



## RESEARCH ARTICLE

# Evaluating Nitrogen Efficiencies and Accumulation in Sugar beet (*Beta vulgaris* L.) Under Tape-Drip Irrigation

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## Abstract

Improving agricultural input efficiencies can lead to both decreasing production costs and saving the environment and landscape. Therefore using new irrigating systems that enable fertigation can be a proper alternative for conservative furrow irrigation. With the aim of optimizing land, water and nitrogen use, during previous years in a research farm of Karaj- Iran a trial was carried out under tape-drip irrigation and in strip factorial plot with a randomized complete block arrangement with 2 levels of On-Rows Spacing (14 and 20 cm), 2 levels of Planting Pattern (40-60 and 40-50) and 4 levels of Nitrogen (zero (N<sub>0</sub>), 50 (N<sub>1</sub>), 75 (N<sub>2</sub>) and 100 (N<sub>3</sub>) percent of the fertilizer recommendation for furrow irrigation). Nitrogen accumulation in separate parts of Sugar beet and in the whole plant determined, then Nitrogen Uptake Efficiency (UPE), Nitrogen Utilization Efficiency of Sugar and White sugar production (UTEs, UTEws) and Nitrogen Use Efficiency to produce Sugar and White sugar (NUEs and NUEws) were calculated. A compound analysis wasn't allowed by Fmax test thus results of each year was analyzed separately. On-rows Spacing levels didn't show any significant differences among studied Traits and Planting Pattern except on a single ground organ and whole plant nitrogen accumulation, UPE and UTE. Nitrogen fertilizer has a significant influence on all traits in both years. Based on the results it has been observed that more the nitrogen fertilizer used more the rate of nitrogen accumulation in sugar beets occurred. However, by increasing use of nitrogen fertilizer UPE improved, but UTE and NUE decreased.

## Introduction:

In the year 2016, more than 116 million Tonnes of nitrogen fertilizers for improving agricultural yields were used globally, and forecasts to grow by 1.6 percent annually (FAO, 2015). Sugar beet is so sensitive to the Nitrogen shortage, that lack of the element could cause a severe decrease in yield. Since Nitrogen is a moving and conveyable element during irrigation, its unusual and irregular use could not only decrease the fertilizer use efficiency but also pollute the underground water resources as the most important factor (Novokova & Nagel, 2009). It has been reported that a great deal of

nitrogen in soil at the last period of Sugar beet growth (after full growth of leaves) could increase the impurities and decrease the sugar yield (Hoffmann, 2005). Improvement in fertilizer implication method can increase NUE (Sowers *et al.*, 1994, Good *et al.*, 2004) but other approaches like UTE and UPE improvement may be helpful to reach the Goal (Hills *et al.*, 1983). Some studies showed that in an excess amount of Nitrogen, UPE gains more importance, however, at the times of Nitrogen scarcity, UTE has the main importance. (Moll *et al.*, 1982; Ortiz-Monasterio *et al.*, 1997). Overall UPE which is less than 40% regards as a weak efficiency for cereals (Peoples

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*et al.*, 1995; Sylvester-Bradley & Kindred, 2009). For Sugar beet, N is required for the formation of the canopy (Malnou *et al.*, 2008) and root cells required for sucrose storage (Milford & Watson, 1971); furthermore, N is not a compound of Sucrose, which is the crop's main product (up to 76% of taproot dry matter; Hoffmann, 2005). Thus, NUE traits of Sugarbeet may behave differently from cereal crops. So far, information on NUE for Sugar beet are limited (Barbanti *et al.*, 2007; Chakwizira *et al.*, 2015). Without fertilizer implication, Sugar beet may accumulate up to 25 Kg N/ha in infertile and 100 Kg N/ha in fertile farms, but with using fertilizers this digits may exceed (Bundy & Andraski, 2005). Another study in the US showed for 10 Tonne.ha<sup>-1</sup> root, leaves absorb 20 kgN.ha<sup>-1</sup> and for 10 Tonne.ha<sup>-1</sup> root and shoot production 40-55 kg N.ha<sup>-1</sup> needed (Buchner & Sturm, 1985). half amount to produce the same amount of root needed (Hills *et al.*, 1983). In another study, it showed that 5 kg of N is needed to produce each Tone of Root (Eckhoff & Flynn, 2008). Some studies showed that the best Nitrogen efficiency occurs at the lower rates of nitrogen application and with increasing fertilizers reaction of the plant to the Nitrogen decreases (Allison *et al.*, 1996; Karimi *et al.*, 2007; Sharmasarkar *et al.*, 2001). Lopez-Bellido *et al.*, 2005 concluded that NUE in sugar beet depends on Nitrogen availability, Nitrogen fertilizer usage and available water. In this study with the hypothesis that reduced leaching and runs off in tape-drip irrigation systems increase the efficiency of fertilizers it has been tried to evaluate that the Nitrogen accumulation in sugar beet different parts and calculate UPE, UTE and NUE in different Nitrogen rate. Moreover, influences of plant population with varying planting pattern and spaces on these traits were also studied.

### Materials and methods:

This study was conducted in Motahary Research Field in Karaj- Iran, in two years of 2013-14 under Split Factorial experimental design with 16 treatments including 2 factors of Nitrogen fertilizer (4 levels of 25, 50 and 100% of recommendation rate in furrow irrigation, and without fertilizer) and planting pattern (2 levels of 40-60cm and 40-50cm with the tapes between 40cm rows) in the factorial format as vertical factors and plant spacing (2 levels of 14 and 20 cm after thinning) as a horizontal factor, with 4 replications under tape-drip irrigation. Prior to sowing operation, soil sampling for determining its nutritional condition was held. calculating the recommended nitrogen was done based on 15 kg urea to increase 1mg nitrate in each kilogram of Soil to the depth of 30cm (Noshad & Jahromi, 2008) as a result in the current experiment -the net amount of nitrogen added to the soil through fertigation on several occasions in every two irrigation intervals based on the nitrogen levels of the treatment were 0 kg/ha in N<sub>0</sub>, 70 Kg/ha in N<sub>1</sub>, 100Kg/ha in

N<sub>2</sub> and 130 Kg/ha in N<sub>3</sub>. Dropper spaces are 20 cm from each other with the pressure of 0.6 bars and 1.2 lit/ha. Harvest operation was conducted at the end of the growing season, and in the laboratory, roots were weighted before providing pulp from them. White sugar yield was obtained by multiplying root yield × sugar percentage. White sugar yield is the most important parameter in sugar beet production which is the amount of sugar that can be extracted from roots, it is always lower than the total sugar yield (Cooke & Scott, 1993). To obtain sugar content, the Polarimetry method by Saccharomat instrument was used which is the most common method, Sodium and potassium contents were measured by flame photometry method. Moreover, a-amino N was measured by betalizer device (Clover *et al.*, 1998). Leaf, Petiole, Crown and taproot material dried to constant weight at 70-105°C was used to calculate the dry matter content of each fraction. Dry matter was analyzed for total N content by wet (Kjeldahl-method) combustion (Bremner & Mulvaney, 1982) and then Nitrogen efficiencies based on proposed equations by Lopez-Bellido *et al.*, (2005) were calculated as follows:

- 1- Nitrogen Uptake efficiency (UPE): is the ratio of total Nitrogen accumulated in plant to the available soil nitrogen up to the depth of 60cm (mineral+fertilizer)

$$UPE = \frac{\text{Total Plant Nitrogen}}{\text{Soil Mineral Nitrogen} + \text{Net Fertilizer Nitrogen}}$$

- 2- Nitrogen Utilization Efficiency to Sugar and White sugar (UTE): is the ratio of Sugar or white sugar to the Total Nitrogen accumulated in the whole plant.

$$UTEs \text{ or } UTEws = \frac{\text{Sugar Yield or White Sugar Yield}}{\text{Total Plant Nitrogen}}$$

- 3- Nitrogen Use Efficiency of Sugar and White Sugar (NUE): is the ratio of Sugar or white sugar to the Total Nitrogen available (soil + fertilizer) in the soil to the depth of 60cm

$$NUEs \text{ or } NUEws = \frac{\text{Sugar Yield or White Sugar Yield}}{\text{Soil Mineral Nitrogen} + \text{Net Fertilizer Nitrogen}} \\ = UTEs \text{ or } UTEws \times UPE$$

**Statistical analysis:** for data evaluation, all data were normally distributed. All ANOVA analyses were performed with the MIXED procedure (Littell *et al.*, 1996) of the software package SAS® Version 9.3 (SAS Institute Inc., Cary, NC, USA). and means were compared according to Duncan's multiple range test and also LSD. Regression trends and Equivalentents were calculated by MS-Excell.

### Results:

Different levels of plant spacing showed no significant differences in nitrogen accumulation in sugar beet organs. Changing planting pattern from 40-50 to 40-60 in both years of this study coincided with more nitrogen accumulation in roots however just in 2014, significant differences at 5% probable level in nitrogen accumulation in the crown, storage roots And consequently in whole

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plants were seen (Table.1). Nitrogen accumulation in Sugar beet organs in both years showed significant differences at different levels of Nitrogen fertilizers treatments ( $p=0.01$ ). Compare Means of Squares showed that in both the years increasing nitrogen fertilizers led to the accumulation of more nitrogen in all Sugar beet organs. the least nitrogen accumulation occurred in the plots without fertilizers (No) which on average of two years was 99.9 kg/ha while the most accumulation of nitrogen happened in the plots with the maximum nitrogen fertilizer usage ( $N_1$ ) which on an average was 239.8 kg/ha. Average nitrogen accumulation in both years showed that 69.6 kg.N.ha<sup>-1</sup> (42%) was stored in Shoot parts and 96.3 kg.N.ha<sup>-1</sup> (58%) was stored in Ground Organs of Sugar beet (Table.1). A past Study showed that 47% of nitrogen accumulates in the shoots and the portion of the leaves are more than the petioles (Yonts & Smith, 1997).

Regression Trend lines (Fig. 1), shows high coefficient between Nitrogen accumulation in the Sugar beet organs and applied Fertilizer (Fig. 1: Polynomial lines as it has appeared in the figure could describe most of the variations which happened in the nitrogen concentration in Sugar beet and its organs under fertigation ( $R^2>0.9$ ). It seems that the very first nitrogen fertilizers applied to the ground can't lead to the high accumulation of this element inside Sugar beet but with further application the rate of nitrogen storage increased rapidly, this may be because of the coherent between soil particles and Nitrogen at the time of nitrogen scarcity in the soil but with adding more fertilizers this coherent may reduce and plants can absorb more Nitrogen from soil with spending less energy on the other nitrogen flows to the plant might be more fluent when excessive amount of nitrogen were available (Fang *et al.*, 2006). The best regression coefficient was between Nitrogen which was accumulated in Leaves and the applied nitrogen rate ( $R^2=0.99$ ). Based on the previous studies, it could be concluded that this high coefficient may be the cause of proper application method (fertigation) and plants would rapidly response to the nitrogen if both time and method application was proper (Alcozen *et al.*, 1993).

To study the effects of Nitrogen and other treatments of current experiment, Sugar yields and Nitrogen efficiencies were calculated.

**Nitrogen Uptake Efficiency (UPE):** plant spacing and Pattern in 2013 didn't have a significant effect on UPE ( $p=0.05$ ), otherworldly, increasing the space between plants on rows from 14cm to 20cm and changing the pattern from 40-50 to 40-60, UPE remains about 0.7 (Table.3). Based on the results in 2014, impacts of on row spacing between sugar beet crops wasn't significant ( $p<0.05$ ) but plant pattern impacts on UPE was significant in 5% statistical level (Table.3). Results based on changing -row spacing from 14cm and 40-50 to 20cm and 40-60 had

changed the UPE from 0.59 to 0.64 but these changes were only significant in planting pattern that is due to a Least Significant Difference in planting pattern ( $LSD=0.04$ ) by comparison with on row spacing ( $LSD=0.11$ ), thus, in general, it can be inferred that lesser plant population can slightly increase Sugar beet UPE from 0.65 to 0.68 (Table 3). On the other word, in tape-drip irrigation with the plant on-row spacing of 14 cm and planting pattern of 40-50, Sugar beets can Absorb 65% of available nitrogen (both mineral and fertilizer) and it improved up to 68% with higher on rows and in rows spaces. Ranjbaran (1994) reported that the highest amount of production occurred when the plant density was 80,000 to 100,000 plants.ha<sup>-1</sup>, and the distance between the rows was 50 cm, and the distance between the plants was 20 cm. Farsi Nejad (1998) reported that using monogerm seeds with a row distance of 50 cm and a plant distance of 15 cm gave the best results in terms of sugar production. Different Levels of Nitrogen Fertilizer Significantly affect UPE in both the experimental years in 2013, UPE in No and  $N_1$  were categorized in the same group through Duncan multiple range test and increase the Nitrogen rate and the UPE. In 2014,  $N_1$  showed the lowest UPE which is 0.46 and No,  $N_2$  and  $N_3$  with 0.54, 0.7 and 0.78 were categorized in higher groups. Overall in two years, it can be inferred that at the soil conditions similar to this trial and tape-drip systems without applying fertilizer, Sugar beets can absorb 59% of soil mineral nitrogen while adding 50% of recommended fertilizer would decrease UPE to 46% of available nitrogen. It seems that adding this low amount of nitrogen isn't sufficient for creating a rapid nutrient flow into the roots but it doesn't mean that Sugar beet can't absorb Nitrogen in the fertilizers because by adding 75 and 100% of recommended fertilizer UPE reaches to 0.73 and 0.8, respectively (Table.3). Lopez-Bellido & Lopez-Bellido (2001) and Zhao *et al.* (2006), found that in cereals UPE decreased with increase N use rate but here we have found that in sugar beet it can just happen at the low rate of N application (up to 50% of Nitrogen recommended rate). with further N application Sugar beets stores more Nitrogen in its organs which cause increase UPE. But the ability to uptake more nitrogen from the soil by its own, can't lead to the higher yields. Excessive nitrogen in plants causes extra vegetative and leaf growth (Giller, 2004) but may result in the lack of sugar accumulation in roots (Werker & Jaggard, 1997). to study that how much of the absorbance help the production, UTE and NUE were calculated, and the results are as follows.

**Nitrogen Utilization Efficiency to produce Sugar and White Sugar (UTE):** analysis of variance Showed different levels of nitrogen had a Significant effect on UTEs and UTEws in both years ( $p<0.01$ ). without using nitrogen fertilizers in No treatment at the year 2013, UTEs was equal to 83.3 and UTEws was 68.8 which were in the same

statistical group with UTEs and UTEws in N<sub>1</sub> which were 70.4 and 58.1 respectively. But with further Nitrogen application UTEs decreased to 53.6 and 47 and UTEws declined as low as 43.6 and 38.6 in N<sub>2</sub> and N<sub>3</sub> treatments, respectively (Table.3). In 2014, the increase in the application of nitrogen led to the lower utilization efficiency of nitrogen. average of the two years indicated the same results (Table.3) from the average results of two years, it can be concluded that Sugar beet crops under tape irrigation fields can utilize 90.8 Kg of Sugar and 71.7 Kg of White Sugar per each Kg of Mineral Nitrogen which was available in the soil and with adding nitrogen fertilizer to the soil, UTEs decreased to 79.3, 53.1 and 44.2 and UTEws decreased to 63.5, 42 and 35.5 in N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub> treatments, respectively. These results are the cause of lower Nitrogen accumulation in plants organs at the time of lower Nitrogen inputs. In 2013, On-row spacing and planting pattern didn't have a significant effect on UTEs and UTEws (p>0.05). moreover, in 2014 On-row spacing didn't show any significant differences in UTEs and UTEws but Planting pattern had a significant effect on these traits at 5% statistical level (Table 3). means comparison shows that in 2014, UTEs and UTEws in sowing pattern of 40-50 was 74.4 and 57.9, at the time when in sowing pattern of 40-60 these traits were 65.8 and 50.3 respectively (Table 3). in 2014, higher Sugar and White sugar yield in Planting pattern of 40-50 (9.55 and 7.44 ton/ha respectively) by comparison with pattern of 40-60 (9/01 and 6.92 Ton/ha respectively, table 2) and also lower nitrogen accumulation in Sugar beet organs in pattern of 40-50 compare to 40-60 (148.4 and 162.1, respectively. Table 1) based on the UTE formula, could be the causes of higher UTE in pattern of 40-50 compare to 40-60. Based on the two years averages it can be concluded that in tape-drip systems with the same conditions of our trial, Sugar beet crops can produce 66.8 kg of Sugar and 53.1 Kg of white sugar per each Kg of Nitrogen that Plants can store in different organs. in accordance with our results in sugar beet, Delogu *et al.* (1998) showed that in cereals, UTE decreased with increasing N fertilizer rates.

**Nitrogen Use Efficiency to produce Sugar and White Sugar (NUE):** based on Variance analysis in both years of the trial, planting pattern and on row spacing didn't have any significant effects on NUEs and NUEws (p>0.05, Table 3). So it can be concluded that in tape-drip irrigation systems changing plant population either by plant pattern or on- row spacing can't lead to any significant changes in the production of Sugar from available Soil mineral Nitrogen. On the other hand, results showing significant effects of different levels of Nitrogen Treatment on NUEs and NUEws in both years (p<0.01, Table 3). Comparison of the means in 2013 shows that the best NUE was in No with the average production of 50.8 Kg of Sugar and 41.9 white sugar per each Kg of available mineral soil nitrogen while in

N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub>, NUEs were 40.4, 40.3 and 38.1 and NUEws were 33.2, 32.3 and 31.1 respectively (Table 3). In 2014, No level of nitrogen application (without fertilizer) had the highest NUEs and NUEws (50.9 and 40.4, respectively) and further nitrogen application coincided with lower NUE. In this year N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub> plots on average produce 39.3, 36.2 and 31.8 kg of sugar and 30.8, 20.7 and 24.5 Kg of white sugar per each kg of available mineral soil nitrogen, respectively (Table 3). The average NUE of these two years showed 16 unit decrease in NUEs and 12 units decrease in NUEws from about 51 Kg sugar and 40 Kg white sugar production from each Kg of available soil mineral nitrogen in No treatment to 35 Kg of Sugar and 28 Kg of White sugar from each kg of available nitrogen in N<sub>3</sub> treatment with application of all recommended rate of fertilizer. With this results it can be concluded that in the same condition with our experiment and in tape-drip systems Sugar beet can produce 41 kg sugar and 32.6 kg white sugar from each kg of available mineral soil nitrogen (fertilizer + Nitrate and Ammonium). These results are supported by the results of Draycott & Christenson (2003); Fan *et al.* (2004) concluded that for Rice, NUE is around 30. Plant NUE is inherently complex, as each step including N uptake, translocation, assimilation, and remobilization is governed by multiple interacting genetic and environmental factors. The limiting factors in plant metabolism for maximizing NUE are different at high and low N supplies, indicating great potential for improving the NUE of current cultivars, which were bred in well-fertilized soil (Xu *et al.*, 2012). NUE may be affected by crop species, soil type, temperature, the application rate of N fertilizer, soil moisture condition and crop rotation (Halvorson *et al.*, 2001). It is reported worldwide that nitrogen use efficiency (NUE) for cereal production including wheat is approximately 33% (Raun & Johnson, 1999). Some past studies evaluated nitrogen efficiencies in irrigated Asian fields as 31 percent (Doberman & Witt, 2002) 19 to 55 percent in Africa (Haefele *et al.*, 2003) and 57 to 66 percent in Europe (Wopereis *et al.*, 1999; De Datta & Buresh, 1990). Any increase in nitrogen efficiency would lead to a great deal of reductions in production cost and soil, water and yield pollutions (Hernandez *et al.*, 1991). Lopez-Bellido & Lopez-Bellido (2001) indicated that NUE

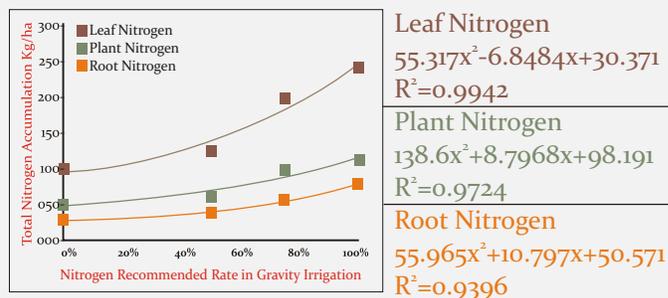


Figure-1: Regression lines of Total Nitrogen Accumulation in Sugar beet Organs in response to Fertilizer rate

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decrease with the increasing fertilizer application is because yield rises less than the N supply in soil and fertilizer. Limon-Ortega *et al.* (2000) and Zhao *et al.* (2006) reported similar results and indicated that NUE decreased with increased N rate.

**Conclusions:**

Based on the above results, in a drip-tape irrigation system, Sugar beet can almost absorb all Nitrogen which was applied (up to the total amount that recommended for conservative irrigation systems). But the rapid rate of nitrogen accumulation in plant organs happened when abundant nitrogen was available and with further N application Sugar beets stores more Nitrogen in its organs which cause increase UPE. So, it could be concluded that in tape- drip systems, Sugar beet have the capacity to uptake

most of the Nitrogen at the maximum fertilizer rate and decreasing nitrogen application would decrease UPE. Study shows that in fertigation, possibly sugar beet uses the dissolved fertilizer nitrogen which is easy to flow inside plant and if there is no ready to use Nitrogen, plants would try to use soil mineral Nitrogen with the lower uptake efficiency. Based on the two years averages it can be concluded that in tape-drip systems with the same conditions of our trial, Sugar beet crops can produce 66.8 kg of Sugar and 53.1 kg of white sugar per each kg of Nitrogen that Plants can store in different organs and 41 kg sugar and 32.6 kg white sugar from each kg of available mineral soil nitrogen (Fertilizer + Nitrate and Amonium).

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Table - 1: Comparisons of Nitrogen Accumulation (Mean value) in Sugar beet Organs(Kg.ha-1)

Treatment/trait		Shoot Nitrogen (Leaf+Petiole)			Ground organ Nitrogen (Root+Crown)			All plant Nitrogen		
		2013	2014	means	2013	2014	means	2013	2014	means
Nitrogen	No	51.3d	30.3c	40.8	57.4c	60.9d	59.1	108.8d	91.1d	99.9
	N1	71.1c	34.3c	52.7	72.4c	75.6c	74	143.5c	109.9c	126.7
	N2	91.6b	68.4b	80	114.4b	119.3b	116.8	206.1b	187.8b	196.9
	N3	113.4a	96.6a	105	134.6a	136.0a	125.3	247.0a	232.7a	239.8
LSD		14.8	12.6		19.4	8.1		26.9	15.4	
ON-row spacing	14	85.2	54.4	69.8	92.3	93.9	93.1	177.5	148.4	162.9
	20	78.6	60.2	69.4	97.1	101.9	99.5	175.7	162.1	168.9
LSD		36.4	17.8		14.5	12.0		34.3	21.8	
Planting pattern	40-50	82.7	56.2	69.4	93.6	92.2b	92.9	176.3	148.4b	162.3
	40-60	81.1	58.5	69.8	95.8	103.6a	99.7	176.9	162.1a	169.5
LSD		10.5	8.9		13.7	5.7		19	10.8	
Means	81.9	57.3	69.6	94.7	97.9	96.3	176.6	155.2	165.9	

Table -2: Mean comparisons of Some Qualitative and Quantitative Sugar beet Root Traits

Treatment/Trait	Root yield (T.ha-1)			Sugar Yield (T.ha-1)			White sugar Yield (T.ha-1)			Sugar Percentage			White Sugar Percentage		
	2013	2014	mean	2013	2014	mean	2013	2014	mean	2013	2014	mean	2013	2014	mean
Nitrogen															
No	54.1c	64.7b	59.4	8.5c	8.6b	8.5	7.0c	6.5	6.8	15.8	13.2b	14.5	13.1	10.1b	11.6
N1	61.3b	66.8a	64.1	9.6b	9.4ab	9.5	7.9b	7.3	7.6	15.7	14.1a	14.9	12.9	11.1a	12.0
N2	69.2a	72.0a	70.6	10.8a	9.7a	10.3	8.8c	7.4	8.1	15.6	13.5ab	14.6	12.7	10.4ab	11.4
N3	71.3a	68.8ab	70.1	11.3a	9.5a	10.4	9.3a	7.4	8.4	15.9	13.8ab	14.8	13.2	10.7ab	11.9
On-row Spacing															
14	64.3	68.7	66.5	10.1	9.4	9.7	8.3	7.3	7.8	15.7	13.8	14.8	12.9	10.74	11.8
20	63.7	67.5	65.6	10.0	9.1	9.6	8.2	7.0	7.6	15.8	13.5	14.7	13.0	10.43	11.7
Planting Pattern															
40-50	63.3	69.7	66.5	9.9	9.5	9.7	8.1	7.4	7.8	15.6	13.7	14.7	12.8	10.72	11.7
40-60	64.6	66.5	65.6	10.0	9.0	9.6	8.5	6.9	7.6	15.9	13.6	14.8	13.1	10.45	11.8
Mean	64.0	68.1	66.0	10.0	9.3	9.65	8.3	7.2	7.7	15.7	13.6	14.75	12.9	10.58	11.75

Table No 3 Comparisons of Nitrogen Efficiencies (: Mean values) in Sugar beet in 2013-2014

Treatment /trait	UPE			UTEs			UTEws			NUEs			NUEws		
	2013	2014	mean	2013	2014	mean	2013	2014	mean	2013	2014	mean	2013	2014	mean
Nitrogen															
No	0.64b	0.54c	0.59	83.8a	97.9a	90.8	68.8a	74.6a	71.1	50.8a	50.9a	50.8	41.9a	38.9a	40.4
N1	0.60b	0.46d	0.53	70.4a	88.2b	79.3	58.1a	68.9a	63.5	40.4b	39.3b	39.8	33.2b	30.8b	32
N2	0.76a	0.70b	0.73	53.6b	52.7c	53.1	43.6b	40.5b	42.0	40.3b	36.2b	38.2	32.9b	27.7bc	30.3
N3	0.83a	0.78a	0.8	47.0b	41.5d	44.2	38.6b	32.4c	35.5	38.1b	31.8c	34.9	31.1b	24.8c	27.9
LSD	0.11	0.06		13.9	9.03		11.9	7.4		3.9	3.8		3.4	3.5	
On-row	14	0.72	0.59	0.65	63.02	73.8	68.4	51.7	57.3	54.5	42.7	40.1	41.4	35.08	31.12 33.1
Spacing	20	0.71	0.64	0.68	64.10	66.4	65.2	52.8	50.9	51.8	42.0	39.0	40.5	34.56	30.02 32.3
LSD		0.14	0.11		20.92	15.4		18.35	6.83		5.46	2.21		3.98	3.62
Planting pattern	40-50	0.71	0.59b	0.65	61.7	74.4a	68.0	50.5	57.9a	54.2	43.6	40.6	42.1	33.7	31.6 32.6
	40-60	0.72	0.64a	0.68	65.4	65.8b	65.6	54.0	50.3b	52.1	41.2	38.5	39.8	35.9	29.5 32.7
LSD		0.09	0.04		9.83	6.3		8.5	5.2		2.8	2.7		2.4	2.5
Means	0.715	0.61	0.665	63.5	70.1	66.8	52.2	54.1	53.1	42.4	39.5	40.9	34.8	30.5	32.6

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