The Effect of Nitrogen Amount on Photosynthetic Rate of Sugar Beet

Baiyan Cai [1], Jingping Ge[2]

(1. College of Dongfang, Harbin, Heilongjiang 150080, China;
2. College of Life Science, Heilongjiang University, Harbin, Heilongjiang 150080, China)

Abstract: There is a significantly positive correlation between nitrogen amount and individual plant leaf area of sugar beet, γ =0.998. Maximum leaf area index (LAI) is 4.87 by deal with N_{120}, and LAI is 3.0 as long as 40 days. It suits to LAI dynamic development regulation of high yields. There is a non-linear correlation between chlorophyll content and photosynthetic rate, but best chlorophyll content is 1.27 mg/g. In different nitrogen, the individual and population photosynthetic rate and all the highest levels, and are good for yield formation and sucrose content accumulation. [Nature and Science, 2004,2(2):60-63]

Key words: sugerbeet; maximum leaf area index (LAI); chlorophyll; photosynthetic rate

1 Introduction

Fertilizers are the main food for plant. Nitrogen is one of the three components in fertilizer, and also affect the photosynthetic rate of sugar beet. This article shows the effect of nitrogen amount on some photosynthetic physiological index related to photosynthetic efficient in the sugar beet plant. This will help to know the physiological bases that the optimal level of nitrogen can make for production.

2 Materials and Methods

2.1 Species used in this experiment

Tianyan No.7.

2.2 Design of this experiment

Five treatments were used upon $P_{90}K_{90}$ (kg/hm^2): N_0, N_{60}, N_{120}, N_{180}, N_{240}. Also used random group design, which including five rows and four repeats. The length of row was 11 m, the width of row was 0.6 m and the plot area was 33 m^2. The basic fertility of soil was: organic matter 25.57 g/kg, total nitrogen 1.71 g/kg, total phosphate 0.78 g/kg, total potassium 24.2 g/kg, alkalized nitrogen 145.1 g/kg, instant phosphate 35.0 mg/kg, instant potassium 202 mg/kg and pH 6.9.

2.3 Measurement methods

Total nitrogen: Distillation.

Total phosphate: Colorimetry.

Total potassium: Flame photometer.

Photosynthetic rate: Infrared ray CO_2 analysis instrument.

3 Results and Analysis

3.1 The individual leaf area and leaf area index (LAI)

The leaves are main assimilation organ of sugar beet (Zhao, 1990). The individual leaf area and leaf area index are closely correlated with the yields (Qu, 1993). The size of leaf area is strongly influenced by the nitrogen content (Table 1). The results showed that the quantities of nitrogen used were extremely remarkable correlated with the size of the leaf area, relative coefficient was γ =0.998**. The leaf area index of each treatment with different nitrogen amount increased slowly at the beginning (Table 1), while increased very fast at phyllome formation stage and earthnut development stage, in the middle of August, would reach peak value.

Because the LAI dealt with N_0 and N_{60} were relatively low (peak values were 2.95 and 3.88, respectively), the leaf couldn't fully utilize land fertility and light, they must have low yields. The LAI dealt with by N_{120} was 3 at the end of phyllome formation stage (25th July) and that was maximum 4.87 at the middle of earthmut development stage. The period would last 40 days when LAI was more than 3.0. Water and hot existed together during this period, the illumination was sufficient, these would benefit for producing great amount of dry material with assimilate organ, promoting the growth of the earthnut. On later stage, the LAI still maintain about 1.0, this was favorable to accumulation of the sugar. The LAI dealt with N_{240} and N_{180} were larger than that dealt with N_{120} notably in the last ten days of July and the first ten days of September. This proved that in the earthnut development stage and sugar accumulation stage, LAI was larger, most productions of photosynthesis was used for the growth of the phyllome, which would lead to the imbalance growth of roots and leaves and not suitable for the formation of roots and sugar.

3.2 The contents of chlorophyll of assimilate organs

The result showed that the contents of chlorophyll increased with the increasing of nitrogen amount, so they were significantly positive correlation, $\gamma = 0.996^{**}$. There was an increasing trend in the content of chlorophyll at the earlier breeding phase (Figure 1). In the middle of July, it reached peak value, and then began to decline. The content of chlorophyll with different nitrogen treatments had the same regularity, but differed largely in change range.

Chlorophyll content dealt with N_{120} had the relatively high photosynthetic rate. The content of chlorophyll and the photosynthetic rate was conic correlation. The regression equation was $y=-26.99x^2+68.62x-31.49$. i.e., the photosynthetic rate increased with the increasing of chlorophyll content. After chlorophyll content get to certain peak value, the photosynthetic rate declined. The optimum chlorophyll content was 1.27 mg/g.

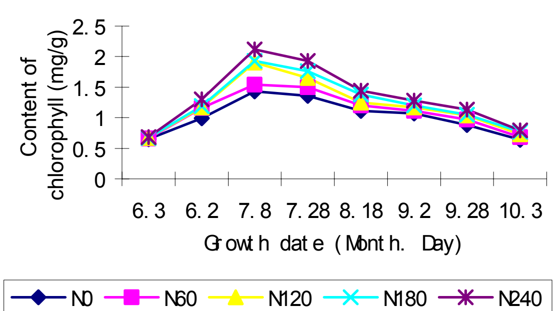

Figure 1. The dynamic variation of the content of chlorophyll of sugar beet leaves

3.3 The photosynthetic rate of single leaf

3.3.1 The photosynthetic rate of single leaf of different growing stages

The photosynthetic rate of single leaf was lower at the beginning, higher at the middle stage, declined at the end, which showed a unimodal curve (Figure 2). The peak value appeared at the earthnut development stage (at the beginning of August), this regularity was in favor of the formation of yields.

There was difference on photosynthetic rate between different nitrogen treatments. Before the beginning of August, the photosynthetic rate increased with the increasing of nitrogen amount used. But following this stage, the photosynthetic rate of single leaf dealt with N_{120} reached the highest, that dealt with N_{240} and N_{180} were lower. The leaf dealt with N_0 always had lower photosynthetic rate through all of the growth. If the nitrogen amount is added properly, the photosynthetic rate will increase, otherwise the speed will decline if it is added high. So it is necessary to employ suitable quantity nitrogen for improving the output of sugar beet and the content of sugar.

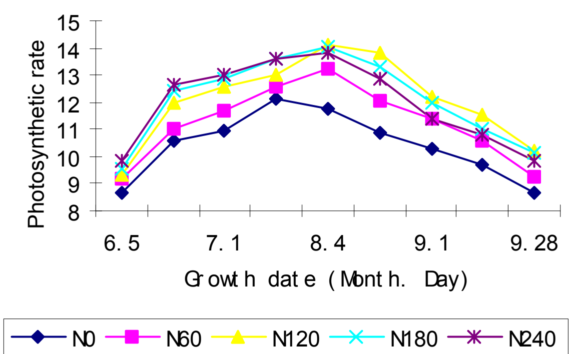

Figure 2 The photosynthetic rate of single leaf with different nitrogen amount

3.3.2 The photosynthetic rate of single leaf on different layers

The photosynthetic rates of leaves on different layers with different nitrogen were all the same (Table 2): upper-leaves>middle-leaves>lower-leaves, and with the increasing of nitrogen amount, the difference between single leaf photosynthetic rates of different layers varied. The photosynthetic rates of upper-leaves varied slightly between different nitrogen treatments, while that of middle-leaves and lower-leaves varied strongly. Because with the increasing of nitrogen amount, the middle-leaves and lower-leaves blocked the sunshine and weakened the illumination, the photosynthetic rates declined. In the treatment of N_0, the lower-leaves would drop because of the lacking of nitrogen at the end of growth, so the photosynthetic rate would decline. The middle-leaves with proper nitrogen amount neither lacking of nitrogen nor blocking the sunshine, so they had high photosynthetic rates, which could improve the individual plant photosynthetic rate and provide sufficient photosynthetic products for the growth of earthnuts.

4 The Level of Nitrogen and the Colony Photosynthetic Rates

In the growing stages of the sugar beet, the variation regularity of colony photosynthetic rate with different nitrogen treatments was the same (Zhang, 1998): showed as unimodal curve (Figure 3). At the beginning of growth, the colony photosynthetic rate increased gradually, and reached the maximum at the beginning of earthnut increasing stage, then declined. The conic equations of colony photosynthetic rate were such obtained, i.e., $y = b_0 + b_1 x + b_2 x^2$ (Table 3). Y indicated the colony photosynthetic rate ($gCO_2 \cdot m^{-2} \cdot h^{-1}$), b_0,b_1,b_2 indicated the regression coefficients and x indicated the days.

There was significantly difference in colony photosynthetic rate with different nitrogen treatments. Before the middle of July, with the increase of nitrogen amount, the colony photosynthetic rate increased. After the middle of July, the colony photosynthetic rate of N_{240} was lower than that of N_{180}, N_{120} and N_{60}, which lasted to the harvest. At the earthnut increasing stage, the colony photosynthetic rate was $N_{120}>N_{180}>N_{60}>N_{240}>N_0$, which showed that the colony photosynthetic rate in earthnut increasing stage was key factors on products.

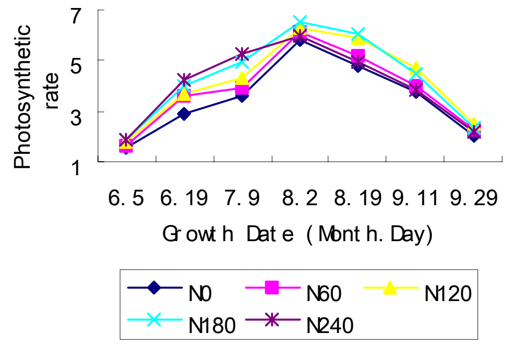

Figure 3. The colony photosynthetic rate with different nitrogen amount

At the sugar accumulation stage, the colony photosynthetic rate was $N_{120}>N_{180}>N_{60}>N_{240}>N_0$, which showed that the nitrogen amount could sustain the high photosynthesis intensity and was benefit for the accumulation of sugar. The results showed that the products were mainly relied on the photosynthetic ability. The nitrogen amount could not be little, for example, the colony photosynthetic rate dealt with N_{60} was higher than that dealt with N_{240}, but was lower than that dealt with N_{120} and N_{180}. If treated with suitable nitrogen amount, the single leaf and colony photosynthetic rate both would have high level, and provide sufficient products (Qu, 1986).

Table 1. Leaf area (LA) of individual sugar beet and leaf area index (LAX) with different nitrogen amount

Treatments	Item	Measure date (Month .Day)							
		5.30	6.17	7.4	7.25	8.15	9.3	9.24	10.3
N_0	LA	115.1	1028.2	2613.5	3540.4	4425.5	3539.3	1632.3	1081.7
	LAX	0.10	0.69	1.74	2.36	2.95	2.46	1.09	0.72
N_{60}	LA	158.2	1214.9	2747.9	4275.4	5369.8	4111.5	1948.3	1279.6
	LAX	0.11	0.81	1.83	2.85	3.88	2.74	1.30	0.85
N_{120}	LA	159.6	1431.6	3051.0	4551.4	7305.1	5018.5	2539.6	1729.8
	LAX	0.11	0.95	2.03	3.03	4.87	3.35	1.69	1.15
N_{180}	LA	163.9	1568.5	3363.2	5877.0	7434.0	5356.3	3721.5	2324.9
	LAX	0.11	1.05	2.24	3.92	4.96	3.57	2.48	1.55
N_{240}	LA	177.8	1748.7	3869.8	6112.5	7845.0	5694.8	3827.2	2633.3
	LAX	0.12	1.17	2.58	4.08	5.23	3.80	2.55	1.76

Table 2 The photosynthetic rate of different layers of single leaf with different nitrogen amount ($\mu malCO_2m^{-2}s^{-1}$)

Date (Month. Day)	Layers	Treatments				
		N_0	N_{60}	N_{120}	N_{180}	N_{240}
7.19	Upper	8.15	9.93	10.52	11.34	11.36
	Middle	7.97	8.06	9.31	10.14	10.83
	Lower	6.31	7.47	8.56	9.21	9.95
8.4	Upper	11.82	12.90	14.72	13.34	12.57
	Middle	8.78	9.34	10.39	9.87	9.63
	Lower	5.38	5.74	6.19	4.32	4.13
8.22	Upper	10.16	12.38	12.87	12.67	12.13
	Middle	5.75	6.78	9.30	8.23	6.38
	Lower	3.29	3.63	4.43	4.21	3.36
9.8	Upper	9.43	10.61	11.94	11.55	10.9
	Middle	6.74	7.17	8.12	7.76	5.64
	Lower	4.79	6.02	7.13	6.11	4.46
9.25	Upper	7.36	7.91	9.05	8.69	8.11
	Middle	3.12	3.67	3.72	3.68	3.30
	Lower	1.19	2.03	2.28	1.91	1.80

Table 3 The regression equation between colony photosynthetic rate and growth days with different nitrogen treatments

Treatments	Regression equation	F
	$Y = b_0 + b_1x + b_2x^2$	16.56^*
N_0	$Y = -2.542 + 0.158x - 8.31*10^{-4}x^2$	16.997^*
N_{60}	$Y = -2.765+ 0.177x - 9.548*10^{-4}x^2$	38.683^{**}
N_{120}	$Y = -3.464+ 0.204x - 1.103*10^{-3}x^2$	14.094^*
N_{180}	$Y = -3.996+ 0.239x - 1.335*10^{-3}x^2$	10.166^*
N_{240}	$Y = -1.533+ 0.168x - 9.833*10^{-2}x^2$	

Correspondence to:

Baiyan Cai
331 Xuefu Road
Nangang District
Heilongjiang Dongfang College
Harbin, Heilongjiang 150080, China
Telephone: 01186-451-86607149 (Office);
01186-451-86609178 (Home)
Mobile phone: 01186-13936139957
E-mail: caibaiyan@0451.com

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