TARIM BİLİMLERİ DERGİSİ (1995) 1 (1) 27-30 DOI: 10.1501/Tarimbil_0000000601

EFFECTS OF NITROGENOUS FERTILIZATION ON YIELD AND NITRATE ACCUMULATION IN SUGAR BEET

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Summary: The effects of increasing N rates on yield and nitrate content of sugar beet plant were studied under field conditions on micro-plots. N was applied at 0, 5, 20, 50, 100, 200 and 500 mg/kg soil rates with two equal portions. At the end of the experiment, fresh and dry weights of the leaves and roots, and total-N and NO_3-N contents of leaves and roots were determined. The results indicated that, all of the measured parameters were increased with the increasing nitrogen rates. The highest yield, total-N and NO_3-N contents were obtained from the 200 and 500 mg/kg N treatments respectively.

Key Words: Sugar beet, nitrogenous fertilization, nitrate accumulation

AZOTLU GÜBRELEMENİN ŞEKER PANCARINDA NİTRAT BİRİKİMİ VE ÜRÜN ÜZERİNE ETKİSİ

Özet: Şeker pancarının verim ve nitrat kapsamına artan düzeylerde uygulanan azotun etkisini belirlemeyi amaçlayan bu çalışma, tarla koşullarında mikroplotlarda yürütülmüştür. Azot toprağa 0, 5, 20, 50, 100, 200, 500 mg/kg düzeylerinde ikiye bölünerek uygulanmıştır. Deneme sonunda bitkilerin yaprak ve kök ağırlıkları, yaprak ve kökün toplam-N ve NO_3-N kapsamları, belirlenmiştir. Araştırmadan elde edilen sonuçlara göre bitkilerin yaş ve kuru ağırlıkları, NO_3-N ve toplam-N kapsamları artan azot düzeylerine bağlı olarak artmıştır. En yüksek ürün, NO_3-N ve toplam-N kapsamları sırasıyla 200 ve 500 mg/kg azot uygulamalarından elde edilmiştir.

Anahtar Kelimeler: Şeker pancarı, azotlu gübreleme, nitrat akümülasyonu.

Introduction

Sugar beet *Beta vulgaris saccharifera* is the raw material in sugar and alcohol production. Sugar beet has had an important role in passing from monoculture to polyculture. In the sugar beet production, fertilization and irrigation are necessary if satisfactory yield is to be attained. Its leaves and melases are among fundamental foods in animal husbandary. Its by-product is additionally used as organic fertilizer and animal food. Sugar beet promotes also new investment areas, such as sugar, alcohol, and cologne industries.

Nitrogenous fertilizers are mainly used by farmers to increase sugar beet yield. Basic effect of nitrogen is to broaden leaf area that enables plants to efficiently benefit from the solar energy. However, overuse of nitrogen has negative effects on sugar beet quality and sugar refinements process. It creates health problems in animal nutrition that is fed with nitrate (NO_3) accumulated leaves of sugar beet or fodder coming from sugar beet roots. Nitrate accumulation usually has no toxic effects on plant tissues, but it may be injurious to animals which consume the foliage. Nitrate poisoning has been common among animals grazing on nitrate-rich forage or feeding on nitrate-rich fodder, hay, or silage. Because certain plant parts eaten as fodder may contain NO_3 in high levels, they represent potential sources of toxicity to human beings.

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Animal feeding on NO_3-rich food suffer from vitamin-A deficiency due to the reduction of NO_3 to NO_2 in animal throat (Phillips 1966). Nitrite (NO_2) increases the iodine requirement of animals, leading to anomalies in thyroid functions (Bloomfield et al. 1961). Nitrates cause abortion in animals when they fed on high NO_3-content foods (Wright and Davidson 1964). It was shown that 3500 mg NO_3 per kg live weight caused to die 50% of rats used in the experiment (Wright and Davidson 1964). Nitrite originating from the reduction of non toxic nitrates is extremely toxic and dangerous. Nitrites cause the formation of carcinogenic, mutagenic, teratogenic, class nitrosoamines in human body by combining with amines (Anonymous 1972). Nitrite is known to be toxic element involved in nitrate poisoning, because, by easy diffusion into vascular system it reacts with haemoglobin to form metheamoglobin. The nitrate content of a plant is an index for toxicity, as nitrate may be reduced to nitrite in stored plant material or by the micro flora of the gastrointestinal tract(Walton 1951, Brown and Smith 1967).

This study was conducted to determine the suitable nitrogen dose to gain maximum yield with reasonable nitrate content.

Materials and Methods

This research was conducted on the micro-plots of Ankara Sugar Institute Experiment Station. Upper 40 cm of the micro-plots(1.40mx1.40m in size) were first removed to prevent the effects of the last-conducted experiment, then they filled with the soil with the pH of 7.96 (1:2.5 water), 10.99% Ca CO_3, 1.72% organic matter, 0.96% N and loam in texture(25.43% clay, 32.2% silt, 42.37% sand).

According to the experimental design, each micro-plot was given 100 mg P /kg soil as TSP(43%P_2O_5). First half of the nitrogen (0, 5, 20, 50, 100, 200, 500 mg N/kg soil) was applied to micro-plots before sowing as $(NH_4)_2SO_4$ and disked in to the surface soil. Ten sugar beet seeds (KWS 0155 monogerm) were sown each seed-bed. There were 21 seed-beds in each micro-plots so that each micro-plots could have 21 sugar beet plants. After a good stand was established, nine out of ten plants were picked up so that each seed-bed could have one plant. Then the second half of the nitrogen was added. The randomised complete block experimental design was constituted with four replications.

In the middle of the growing period and at the harvesting time, namely; leaf 1 and leaf 2 were sampled, washed, dried and analysed. After harvesting, fresh and dry weights were determined. Leaf NO_3-N and total-N contents were determined. After washing, sugar beet roots were weighed to determine the fresh and dry yields then chopped into small pieces for NO_3-N and total-N determinations.

NO_3-N was determined as described by Schouwenburg and Walinga (1975) and Anonymous (1991) and Total-N by Kjeldahl method (Jackson 1962).

Results and Discussion

Fresh and Dry Weights of Leaves and Roots; Fresh and dry weights of leaves and roots as a function of seven N rates incorporated into the soil are presented in Table 1. It was evident that N application increased the fresh and dry weights of leaves and roots.

However increases in dry weight and fresh weights of leaves and roots up to 50 mg N/kg soil fertilization rate were not as significant as 100, 200 and 500 mg N/kg doses. In other words, growth rate was considerably enhanced by increasing N rates from 50 to 500 more than those from 0 to 50 mg N/kg. At any N level, these parameters were appreciably higher than control.

Maximum fresh and dry yield of leaves and roots were reached at 200 and 500 mg N/kg soil fertilization rates . In the roots, higher N rates promoted better yields. Similar increases were reported by the other authors (Boawn et al. 1960, Smith et al. 1973, Zubenko et al. 1977, Vilsmeir 1985)

Nitrate Content of the Leaves and Roots; NO_3-N contents of leaves and roots are presented in Table 2. The NO_3-N content of leaves and roots were increased by nitrogen applications

Increases in NO_3-N contents of leaves and roots up to 100 mg N/kg soil were limited. After this level, increases were fairly considerable. The increase in roots NO_3-N content was less dramatical than that of leaves, although the general pattern was similar to that of leaves. The nitrate accumulation in respective plant parts was generally increased with higher nitrogen rates. It was determined that nitrate accumulation in the leaves more appreciable than that of the roots. Unlike leaf 2, the nitrate content of leaf 1 increased consistently with increasing N levels. The highest concentration of NO_3-N in the leaves and in the roots were found at the 500 mg/kg rate of N applications. Results from previous study (Brown and Smith 1967) has shown that 0 to 224 kg N/ha nitrogenous fertilization increased the NO_3-N content of sugar beet leaves and roots. NO_3-N content of leaf 1 was higher than that of leaf 2. Because NO_3-N is carried from leaves to the roots. Nitrate content of leaves decreases at harvest time (Lorenz 1978).

Table 1. Fresh and dry weights of leaves and roots

Nitrogen mg/kg	Fresh weight kg/da		Dry weight kg/da	
	Leaf 2	Root	Leaf 2	Root
0	1454 c	3648 d	393 de	811 d
5	1443 e	3992 d	367 e	908 cd
20	1902 d	4337 cd	485 d	974 cd
50	1851 d	5102 bc	469 d	1137 bc
100	3050 c	5472 ab	755 c	1219 ab
200	4197 b	6378 a	979 b	1387 a
500	5778 a	6314 a	1163 a	1285 a
LSD 5%	336	1008	94	275

Table 2. NO3-N contents of leaves and roots, mg/kg dry weight

Nitrogen mg/kg soil	Leaf 1	Leaf 2	Root
0	120 c	139 b	23 c
5	163 c	145 b	14 c
20	320 c	91 b	19 c
50	410 c	130 b	19 c
100	815 c	133 b	20 c
200	3025b	445 b	190 b
500	6675a	2500 a	680 c
LSD 5%	797	472	78

Table 3. Total N content of leaves and roots, %

Nitrogen mg/kg soil	Leaf 1	Leaf 2	Root
0	2.24 cd	2.35 bc	0.52 de
5	2.01 de	2.25 bc	0.49 e
20	1.91 e	1.92 d	0.51 de
50	2.25 cd	2.22 bc	0.54 d
100	2.42 c	2.06 cd	0.59 c
200	3.15 b	2.49 b	0.80 b
500	3.54 a	3.08 a	1.14 a
LSD 5%	0.29	0.28	0.045

Total-N Content of Leaves and Roots; As presented in Table 3, nitrogen content of leaf 1 was similar to that of leaf 2. Leaf 1 , leaf 2 and roots nitrogen contents increased after 50 mg N/kg soil application. Likely because the plants grew, nitrogen applications up to 100 mg N/kg soil did not affect the total-N content of plants rapidly and nitrogen diluted in yield. Since the N deficiency quenched after 50 mg N/kg soil, plant growth, protein synthesis, and N content increased. At 500 mg N/kg level, total-N content of leaves and roots were highest among all levels of N treatments.

Table 3 shows that roots contained less total-N than leaves. General response of total-N in the leaves to various treatment was similar to that of the roots. Similar results were also pointed out by several other researchers (Thorne and Watson 1956, Carter et al 1974, Lorenz 1978, Vilsmeir 1985, Chochola 1981).

Nitrogen Assimilation Rate; The ratio of accumulated NO_3-N in plant tissue to total-N shows assimilation rate which correlation is very meaningful in evaluation. Assimilation rate is given in Table 4 which was calculated from Table 2 and 3.

As seen from Table 4, assimilation rate was hardly fit to the nitrogen rate applied. Non-assimilated N content of leaf 1 was higher than that of leaf 2 like NO_3-N content of those. Non-assimilated N content of leaf 1 increased with nitrogen rates. Non-assimilated N contents were found 9.60% and 18.85% at 200 and 500 mgN/kg soil respectively. There was no significant relation between assimilation rates of the leaf 1, 2 and the roots up to 100 mg N/kg soil. Non-assimilated NO_3-N contents increased after this level, probably that NO_3

Table 4. Nitrogen assimilation rate, %

Nitrogen mg/kg soil	Leafl	Leaf2	Root
0	0.63	0.68	0.44
5	0.91	0.72	0.28
20	1.68	0.47	0.37
50	1.92	0.59	0.35
100	3.37	0.64	0.33
200	9.60	1.78	2.37
500	18.85	8.11	5.96

was accumulated in the plant tissues where it may not be assimilated. While total-N content of the plants changed slightly, quantity of NO_3 accumulated in plant tissue substantially increased.

It can be concluded that young leaves of sugar beet may not be convenient for using in animal feeding. Leaf or root residues which historically received high amounts of nitrogenous fertilizers should also be avoided in animal feeding.

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Eserin Kabul Tarihi : 18.08.1995