ARAŞTIRMA MAKALESİ	RESEARCH ARTICLE

Determination of Nitrogen Leaching Under Precipitation Conditions from Weighted Lysimeter Planted Walnut (Juglans regia L.)

Tartılı Lizimetreye Dikilmiş Cevizden (Juglans regia L.) Yağış Koşullarında Yıkanan Azotun Belirlenmesi

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Abstract

Many minerals such as especially nitrogen leaching out from the soil in exceed precipitation leach. This situation is a very important factor causing economic losses and environmental pollution. The aim of the study is to determine amount of the nitrogen leaching from the soil by precipitation outside the irrigation season from a weighing lysimeter controlled by a programmable logic controller (PLC). The research was carried out under Kahramanmaraş conditions in the five-month period between December 2018 - April 2019. In the study, a weighed lysimeter with a diameter of 113 cm (1 m^2) and a depth of 130 cm was used and on which three-year-old (Maraş 18) walnut was planted. Two pluviometers were used to measure the amount of precipitation falling on lysimeter and the drained water from it. At the beginning of the experiment, 300 gr DAP (diammonium phosphate) fertilizer was applied to the lysimeter soil. A PLC automation system has been created that controls lysimeter and pluviometers for the research. The PLC automation system measured a total precipitation of 868.1 mm and drainage water of 686.6 mm Nitrogen concentrations and loads in the drainage water were determined from 26 water samples taken in the experimental period. In analysis of water samples, it was determined that nitrogen of 12.7 kg was leached from the soil of one hectare with the effect of precipitation. The leaching amount of nitrogen was 8.4%, of which 24% was in the form of ammonium (NH$_4$) and 76% in the form of nitrate (NO$_3$). The highest nitrogen leached with 5.4 kg per hectare in December, when the precipitation was the highest (264.1 mm). According to the results, as amount of precipitation increased, the leaching amount of nitrogen increased leach. Therefore, application programs of nitrogen fertilizer should be prepared by taking into consideration the precipitation regime of the region. It is very important for economy, the environment and human health.

Keywords: Drainage water, Nitrogen leaching, Lysimeter, Pluviometer, Precipitation

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Öz

Uzun süreli yağışlar başta azot olmak üzere birçok mineral maddenin topraktan yıkanarak uzaklaşmasına neden olmaktadır. Bu durum ekonomik kayıplara ve çevre kirliliğine neden olan çok önemli bir faktördür. Çalışmanın amacı, programlanabilir mantık denetleyici (PLC) tarafından kontrol edilen bir tartılı lizimetreden sulama sezonu dışında meydana gelen yağışların etkisiyle topraktan yıkanan azotu belirlemektir. Bu araştırma, Kahramanmaraş ili koşullarında, sulamanın yapılmadığı Aralık 2018 – Nisan 2019 aylarını kapsayan beş aylık bir dönemde gerçekleştirilmiştir. Araştırmada, üzerinde üç yaşında ceviz fidanı (Maraş 18) bulunan, 113 cm çapında (1 m^2) ve 130 cm derinliğinde olan bir tartılı lizimetre kullanılmıştır. Bu lizimetreye yağışla giren ve sızarak uzaklaşan su miktarlarını ölçmek için iki farklı plüviyometre kullanılmıştır. Deneme başlangıcında lizimetre toprağına 300 gr DAP (diamonyum fosfat) gübresi uygulanmıştır. Araştırma için lizimetreyi ve plüviyometreleri kontrol eden bir PLC otomasyon sistemi oluşturulmuştur. Oluşturulan bu otomasyon sistemi kullanılarak, araştırma dönemi boyunca toplam 868.1 mm yağış ve 686.6 mm drenaj ölçülmüştür. Aynı dönem içerisinde alınan 26 adet su örneklerinden drenaj suyu içerisindeki azot konsantrasyonları ve yükleri belirlenmiştir. Su örneklerinde yapılan analizlerde yağışların etkisiyle hektardan 12.7 kg azotun topraktan yıkanarak uzaklaştığı belirlenmiştir. Belirlenen bu değer, başlangıçta lizimetre toprağında bulunan toplam azotun % 8.4'ü olup bu değerin %24'ü amonyum (NH$_4$) ve %76'sı nitrat (NO$_3$) formundadır. En fazla azot yıkanması, yağışların en fazla olduğu Aralık ayında (264.1 mm) hektarda 5.4 kg olarak gerçekleşmiştir. Elde edilen bu sonuçlara göre artan yağış miktarları topraktan yıkanan azot miktarlarını arttırmıştır. Bu yüzden azotlu gübre uygulama programları, bölgenin yağış rejimi dikkate alınarak hazırlanmalıdır. Bu durum çevre ve insan sağlığı açısından çok önemlidir.

Anahtar Kelimeler: Azot yıkanması, Drenaj suyu, Lizimetre, Plüviyometre, Yağış,

1. Introduction

Nitrogen is a very important plant nutrient being in organic and inorganic forms in the soil (Prakasa Rao and Puttanna, 2000). The reason for this is that it takes place in the structure of organic compounds with important functions such as amide, amino acid, chlorophyll, protein and nucleic acid (Müftüoğlu and Demirer, 1998). Although it is an important source of nutrients in crop production, improper fertilizer applications can cause significant harm in terms of health, environment and economy (Çetin et al., 2020). Agricultural pollution is more difficult to control than other pollution (Sünal, 2012). Therefore, in order to reduce the negative effects of nitrogen, it is necessary to analyze its behavior in the soil well (Güzel et al., 2008).

When nitrogen is not taken up by plants, by being carried along with rainfall, and surface and irrigation water it can cause eutrophication in surface water, nitrate accumulation in underground water, acid rain in gas form and environmental problems such as greenhouse effect. As a result, high amount of nitrate absorbed by the human body, it causes the formation of nitrosamine compounds known as mutagenic, teratogenic, toxic and carcinogenic (Gupta and Khosla, 2012; Karaşahin, 2014).

Nitrogen is the most leachleached nutrient from the soil. In the leaching, high nitrogen doses and some fertilizer forms are important factors leach (Kant et al. 2006). Most of the nitrogen applied to the soil turns into nitrate (NO_3) form (Barraclough et al. 1984), rainfall and irrigation water facilitates the movement of nitrate in the soil profile (Ju et al. 2003; İbrikci et al. 2016). This is because clay surfaces and nitrate (NO_3) are negatively charged and this compound (NO_3) is soluble. Ammonium (NH_4) is mostly fixed by soil colloids and therefore, it is assumed that ammonium (NH_4) is immobile leachand nitrate (NO_3) is mobile in terms of leaching (Wiklander 1977; Johnsson et al. 1987; Aulakh and Singh 1997; Chowdary 2004).

Nitrate, which moves rapidly in the soil along with the water and mixes with underground water used as drinking water, could cause serious environmental and health problems (Özekici, 2008). The accepteble upper limit ofnitrate and ammonium were determined as 50 mg L^{-1} and 0.50 mg L^{-1} in drinking water by Europeann union and Turkey, (Anonymous, 2005; Anonymous, 2010). In the research conducted in Turkey, it was reported that the ratio of nitrogen in groundwater exceeded the specified nitrogen standard for drinking water. Similarly, groundwater samples were taken from 59 points around Nif Mountain, one of the important water resources of İzmir province and it was founded thatthe amount of the nitrate in groundwater was more than 50 mg L^{-1} (Polat et al. 2007) and in the onather study conducted in 20 wells in Antalya Kumluca region, NO_3 concentrates were found cahnged between 246 and 164.91 mg L^{-1} (Kaplan et al. 1999) and also it was reported in the study conducted in 42 drilled deep well in Erzurum Gümüşhacıköy Aquifer, the NO_3 and NH_4 concentratons in 8 deep wells used as drinking water were above the drinking water standard (Ersoy and Ersoy, 2007).

In the 75% of Turkey's erable land it is poor in terms of nitrogen due to leachleaching, erosion and losses in gaseous form (Yetgin, 2010; Karaman, 2012). Therefore, fertilization has an important for sustainable crop production (Sönmez et al. 2008). Nitrogenous fertilizer consumption takes the first place in Turkey (Akdağ and Zengin 2020) and it increases every year, although it varies according to the variety used. For example, the use of nitrogenous fertilizers, which was 6.397,000 tons in 2010, was 8.010,000 tons in 2019 (Anonymous, 2019b).

Turkey is in fourth rank in the world in terms of walnut grower. Kahramanmaraş province is the first rank in walnut production and then it has been spread over a geographical area of the country (Güvenç and Kazankaya, 2019). As walnut production increases year and year throughout the province, nitrogen consumption will be also increases. Increasing nitrogen consumption every year could cause pollution of nature as well as economic losses and threatens human health. Therefore, it is an important issue that needs to be addressed on. In this study, it was aimed to determine the nitrogen leachleaching under precipitation conditions from weighing lysimeter controlled by PLC.

2. Materials and Methods

2.1. Study area

Study was conducted between in December 2018 and April 2019 atthe Research and Application of of Agricultural Faculty, Sütçü İmam University, Kahramanmaras/ Turkey. The trial area is between 37°35′36 ″ north latitude and 36°49′20 ″ east longitude and approximately 508 m above sea level. The average precipitation and temperature are

719.7 mm and 16.6 °C, and the Mediterranean climate is dominant in experimental area (Uzun et al., 2018). The physical and chemical properties of the lysimeter soil are given in *Tables 1* and *2*. In terms of plant growth, lysimeter soil does not have any negative effects according to physical and chemical analysis.

Table 1. Some physical properties of soil

Depth (cm)	Sand %	Clay %	Silt %	Texture	Field capacity Pw (%)	Permanent wilting point Pw (%)	Bulk density (g cm⁻³)
0-30	49.50	20.32	30.18	Clay Loam (CL)	35.04	22.39	1.38
30-60	36.28	23.91	39.80	Clay Loam (CL)	35.99	24.17	1.36
60-90	31.81	23.97	44.22	Claye (C)	41.19	20.43	1.50

Table 2. Some chemical properties of soil

Layer Depth (cm)	0-30	30-60	60-90
Saturation point (%)	81	89	92
pH	8.05	7.83	7.70
EC dS m⁻¹	1.00	0.90	0.94
Lime %	9.03	10.64	13.87
Organic Matter %	1.58	1.25	1.22
Useful Phosphorus (P_2O_5) kg da⁻¹	4.31	3.07	1.45
Useful Potassium (K_2O) kg da⁻¹	68.04	54.84	47.24
Useful Calcium (Ca) mg kg⁻¹	11,285.19	11,029.68	10,872.21
Useful Magnesium (Mg) mg kg⁻¹	501.13	502.69	503.76
Exchangeable Sodium (Na) mg kg⁻¹	54.50	38.40	55.42
Useful Iron (Fe) mg kg⁻¹	0.46	0.52	0.43
Useful Manganese (Mn) mg kg⁻¹	0.82	0.76	1.03
Useful Copper (Cu) mg kg⁻¹	1.21	1.15	1.16
Useful Zinc (Zn) mg kg⁻¹	0.71	1.93	2.08

2.2. Lysimeter tank

Lysimeter was constructed in 2018 to determine the water consumption of the walnut plant *(Figure 1)*. Tank of lysimeter is cylindrical, 113 cm in diameter and 130 cm in depth and sat on four legged stand with 10 cm height. A stainless chrome-nickel coated 0.5 cm mesh sieve is placed in bottom of tank to facilitate the leakage of water and to prevent the mixing of soil. There is a 115 cm deep soil layer in the lysimeter. Surface flow was prevented by leaving a 5 cm gap above the lysimeter. It was tried to minimize its exposure to solar radiation and environmental temperature by covering it with glass wool with a thickness of 10 cm. Glass wool is also protected from environmental effects by wrapping it with a nylon cover. There is a 3-year-old Maraş 18 variety walnut tree on it, which was planted in the year of 2018.

2.3. Weighbridge

Lysimeter is placed on an electronic scale with four tons capacity, 0.2 kg accuracy, 4 load cells, converter board and RS232 output.

2.4. Automation panel and PLC

The panel consists of 1 PLC device, 1 power supply, 4 terminal groups and 3 automatic fuses. In the study, a PLC with PM564-TP-ETH type CPU was used to measure precipitation and drainage water with the signals receiving from digital pluviometers and to save daily measurement values to the SD card.
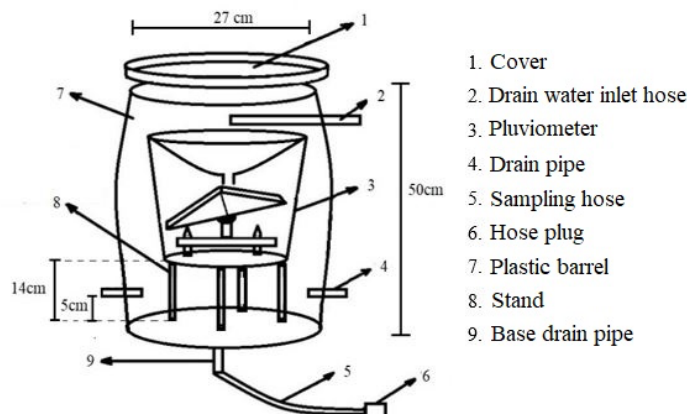
2.5. Pluviometer

In the research, 2 digital pluviometers with buckets and with 20.000 mm^2 funnal area were used. One of them measuring precipitation was placed on the weather station pole, and the other one measuring the drainage was placed in the drainage tank *(Figure 1)*.
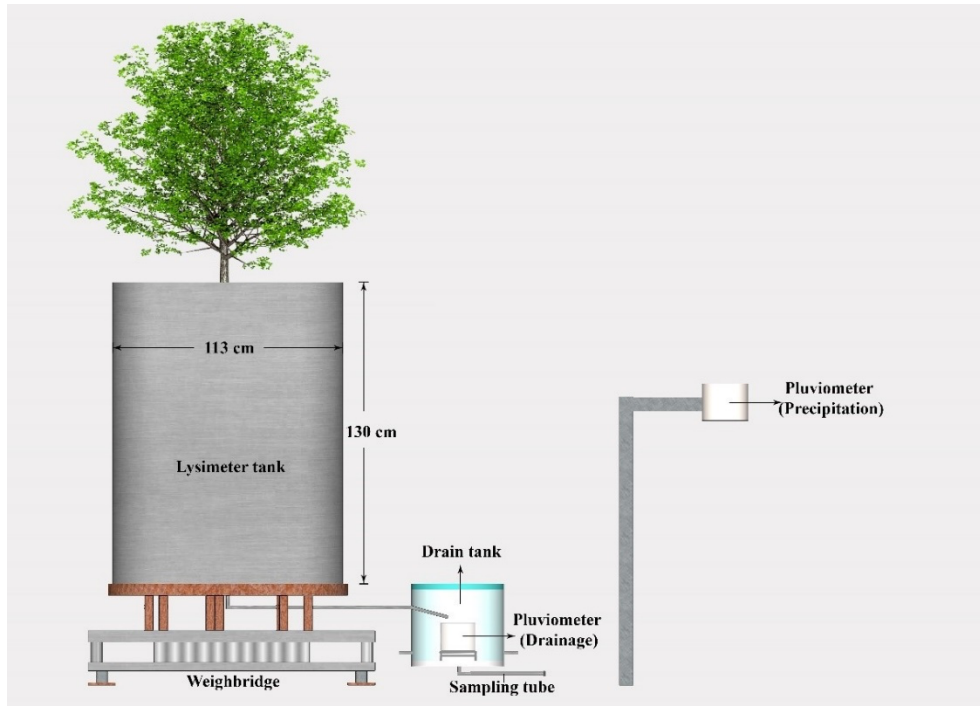
Figure 1. Lysimeter system

2.6. Drain tank

To directly measure the drained water from the lysimeter by pluviometer, a plastic barrel of 25 liters (27 cm in diameter and 50 cm in height) with 1 inlet and 4 outlets was utilized and the pluviometer sat on a stand of 14 cm height in tank. The three holes of them were drilled at a height of 5 cm on the bottom-side of the tank to accumulate at least 1 liter of water inside the tank and to provid excess water flow freely. The rest outlet on the center of the bottom was connected to one end of the pipe of 1 meter lenght, which the other end was plugged with a stoppper. Openning the plugged end, water samples for nitrogen anlysis was collected with plastic bottles of 500 ml *(Figure 2)*.

1. Cover
2. Drain water inlet hose
3. Pluviometer
4. Drain pipe
5. Sampling hose
6. Hose plug
7. Plastic barrel
8. Stand
9. Base drain pipe

Figure 2. Drain tank and pluviometer

2.7. fertilizer application

On 24 November 2018, 300 gr Diammonium Phosphate (DAP) fertilizer was applied to the lysimeter soil. DAP is a compound fertilizer containing two important plant nutrients such as nitrogen and phosphorus. The compound fertilizer contains 18% nitrogen (N) and 46% phosphorus (phosphorus pentoxide, P2O5). The nitrogen content of the fertilizer is in the form of ammonium (NH_4^+) (Güzel et al., 2008; Anonymous, 2019a). The applied fertilizer was mixed with the hoe and covered with soil. Nitrogen inputs and outputs per hectare were calculated by assuming arrangement of the 10x10 m walnut.

2.8. *Precipitation* and drainage measurements

The research started on November 25, 2018, but 5-day records for November are included in December. The automation system measured amount of rainfall and drainage and recorded them to the SD card every night at 23:59 o'clock in the experimental period of 157 day. In the period, the beginning and end of the months were determined according to the effect of monthly rainfall on the drainage of the next month. The start and end of months were given in *Table 3*. Monthly amounts of rainfall and drainage were determined based on the months.

Table 3. Starting and ending of the months

Months	Date range
December	25.11.2018-29.12.2018
January	30.12.2018-29.01.2019
February	30.01.2019-02.03.2019
March	03-31.03.2019
April	01-30.04.2019

The amount of precipitation (P) and drainage (qi) were calculated on a daily basis using Equation 1 (Gençoğlan et al. 2020).

$$P = \frac{S.H}{A}$$

(Eq.1).

Where, P; daily precipitation (mm), S; tipping number of bucket, H; bucket tipping volume (mm^3) and A; the funnal surface area of pluviometer (mm^2). The funnal surface area (A) of precipitation pluviometer for is 20.000 mm^2. Since the drainage pluviometer measures the water leaching from the lysimeter, the funnal surface area is 10^6 mm^2, which is the lysimeter surface area. Tipping volumes of buckets of precipitation and drainage pluviometers were determined as 5.100 mm^3 and 3.245 mm^3, respectively, by calibration.

2.9. Water and soil analysis

The first soil sample from lysimeter was taken on 25.11.2018 before fertilizer application and the last one on 15.05.2019. The first water sample leaching from the lysimeter by drainage after rains were taken on 03.12.2018 and the last sample on 08.04.2019. The leaching completely ended on 11.04.2019 and there was no leaching after this date. Therefore, while calculating the amount of the leached nitrogen, the amount of precipitation and drainage that occurred until 11.04.2019, when the leakage from the lysimeter was completely finished, was taken into account.

Water samples were taken from the water accumulated in the drainage tank after daily rainfall. After the samples were taken with 500 ml plastic bottles, and labeled with their dates and then stored at +4° C in a refrigerator. For nitrogen analysis, the Kjeldahl method was applied to the samples in 3 replication (Bremner and Mulvaney, 1982; Kacar, 2009). Nitrogen concentration values (NO_3, NH_4, mg L^{-1}) were calculated as load values (NO_3-N, NH_4-N, as kg ha^{-1}). NO_3 + NH_4 total nitrogen concentration (mineral nitrogen) represents NO_3-N + NH_4-N the total nitrogen load (N).

The concentrations of NO₃ and NH₄ in each sample were calculated using Equation 2.

$$c_i = \frac{t \cdot s}{r} 20.f \qquad \text{(Eq.2).}$$

Where, ci; the amount of concentration (mg L⁻¹), t; the amount of witness solution (50 ml⁻¹), s; amounts of standard acid (mg) used in the titrated 50 ml sample distillates, r; standard amount of acid (mg) used in the titrated 50 ml witness distillates and f refers to the dilution factor. The dilution factor (f) is used only in calculations in soil samples. In the calculation of nitrogen concentrations in soil samples, soil of 5 mg was completed to 50 mg by extraction application. Therefore, Equation 1 is multiplied by the dilution factor (f) 50/5 = 10 for soil samples. In the calculations of water samples, f is taken as 1.

Monthly NO₃ and NH₄ concentrations were calculated using Equation 3, for the monthly precipitation in experimental period.

$$C_j = Q^{-1} \sum_{i=1}^{n} c_i.q_{i_i} \qquad \text{(Eq.3).}$$

Where, Cj; monthly nitrogen (NO₃ + NH₄) concentration (mg L⁻¹), Q; the total monthly amount of drainage water (mm), n; monthly number of samples, ci; the nitrogen concentration (mg L⁻¹) and qi amount of the drained water after rainfall (mm). Monthly total nitrogen loads (NO₃-N + NH₄-N) were calculated using Equation 4.

$$L_j = 0.01. \, C_j. \, Q. \, k \qquad \text{(Eq.4).}$$

Where, Lj; monthly nitrogen load (kg N ha⁻¹), Cj; monthly nitrogen concentration (mg L⁻¹), Q; the total monthly amount of drained water (mm), k; the conversion coefficient. The oefficients were found by proportioning the atomic weight of the nitrogen element (N) to the molecule weights of the NO₃ and NH₄. These values are 0.225 for NO₃ and 0.776 for NH₄.

Regression analyzes were made between rainfall, drainage and leached nitrogen amounts to estimate the amount of nitrogen leaching from the lysimeter soil above the field capacity after rainfall. In the equations, total nitrogen load Np for precipitation and Nd for drainage (kg N ha⁻¹) were dependent variables, and amounts of precipitation (P) and drainage (d) (mm) were taken as independent variables.

3. Results and Discussion

3.1. Precipitation and drainage water

The automation system made 157 measurements with 24 hour intervals to measure the water leaching from the lysimeter after rainfall in rainy of 97days.

During experiment, a total of 868.1 mm of precipitation and 686.6 mm of drainage were measured and given in *Table 5*. The measured precipitation was well above the 533 mm average rainfall of Kahramanmaraş province for the same and long term (Anonymous, 2022). The highest precipitation and drainage was in December with 264.1 and 221.4 mm, and the lowest with 48.4 and 20.7 mm in April, respectively. In the table, there was parallelism between the amount of precipitation falling on lysimeter and drainage water from the lysimeter. The reasons for the parallelism were; being the soil moisture above the field capacity during the experimental periods and having the high precipitation causing the increased water leaching (İbrikçi et al. 2016), and degrading to a certain extent structure of the soil filled the lysimeter and being no runoff from lysimeter.

3.2. Nitrogen analysis results

Nitrogen analysis showed that, only NH₄ was obtained in the soil samples but NO₃ was not found. At the beginning of the experiment, the NH₄ of 68.6 mg kg⁻¹ (146.8 kg N ha⁻¹) in total was detected from the soil samples. Nitrogen in the form of NH₄ of 1.9 mg kg⁻¹ (4.2 kg N ha⁻¹) was applied externally to the lysimeter soil. Thus, at the beginning of study in the soil, the both nitrogen 68.6 mg kg⁻¹ (146.8 kg N ha⁻¹) + 1.9 mg kg⁻¹ (4.2 kg N ha⁻¹))

made a total of 70.5 mg kg^{-1} (151.03 kg N ha^{-1}) NH$_4$ *(Table 4)*. At the end of the experiment, a total of 20.7 mg kg^{-1} (44.3 kg ha^{-1}) nitrogen was determined in the form of ammonium in the soil.

According to this value, it was determined that 70.7% (106.7 kg N ha^{-1}) of the total nitrogen was lost in the top soil depth of 20 cm at the end of the experiment *(Table 4)*.

Table 4. Amounts of nitrogen in lysimeter soil

	mg N kg^{-1}	kg N ha^{-1}
December 2018	70.5	151.03
April 2019	20.7	44.3
Lost Nitrogen	49.8	106.7
Leaching	6.8	12.7

Drainage water analysis showded that concentrations of NO$_3$, NH$_4$ and mineral nitrogen (NO$_3$ + NH$_4$) varied between 4.5-8.2 mg L^{-1}, 0.1-1.1 mg L^{-1} and 4.7-9.0 mg L^{-1}, respectively *(Table 5)*. In drainage water samples, NO$_3$ concentrations were highest with 8.2 mg L^{-1} in March and the lowest with 4.5 mg L^{-1} in January. NH$_4$ concentrations were determined to be the highest (1.1 mg L^{-1}) in December and the lowest (0.1 mg L^{-1}) in January. Mineral nitrogen (NO$_3$ + NH$_4$) concentrations were found the highest (9.0 mg L^{-1}) in March and the lowest (4.7 mg L^{-1}) in January. During the trial season, monthly NO$_3$-N loads in the drainage water varied between 0.4-3.6 kg N ha^{-1}, NH$_4$-N loads 0.1-1.9 kg ha^{-1} and total nitrogen (N) loads between 0.5-5.4 kg N ha^{-1}. In water samples, NO$_3$-N loads were the highest (3.6 kg N ha^{-1}) in December and the lowest (0.4 kg N ha^{-1}) in April; NH$_4$-N loads were determined the highest (1.9 kg N ha^{-1}) in December and the lowest (0.1 kg N ha^{-1}) in April. According to these results, the highest amount of nitrogen (N) leached from the lysimeter by the effect of the precipitation in December (5.4 kg N ha^{-1}) and the lowest (0.5 kg N ha^{-1}) in April.

The total leached amount of nitrogen was found to be 12.7 kg N ha^{-1}. This figure was equal to 8.4% of the total (151.03 kg N ha^{-1}) nitrogen (N) in the soil at the start of experiment and 11.9% (12.7 kg N ha^{-1}) of the total nitrogen loss (106.7 kg ha^{-1}). Apart from the 12.7 kg N ha^{-1} leaching loss, reasons such as ammonium fixation, denitrification, volatization (Güzel et al. 2008) and walnut plant usage are thought to be effective in the loss of 106.7 kg N ha^{-1} nitrogen. Linn and Doran (1984) reported that denitrification may cause nitrogen loss between 2-73% in water-saturated soils, Denmead et al. (2005) found that 0.220 kg ha^{-1} nitrogen oxide is lost per day when the water-filled pore space of a sugarcane soil was between 60-80%, similarly when the pore space is between 30-60% this value is 0.096 kg ha^{-1} per day. Özbek et al. (2007), noted that 30-50% of the nitrogen applied to the soil can be lost by denitrification. In addition, it was estimated that some of the fertilizer removed from the soil by ammonia (NH$_3$) volatization, which was mixed in the first 5 cm soil. Güzel et al. (2008) reported that the ammonia loss was at maximum when the moisture content of the top soil was in the field capacity and additionally this loss was reported to reach up to 70% when the soil dried gradually with evaporation in laboratory conditions, and.

Table 5. Nitrogen concentrations and load values leached with drainage

Months	Concentrations (mg L^{-1})			Loads (kg ha^{-1})			Precipitation	Drainage
	NH$_4$	NO$_3$	Total	NH$_4$-N	NO$_3$-N	Total	(mm)	(mm)
December	1.1	7.2	8.2	1.9	3.6	5.4	264.4	221.4
January	0.3	4.5	4.7	0.5	2.5	3.0	259.0	247.6
February	0.1	6.3	6.4	0.1	1.6	1.7	154.8	114.4
March	0.8	8.2	9.0	0.5	1.5	2.0	141.8	82.5
April	0.9	8.0	8.9	0.2	0.4	0.5	48.4	20.7
Total	0.6	6.2	6.8	3.1	9.6	12.7	868.1	686.6

As seen in *Table 5*, concentration and load values were 8.2 mg L^{-1} and 5.4 kg ha^{-1}, respectively in December which was the first month of the study. Nitrogen concentrations dropped to 4.7 mg L^{-1} in January in which precipitation was 259 mm. Concentration values started to increase with the decrease of rainfall after February.

İbrikçi et al. (2016) reported that the decrease in drainage due to rainfall in winter months increased nitrogen concentrations. In addition, In addition, it is thought that since after this month soil temperature increased accelerated nitrification and may have increased the nitrogen concentrations(Muchow, 1994; Başer, 2006).

76% of the leached 12.7 kg N ha^{-1} nitrogen is in the form of nitrate (9.6 kg N ha^{-1}) and 24% (3.1 kg N ha^{-1}) in the form of ammonium. Barraclough et al. (1984) reported that the nitrate leached in the ranging of 9-75% in different fertilizer dosage applications. Ju et al. (2003) found that excessive rainfall is a factor that facilitates the movement of nitrate in the profile. İbrikci et al. (2016) reported that the plant pattern, precipitation and the amount of irrigations have important effect on the nitrate concentration in the drainage water.

The reason of nitrogen leaching by the effect of rainfall is that nitrate is a soluble and negatively charged and called the mobile ion in the soil. So, it moves naturally towards deeper of the soil along with the drainage water and finally contemnated the ground water (Özekici, 2008; Anonymous, 2013b). Therefore, nitrogen loss was by the mean of nitrogen by leaching from the soil. On the other hand, ammonium is assumed to be immobile as it is largely fixed to soil colloids and is not easily transported by water flow except under special conditions (Wiklander 1977; Johnsson et al. 1987; Aulakh and Singh 1997; Chowdary 2004; Karnez et al. 2013; İbrikci et al. 2012, 2015).

The linear regression equations were found as $N_p = 0.015p + 0.011$ ($R^2 = 0.745$) and $N_d = 0.015d + 0.228$ ($R^2 = 0.722$), respectively *(Figure 3)*. According to the R squars, precipitation has the power to explain the leached nitrogen by approximately 75% and drainage by 72%. These equations showed that the leached amount of nitrogen (N_P) and nitrogen (N_d) after rains could be estimated. As can be seen from the equation in *Figure 3*, when the precipitation of 20 mm occured, for example, the leached amount of nitrogen was 0.31 kg ha^{-1}, and with drainage of 20 mm, 0.53 kg ha^{-1} However, when rainfall and drainage stop (P = 0), it is estimated that some nitrogen ($N_p = 0.011$ kg ha^{-1} and $N_d = 0.228$ kg ha^{-1}) is leached away. Hess et al. (2020) reported in their study that the increase in the amount of precipitation increased N leaching and this situation had economic and environmental damages.
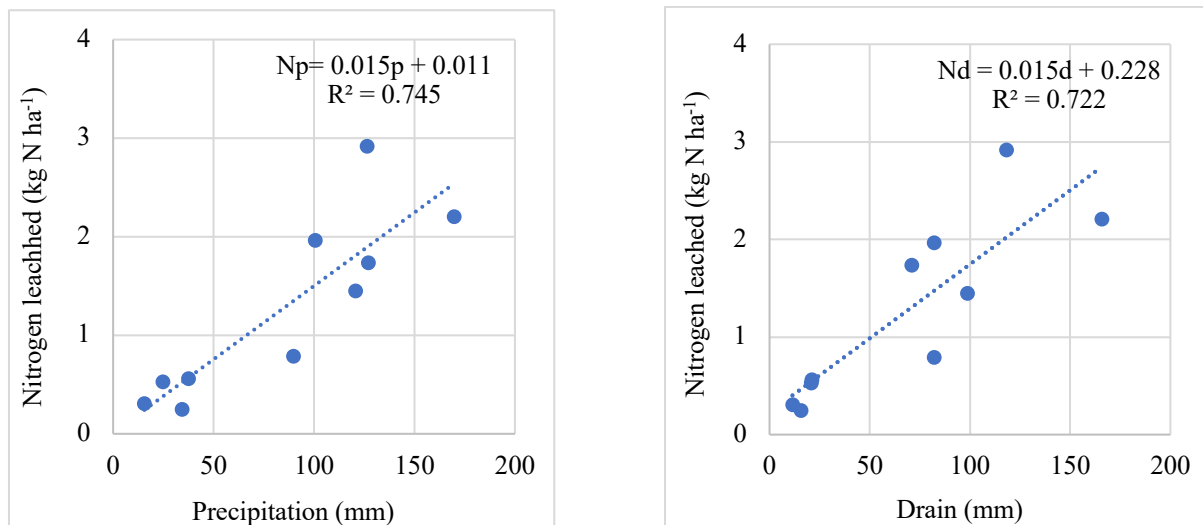

Figure 3. Relationships between precipitation, drainage, and soil leached nitrogen (N)

4. Conclusions

The automation system created made 157 measurements with 24-hour intervals to measure the water leaching from the lysimeter after rainfall in the rainy of 97days. The system recorded 868.1 mm of rainfall and 686.6 mm of drainage during the period. The highest rainfall was 264.1 mm in December 2018, the lowest precipitation was 48.4 mm in April 2019, the highest drainage was 247.6 mm in January 2019, and the lowest was 20.7 mm in April 2019. It was determined that 12.7 kg N ha^{-1} nitrogen was leached along with the drainage water, and this value was 8.4% of the total nitrogen found in the lysimeter soil at the beginning. Of the leached nitrogen, 24% (3.1 kg N ha^{-1}) is in the form of ammonium and 76% (9.6 kg N ha^{-1}) of nitrate. The results showed that applying nitrogenous (N) fertilizer to the soil regardless of seasonal rainfall, would increase nitrogen leaching.

While preparing the fertilization program in agricultural production, the type, dose, fertilization time and form of

nitrogenous fertilizers should be planned correctly, taking into account the precipitation of the region. If possible, nitrogen fertilizer should not be applied in periods of excessive rainfall or should be applied by splitting. This will provide a significant gain in terms of both protecting human health and contributing to the country's economy by reducing the input costs in production by preventing the environmental and economic impact of nitrogen loss.

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