jotaf **Journal of Tekirdag Agricultural Faculty**
Tekirdağ Ziraat Fakültesi Dergisi

Ocak/2025 2025, 22(1)
Başvuru/Received: 29/05/24
Kabul/Accepted: 07/01/25
DOI: 10.33462/jotaf.1491888

http://dergipark.gov.tr/jotaf
http://jotaf.nku.edu.tr/

ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

The Influence of Nitrogen Rates on Yield and Some Quality Parameters of Sweet Corn (*Zea mays saccharata* Sturt.) Growing in Diyarbakır Districts of Türkiye

Diyarbakır İlinde Yetiştirilen Tatlı Mısırda (*Zea mays saccharata* Sturt.) Farklı Azot Seviyelerinin Verim ve Bazı Kalite Parametreleri Üzerine Etkisi

Özlem AVŞAR[1*], Betül KOLAY[2], Uğur BİLGE[3]

Abstract

Sweet corn (*Zea mays saccharata* Sturt), is a maize subspecies with rapidly increasing consumption in the world and in Türkiye both in terms of its nutritional content and various uses in fresh, frozen and canned form. Nitrogen plays a crucial role in promoting most of plants growth and productivity. Plant nutrient recommendations are important to maximise profit and productivity in sugar maize production. The influences of nitrogen (N) fertigation on yield and some quality parameters of sweet corn under South Eastern Anatolia Region (Diyarbakır) conditions of Türkiye were investigated in that trial. Fertigation applications were executed under regional conditions of Diyarbakır on the experimental land of GAPUTAEM (GAP International Agricultural Research and Training Center). "BATEM Tatlı" variety of sweet corn was utilized as the plant material. The trial was arranged as randomized complete block design with 4 replications and five different N applications (0-75-150-225-300 kg ha^{-1}) were implemented to trial plots through a fertigation system. During the 2015 and 2016 growing season that the trial was carried out a total of 520 mm and 476 mm of irrigation water were applied, respectively. According to the study results N levels had a significant effect on fresh grain yield, crude protein ($p < 0.01$) and crude oil ($p < 0.05$). Furthermore, increased N levels had no effect on brix (dissolved solids in a liquid), L* (brightness) and a*/b* (redness/yellowness) values. Fresh grain yield (11000 kg ha^{-1}) of sweet corn under the effect of 150 kg ha^{-1} nitrogen treatment was the highest. The maximum crude protein (12.60) was recorded from 300 kg ha^{-1} N and crude oil (5.56) under the effect of 225 kg ha^{-1} nitrogen treatment was the highest. This study provides guidance for nitrogen management in sweet corn production in arid regions, such as the Southeast Region of Türkiye. Implementing 150 kg N ha^{-1} with a fertigation system is a sustainable method for sweet corn production.

Keywords: Nitrogen, Fertigation, Sweet corn

[1*]**Sorumlu Yazar/Corresponding Author:** Özlem Avşar, GAP Uluslararası Tarımsal Araştırma ve Eğitim Merkezi Müdürlüğü, Diyarbakır, Türkiye. E-mail: ozlem.avsar@tarimorman.gov.tr OrcID: 0000-0002-2408-7548

[2]Betül Kolay, GAP Uluslararası Tarımsal Araştırma ve Eğitim Merkezi Müdürlüğü, Diyarbakır, Türkiye. E-mail: betül.kolay@tarimorman.gov.tr OrcID: 0000-0002-9505-0152

[3]Uğur Bilge, GAP Uluslararası Tarımsal Araştırma ve Eğitim Merkezi Müdürlüğü, Diyarbakır, Türkiye. E-mail: udrbilge@gmail.com OrcID: 0000-0001-8909-723X

Atıf: Avşar, Ö., Kolay, B., Bilge U. (2025). Diyarbakır ilinde yetiştirilen tatlı mısırda (*Zea mays saccharata* Sturt.) farklı azot seviyelerinin verim ve bazı kalite parametreleri üzerine etkisi. *Tekirdağ Ziraat Fakültesi Dergisi,* 22(1): 175-186.
Citation: Avşar, Ö., Kolay, B., Bilge U. (2025). The influence of nitrogen rates on yield and some quality parameters of sweet corn (*Zea mays saccharata* Sturt.) growing in Diyarbakır districts of Türkiye. *Journal of Tekirdag Agricultural Faculty,* 22(1): 175-186.

Öz

Tatlı mısır gerek besin içeriği gerekse taze, dondurulmuş ve konserve şeklindeki değişik kullanımı ile dünyada ve Türkiye'de hızla tüketimi artan bir mısır alttürüdür. Azot, birçok bitkinin büyümesinde ve verimliliğinde önemli bir rol oynamaktadır. Tatlı mısır üretiminde kârı ve verimliliği en üst seviyeye çıkarmak için gerekli bitki besin elementi tavsiyeleri önem taşımaktadır. Bu çalışma da Türkiye'nin Güneydoğu Anadolu Bölgesi (Diyarbakır) koşullarında farklı azot (N) gübreleme seviyelerinin mısırda (*Zea mays saccharata* Sturt.) verim ve bazı kalite parametreleri üzerine etkileri araştırılmıştır. Çalışma Diyarbakır ili koşullarında GAPUTAEM (GAP Uluslararası Tarımsal Araştırma ve Eğitim Merkezi) deneme arazisinde yürütülmüş ve bitki materyali olarak BATEM tatlı tatlı mısır çeşidi kullanılmıştır. Araştırma tesadüf blokları deneme desenine göre 4 tekerrürlü olarak düzenlenmiş ve fertigasyon sistemi ile beş farklı N uygulaması (0-75-150-225-300 kg ha^{-1}) yapılmıştır. Denemenin yürütüldüğü 2015 ve 2016 yetiştirme sezonu boyunca sırasıyla toplam 520 mm ve 476 mm sulama suyu uygulanmıştır. Çalışma sonuçlarına göre, N seviyelerinin taze dane verimi, ham protein ($p < 0.01$) ve ham yağ ($p < 0.05$) üzerinde istatistiki olarak önemli bir etkiye sahip olduğu görülmüştür. Ayrıca artan N seviyelerinin brix (sıvıdaki çözünmüş katı madde), L* (parlaklık) ve a*/b* (kırmızılık/sarılık) değerleri üzerinde herhangi bir etkisi olmamıştır. Tatlı mısırın en yüksek taze dane verimi (11000 kg ha^{-1}) 150 kg ha^{-1} azot uygulamasından elde edilmiştir. En yüksek ham protein değeri (12.60) 300 kg ha^{-1} N'den elde edilirken, ham yağ ise (5.56) 225 kg ha^{-1} azot uygulamasında en yüksek değere sahip olmuştur. Bu çalışma, Türkiye'nin Güneydoğu Bölgesi gibi kurak bölgelerde tatlı mısır üretiminde fertigasyon yöntemiyle uygulanması gereken optimum azot uygulaması konusunda yol göstermekle birlikte 150 kg N ha^{-1} uygulaması sürdürülebilir bir yöntem olarak öne çıkmıştır.

Anahtar Kelimeler: Azot, Fertigasyon, Tatlı mısır

1. Introduction

Cereals are major products which cover a wide area of the world. Among cereals, corn is crucial for both human nutrition and animal feed. As a result of the development of high-yield regular, breeding different varieties and its extensive adaptation to environmental conditions, corn took a part as a leader, beating rice and wheat. In terms of grain production per hectare, it is the highest-grading cereal. For a large number of industrial output and biofuels, corn is essential and has a great economic importance not only for human consumption but also for animal nutrition (Shyam et al., 2021). Sweet corn (*Zea mays* L.) may be distinguished from other types of corn consumed before the physiologic ripening period with a short shelf life due to a higher respiration rate, which remains fresh and before all sugar's conversion towards starch (Okumura et al., 2013). Furthermore, compared to field corn, sweet corn offers higher prices for kg ha^{-1} but yields are low. Lack of systematic research and the absence of better varieties are major reasons for this low yield (Khan et al., 2017). The sweetness taste of sweet corn is owing to a genetic mutation in the field corn's su ("sugary") gene, which affects the conversion of sugar to starch in the grain's endosperm. Standardized practices for cultivating and managing the process of sweet corn after harvest have been widely prevalent (Singh et al., 2014). Consuming sweet corn, which is present in various dishes as an ingredient, has become popular in Türkiye due to its numerous health benefits.

Among the essential nutrients for proper plant cultivation including sweet corn, nitrogen (N) has a significant role as it is required for chlorophyll production and protein synthesis (Basal and Szabo, 2020). Supplementing nitrogen fertilizer is necessary to meet the demand of plants, as the naturally present N in soil is usually insufficient for achieving high yields (Sainju and Singh, 2008). During the vegetative growth period, leaves require a large quantity of nitrogen, and healthy leaf growing is crucial for both fruit production and retention (Oosterhuis et al., 1983). When plants experience a shortage of nitrogen, they tend to display stunted growth and smaller leaves. Due to the high mobility of nitrogen through phloem, older leaves demonstrate chlorosis at the beginning of nitrogen absence. The lack of N causes the chloroplast disruption and if the nitrogen deficiency is not compensated, the plant may die (Alimohammadi et al., 2011).

Sweet corn responds differently to nitrogen fertilizer application, which depends on soil properties, irrigation methods, N application time and frequency. However, the relationship between nitrogen application and its effect on the yield of sweet corn is not well-understood, especially when excessive nitrogen is applied via drip fertigation. Based on the different climatic conditions, plant varieties as well as sowing time, researchers suggest a varying rate of application of N for sweet corn. The most effective N application rate for sweet corn was reported as 110.8 kg ha^{-1} N (Okumura et al., 2014), 240 kg ha^{-1} N (Bhatt, 2012), and 120 kg ha^{-1} N (Masood et al., 2003) whereas some other researchers (Khazaei et al., 2010) revealed that the grain yield was not affected by the difference in nitrogen rate. Developing optimum nitrogen management implementations for plants can enhance grain yield, efficiency, quality and profitability for producers while reducing soil nitrate accumulation and minimizing leaching to groundwater (Schlegel and Havlin, 1995). As a notable crop, sweet corn requires large amount of nitrogen, which can be supplemented by applying fertilizer to the soil.

Freshwater is crucial for agricultural activities as it is used to irrigate cultivated area and provide water for plants (Jeet et al., 2022). Meteorological forecasts predict that water scarcity will be a critical factor affecting food security and environmental safety. Improving the water and N use efficiency is crucial for sustainable agriculture, rural development, and environmental protection (Šútor and Gomboš, 2006).

To provide the required nutrients and irrigation water of the plant, it is important to consider the amount, method, and frequency of application. From this point of view drip irrigation is a proven method that offers agronomic, economic, and agro-technical benefits for efficient water and fertilizer use. It can replace surface irrigation, with 90% water use efficiency (Allen, 1998). Drip fertigation is an efficient farming technique that involves the application of liquid fertilizer through irrigation. One of the most significant advantage of drip fertigation is providing crop nutrients on an as-needed basis by delivering water and nutrients directly to the crop root zone, which helps to reduce the possibility of environmental contamination. This technique is also known as "spoon-feeding" and helps in precise delivery of water and nutrients to the crops. One previous study suggested that drip fertigation can improve sweet corn yield in open fields, producing up to four ears per stalk (Takeshita et al., 2019).

Prevalent embracement of drip irrigation corn yields and irrigation water efficiency have improved over the last few years in Türkiye unfortinately water use efficiency in South East Anatolia Region included Diyarbakır province is still far lower because of applying surface irrigation systems in corn cultivation. Additionally, local farmers are generally tended to apply high rates of N-fertilizers to obtain high yields. However, excessive use of N leads to serious environmental risks through its loss into the environment rather than better absorption. Regarding the findings of the study conducted in the Southeast Anatolia Region, an increase in the yield of sweet corn and grain protein content with an increase in N rates and the highest fresh ear yields were obtained at 240 kg N ha^{-1} through furrow irrigation system (Öktem, 2007). In the meantime, reported that further studies are necessary to assess the impact of NPK fertilizer applications on maize production in a moderate semi-arid environment.

As a consequence, further improvements related to increasing water use efficiency and optimum N management strategies remain a significant requirement for the region as mentioned by (Nasseri, 2021). Although several studies have been conducted on corn production via drip fertigation, utilize various nitrogen levels, limited research has been carried out on sweet corn, applying different rates of nitrogen in Türkiye and also in Southeast Anatolia Region.

Based on the above discussion, the main goals of this study were to assess how sweet corn production responds to varying levels of nitrogen, and to increase the farmer's income by improving the yield while optimizing N rates.

2. Material and Method

A field study was performed at GAP International Agricultural Research and Training Center (GAPUTAEM) Diyarbakır, Türkiye, in 2015-2016 years, to investigate the reaction of sweet corn to nitrogen levels on the yield and some soil properties. Deep craks (up to 80-90 cm) arises on the soil surface in summer as a consequence of clay-based feature of soil (Gürsoy et al., 2006).

The soil was sampled from 0-30 cm depth through a drill and analysed at GAPUTAEM laboratory and the findings is given in *Table 1*. The soil of experimental area was clay-loam, low in organic matter, high in obtainable potassium and low in phosphorus with no salinity problems. The mean bulk density of the soil in 2015 and 2016 growing season is 1.33 and 1.25 g cm^{-3} is respectively. The field had not been planted any plant about 2 years before this experiment was conducted. With the assistance of a pressure plate, field capacity (FC) and permanent wilting point (PWP) values were determined, and the available water capacity (AWC) was calculated as subtraction from FC to PWP values (Tüzüner, 1990).

Table 1. Some soil features of experimental site

Years	2015	2016
Texture	Clay-Loam (C-L)	Clay-Loam (C-L)
EC (dS m^{-1})	1.65	0.90
pH	8.10	8.25
CaC03 (%)	9.97	11.00
P2O5 (kg ha^{-1})	3.21	4.02
K2O (kg ha^{-1})	243	243
Organic Matter (%)	“0.95	1.10
Bulk Density (g/cm^3)	1.33	1.25
Field Capacity (%)	44.05	44.03
Permanent Wilting Point (%)	30.04	30.08

Diyarbakır is one of the provinces in the Southeastern Anatolia Region where continental climate prevails.

Table 2 shows the climatic data for the years in which the study was conducted (2015-2016) and for long years. In the light of this information, it is observed that the average temperature values of 2016 (15.7 °C) are above the average temperature values of 2015 and long years. *Table 2* shows that the average maximum temperature value (40 °C) determined in July 2015 is above the average maximum temperature values of long years and 2016 and the average monthly precipitation values for long years (68.2 mm) are higher than the average precipitation values in 2015 and 2016 years.

Table 2. Monthly data of the climate in Diyarbakır for long period and during the 2015-2016 growing season of sweet corn

Meteorological data	Years	April	May	June	July	August
Average temperature (°C)	Long Years	13.8	19.2	26.3	31.1	30.4
	2015	12.4	18.8	26.1	31.7	30.9
	2016	15.7	19.9	26.8	31.6	31.9
Average maximum temperature (°C)	Long Years	20.4	26.5	33.6	38.4	38.2
	2015	19.2	27.1	34.4	40	39.3
	2016	23.7	27.5	34.7	39.2	40.5
Average minimum temperature (°C)	Long Years	7.2	11.3	16.9	21.8	21.1
	2015	5.5	10.3	15.9	21.4	21.2
	2016	7.1	11.6	17.3	22.5	22.1
Monthly average rainfall (mm)	Long Years	68.2	42.9	8.1	0.7	0.4
	2015	48.6	48.2	7.4	0	0
	2016	29	41.4	18.4	0	0.2

Reference: Diyarbakir meteorological directorate https://www.mgm.gov.tr/ ; *among 1950-2014 years

2.1. Characteristics of the plant material

Türkiye's first local sweet corn variety developed by the Directorate of Western Mediterranean Agricultural Research Institute was registered in 2013. The variety was developed within the scope of Sugar Maize Variety Development studies, which is a sub-project of the Mediterranean Region Maize Breeding Research project supported by the General Directorate of Agricultural Research and Policies (TAGEM). BATEM TATLI is a standard type of sweet corn variety with an average fresh cob yield of 1 513 kg ha^{-1} and grain yield of 589 kg ha^{-1} with crude protein (10.7%), crude fat (6.7%), starch (53.3%) and sugar (4.8%) contents. Sweet corn, which is a hot climate plant, requires at least eight hours of direct sunlight per day. Planting should occur after the last frost of spring, and when the soil's temperature at a depth of 7-8 cm is at least 10-12.7 °C. Low soil temperature causes low germination rate and negatively affects cultivation. Harvesting fresh corn varies depending on the region and climate, but typically takes 70-80 days (Anonymous, 2014).

2.2. Irrigation system and nitrogen treatments

The experiment was organized as a randomized complete block design, which included four replications. The trial area was tillaged and levelled before planting. Sweet corn seeds were planted by hand with a row spacing of 70 cm and 20 cm (intra-row spacing) with a sowing depth of 5-6 cm and 71400 seeds per hectare on April 20 and 25, 2015 and 2016 respectively. The experiment consisted of 20 plots in total, with 5 plots in each block and a distance of 3 meter was maintained between blocks and 2-meter between plots. The experiment comprised of 20 plots in total, with 5 plots in each block.

All observations were attained from two rows in each plot and all treatments were harvested at the milk stage, based on the thumbnail method (Çetinkol, 1989). During both years, the initial irrigation was implemented using sprinkler irrigation for uniform emergence. For the remaining irrigations, drip irrigation method was implemented twice a week and the amount of irrigation water was determined by measuring the amount of evaporation from Clas A Pan adjusting the wetting area ratio accordingly. The soil water content was monitored by gravimetric method at 15-day intervals during the drip irrigation treatment to a depth of 90 cm every week and irrigation water was applied to reach the field capacity, from a depth of 30 cm on each plot. The drip irrigation and fertigation were scheduled once in five days and ten days respectively as required the treatments. As a result of the analyses, irrigation water electrical conductivity value (EC): 0.60 dS/m, pH: 7.6 were determined. Required irrigation water has been calculated depend on the Class A pan evaporation, utilizing the given equation.

$$I = A.Ep.Kp.Pc \quad \text{(Eq. 1)}$$

Where I equals required irrigation water (I), A equals irrigated plot area (m^2), Ep equals cumulative evaporation quantity for 5 day intervals (mm), Kp equals coefficient (including pan coefficient kp, crop coefficient kc), and Pc equals canopy cover area (%). The canopy cover percentage was initially set at 30% for the first irrigation, and the subsequent irrigations performed via measured values.

Utilizing the water balance equation and soil water measurements, plant water consumption was estimated. The formula for calculating plant water consumption includes irrigation, precipitation, water leakage, and soil water content changes during the season. The formula for calculating plant water consumption includes irrigation, precipitation, water leakage, and soil water content changes during the season as shown:

$$ET = I + P \pm DS - D \qquad \text{(Eq. 2)}$$

Where: ET is evapotranspiration (mm), I irrigation (mm), P precipitation (mm), D deep percolation (mm) and DS is change of soil water storage. Assuming negligible deep percolation losses below the root zone, the study implemented irrigation based on field capacity. Soil water content was measured every 15 days at 0-90 cm soil layer during both growing seasons using the gravimetric method (oven dry basis). During the cultivation periods of 2015 and 2016, 520 mm and 476 mm of irrigation water were respectively implemented. Chemical pesticides were applied and weed control applications were implemented during the entire plant growth season. The crop evapotranspiration for 2015 and 2016 was calculated as 554 mm and 495 mm, respectively. Five pure nitrogen dosses (0, 75, 150, 225 and 300 kg ha^{-1}) were performed in the trial. Nitrogen doses were determined as the lower and upper values of the nitrogen levels applied by the farmers cultivating maize. Triple Super Phosphate (42% P_2O_5) and Ammonium Sulphate (21% N) were utilized as the base fertilizer, and Ammonium Nitrate (33% N) was applied as the top fertilizer. The reason for selecting these fertilizers is that they can be used for fertilizing through the fertigation system. Based on the soil analysis conducted in both years of the experiment, an equal amount of 100 kg ha^{-1} phosphorus and 1/5 of the designated nitrogen was added to each parcel as a base fertilizer. The remaining 4/5 of the nitrogen was applied equally once every two irrigations using the fertigation method till one week before the harvest. With this fertilization schedule, the sweet corn plant's nitrogen demand is adequately met during the necessary periods (Çetin and Tolay, 2009).

Due to the sufficient potassium content of soil potassium fertilization was not implemented during both growing seasons. The plants were harvested on August 1 and August 3, 2015 and 2016 respectively, during the milk stage.

In the trial, fresh grain yield, brix value, crude protein content, crude oil content, brightness (L*) and yellowness/redness (a*)/(b*) values were explored. In the middle of two rows for each parcel, observations on brix, crude protein content, crude oil content, brightness (L*) and yellowness/redness (a*)/(b*) values have been made from 10 random chosen plants while the fresh grain yield were attained from every plant in the middle of a pair of rows. The calculations of the properties investigated in the study were performed according to the methods of the Ministry of Agriculture and Forestry, Agricultural Values Measurement Trials Technical Instruction (Anonymous, 2015). The data obtained in the study were evaluated via JMP 5.1 statistical package. Analysis of variance (ANOVA) and Least Significant Difference (LSD 0.05) test was attained by combination of two years.

3. Results and Discussion

Perusal of the data revealed that different N level applications had a significant ($P \leq 0.01$) effect on fresh grain yield (FGY) of sweet corn. Maximum FGY values (11000.7 kg ha^{-1}) was reported when N was applied at the rate of 150 kg ha^{-1}, but further increase in N rate for both years has negative significant effect on FGY (*Table 3*). These results in line with Kara and Kırtok (2006), Yılmaz (2005) who emphasized that FGY increased with increasing nitrogen level. Turgut (1998), stated that the highest yield of sweet corn fresh ear yield was attained at 280 kg ha^{-1} of nitrogen level based on regression analyses via surface irrigation method. The effects of the years on FGY were defined to be significant ($P \leq 0.01$) in the study. In comparison to 2016, the average value of FGY increased in 2015. Average maximum temperature values of 2015 (39.3 °C) were higher than 2016 (40.5 °C). High temperature values occurred hourly especially during the flowering period in July affected the yield values. The high yield values in 2015 can be associated with climate data. Upon examining *Table 2*, it becomes apparent that average monthly precipitation values for 2016 were lower than those of 2015. This indicates that the growing season in 2016 was drier than in 2015, and the higher yields in the latter year can also be attributed to the study being conducted on a fallow field.

Table 3. Influence of different nitrogen rates on some properties of sweet corn in the 2015-2016 growing seasons

		N levels					
		0 kg ha^{-1}	**75 kg ha^{-1}**	**150 kg ha^{-1}**	**225 kg ha^{-1}**	**300 kg ha^{-1}**	**Mean**
Fresh grain yield (kg ha-^{1})**	2015	7 920.5	10 330.7	14 040.2	12 500.7	8 660.7	10 690.6 a
	2016	5 070.7	6 650.7	7 970.2	6 410.5	6 310.5	6 480.7 b
	Mean	6 500.1 d	8 490.7 bc	11 000.7 a	9 460.13 ab	7 490.1 cd	
	CV (%)	18	LSD $_{(0.01)}$: Nitrogen Levels:165			LSD $_{(0.01)}$: Years:215	
Brix **	2015	23.00	24.13	22.38	21.75	23.00	22.90 b
	2016	27.13	25.88	25.13	26.25	24.75	25.82 a
	Mean	25.19	25.00	23.75	24.00	23.88	
	CV (%)	8.2	LSD $_{(0.01)}$: Years:1.9				
Crude protein (%)**	2015	10.60	11.33	11.45	11.70	11.73	11.36
	2016	10.80	11.00	11.65	11.90	12.40	11.55
	Mean	10.70 d	11.16 c	11.55 bc	11.80 ab	12.60 a	
	CV (%)	3.4	LSD $_{(0.01)}$: Nitrogen Levels:0.4				
Crude oil (%) *, **	2015	5.18	5.28	5.30	5.33	5.20	5.25 b
	2016	5.45	5.60	5.73	5.80	5.73	5.66 a
	Mean	5.31 b	5.44 ab	5.51 a	5.56 a	5.46 ab	
	CV (%)	16	LSD $_{(0.05)}$: Nitrogen Levels:0.16			LSD $_{(0.01)}$: Years:0.07	
L(Brightness) *	2015	68.45	65.80	71.07	66.89	67.87	67.87 b
	2016	69.00	69.25	71.88	69.00	70.20	70.20 a
	Mean	68.70	67.53	71.47	69.52	67.94	
	CV (%)	8.9	LSD $_{(0.05)}$: Years:2.26				
Yellowness/redness (a*/b*)	2015	0.280	0.283	0.243	0.270	0.330	0.280
	2016	0.270	0.285	0.288	0.278	0.288	0.280
	Mean	0.275	0.284	0.265	0.274	0.309	
	CV (%)	14					

** significant at the level of 0.01; * significant at the 0.05 level

Based on regression analysis between nitrogen levels (X) and FGY (Y). FGY increased in a quadratic way for N rates (*Figure 1*). The relation among N levels and FGY was formed by y: 538.51 + 2.82 X – 0.467 X^2 (R^2: 0.15) equation. Increase N levels up to 150 kg ha^{-1} leads to increase in FGY. Lower FGY values were attained from 225 and 300 kg ha^{-1} N rates. A previous study, in which the recommended N level for sweet corn was 300 kg ha^{-1} under surface irrigation conditions was performed in the same field that this study was conducted (Kılınç et al., 2023). However, in the mentioned study, it has been detected that applying only 150 kg ha^{-1} of nitrogen using a fertigation system can result in the highest sweet corn yield, which is only half of the recommended nitrogen level. This finding not only helps reduce the production cost for producers, but also helps prevent soil and water pollution, which is vital for sustainable agriculture.

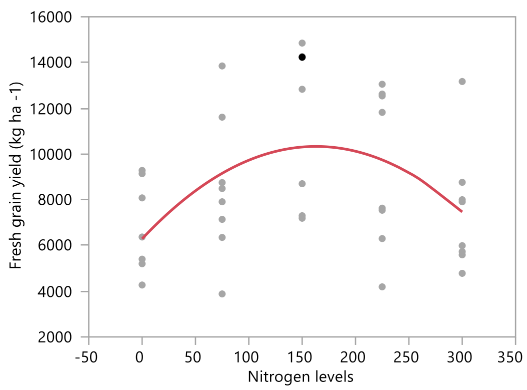

Figure 1. Influence of nitrogen levels on fresh grain yield

Starch and oil are crucial components of corn grain. Sweet corn quality can be assessed based on its protein, oil content, and brix (total soluble solids). Brix represents the percentage of solids present in the kernel juice and is directly related to the overall plant quality. In fact, it encompasses a blend of sucrose, fructose, vitamins, minerals, amino acids, proteins, hormones, and other solid components. A higher brix level indicates superior taste and nutritional value (Harrill, 1998). At milk maturity, about l0 g of grains from the mid-section of each of 10 ears were cut and squeezed by hand and the milky endosperm fluid was poured onto a refractometer and measured in °Brix, which is an estimated expression of total sugar. The utilize of different N rates did not lead to a significant difference in brix values, although there was an increase by 25.82% during 2016 growing season (*Table 3*). According to White et al. (2007), the composition of grain is affected by environment factors such as temperature, soil type, planting date, year and location leading to changes in quality.

Regression analysis was performed to determine association between nitrogen levels (X) and brix values (Y) The relationship between them viewed as Brix = 22.694286 – 0.0216667 X+ 0.0023175 X^2 (R^2: 0.007211) the equation. No significant difference in brix was observed for any of N levels (*Figure 2*).

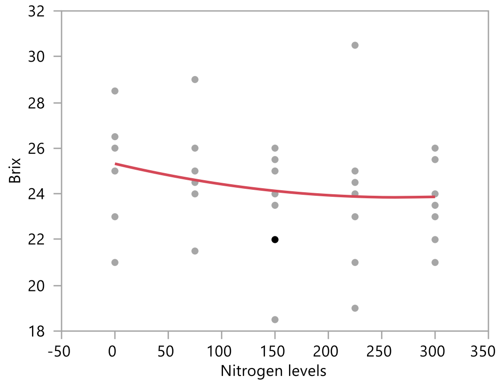

Figure 2. Influence of nitrogen levels on brix value

Applying different rates of nitrogen fertilization affected both the crude protein and oil contents of sweet corn grains, as illustrated in *Table 3*. The grains were dried in an oven following harvest. Four replicates of each sample from each N rate were examined. Ten subsamples for the protein and oil contents of each plot were gathered using near-infrared (NIR) technology. The values of crude protein ranged from 10.70% to 12.06%. The application of 300 kg ha^{-1} N level resulted in the highest and 0 kg ha^{-1} eventuated the lowest (10.70%) crude protein content. Goldberg (2003) reported that cereals contain 6-15% protein and that most corn protein (75%) comes from the endosperm (Shewry, 2007), which is consistent with these findings. One of the reasons for the rise in protein in grain could be due to the presence of N, which is part of protein (Haque et al., 2001). One possible explanation for the rise in protein content is that nitrogen is a building block of amino acids, and amino acids build up nitrogen over time. The oil content of sweet corn grains ranged from 5.31% to 5.56%. The highest oil content values were achieved from 2016 growing season (5.66%) and 225 kg ha^{-1} N application (5.56%) while the lowest ones obtained from 0 kg ha^{-1} (5.31) and 2015 growing season (5.25). No interaction existed between the effect of the year and different N applications. Similarly, according to Patil et al. (1996) the application of N increased oil content. This could be due to fact that synthesis of fat requires N. In contrast, Holou and Kindomihou (2011), reported no interaction (P = 0.14) existed between the effect of the year and that of the N rate and N fertilization did not significantly affect the average oil content of the grain.

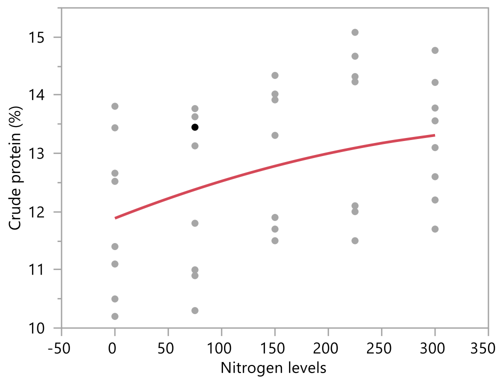

Figure 3. Influence of nitrogen levels on crude protein

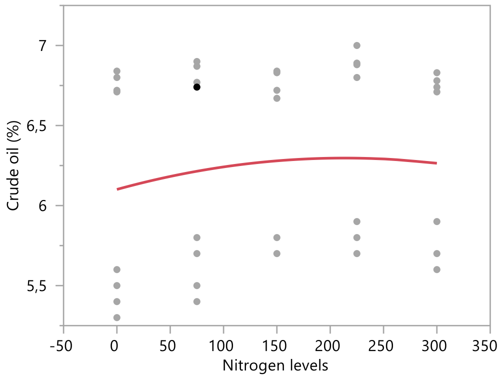

Figure 4. Influence of nitrogen levels on crude oil

A significant correlation between the crude protein content and the different N concentrations was observed in the regression analysis and the relationship was interpreted according to y:12.069536 + 0.0475333 X – 0.0008159 X^2 (R^2: 0.147289) the equation. The crude protein content was increased as N application levels increased.

Regression analysis was performed to determine association between nitrogen levels (X) and oil content (Y) and the relationship between N levels and oil content based on y: 6.1976429 + 0.00545 X – 0.0004302 X^2 (R^2: 0.014544) the equation (*Figure 4*).

Grain colour was determined by calculating L, a* and b* parameters obtained by spectrophotometer (model: CM-3220d, Minolta, Japan) according to CIELAB colour system and reported in terms of L*, a*/b* values at three different points on the cobs, including the tip, middle and bottom of the cob. The L* value symbolizes the brightness, the* value redness (positive value) and greenness (negative value), and the b* value is the yellowness (positive value) and the blueness (negative value).

Colour properties of fresh grains were shown in *Table 3*. Grain brightness values were not significantly influenced by N rates in both years. The mean values were between 67.53 and 71.47. The second year of the experiment has signified a significant increase (P≤0.05) in bright quality. This indicates that the grains grown in 2016 (70.20) were brighter in colour than those grown in 2015 (67.87). Regression analysis was performed to determine association between nitrogen levels (X) and L * values (Y) and the relationship between them viewed as y: 72.955036 + 0.0232 X – 0.0110825 X^2 (R^2: 0.099892) the equation (*Figure 5*).

The results in *Table 2* indicated that a*/b* colour parameters were not significantly affected by different nitrogen rates and also no difference between years was reported. Regression analysis was executed to investigate the relationship between nitrogen levels (X) and a*/b* colour parameters (Y) with Y:2646429 + 0.0001667 X + 0.0000254 X^2 (R^2: 0.008666) the equation (*Figure 6*).

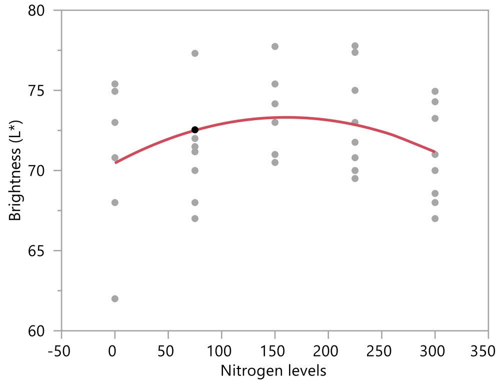

Figure 5. Influence of nitrogen levels on brightness (L*)

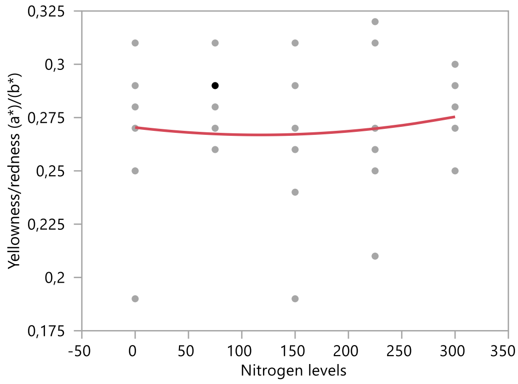

Figure 6. Influence of nitrogen levels on yellowness/redness (a*)/(b*)

4. Conclusions

This experiment targeted to evaluate the appropriate nitrogen level for sweet corn using the fertigation system, relying on two years of data. Increasing nitrogen application rates caused an increase in fresh grain yield of BATEM TATLI sweet corn variety up to 150 kg ha^{-1} N level while higher N applications (225 and 300 kg ha^{-1}) cause a decrease. The highest crude oil (5.56) was obtained under the treatment of 225 kg ha^{-1} nitrogen, while the maximum crude protein (12.60) was recorded under the treatment of 300 kg ha^{-1} N. However, nitrogen levels had no marked effects on brix, L* and a*/b* values. The impact of different climatic conditions on FGY, brix, crude oil, and L properties showed significant differences between years.

According to the results of the study 150 kg ha^{-1} of nitrogen was acquired to be the optimum level for sweet corn production. Farmers in the South-eastern Anatolia region who produce corn performing surface irrigation methods tend to apply around 250-300 kg ha^{-1} N of nitrogen. Nevertheless, the study presented that almost half of this nitrogen amount is overused, resulting in inefficiencies and potential environmental impacts. However, further research is required to examine the effects of different nitrogen levels on various sweet corn varieties under field conditions.

Acknowledgment

That trial was financially supported by Republic of Türkiye, the Ministry of Agriculture and Forestry, TAGEM (General Directorate of Agricultural Research and Policies) with TAGEM/TBAD/14/A12/P03/002 project no.

Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Author Contributions

The authors of the manuscript declare that they have contributed equally to the study.

References

Alimohammadi, M., Yousefi, M. and Zandi, P. (2011). Impact of nitrogen rates on growth and yield attributes of sweet corn grown under different Phosphorus levels, *Journal of American Science,* 7(10): 201-206.

Allen, R. G. (1998). Crop Evapotranspiration-Guideline for computing crop water requirements. *Irrigation and Drain,* 56: 300.

Anonymous (2014). Features of BATEM TATLI variety. https://arastirma.tarim.gov.tr/batem (Accessed Date: 01.03.2015).

Anonymous (2015). Ministry of Agriculture and Forestry. "Measuring Agricultural Values Technical Instructions". https://www.tarim.gov.tr

(Accessed Date: 10.08.2015).

Basal, O. and Szabó, A. (2020). Yield and quality of two soybean cultivars in response to drought and N fertilization. *Journal of Tekirdag Agricultural Faculty,* 17(2): 203-210.

Bhatt, P. S. (2012). Response of sweet corn hybrid to varying plant densities and nitrogen levels. *African Journal of Agricultural Research,* 7(46): 6158-6166. https://doi.org/10.5897/AJAR12.557

Çetin, Ö. and Tolay, I. (2009). Fertigation: Fertilisation combined with irrigation. *Hasad Publishers*, 160 (In Turkish).

Çetinkol, M. (1989). Sweet corn production. *Hasad Monthly Agriculture and Livestock Journal,* 4(46), 20-23 (In Turkish).

Goldberg, G. (2003). Recommendations of The Task Force. Plants: diet and health. The report of a British Nutrition Foundation Task Force, 282-285.

Gürsoy, S., Kılıç, H. and Sessiz, A. (2006*). Determination of the most suitable seedbed preparation and sowing method after cotton harvest in cotton-wheat crop rotation system in Southeastern Anatolia Region*. Final Report of Research Project. Republic of Turkey Ministry of Agriculture and Rural Affairs, General Directorate of Agricultural Research, Southeastern Anatolia Agricultural Research Institute (In Turkish).

Haque, M. M., Hamid, A. and Bhuiyan, N. I. (2001). Nutrient uptake and productivity as affected by nitrogen and potassium application levels in maize/sweet potato intercropping system. *Korean Journal of Crop Science*, 46(1), 1-5.

Harrill, R. (1998). Using a Refractometer to Test The Quality of Fruits and Vegetables. Pineknoll Publishing, U.S.A.

Holou, R. A. Y. and Kindomihou, V. (2011). Impact of nitrogen fertilization on the oil, protein, starch, and ethanol yield of corn (*Zea mays* L.) grown for biofuel production. *Journal of Life Sciences,* 5: 1013-1021.

Jeet, P., Singh, D. K., Sarangi, A., Mali, S. S. and Singh, A. K. (2022). Delineation of potential water harvesting site for agriculture water planning in Betwa basin of India using geospatial and analytical hierarchical process technique. *Geocarto International*, 37(25): 8315-8335.

Kara, B. and Kırtok, Y. (2006) Determination of the yield, nitrogen uptake and use efficiency of corn on the different plant density and nitrogen doses in the Çukurova conditions. *Çukurova University Journal of Agriculture Faculty*, 21: 23–32.

Khan, Z. H., Khalil, S. K., Iqbal, A., Ullah, I., Ali, M., Shah, T. and Shah, F. (2017). Nitrogen doses and plant density affect phenology and yield of sweet corn. *Fresenius Environmental Bulletin, 2*6(6): 3809-3815.

Khazaei, F., Alikhani, M. A., Yari, L. and Khandan, A. (2010). Study the correlation, regression and path coefficient analysis in sweet corn (*Zea mays var. saccharata*) under different levels of plant density and nitrogen rate. *Journal of Agricultural and Biological Science*, 5(6): 14-19.

Kılınç, S., Atakul, Ş., Kahraman, Ş., Aktaş, H., Erdemci, İ. and Gül, İ. (2023). The effect of sowing times on some yield and quality characteristics of sweet corn (*Zea mays sacchararata* Sturt.) varieties. *Kahramanmaraş Sütçü İmam University Journal of Agriculture and Nature.,* 26(2): 282-292. https://doi.org/10.18016/ksutarimdoga.vi.1049530

Masood, M., Shamsi, I. H., Hussain, N. and Shah, W. A. (2003). Performance of various maize varieties as affected by different NP levels, *Asian Journal of plant Science,* 2(7): 535-538.

Nasseri, A. (2021). Long-term water productivity of maize (*Zea mays* L.) from limited irrigation conditions under moderate semi-arid environment. *Journal of Tekirdag Agricultural Faculty*, 18(3): 400-410.

Oktem, A. (2007). Effect of nitrogen on fresh ear yield, protein content and micronutrient concentration of sweet corn. *Philippine Agricultural Scientist*, 90(4): 289-294.

Okumura, R. S., de Cinque Mariano, D., Franco, A. A. N., Zaccheo, P. V. C. and Zorzenoni, T. O. (2013). Sweet corn: Genetic aspects, agronomic and nutritional traits. *Applied Research & Agrotechnology,* 6(1)*:* 105-114.

Okumura, R. S., Vidigal Filho, P. S., Scapim, C. A., Marques, O. J., Franco, A. A. N., Souza, R. S. and Reche, D. L. (2014). Effects of nitrogen rates and timing of nitrogen topdressing applications on the nutritional and agronomic traits of sweet corn. *Journal of Food, Agriculture and Environment,* 12(2): 391-398.

Oosterhuis, D. M., Chipamaunga, J. and Bate, G. C. (1983). Nitrogen uptake of field-grown cotton. I. Distribution in plant components in relation to fertilization and yield. *Experimental Agriculture,* 19(1): 91-101. https://doi.org/10.1017/S0014479700010553

Patil, D. B., Lakkineni K. C. and Bhargawa, S. C. (1996). Seed yield and yield contributing characteristics as influenced by N supply in rapeseed-mustard. *Journal of Agronomy and Crop Science,* 177: 197–205.

Sainju, U. M. and Singh, B. P. (2008). Nitrogen storage with cover crops and nitrogen fertilization in tilled and nontilled soils. *Agronomy Journal,* 100(3): 619-627. https://doi.org/10.2134/agronj2007.0236

Schlegel, A. J. and Havlin, J. L. (1995). Corn response to long-term nitrogen and phosphorus fertilization. *Journal of Production Agriculture*, 8(2): 181-185.

Shewry, P. R. (2007). Improving the protein content and composition of cereal grain. *Journal of cereal science,* 46(3): 239-250. https://doi.org/10.1016/j.jcs.2007.06.006

Shyam, C. S., Rathore, S. S., Shekhawat, K., Singh, R. K., Padhan, S. R. and Singh, V. K. (2021). Precision nutrient management in maize (*Zea mays*) for higher productivity and profitability. *The Indian Journal of Agricultural Sciences*, 91(6): 933-935.

Singh, I., Langyan, S. and Yadava, P. (2014). Sweet corn and corn-based sweeteners. *Sugar Tech,* 16: 144-149. https://doi.org/10.1007/s12355-014-0305-6

Šútor, J. and Gomboš, M. (2006). Volume changes of heavy soils of east Slovakian lowland. *Cereal Research Communications*, 34(1): 299-302.

Takeshita, M., Nakanishi, K., Takahashi, T., Minohara, T., Maeyama, T., Hibi, T. and Goto, H. (2019). Effects of drip irrigation and fertigation on yield and production of multiple ears of sweet corn in Japan. *Japanese Journal of Farm Work Research*, 54(3): 151-161.

Turgut, İ. (1998). Effect of plant density and nitrogen doses on fresh ear yield and yield components of sweet corn grown under Bursa conditions. *Turkish Journal of Agriculture and Forestry,* 24(2000): 341- 347.

Tüzüner, A. (1990). Soil and Water Analysis Laboratory Manual. Ministry of Agriculture, Forestry and Rural Affairs, General Directorate of Rural Services, Ankara,. Türkiye.

White, P. J., Pollak, L. M. and Duvick, S. (2007). Improving the fatty acid composition of corn oil by using germplasm introgression. *Lipid Technology*, 19(2): 35-38. https://doi.org/10.1002/lite.200600009

Yılmaz, M. F. (2005). *The effect of different row spacing and nitrogen doses on yield, yield components and seed quality of second crop maize (Zea mays L.) under Kahramanmaraş conditions.* (MSc. Thesis). Department of Field Crops, Kahramanmaraş Sütçü İmam University, Institute of Science and Technology, Kahramanmaraş, Türkiye.