The Effects of Intensıve-Use of Fertilizers on Nitrate Accumulation in Vegetables

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Abstract

To be able to meet the increasing food need as a result of rapid increasing population in the World more fertilizer are being applied beside genetical breeding in plants. The resulting negative effects of fertilization on environment are as follows; by the increased usage of nitrogenous fertilizer the increased leakage from the soil profile with subsequent high nitrate concentrations in water, especially as a result of surface soil erosion by the involvement of phosphorus fertilizers into the water phosphate concentrations increases in the still water and flowing water, by over usage of fertilizer, accumulation of some items in plants with the subsequent occurrence of negative effects seen in the ones fed with those, by the application of nitrogenous fertilizer into the soil the occurrence of greenhouse effect by the involvement of gaseous into the atmosphere such as nitrogen oxides and ammonia as a result of volatilization. Moreover, the salinity problem of soils comes out as a result of over fertilizer employment. The factors affecting the accumulation of nitrate and nitrite in the vegetables; nitrogen source and its amount, nitrogen application time, soil properties, the climate effect, mineral nutrition of plant, the form of applied fertilizer, the differences among species and varieties, plant variety, plant age and fertilization timing must be balanced well to prevent nitrate accumulation in the vegetables. The only at the sufficient level is to be analyzed of soil before the fertilization. The precautions can be pointed out as follows: to harvest the plants having edible leaves afternoon, to keep the vegetables in the suitable conditions if not being utilized just after the harvest, to be grown of the plant species having less accumulation of nitrate accumulation, fertilization of molybdenum in the acidic soils as a result of in availability of molybdenum to the plants resulting from iron and aluminum

Key words: Vegetable, nitrogen, nitrate, nitrite, accumulation

1. Introduction

The world, along with the rapid increase of the population in order to meet the increased nutritional needs brought about, in the last century is faced with environmental and soil pollution caused by the intensive use of agricultural chemicals. Studies indicate that farming will be even done more intensely in the future. Correspondingly, environmental issues occur. The deterioration of the ecological balance and biological development, chemical residues in agricultural products has become a threat to human health. Intensive use of fertilizers and pesticides often leads to the formation of significant danger to humans and their environment. The need of getting more product of the unit area has come out due to the increase of our country's population by 2.5% per year and the decrease of cultivated land[1].

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To obtain more yield per unit area, genetic breeding along with the use of more commercial fertilizer of plants is used. Fertilization is done in order to provide cultivated plants with nutrient elements not found in soil adequately. The addition of nutrients to the soil is with organic and mineral fertilizers.

Negative effects of fertilization on the environment are ; the rise of the increasing use of nitrogenous fertilizers washed from the soil and ultimately the rise of the nitrate concentration in the water, especially as a result of the relocation of the surface soil, phosphorus fertilizers are mixed into the water and the rise in the scope of phosphate in rivers and stagnant waters, as a result of excessive use of fertilizers, the concentration of certain substances in plants and the emergence of adverse effects in those who eat them, the formation of greenhouse effect with the participation of gases such as nitrousoxide and ammonia into the atmosphere caused by nitrogenous fertilizers applied to the soil[2]. In addition, soil is getting salty because of surplus use of fertilizers. By washing of saline soils, subsoil water is getting saltier and since the salty water is used as irrigation water, the rate of saline soil gets higher. In particular, where greenhousing is carried out intensely and drinking water transmission lines are not found, well water is offered for both human and animal use. As a result of washing of various ions, especially nitrate ,salty water wells lose their properties of being potable and healthy. In a well drilled in the Bursa plain it was stated that the (NO_3) concentration went up to 110-150 mg/l from 16-20 mg/l in seasons fertilization has been made[3].

The leading fertilizers applied to our lands to a large amount are nitrogen fertilizers. Because nitrogen is the basic nutrient element which is responsible for plant vegetative development.

The effect of nitrogenous fertilization on the accumulation of nitrate nitrogen leads to product decrease because of the lack of nitrogen at a very high level, therefore growers are applying nitrogen fertilizer at high rates to take control of the reduction that may occur in crop yields.

The reason why nitrogen is the most needed macronutrient for higher plants taken in from the soil is that proteins and nucleic acids which are the main elements of living material contain more than 15% of nitrogen. For this reason, plants require nitrogen to grow well and give maximum yield[4].

In plants there is a considerable amount of nitrogen behind hydrogen, carbon and oxygen. The nitrogen content in young plants is significantly higher than those in mature plants. Plants absorb nitrogen in the form of nitrate (NO_3) and ammonium (NH_4) ions. The major part of inorganic nitrogen received by the plant is in the form of nitrate.The ammonium ion is unstable and is ultimately converted in the soil to nitrate[5].

For the conversion of nitrogen in nitrate form, which is absorbed by the plant , to simple or complex vegetative proteins or other compounds that are not in the form of plant protein, the assimilation of inorganic nitrogen is required. Nitrate is reduced to ammonia by the plant before it can be assimilated. This process is called nitrate reduction[5].

Nitrate reduction to ammonia is carried out in two steps in plant tissues. In the first phase of reduction nitrate (NO3) is converted to Nitrite (NO2) and in the second phase it (NO2) is converted to ammonia (NH3) .

- $NO_3+8H+8e$_____NH_3+2H_2O+OH
- Nitrate assimilation is likely to be in roots and leaves of plants[6].

If nitrate is present in the soil, the plant takes more nitrogen than it needs and nitrate accumulation in the plant occurs. If the nitrate amount is less, a large part of nitrate is generally reduced in the root. When the nitrate amonut increases, it is moved to the body through the xylem transmission pipes, which are on the reduction capacity of the root. Nitrate mostly accumulates in sheets in the mesophilic[7].

The nitrate content in fruit and seed is usually low. Nitrate accumulation in plants usually occurs when there is an imbalance between uptake and assimilation of nitrogen by plants[8-9].

2. Factors affecting the accumulation of nitrate and nitrite in vegetables ;

2.1. Nitrogen source and amount:

There are several factors that affect the nitrate content in vegetables. Especially in green leafy vegetables whose leaves are consumed as the amount of applied nitrogen fertilizers increases nitrogen concentration of the plants increases as well.

A study which was carried out on cabbages in Erzurum shows that as the amount of fertilizers increased, nitrate content of the plant increased. In terms of fertilizer variety for cabbage the highest amount of nitrate accumulation has been found in nitrogen fertilizers. Considering the amount of nitrate in the plant for profitable and good quality crop, 34 kgs of urea applied to per decare under conditions of Erzurum for growing cabbage has been found suitable[10].

In Ankara , for spinach application of 7.5 kgs of fertilizer per decare has been found suitable both in terms of maximum crop yield and nitrate accumulation which was in between authorised limits[11].

In Adana , lettuce was grown by using organic farm fertilizer, by mineral urea and with combination of both in different amounts and it was shown that nitrogen which was applied in organic form decreased the amount of nitrate compared to mineral form[12].

2.2. Nitrogen application time;

Both whole amount of nitrogen, necessary for the development of the plant, can be applied before the planting or can be splitted. The latter is better to satisfy the need of the plant. Especially during winter, for longer time of vegetation nitrogen can be easily lost due to leaching therefore split application is preferred.

It was determined that excess accumulation of nitrate in greenhouse grown cucumbers in Mersin province, was lower in sandy soils due to leaching compared to clay loam soils where leaching is less[13].

2.3. Soil properties and the effect of the climate;

Nitrogen content of the plants is widely effected by soil and climatic factors. Plants grown in nitrogen-rich soils have more nitrogen contents than the plants grown in nitrogen deficient soils. Nitrogen used in sandy soils does not accumulate and leach from the soil profile, heavier soil textures accumulates more nitrogen. The amount of the fertilizer used gains more importance for the middle and heavy soil textures, while it is not that important for sandy soils[14-15]. The amount of water in the soil also effects the nitrogen content. It was found that during the harvest period, higher amounts of the water in the soil resulted in higher nitrate concentrations in carrot [16].

2.4. Light;

Light plays important role on the nitrate metabolism of the plants. Previous researches conducted indicated that nitrate concentration increases during the winter season when the light intensity is lower, while in the higher light intensity nitrate concentration decreases[17]. Nitrate reductase enzyme activity decreases in the dark causing decrease of the nitrate reduction. Nitrate contents differs according to the time of the day. In the high light intensity, nitrate content of spinach and lettuce are less in the afternoon compared to those of in the morning. Accumulation of nitrogen in the form of nitrate is grater in the leaves harvested in the morning compared to the leaves harvested in the afternoon. The reason behind this is the maximum effect of light intensity and duration on the above ground parts of the plants' reducing nitrogen in the form of nitrate. Therefore green vegetables must be harvested in the afternoons not in the mornings[18-19].

2.5. Temperature;

There is a relationship between uptake of the nitrogen and temperature. Generally, nitrate contents of the plants increases with the increasing temperatures. Due to higher temperatures in the roots nitrate absorption increases. Nitrate and ammonium uptake lessens with lower temperatures. Nitrate reduction is positively effected by temperature. The amount of nitrate reductase enzyme which takes part in the nitrogen metabolism of the plant and effected by the water content of soil therefore nitrate accumulation on the plants is higher in drought conditions. It is thought atmospheric humidity may effect nitrate accumulation. Lower atmospheric humidity accelerate transpiration and thus increasing water transportation through which nitrate can faster be transported and reduced. Lower water transportation in the plants causes nitrate accumulation[20].

2.6. Growing conditions;

It was observed that lettuce grown in greenhouse accumulated more nitrate than field-grown lettuce. The difference between the conditions such as temperature, light, humidity and rain,

as well as different irrigation methods (furrow in the field vs. drip irrigation in the greenhouse) may be the reason[21].

2.7. Mineral Nutrition of the Plant;

If Molybdenum deficiency occurs, nitrogen assimilation slows down causing accumulation of nitrate form of nitrogen. In such case, nitrate cannot be transformed in to ammoniac and ammonium which is necessary for amino acid synthesis cannot sufficiently be found. Because, Molybdenum is one of the components of the nitrate reductase enzyme and lower amounts of it causes nitrate accumulation on the leaves. In other words, Molybdenum addition to the soil lowered the nitrate amounts of the plant leaves. Potassium presence in the environment increases nitrate transportation into the plant, increasing the nitrate accumulation in the plant. On the other hand, calcium and sodium presence increase the nitrate reduction in the roots[22-23-24-25].

2.8. Crop Storage;

Nitrite amount of the plants increases with the poor aerated storage conditions. Therefore, aeration conditions of the vegetables in storage must be paid attention. Nitrate content of the potassium nitrate applied plants does not differ depending on the storage duration and temperature. On the other hand, nitrate accumulation occurs in ammonium sulfate and urea applied plants depending on the storage conditions and temperature[11].

2.9. Type of the fertilizer;

Fertilizers containing nitrate form of nitrogen causes higher increase in nitrate concentrations compared to the other fertilizers. Ammonium nitrate causes more nitrate accumulation compared to urea and ammonium sulphate. The reason behind this is solubility of this fertilizer is higher than the other types of fertilizers and plants can easily utilize the nitrate[26].

In this study was to determined influence of organic (manure) and inorganic (ammonium sulphate) fertilizer on lettuce nitrate content. There were three green varieties (Krizet, Filipus and Invicta) and three red varieties (Versai, Cherokee and Paradai) in this study. Plots were fertilized 200 kg/ha N from either sources before planting. As a result, the fertilizer sources have an effect on nitrate content of the plant and the effect was statistically different. Plant fertilized by inorganic source had 3002.9 mg/kg nitrate and it was almost 2 times higher than manure (1455.5 mg/kg). All of the varieties had lower nitrate content in manure treatment compare to their inorganic treatments. For example, Krizet had 4025.9 mg/kg nitrate in inorganic fertilization but the manure application reduced the nitrate content to 1283.5 mg/kg which was more than three times less than the inorganic treatment. Statistical analysis showed that there was not a significat difference among the green varieties nitrate content that was

seen among the red varieties. The results of this study imply that fertility balance and sources are quite substantial to nitrate accumulation on lettuce[27].

In present study, nitrate content were determined in seven different color carrot (White Satin, Yelow Stone, Parmex, Atomic Red, Cosmic Purple, Purple Haze, Eregli Siyahi) root and foliage. The field was fertilized 90 kg/ha (1/2 from manure+1/2 from ammonium sulphate) before the planting. Root and foliage were harvested and grinded for the further chemical analysis. The results showed that White Satin and Atomic Red had the highest root nitrate content compare to other varieties. The lowest root nitrate was observed on Cosmic Purple (636.4 mg/kg). On the other hand, same variety had the highest foliage nitrate. Eregli Siyahi had the lowest foliage nitrate content (639.2 mg/kg). Results demonstrated that foliage and root nitrate content differs depend on the varieties[28].

This study was carried out under field condition during 2009-2010 years in Hatay-Samandag. In this experiment was tested the effects of 4 nitrogen doses of ammonium sulphate (D0:0, D1:10,D2:20 and D3:30 kg da-1 N) and 5 different irrigation levels (I100: full irrigation, deficit irrigations I25, I50, I75, and excessive irrigation I125) to nitrate, nitrite and chlorophyll contents of parsley plants. High nitrate and nitrite were determined at first harvest in cold period (25-26 January 2010).Comparing to nitrogen-free treatments, nitrogen applications led to an increase to plant nitrate accumulation but a decrease to nitrite accumulation. Comparing with first harvest, second harvest in hot period (31 March-1 April 2010) was resulted with quite a few nitrate and more nitrite values. Increasing nitrogen levels had increased nitrate and nitrite values. In both harvest, small irrigation amounts caused lower nitrate accumulations as to other irrigation levels. Nitrate and nitrite contents in second harvest had decreased with excessive irrigation (I125) according to full irrigation (I100)[29].

2.10. Difference between species and varieties,

It was determined that leaf vegetables, such as spinach, lettuce, cabbage can store nitrate amounts of up to 10% or more of their dry weight. It was pointed out that consuming of these vegetables may pose health risks if the fertilizers misapplied while growing in the field[30].

2.11. Plant species;

The vegetables contains less than 200 mg/kg nitrate, asparagus, chichory, bean, peas, mushroom, potatoes, sweet pepper, sweet potatoes, tomatoes.
The vegetables contains less than 500 mg/kg nitrate, kale, cauliflower, cucumber, eggplant, melon, onion, turnip
The vegetables contains less than 1000 mg/kg nitrate, cabbage, red cabbage, carrot, French beans, pumpkin
The vegetables contains less than 2500 mg/kg nitrate, celery, cress, leek, parsley
The vegetables contains more than 2500 mg/kg nitrate, beet, stalk celery, chervil, lettuce, raddish, spinach[31].

2.12. Plant age;

Nitrogen contents differs depending on the plant age. Young leaves and root shoots are rich in enzymes. Young leaves at the end of development has 10 times more nitrate reductase

enzyme than old leaves. Nitrogen contents of the young plants or much more higher than the ones closing to the maturity. Stems of spinach have more nitrates than leaves. Outer leaves of lettuce have up to 3 times more nitrates than inner leaves. The reason of this is the age of the leaves rather than the position of them. Outer leaves are older than the inner ones and thus nitrate accumulation is higher. Similarly, it was determined that increasing age of the spinach plants resulted in higher nitrate contents of their leaves[32-11].

Conclusions

In the plants of which the leaves are edible, the harvest should be done in the afternoon, in case of not consuming just after the harvest the plants should be kept in good conditions, plant genotypes that include less nitrate should be bred, fertilizers such as potassium chloride, potassium sulphate, calcium chloride and micro nutrition elements such as iron, manganese molybdenum should be applied to soil with nitrogenous manure, since iron and aluminum makes molybdenum useless for the plant in acid reaction soil, molybdenum fertilizing is compulsory for such soil. Aforementioned precautions could be indicated to prevent nitrate accumulation in plants.

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