combined analysis of variance, simple analysis of variance was also done. Duncan's multiple range test (α=0.05) was used for mean separation.

RESULTS AND DISCUSSION

Dry weight of the plant

The results of the combined analysis of variance for data collected from six plant growth stages within two years showed that N increase had no significant effect on the proportion of total leaf dry weight to total dry weight. At 64 and 217 days after emergence, the leaf dry weight proportion to total dry weight in all treatments were 55 and 6%, respectively. On the other hand, N increase enhanced the proportion of petiole and crown dry weight. At 64 days after emergence, the proportion of petiole to total dry weight, in zero and 240 kg/ha treatments were 19% and 23%, respectively. 217 days after emergence, the above values were decreased to 7 and 9%, respectively. Increased N application increased the proportion of crown dry weight to total dry weight and 217 days after emergence, the ratio was 11 and 14% for zero and 240 kg/ha treatments, respectively. Unlike petiole and crown, N increase caused a reduction in root dry weight, as in 217 days after emergence, from 76% in zero treatment to 71% in 240 kg/ha treatment (Table 2). The results are consistent with several studies which have demonstrated the increase in beet tops dry matter weight with no increase in root dry weight (Shock et al. 2000; Draycott 2006).

Leaf area index, leaf number and canopy expansion

Owing to the significant interaction between year and N application in combined analysis of variance for both years, simple analysis of variance was done in 10 sampling stages for N rates, leaf area index, leaf number and canopy expansion (data were not reported). In the first year and throughout the growth stages, no significant difference was observed among N treatments in relation to leaf area index, leaf number and canopy expansion rate. Leaf area index and leaf number increased in a period of 161 to 176 days after emergence. Mean leaf area index value for all treatments in 64 and 176 days after emergence was 1.3 and 7.3, respectively and in final harvest it was 3.4 (Table 3). For leaf number it was 14, 40 and 26 (Table 4). In the second year of the experiment, N rates showed a significant difference for leaf area index, however, no difference was found for leaf number. With N rate increase, leaf area index increased and based on the results, treatments 120, 180 and 240 kg/ha were placed in one group and zero and 60 kg/ha treatments in another group. Sixty four days after emergence, leaf area index in zero and 240 kg/ha treatments was 0.2 and 1.6, respectively. Compared to first year, leaf area index in all treatments reached to maximum value in 176 days after emergence, and the minimum (5) and the maximum (8) value of it belonged to 60 and 180 kg/ha treatments (Table 4). In general, in the second year, leaf area index was lower during the early plant growth stages compared with the first year and the main reason was lower temperature in early November until early March in this year. In the second year, leaf area index in zero and 60 kg/ha treatments was lower than the other treatments which was probably a result of lower N accumulation in soil (Table 1). The results of both years demonstrated that increase in N application while the soil N was low, increased leaf area index with no influence on leaf number which is in agreement with Gohari (1994). No significant difference was found between N rates for canopy expansion rate in the first year and the canopy expansion of all treatments reached to 90%, 83 days after emergence. In the second year, increase in N application significantly decreased the canopy expansion timing, as 120, 180 and 240 kg/ha treatments were placed in one group, and the 0 and 60 treatments in another group (Figure 1). Compared with the first year, low temperature in the second year increased the canopy expansion timing and in higher N levels, so that canopy expansion rate reached to 88%, 123 days after emergence.

N concentration in plant

In the first year and during the period of six sampling stages, no significant difference was found for the effect of N treatment on N concentration in different plant organs. Figure 2 shows the average partitioning of N concentration for leaf, petiole, root and crown in five N treatments. As it shows, leaf had the highest N concentration followed by petiole, crown and root which is consistent with Draycott (1993). Mean N concentration of dry leaves for five N rates at final harvest was about 6.1%. The pattern of N concentration in all plant organs were similar and were higher in the early plant growth stages, followed by a decrease 64 days after emergence. From 94 to 190 days after emergence, N concentration was stable and increased in the late plant growth stage similar to Sharifi (1993). In fact, variation in N concentration followed plant growth's pattern during the growing season which is similar to Draycott (2006).

N uptake by plant

N treatments had no significant effect on N content of different plant organs in different sampling stages; therefore, the average of five treatments was considered (Fig. 3) which may be a result of N adequacy in the soil. The amount of N accumulated in leaf and petiole was high until 161 days after emergence and for leaf it was higher than petiole and root. The daily accumulation of N for leaf, root and petiole was 86, 66 and 42 kg/ha, respectively. From 161 days after emergence until the end of the growing season, N accumulation in leaf and petiole decreased. N uptake by root displayed an increasing trend until the final growth stage and the daily intake of it was 1.96 kg/ha (from 161 to 217 days after emergence), three times more than the previous period. N increase in root was likely due to the remobilization of N from old leaves to root (Draycott 2006). 161 days after emergence, N accumulation in crown was

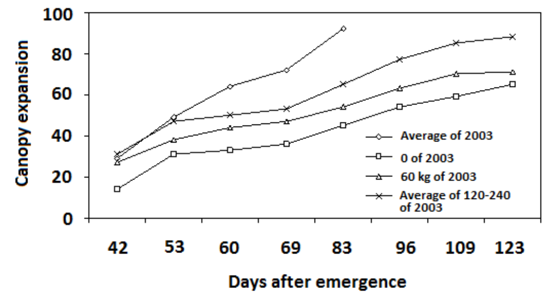

Fig. 1. The effect of N treatments on canopy expansion of sugar beet during the growing season (2002-and 2003)

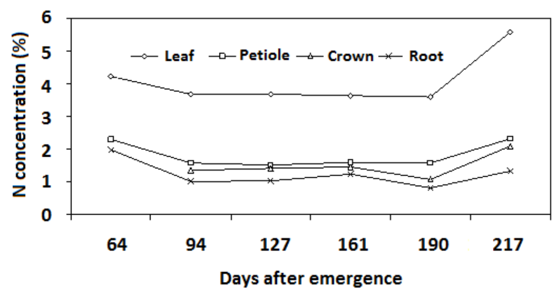

Fig. 2. Variation in N concentration of different sugar beet plant organs in the growing season (2003-2004)

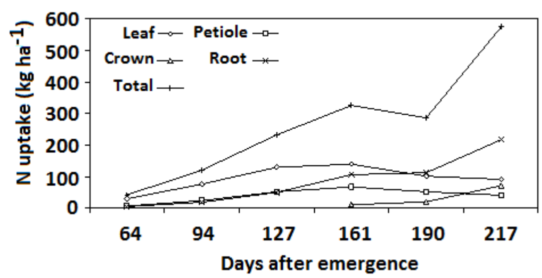

Fig. 3. N taken up by different sugar beet organs in the growing season 2003-2004 (the values are the average of two years)

remarkable and continued until the end of the growing season with daily intake of 1.3 kg/ha (from 161 to 217 days after emergence). Thus, N accumulation by leaves, petiole, crown and root is consistent with their growing period. This trend confirms the results obtained by Sharifi (1994). Accumulation of N in dry leaves at final harvest of the first year (217 days after emergence) was about 152 kg/ha. Due to residual leaves and petiole, 285 kg/ha of N taken up was returned to the soil and about 289 kg/ha was removed by the root and crown. Therefore, after harvest, 50% of the N taken up has been returned to the soil. In the second year, due to the low amount of organic matter and soil mineral N (Table 1), N fertilizer influenced N concentration in all plant organs. Increasing the N rat increased N concentration in

Table 2. Average ratio of shoots dry weight to total dry weight under different N treatments during the growing season (mean of 2003-2004)

N treatments (kg/ha)	Days after emergence																				
	64			94			127			161				190				217			
	Leaf	Petiole	Root	Leaf	Petiole	Root	Leaf	Petiole	Root	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown
0	56 a*	19 c	24 a	38 b	21 b	42 a	30 a	21 b	50 a	22 ab	22 ab	53 ab	4 a	13 a	15 b	64 ab	7 a	6 a	7 a	76 a	11 b
60	55 a	22 ab	24 a	38 b	23 a	39 b	30 a	21 b	49 a	20 b	20 b	56 a	4 a	13 a	16 b	61 b	7 a	5 a	7 a	77 a	11 b
120	55 a	22 ab	24 a	37 b	24 a	39 b	29 a	22 ab	49 a	22 ab	20 b	55 a	4 a	12 a	16 b	66 a	7 a	7 a	8 a	72 b	14 a
180	54 a	21 b	24 a	39 ab	24 a	37 b	31 a	24 a	45 b	23 a	23 a	50 bc	4 a	13 a	18 a	61 ab	8 a	6 a	8 a	73 ab	13 ab
240	55 a	23 a	24 a	41 a	25 a	34 c	31 a	24 a	45 b	23 a	23 a	49 c	4 a	13 a	18 a	61 ab	8 a	7 a	9 a	71 b	14 a

*Means with the same letter in each column are not significantly different at 5% probability level.

Table 3. Mean leaf area index ($m^2 m^{-2}$) influenced by different N treatments (2003-2005)

N treatments (kg/ha)	Days after emergence in 1st and 2nd year																			
	64		78		94		127		144		161		176		190		204		207	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	1.3 b	1.3 b	2.7 a	0.5 b	4.9 a	0.6 a	5.3 a	1.1 c	6.6 a	2.8 b	7.3 a	4.2 b	7.1 a	5.6 ab	4.8 a	4 b	3.9 a	1.8 b	3.2 a	1.3 b
60	1.3 b	0.3 b	2.7 a	0.7 b	3.8 a	0.8 b	5 a	1.3 bc	5.9 a	2.5 b	6.9 a	3.9 b	6.8 a	5 b	5.3 a	4.1 b	4 a	2.5 b	2.8 a	1.8 ab
120	1.4 b	0.3 a	2.4 a	1 a	4.4 a	1.6 a	4.7 a	1.9 ab	7.1 a	3.7 ab	7.1 a	4.3 b	6.8 a	5.4 ab	5.9 a	4.5 ab	3.4 a	3.4 a	3.8 a	2.1 ab
180	1.1 c	0.3 a	2.5 a	1.2 a	5 a	1.8 a	5.2 a	1.9 ab	6.9 a	4.5 a	6.8 a	5 ab	7.6 a	8 a	6.1 a	5.3 ab	4.1 a	3 a	3.2 a	2.3 a
240	1.6 a	0.3 a	2.9 a	1.1 a	5.1 a	1.7 a	5.1 a	2.3 a	7.1 a	4.9 a	8.1 a	5.6 a	8.1 a	7.3 a	5.9 a	5.8 a	3.9 a	3.2 a	3.9 a	2.6 a

*Means with the same letter in each column are not significantly different at 5% probability level.

Table 4. Mean leaf number influenced by N treatments (2003-2004)

N treatments (kg/ha)	Days after emergence in 1st and 2nd year																			
	64		78		94		127		144		161		176		190		204		207	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0	15 a	9 b	17 a	14 c	24 b	15 b	34 ab	25 a	38 a	30 b	43 a	35 b	39 a	34 b	33 a	37 a	31 a	28 a	28 a	21 b
60	15 b	10 b	17 a	15 bc	24 b	15 b	32 ab	25 a	37 a	33 b	39 a	36 ab	38 a	39 ab	37 a	39 a	28 a	27 a	25 a	26 ab
120	14 ab	12 a	19 a	15 bc	25 ab	18 ab	33 ab	27 a	39 a	34 ab	39 a	35 b	40 a	38 ab	38 a	38 a	32 a	26 a	27 a	26 ab
180	14 ab	12 a	18 a	17 a	26 a	19 a	28 b	29 a	40 a	33 ab	40 a	39 ab	41 a	42 a	39 a	36 a	31 a	30 a	25 a	30 a
240	14 ab	13 a	18 a	16 a	25 ab	18 ab	36 a	28 a	39 a	36 a	42 a	40 a	42 a	42 a	37 a	36 a	30 a	28 a	27 a	28 a

*Means with the same letter in each column are not significantly different at 5% probability level.

all plant organs (Table 5). N percentage in different parts of the plant followed a similar pattern to the first year; increased during the early plant growth stages and decreased throughout the season with an increase 190 days after emergence. Although N increase caused an increase in plant growth, but lower temperature in the second year compared with the first year, decreased plant growth potential and N uptake in all parts of the plant (Table 6). 64 days after emergence, the rate of accumulated N in the leaves at 240 kg/ha (second year) and zero (first year) treatments was 16 and 30 kg/ha, respectively, whereas N uptake of the zero treatment in the first year was about 2 times more than 240 kg/ha treatment in the second year. This shows the importance of the soil resources in supplying the required N and the effect of environmental conditions on sugar beet growth and also supports findings of other researchers (Abshahi 1988). In the second year, N concentration of the dry leaves increased from 1.4% in zero treatment to 1.7% in 240 kg/ha treatment and the amount of accumulated N in dry leaves of these treatments were 38 and 72 kg/ha, respectively. With this in mind that the leaf, petiole and dry leaves remain on soil surface, N taken up in zero and 240 kg/ha treatments (186 and 351 kg/ha, respectively) is returned to the soil (98 and 179 kg/ha, respectively) in approximately 50% rate, similar to the results of the first year. Based on the results of both years, it can be concluded that 50% of the N taken up by the leaf, petiole and dry leaves is returned to the soil at harvest. In a study by Haunold (1993) on ^{15}N in Austria, it was showed that 50% of the applied N was taken up by the plant, 20% remained in soil, and 30% disappeared (probably through denitrification, conversion to organic form, sublimation, and leaching). This suggests that N fertilizer acts only as a supplement in soil and highlights the necessity of reduction in fertilizer application.

Quantitative and qualitative characteristics

In the first year, as many other characteristics, N treatments had no significant effect on root and sugar yield (Table 7). For instance, 64 days after emergence (first year), root yield of the 0 and 240 kg/ha treatments was equal to 1.9 t/ha, and in 217 days after emergence (at final harvest), yield value of the two treatments were 95.1 and 95.8 t/ha, respectively. This suggests that where the soil N is high, the maximum performance can be achieved without the usage of mineral fertilizers (Draycott 2006). Unlike the first year, N application in the second year significantly increased the root and sugar yield. 217 days after emergence, root yield increased from 56.1 t/ha in zero treatment to 80.9 t/ha in 240 kg/ha, and for sugar yield from 8 t/ha in zero treatment to 11.2 t/ha in 240 kg/ha treatment at harvest (Table 8). The treatments 120, 180 and 240 kg/ha were placed in one group in terms of sugar yield. Thus, despite lower amount of organic matter and N in the soil of the second year, 120 kg/ha N is recommended and further increase in N application only increases the costs and reduces the fertilizer efficiency. Therefore, the results obtained by other researchers (Blaylock 1995) highlights the importance of considering the amount of organic matter and organic N in the soil, especially nitrate in N fertilizer application. Tables 9 and 10 show the simple analysis of variance for quantitative traits and mean comparisons of these traits in the two years of the experiment, respectively. Sugar percentage decreased from 13.7 in both 0 and 60 kg/ha treatments to 12.5% in 120 kg/ha treatment and further increase in N application didn't influence sugar percentage. In the second year, although N application decreased sugar percentage but the difference was not significant. Sugar percentage decreased from 16.7 in 0 treatment to 15.5 in 240 kg/ha treatment. In both years, the mount of sodium in root increased significantly with N increase, as in the first year from 2.8 meq in treatment zero to 4.1 meq/100 gram root in 240 kg/ha treatment, and in the second year from 1 in treatment zero to 1.4 meq/100 gram root in 240 kg/ha treatment. Amino nitrate was only affected by N application at 1% level in the second year. Increase in N rate from zero to 240 kg/ha increased amino nitrate from 1.4 to 1.9 meq. In both years, the extraction coefficient of sugar was influenced by N increase at 1 and 5% probability levels and increase in N rate decreased its value. In the first year, it decreased from 81 in zero treatment to 75% in 240 kg/ha treatment and in the second year these values were 90 and 88%, respectively. Molasses sugar was also increased significantly ($p<0.05$) with N application increase. In the first year, from 2.6% in zero treatment to 3% in 240 kg/ha treatment and in the second year these values were 1.6 and 1.8%, respectively. The effect of cultivar and the interaction between cultivar and N were not significant for qualitative traits in both years. These results are consistent with several studies which have demonstrated that N application increases root and sugar yield and decreases qualitative traits (Sharifi 1992;

Table 5. Grouping of mean N concentration (%) in different parts of sugar beet influenced by different amounts of N in the second year

N treatments (kg/ha)	Days after emergence																					
	64			94			127				161				190				217			
	Leaf	Petiole	Root	Leaf	Petiole	Root	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown
0	3.8 b	2.2 ab	1.9 a	3.7 b	1.7 b	1.3 b	3.4 b	1.5 ab	1.2 a	1.6 a	4.4 b	1.4 bc	0.9 a	1.3 ab	5.3 c	1.7 a	0.6 b	1.3 a	5.5 a	1.9 a	0.7 ab	1.4 a
60	4.2 a	2.4 a	1.9 a	3.9 a	1.9 ab	1.4 ab	3.7 a	1.2 c	1.2 a	1.5 a	4.2 b	1.3 c	0.8 a	1.2 b	5.4 bc	1.6 a	0.7 ab	1.3 a	5.4 a	1.9 a	0.6 b	1.3 a
120	4.4 a	1.9 b	1.8 a	4.4 a	2.2 a	1.5 ab	3.8 a	1.5 ab	1.3 a	1.6 a	4.4 b	1.4 bc	0.8 a	1.3 ab	5. a9	1.7 a	0.6 b	1.4 ab	5.6 a	1.9 a	0.8 ab	1.3 a
180	4.2 a	2.2 ab	1.8 a	4.5 a	2.3 a	1.5 ab	3.7 a	1.4 b	1.3 a	1.5 a	4.4 b	1.5 ab	0.9 a	1.3 ab	5.7 abc	1.8 a	0.7 ab	1.4 ab	5.6 a	2 a	0.9 a	1.4 a
240	4.2 a	2.1 ab	1.9 a	4.4 a	2.3 a	1.6 a	3.8 a	1.6 a	1.3 a	1.6 a	5 a	1.6 a	0.9 a	1.4 a	5.8 ab	1.8 a	0.9 a	1.5 ab	5.8 a	1.9 a	0.9 a	1.4 a

*Means with the same letter in each column are not significantly different at 5% probability level.

Table 6. Grouping of the mean N (kg/ha) in different organs of sugar beet under different treatments of N in the second year

N treatments (kg/ha)	Days after emergence																				
	64			94			127			161				190				217			
	Leaf	Petiole	Root	Leaf	Petiole	Root	Leaf	Petiole	Root	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown	Leaf	Petiole	Root	Crown
0	4 b	1 b	1 b	15 d	3 c	7 b	30 b	6 b	21 b	102 b	27 c	50 a	4 a	101 b	38 d	60 c	9 c	40 c	20 c	74 b	15 b
60	8 b	2 ab	1 b	20 c	4 c	9 b	41 ab	7 b	24 b	93 b	23 c	54 a	4 a	111 ab	43 d	79 bc	12 bc	50 bc	25 bc	87 ab	19 b
120	13 a	3 a	2 b	43 b	10 b	16 a	63 ab	14 ab	40 a	119 b	33 bc	57 a	4 a	130 ab	53 c	80 bc	16abc	57 b	28 abc	126 ab	32 a
180	15 a	3 a	3 a	50 a	12 a	16 a	69 a	15 ab	42 a	132 ab	42 ab	62 a	5 a	153 ab	69 b	100 ab	20 ab	68 a	39 a	139 a	33 a
240	16 a	3 a	3 a	48 a	12 a	18 a	76 a	19 a	44 a	165 a	47 a	66 a	6 a	163 a	76 a	117 a	21 a	72 a	35 ab	140 a	32 a

*Means with the same letter in each column are not significantly different at 5% probability level.

Table 7. Grouping of the mean root and sugar yield (t/ha) affected by different N levels in the first year

N treatments (kg/ha)	Days after emergence									
	64+	94+	127		161		190		217	
	Root	Root	Root	Sugar	Root	Sugar	Root	Sugar	Root	Sugar
0	1.9 ab	11.3 a	23.7 a	2.4 a	46.6 a	5.2 a	68.1 b	7.8 a	95.1 a	10.9 a
60	1.5 b	10.9 a	22.6 a	2.6 a	49.9 a	5.6 a	72.9 ab	7.1 a	82.9 a	10.4 ab
120	1.2 a	12.2 a	22.3 a	2.5 a	48.1 a	5.2 a	83.3 a	8.4 a	89.4 a	9.7 b
180	1.7 ab	12.7 a	20.7 a	1.2 a	49.2 a	5.1 a	75.2 ab	7.6 a	92.3 a	9.9 ab
240	1.9 ab	10.4 a	24.3 a	2.4 a	45.6 a	4.6 a	82.1 ab	8 a	95.8 a	10.1 ab

+ At this time, sugar yield was not determined since the sugar percentage was not measured
* Means with the same letter in each column are not significantly different at 5% probability level

Table 8. Grouping the average of root and sugar yield affected by different N level in the second year of the experiment (t/ha)

N treatments (kg/ha)	Days after emergence														
	64+		94+		127		161			190			217		
	Root (t/ha)	N taken up (kg/ha)	Root (t/ha)	N taken up (kg/ha)	Root (t/ha)	N taken up (kg/ha)	Root (t/ha)	Sugar (t/ha)	N taken up (kg/ha)	Root (t/ha)	Sugar (t/ha)	N taken up (kg/ha)	Root (t/ha)	Sugar (t/ha)	N taken up (kg/ha)
0	0.3 b	5.8 c	2.8 b	24.9 c	9.7 b	56.7 c	29.5 a	3.3 a	183.1 b	46.6 b	6.4 b	208.5 c	56.1 b	8 b	186.6 b
60	0.5 b	11.2 b	3.2 b	32.8 c	10.1 b	72 bc	33.9 a	4 a	174.8 b	55.6 ab	7 ab	244 bc	53.4 b	9.4 ab	240.2 b
120	0.9 a	18.3 a	5.9 a	69.1 b	14.2 ab	117.4 abc	35.7 a	4.1 a	213.6 ab	68.9 a	8.9 a	279.1 b	76.5 a	10.7 a	329.1 a
180	1 a	20.3 a	6.2 a	78.1 a	16.8 a	126.5 ab	36.5 a	4 a	241.1 ab	70.1 a	8.9 a	342.1 a	76.2 a	10.6 a	343.2 a
240	1 a	21.5 a	6.2 a	77.9 a	15.6 a	139.4 a	37.9 a	4.2 a	283.9 a	70 a	8.9 a	377.2 a	80.9 a	11.2 a	351.5 a

+ At this time, sugar yield was not determined since the sugar percentage was not measured.
*Means with the same letter in each column are not significantly different at 5% probability level.

Table 9. Mean squares of different qualitative characters affected by different N fertilizers within two years of the experiment (2004-2005)

Source of variation	Degree of freedom	Sugar (%)		Root impurities						White sugar (%)		Purity		Molasses sugar	
				Potassium		Sodium		Amino nitrogen							
		1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Replication	3	0.007^{ns}	3.5^{ns}	0.03^{ns}	0.06^{ns}	0.39^{ns}	0.09^{ns}	1.1^{ns}	0.031^{ns}	3.1^{ns}	1.4^{ns}	3.4^{ns}	2.7^{ns}	0.05^{ns}	0.03^{ns}
N	4	4.6^{**}	6.3^{ns}	0.16^{ns}	0.24^{ns}	3.66^{**}	0.25^{**}	0.9^{ns}	0.038^{**}	6.9^{ns}	1.9^{*}	77^{**}	4.7^{*}	0.47^{*}	0.07^{*}
Cultivar	1	0.011^{ns}	1.98^{ns}	0.23^{ns}	0.49^{ns}	0.68^{ns}	0.4^{ns}	0.86^{ns}	0.14^{ns}	2.57^{ns}	1.4^{ns}	4.6^{ns}	0.1^{ns}	0.1^{ns}	0.04^{ns}
Cultivar × N	4	0.65^{ns}	0.92^{ns}	0.09^{ns}	0.04^{ns}	0.28^{ns}	0.04^{ns}	0.28^{ns}	0.07^{ns}	1.5^{ns}	0.21^{ns}	2.4^{ns}	0.4^{ns}	0.03^{ns}	0.01^{ns}
Error	27	0.61	16.87	0.173	0.097	0.703	0.045	0.397	0.05	4.122	0.662	11.86	1.24	0.115	0.023
Coefficient of variation		6.1	4.9	9.1	7.58	24.1	18.1	16.6	14	19.7	5.7	4.4	1.2	12	9

ns=not significant, *p<0.05, **P<0.001, ***p<0.0001

Table 10. Grouping of the average of different qualitative characteristics of sugar beet under different N fertilizers in two years (2003-2004)

N treatments (kg/ha)	Sugar (%)		Potassium		Sodium		Amino nitrate		White sugar (%)		Extraction coefficient		Molasses sugar	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
0	13.7 a	16.7 a	4.6 a	4.2 ab	2.8 b	1 c	3.4 b	1.4 b	11.1 a	15.1 a	81 a	90 a	2.6 b	1.6 bc
60	13.7 a	16.2 b	4.7 a	4.3 a	2.7 b	1.1 bc	3.7 ab	1.4 b	11.1 a	14.5 ab	81 a	89 ab	2.6 b	1.7 ab
120	12.5 a	15.9 ab	4.7 a	3.9 a	4.1 a	1 c	4 ab	1.4 b	10.6 a	14.4 ab	74.9 b	90 a	3.1 a	1.5 c
180	12.5 a	15.8 b	4.5 a	4 ab	3.7 a	1.3 ab	3.6 ab	1.7 a	9.6 a	14.1 b	76.9 b	89 ab	2.9 ab	1.7 ab
240	12.1 a	15.5 b	4.4 a	4.1 ab	4.1 a	1.4 a	4.3 a	1.8 a	9.1 a	13.7 b	75 b	88 a	3 a	1.8 a

Means with the same letter in each column are not significantly different at 5% probability level.
a= meq/100g root

Hosseinpour 1993; Gohari 1994).

CONCLUSION

The results of this study showed that the amount of organic matter and soil mineral N especially nitrate have an important role in application of N in sugar beet cultivation. With 75% organic matter and 25 mg/kg nitrate in soil before planting (first year), root yield, sugar yield, and other growth characteristics were not affected by N application. While with the existence of 49% organic matter and 7.8 mg/kg nitrate in the soil, before planting in the second year, root yield increased from 56.1 t/ha in zero treatment to 80.9 t/ha in 240 kg/ha treatment. In addition, growth characteristics were also affected by N application. N increase in both years decreased qualitative characteristics. In both years, N increase led to an increase in proportions of petiole and crown to total biomass and a decrease in root proportion. It demonstrated that decrease in root dry matter percentage may decrease sugar yield, although N application increased. Based on the results of this study, it is necessary to consider the organic matter amount of the soil, especially nitrate amount in application of N fertilizer in sugar beet cultivation. If the rate of nitrate was more than 25 mg/kg, the fertilizer should not be applied. In order to apply N based on soil nitrate, more investigations are needed before planting and during the top dressing of N fertilizer.

ACKNOWLEDGEMENT

The authors express their gratitude to Mr. Hossein Fathi Rad, Hasan Mandani, Kazem Nasiri and NorAli Almasi for their assistance in this research.

REFERENCES

Abshahi A. The Use of residual nitrogen of soil and sugar beet leaves in wheat.proceeding of the 1th Iranian Crop Production and Breeding Congress. Sep. 6-9, 1988. Karaj-Iran.

Anderson FN, Peterson GA. Effect of incrementing nitrogen application on sugar yield of sugar beet. Agron. J. 1988. 80:709-712.

Azam F. Added nitrogen interaction in the soil– plant system, A review. Pakistan Journal of Agronomy: 2002. 1(1):54-59.

Blaylock AD. Profitable nitrogen management for sugar beet production. University of wayoming, cooperative extention service. 1995. B-1015.

Bravo S, Lee GS, Schmehl WR. The effect of planting date, nitrogen fertilizer and harvest date on seasonal concentration and total content of six macronutrient in sugar beet. J. Am. S.S. B. Technol. 1989. Vol.26, No.1, P:34-49.

Bremner JM, keeney DR. Determination and isotope-ratio analysis of different forms of nitrogen in soils. III. Exchangeable ammonium, nitrate by extraction – distilation methods. Soil Sci. Soc. Am Proc. 1966. 30, 577-582.

Bremner JM. Total nitrogen. In: Black, C.A.(Ed.), Methods of soil Analysis,part 2. American Society of Agronomy, Madison, USA. 1965. pp1149-1172.

Broeshart H. ^{15}N tracer techniques for the determination of active root distribution and nitrogen uptake by sugar beet. International Institute for sugar beet research. Symposium 'Nitrogen and Sugar Beet'. 1983. pp. 121-4.

Carter J. Effect of fall and spring applied nitrogen fertilizer on growth and yield of sugar beet. J. Am.S.S.B. Technol. 1984. Vol.22, No. 3&4, p: 252-266.

Carter J, Traveller J. Effect of time and amount of nitrogen on sugar beet growth and yield, Agron. J. 1981. 73:655-671.

De Koeijer TJ, Debuck AJ, Wossink GAA, Oenema J, Renkema JA, Struik PC. Annual variation in weather: Its implication for sustainability in the case of optimizing nitrogen input in sugar beet. Europ. J. Agronomy. 2003. 19: 251-264.

Draycott AP. Sugar Beet . Blackwell publishing Ltd, London. 2006. 474 pp.

Draycott AP. Nutrition: in the sugar beet crop principle and practice: Cook, D.A. and Scott, R.K. Chapman &Hall, London. 1993. 239 pp.

Ebrahimian, H.R.The effect of wheat and Sudan grass residues and nitrogen on winter sugar beet. Iranian Sugar beet journal. 1994.10(1-2):8-15. (in Persian, abstract in English)

Gohari J. The effect of different amount and source of nitrogen fertilizer on sugar beet yield and quality. Journal of Sugar beet. 1994.10(1-2):23-34. (in Persian, abstract in English)

Halvorson AD, Hartman GP. Nitrogen needs of sugar beet produced with reduced- tillage systems. Agron. J. 1988. 80:719-722.

Halvorson AD, Hartman GP. Long-term nitrogen rate and source influence sugar beet yield and quality. Agron. J. 1975. 67:389-392.

Haunold E. Isotopostudie uber die nutzung von dunger and bodenstickstoff durch die zuckerrube. Proceedings of IIRB congress. 1983. pp.136-144.

Hill FJ, Broadbent FE, Lorenz OA. Fertilizer nitrogen utilization by corn, tomato and sugar beet. Agron. J. 1983. 75:423-426.

Hosseinpour M. Interaction effect of nitrogen and potassium fertilizer and plant density on yield and quality of sugar beet in Dezful.1993. M.Sc. thesis. Tarbiat Modares University-Tehran. (in Persian)

Lee GS, Dunn G, Schmehl WR. Effect of date of planting and nitrogen fertilization on growth component of sugar beet. J. Am. S.S.B. Technol. 1987. Vol. 24, No. 1,P:80-100.

Loomis RS, Nenins DJ. Interrupted nitrogen nutrient effect on growth, sucrose accumulation and foliar development of the sugar beet plant. J. Am. S.S.B. Technol. 1963.Vol.12, No. 4, p:309-322.

Mohammad Khani A. The effect of plant population and nitrogen fertilizer rate on sugar beet yield and juice purity of sugar beet. A thesis presented for degree of master of agricultural science in plant science at Massey university-Newzeland. 1992.

Mortvedt JJ, Westfall DG, Croissant RL. Fertilizing of sugar beet. No. 0.542. (1996). www.colostate.edu

/depts./coopext.
Ohnishi M, Horie T, Homma K, Supapoj N, Takano H, Yamamoto S. Nitrogen management and cultivar effects on rice yield and nitrogen use efficiency in Northeast Thailand. Field Crop Research. 1999. 64: 109-120.
Sharifi H. Plant growth parameters and study of important quality traits of sugar beet multigerm variety resistance to bolt in Dezful. 1993. M.Sc. thesis. Dezful Azad University. (in Persian)
Sharifi H, Orazi zadeh MR. The effect of planting date, growth duration period and nitrogen on sugar beet yield and quality in Dezful. 1992. Final report. No. 81/234. Safi-Abad Agric. Res. Center – Dezful-Iran.
Shock CC, Seddigh M, Sounders LD, Stiber TD, Miller JG. Sugar beet nitrogen uptake and performance following heavily fertilized onion. Agron. J. 2000. January-february, 92: 11-15.
Sinebo W, Gretzmacher R, Edelbauer A. Genotypic variation for nitrogen use efficiency in ethiopian barley. Field crop research. 2004. 85: 4.-60.
Singh U, Ladha JK, Castillo EG, Punzalan G, Triol-padre A, Duqueza M. Genotypic variation in nitrogen use efficiency in medium-and long-duration rice. Field Crop Research. 1998. 58: 35-53.
Timsina J, Singh U, Badaruddin Meisner C, Amin MR. Cultivar, nitrogen, and water effects on productivity, and nitrogen-use efficiency and balance for rice-wheat sequences of Bangladesh. Field Crop Research. 2001. 72:143-161.
Winter SR. Sugar beet response to nitrogen as affected by seasonal irrigation. Agron. J. 1990. 82: 984-988.

-31585, Karaj, I.R. Iran