THE EFFECT OF NITROGEN APPLICATION IN DIFFERENT DOSES BY FERTIGATION METHOD ON GRAIN YIELD, YIELD COMPONENTS AND QUALITY OF CORN (*Zea mays* L.)

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Abstract. This study was aimed to determine the most appropriate nitrogen amount for maize using fertigation method. Trials were conducted in 2018 and 2019 with 4 replicates according to the randomized blocks design in Sanliurfa, Turkey. Each plot area was 14 m^2 (5 m x 2.8 m) and consisted of four rows of 5 m in length. DKC-6664 maize variety was used in the study as a crop material. Drip irrigation system was used with 5-day intervals according to daily evaporation values. Irrigation water was given using 1.25 coefficient of Class A Pan evaporation. Ten separate nitrogen doses were applied with the irrigation water at 0 kg da^{-1}, 4 kg da^{-1}, 8 kg da^{-1}, 12 kg da^{-1}, 16 kg da^{-1}, 20 kg da^{-1}, 24 kg da^{-1} 28 kg da^{-1}, 32 kg da^{-1} and 36 kg da^{-1} (1 da = 1000 m^2). According to the results of the two-year average, grain yield ranged from 434 to 1594 kg da^{-1}. The leaf area per plant varied between 112 and 621 cm^2 $plant^{-1}$, protein content between 7.39% and 8.84%, starch content between 70.90% and 71.62%, and oil content between 4.20% and 4.66%. In general, the properties examined increased from the N0 application to the N28 application. Increasing nitrogen doses applied by fertigation method had a positive effect on the investigated properties. Based on average of years, the highest grain yield was determined in 28 kg da^{-1} nitrogen application with fertigation system. However, no statistical difference was observed between N24 and N28 applications.
Keywords: *maize, N, drip irrigation, protein, starch, oil*

Introduction

Corn is an annual hot climate cereal. It can be grown in tropical and subtropical temperate climates, and it can be cultivated almost anywhere in the world. Corn is a plant used as human food, animal feed and industrial raw material.

Stalk, leaves and grains are used as animal feed (Oktem and Oktem, 2020a). Grains and starch are used in human nutrition and in the food industry. In addition to these consumption areas, it is also consumed as a snack. Moreover, its use in the oil, sweetener industries and biofuel-bioethanol production has been increasing in recent years (Oktem and Oktem, 2020b).

Due to global warming and the gradual decrease of water resources, research and development studies on the effective use of water have increased. The use of pressurized irrigation systems such as drip irrigation has come to an important point concerning the use of water, which is an important input in the agricultural sector, at an optimum level. Drip irrigation system saves water compared to other irrigation systems and increases the effective use of water by the plant. In addition, drip irrigation system allows plant nutrients to be given in combination with irrigation water (Oktem, 2008a).

Nitrogen is absolutely essential and the most widely used plant macronutrient. The application of nitrogen fertilizers together with irrigation water in drip irrigation systems (fertigation) provides an increase in fertilizer use efficiency and yield. Therefore,

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irrigation methods and nitrogen fertilization application are key factors in increasing the yield of plants. Proper management of these two factors is necessary for environmental protection and high production (Oktem, 2008b).

Determining the appropriate fertilizer dose in the corn plant is important in terms of high efficiency, cost reduction and minimum damage to the environment. In previous studies, it was stated that the most appropriate nitrogen dose in corn plant was 25 kg N da^{-1} (Cokkızgın, 2002).

In another study, it was stated that increasing nitrogen doses had a positive effect on vegetative parameters; however, it was stated that the applications made above 25 kg N da^{-1} were not statistically significant (Kaplan and Aktas, 1993). Although the highest yield was obtained from 36 kg N da^{-1} dose in the study conducted on maize plant, it was stated that statistically 27 kg N da^{-1} dose was more appropriate (Kara, 2006).

In a study in which 5 different nitrogen doses (0, 24, 32, 40 and 48 kg N da^{-1}) were tested in two corn varieties (89MAY70 and Shemal), it was found that nitrogen doses positively affected the grain yield and the highest grain yields were obtained from 40 and 48 kg da^{-1} nitrogen doses (Tunalı et al., 2012). In a study where four different nitrogen doses (0, 7, 14 and 21 kg da^{-1}) were researched it has been reported that nitrogen doses have a statistically significant effect on plant height, first ear height and grain yield (Can and Akman, 2014).

It has been reported that the highest yield values were obtained from 15 kg da^{-1} N doses in the sweet corn plant, where 0, 7.5, 15, 22.5 and 30 kg da^{-1} pure nitrogen doses were applied by the fertigation method (Avsar et al., 2018).

The aim of this study is to determine the most appropriate amount of nitrogen to be applied by fertigation method in drip irrigation in maize plant and to find out the effects of applied nitrogen on yield and yield components of maize plant and quality.

Material and methods

Study design and experimental procedures

This study was carried out at the second crop conditions of the Harran Plain, Sanliurfa, Turkey in 2018 and 2019. The research was set up in a randomized block design with 4 replications. DKC-6664 single cross hybrid corn variety was used as plant material in the study. The climate data of the research area is given in *Table 1*, and the soil properties are given in *Table 2*. During the trial years, the temperature increased above 40 ^{0}C in June, July and August, and the average relative humidity was observed between 29.3% and 36.6%. There was no rainfall in July and August and rainfall was very low in June and September (*Table 1*). There was no climatic factor limiting corn cultivation, and the plants were grown without any problems with the irrigation.

The soil of the trial area is low in organic matter, calcareous, high in potassium, and has a harmless salinity (*Table 2*). The soil characteristics of the experimental area are alluvial, flat and deep soils. Typical red profiles have clay texture. The entire profile is very calcareous and has a pH between 7.3 and 7.8 (Dinc et al.,1988).

Before planting, the soil was first plowed with a mouldboard plough, then processed with a goble disc and made ready for planting by pulling the float. In the experiment, each plot consisted of 4 rows with a 5 m length. Row spacing was 70 cm, intra row spacing was 16 cm and sowing depth was 5-6 cm. Sowing was done on 25 June 2018 and 24 June 2019 with a pneumatic seed drill. Chemical spraying was done against weeds and pests. Harvesting was done when the plants were completely dry.

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Table 1. *Climatic data of 2018 and 2019 years of the research area*

	Lowest temperature (^{0}C)		Highest temperature (^{0}C)		Average temperature (^{0}C)		Average relative humidity (%)		Precipitation (mm)	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
April	9.3	5.9	32.1	26.8	19.9	14.4	38.4	67.0	35.8	97.4
May	12.2	10.1	36.3	40.3	23.0	25.2	50.1	35.8	64.5	7.3
June	16.2	18.6	43.1	44.1	28.6	30.7	36.6	30.6	10.1	8.9
July	21.2	19.7	43.2	42.3	31.9	31.7	34.2	29.6	0.0	0.0
August	20.8	20.7	42.2	45.8	32.2	32.8	33.6	29.3	0.0	0.0
September	17.7	15.9	41.5	39.5	28.8	27.9	31.3	30.3	2.2	0.2
October	9.3	11.3	34.2	36.2	21.6	22.9	45.6	44.9	39.4	45.1
November	5.4	-	27.5	-	13.0	-	72.5	-	106.6	0.0

Table 2. *Some physical and chemical properties of the trial area soil*

Soil properties	**2018**		**2019**	
Deep	**0-20**	**20-40**	**0-20**	**20-40**
pH	7.81	7.91	7.95	7.87
EC (ds/m)	1.31	1.00	0.91	0.90
Lime (%)	26.90	26.90	28.10	27.30
Phosphorus P_2O_5 (kg da-^{1})	6.42	4.12	4.69	4.69
Potassium K_2O (kg da-^{1})	213.30	171.60	145.20	150.30
Organic matter (%)	2.01	1.61	1.69	1.60
Nitrogen (%)	0.15	0.14	0.12	0.12
Sandy (%)	25.28	25.28	30.00	28.00
Clay (%)	56.00	52.00	48.88	48.80
Silt (%)	18.72	22.72	21.12	23.12

An analysis-of-variance (ANOVA) was performed using Jump statistical package program to evaluate statistical differences between research results. Means of the data obtained from research were compared using DUNCAN test at $P \leq 0.05$ (Yurtsever, 1984).

Application of irrigation water

Sprinkler irrigation was applied in all plots immediately after planting to obtain a sufficient output. When the plants have 3-4 leaf, nitrogen doses were started to be given to all plots with the drip irrigation system. During both trial years, laterals were placed in the drip irrigation system, one lateral to two plant rows, with 140 cm spacing (Oktem, 2008a).

The irrigation water to be given to the parcels was calculated as 1.25 times the 5-day cumulative evaporation amount obtained from the Class-A Pan container (Oktem, 2008a). Irrigation water was given to the parcels at 5-days intervals after correcting with the soil cover percentage of the plant (Oktem, 2006).

During the 2018 growing season of the experiment, 790 mm of total irrigation water was applied, and 759 mm during the 2019 growing season. Some chemical properties of irrigation water used in the research was given *Table 3*.

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Irrigation was continued until the end of the physiological maturity period of the plants. *Fig. 1* shows design of drip irrigation and fertigation system in the research.

Figure 1. *Design of drip irrigation and fertigation system in the reseach area*

The equation (*Eq.1*) given below was used in the calculation of irrigation water (Oktem and Oktem, 2009).

$$I = Ep \text{ x } Kcp \text{ x } P \text{ x } A \quad \text{(Eq.1)}$$

In the equality I is the amount of irrigation water (lt), EP is Evaporation from Class A-Pan (mm), Kcp is Pan coefficient (Kcp= 1.25), P is Cover percentage (%), A represents the parcel area (m^2).

The following equation (*Eq.2*) was used in the calculation of the cover percentage (Kanber and Gungor, 1986).

$$\% P = a/b \text{ x } 100 \quad \text{(Eq.2)}$$

In the equality a = The width of the projection of the above-ground part of the plant, b = It represents distance between two plants.

Application of fertilizers

Fertilization was done considering the soil analysis results of the experimental area. Ten pure nitrogen doses were used in the trial that is 0 kg da^{-1}, 4 kg da^{-1}, 8 kg da^{-1}, 12 kg da^{-1}, 16 kg da^{-1}, 20 kg da^{-1}, 24 kg da^{-1}, 28 kg da^{-1}, 32 kg da^{-1} and 36 kg da^{-1} (1 da = 1000 m^2). The total nitrogen doses were divided into 10 equal parts considering vegetation period of used variety and given with the drip irrigation system until the end of tasselling period. Nitrogen was given according to BBCH scale from phenological growth stage 1(13) to 5(59) (Lancashire et al., 1991). 1/10 of the total amount of pure nitrogen to be given and the whole amount of pure phosphorus (10 kg P_2O_5 da^{-1}) were given at once with planting. In the experiment, triple super phosphate $CaH_4(PO_4)_2.H_2O$ (43-44%) fertilizers were used as phosphorus source and urea (46% N) fertilizers were used as nitrogen source. In order to prevent the passage of nitrogen, a space of 2.0 m was left between the plots and 3.0 m between the blocks.

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Results and discussion

Plant height (cm)

It was determined that the effect of nitrogen amount applied at different doses by the fertigation method on plant height was statistically significant (P≤0.01). The plant height values in 2018, 2019 and the average of the two years of the study varied between 170.75 - 270.38 cm, 179.60 - 284.60 cm and 175.18 - 277.49 cm, respectively (*Table 3*). In both experimental years, the lowest plant height was obtained from the N0 application, and the highest plant height was obtained from the N28 application (*Fig. 2*). Although genetic factors affect plant height (Oktem and Oktem, 2013), in parallel with our findings, some researchers reported that plant height increased depending on nitrogen applications (Oktem, 2008b; Cerny et al., 2012; Ullah et al., 2015; Avsar et al., 2018).

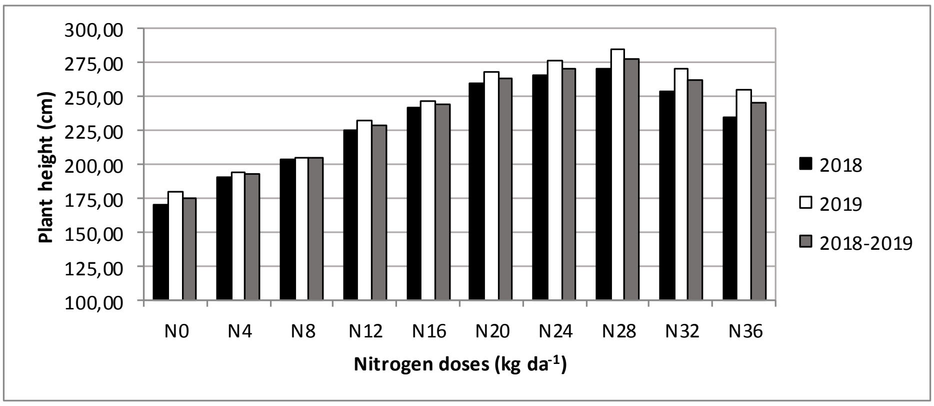

Figure 2. *Plant height values at different nitrogen doses given by fertigation method*

Table 3. *Plant height and stem diameter values at different nitrogen doses given by fertigation method*

N Doses	Plant height** (cm)			Stem diameter** (mm)		
(kg da^{-1})	2018	2019	2018-2019	2018	2019	2018-2019
N0	170.75 g†	179.60 g	175.19 g	10.65 e	10.85 g	10.75 g
N4	191.00 f	194.00 f	192.50 f	12.65 d	12.80 f	12.73 f
N8	204.13 e	205.50 f	204.81 e	15.03 c	14.80 e	14.91 e
N12	225.25 d	232.30 e	228.75 d	15.88 c	15.95 d	15.91 d
N16	242.50 c	246.30 d	244.38 c	15.78 c	16.05 d	15.91 d
N20	260.25 ab	267.60 bc	263.94 b	19.18 ab	19.55 b	19.36 b
N24	265.75 a	276.10 ab	270.94 ab	20.08 a	20.48 a	20.28 a
N28	270.38 a	284.60 a	277.50 a	20.10 a	20.45 a	20.28 a
N32	253.75 b	271.10 ab	262.44 b	17.95 b	18.63 c	18.29 c
N36	235.13 c	255.40 cd	245.25 c	12.98 d	13.28 f	13.13 f
Mean	231.89	241.25	236.57	16.03	16.28	16.15
CV	1.55	1.97	1.55	3.02	1.61	2.31

†: There is no significant difference at 0.05 level between the averages shown in the same letter according to Duncan test, **: denotes P≤0.01

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Stem diameter (mm)

According to the results of analysis of variance, the effect of different nitrogen doses applied by fertigation method on stem diameter was found to be statistically significant (P≤0.01). It was observed that the stem diameter varied between 10.65 mm (N0) and 20.10 mm (N28) in 2018, and between 10.85 mm (N0) and 20.48 mm (N24) in 2019 (*Table 3*). According to the combined analysis results of two years; stem diameter ranged from 10.75 to 20.28 mm (*Fig. 3*). The lowest stem diameter was obtained from the N0 application (10.75 mm), and the highest stem diameter (20.28 mm) was obtained from the N28 application (*Table 4*). Similar to our results, it has been reported that stem thickness increases depending on nitrogen applications (Oktem and Oktem, 2005; Kara, 2006; Kılınc et al., 2018; Kahriman et al., 2020).

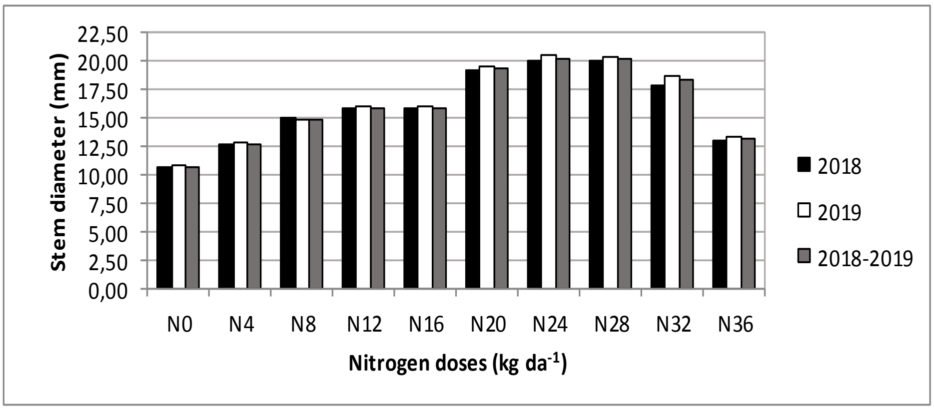

Figure 3. *Stem diameter values at different nitrogen doses given by fertigation method*

Table 4. *Ear length and ear diameter values at different nitrogen doses given by fertigation method*

N doses	Ear length** (mm)			Ear diameter** (mm)		
(kg da^{-1})	2018	2019	2018-2019	2018	2019	2018-20
N0	7.05 h†	6.93 i	6.99 i	34.53 e	33.90 g	34.22 f
N4	8.53 g	8.40 ı	8.47 ı	36.25 e	36.15 f	36.20 e
N8	12.13 f	10.90 h	11.52 h	41.23 d	41.73 e	41.48 d
N12	13.65 e	12.48 g	13.07 g	42.75 cd	43.68 de	43.22 c
N16	14.68 d	14.88 e	14.78 e	43.85 c	43.85 de	43.85 c
N20	16.85 c	16.45 d	16.65 d	47.78 b	47.95 ab	47.87 b
N24	18.68 b	18.90 b	18.79 b	48.50 ab	49.33 ab	48.92 ab
N28	20.88 a	21.45 a	21.17 a	50.60 a	50.73 a	50.67 a
N32	17.60 bc	17.60 c	17.60 c	46.68 ab	47.65 bc	47.17 b
N36	14.03 de	13.98 f	14.01 f	44.18 c	45.23 cd	44.71 c
Mean	7.05	6.93	6.99	43.64	44.02	43.83
CV	8.53	8.40	8.47	2.01	2.04	1.99

†: There is no significant difference at 0.05 level between the averages shown in the same letter according to Duncan test, **: denotes P≤0.01

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Ear length (cm)

The effect of different nitrogen doses applied by fertigation method on ear length was determined to be statistically significant (P≤0.01). In 2018, 2019 and the average of the two years, the ear lengths varied between 7.05 and 20.88 cm, 6.93 and 21.45 cm and 6.99 and 21.17 cm, respectively (*Fig. 4*).

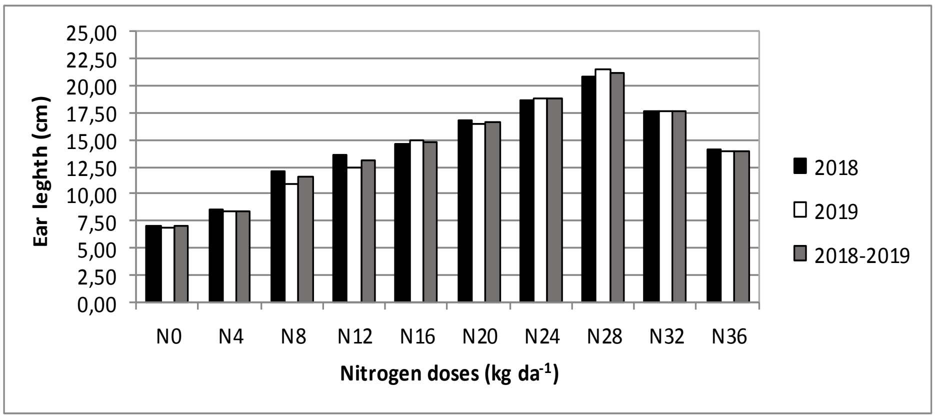

Figure 4. *Ear length values at different nitrogen doses given by fertigation method*

In both trial years, the lowest ear length was obtained from the N0 application, and the highest ear length was obtained from the N28 application (*Table 4*). Similar to our findings, it has been reported by some researchers that as the nitrogen dose increases, the ear length increases (Saruhan and Sireli, 2005; Oktem and Oktem, 2005; Kara, 2006; Oktem, 2008b; Safdarian et al., 2014).

Ear diameter (mm)

The effect of different nitrogen doses on ear diameter in corn plant grown by fertigation method was found to be statistically significant (P≤0.01). According to 2018 values, the lowest ear diameter was obtained from the N0 subject (34.53 mm), and the highest ear diameter was obtained from the N28 subject (50.60 mm). Ear diameter varied between 33.90 mm (N0) and 50.73 mm N28 in the 2019 growing season (*Table 4*).

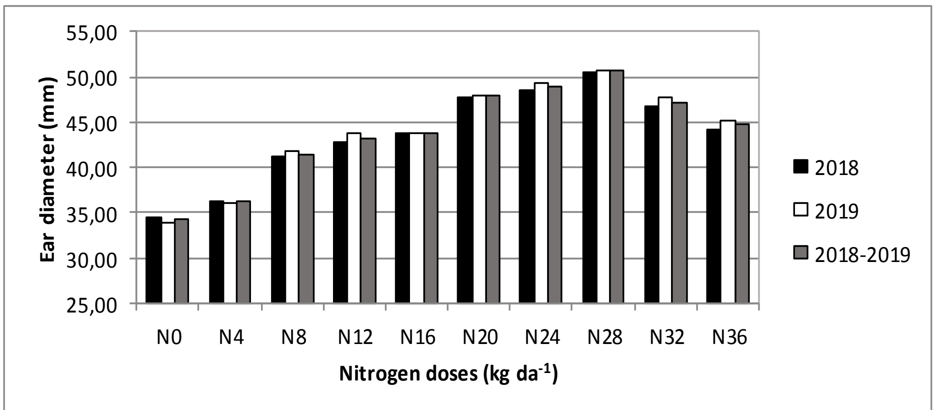

Figure 5. *Ear diameter values at different nitrogen doses given by fertigation method*

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According to the average of two years; the lowest ear diameter was found in N0 (34.22 mm), and the highest ear diameter (50.67 mm) was found in N28 (*Fig. 5*). In parallel with the increase in nitrogen doses, the ear diameter values also increased. Some researchers have stated in their studies that the ear diameter increases depending on the increased nitrogen doses (Saruhan and Sireli, 2005; Kara, 2006; Oktem, 2008b; Can and Akman, 2014).

Thousand kernel weight (g)

The effect of different nitrogen amounts on thousand kernel weight in corn plant was found to be statistically significant (P≤0.01). According to the 2018 values of the study, it was observed that the thousand-kernel weight varied between 274 g and 319 g, and in the 2019 growing season, it varied between 309 g and 373 g (*Table 5*).

Table 5. *Thousand kernel weight and grain yield values at different nitrogen doses given by fertigation method*

N doses	Thousand kernel weight** (g)			Grain yield** (kg da^{-1})		
(kg da^{-1})	2018	2019	2018-2019	2018	2019	2018-2019
N0	310 ab	309 d†	310 c	315 h	553 h	434 f
N4	299 abc	333 c	316 c	610 g	846 g	728 e
N8	274 c	344 bc	309 c	892 f	1047 f	970 d
N12	297 abc	331 c	314 c	1074 e	1189 e	1132 c
N16	300 abc	339 bc	320 bc	1229 c	1331 d	1280 b
N20	305 ab	349 b	327 abc	1301 bc	1393 c	1347 b
N24	315 a	369 a	342 ab	1428 ab	1499 b	1464 a
N28	319 a	373 a	346 a	1567 a	1621 a	1594 a
N32	297 ab	370 a	334 abc	1201 cd	1351 cd	1276 b
N36	289 bc	369 a	329 abc	1106 de	1105 f	1106 c
Mean	301	349	325	1072	1194	1133
CV	6.36	1.75	4.45	5.60	3.46	3.83

†: There is no significant difference at 0.05 level between the averages shown in the same letter according to Duncan test, **: denotes P≤0.01

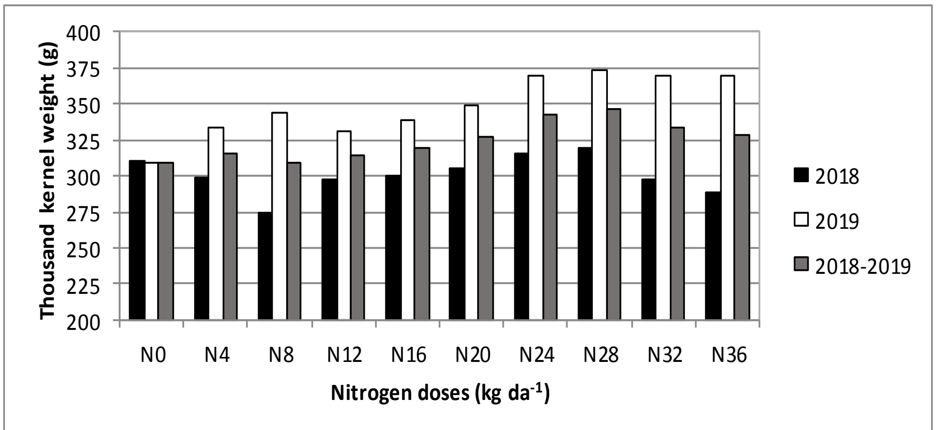

Figure 6. *Thousand kernel weight values at different nitrogen doses given by fertigation*

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According to the combined analysis results of two years; the thousand kernel weights varied between 310 g and 346 g in different N treatments. Increasing nitrogen doses had a positive effect on the grain weight (*Fig. 6*). Some researchers reported that the thousand kernel weight increased with increasing nitrogen doses and reported similar results with our findings (Amaral et al., 2005; Kara, 2006; Yururdurmaz, 2007).

Grain yield (kg da^{-1})

According to the results of analysis of variance, it was determined that the effect of different nitrogen doses given by fertigation method on grain yield was statistically significant ($P \leq 0.01$). In 2018, 2019 and the average of the two years of the research, it was observed that the grain yield values changed between 315 and 1567 kg da^{-1}, between 553 and 1621 kg da^{-1}, and between 434 and 1594 kg da^{-1}, respectively. In both trial years, the lowest grain yield was found in N0 application and the highest grain yield was found in N28 application (*Table 5*). But N24 and N28 applications were in the same statistical group at means of years. As the amount of nitrogen increased, the grain yield increased up to 28 kg da^{-1} nitrogen dose, after which a decrease was observed.

Increasing nitrogen doses had a positive effect on grain yield (*Fig. 7*). The nitrogen use efficiency can vary according to genotypes. Supporting our findings, some researchers stated that grain yield increased in response to increasing nitrogen dose (Allen et al., 2000; Oktem et al., 2001, 2010; Blumental et al., 2003; Tunalı et al., 2012; Yolcu, 2014; Avsar et al., 2018; Koca and Ibrikci, 2019). A significant second order polynomial relationship was found between grain yield and nitrogen doses in average of both years as shown in *Fig. 7* ($P \leq 0.01$). The relationship equation was $y = -28.831x^2 + 402.39x + 29.775$ ($R^2 = 0.9529$). From the regression analysis (*Fig. 7*), it seems appropriate to give 24 kg da^{-1} nitrogen to corn by fertigation method.

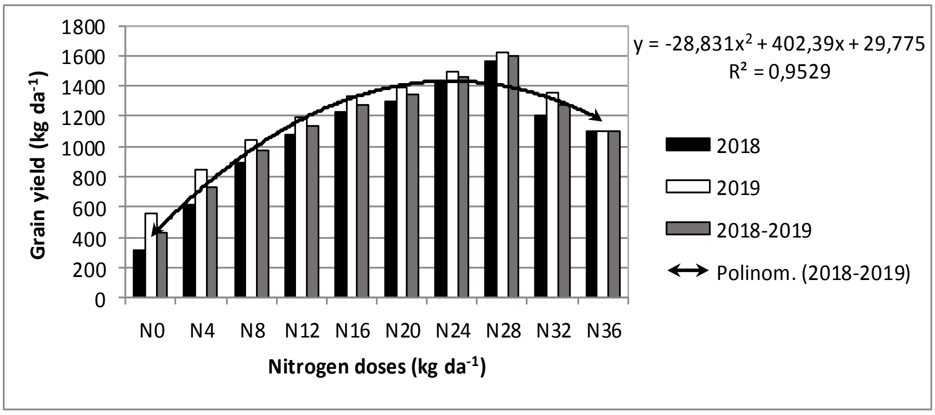

Figure 7. *Gain yield values at different nitrogen doses given by fertigation method*

Leaf area of plant (cm^2 bitki^{-1})

The effect of different nitrogen amounts on the leaf area of the plant was found to be statistically significant ($P \leq 0.01$). In the 2018 trial year, the leaf area per plant varied between 108 cm^2 plant^{-1} (N0) and 613 cm^2 plant^{-1} (N28). In 2019, the lowest leaf area was taken from the N0 application (116 cm^2 plant^{-1}), and the highest plant (629 cm^2 plant^{-1}) was taken from the N28 application (*Table 6*).

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Table 6. *Leaf area and protein content of kernel values at different nitrogen doses given by fertigation method*

N doses (kg da^{-1})	**Leaf area** (cm^2 plant-^{1})**			**Protein content** (%)**		
	2018	**2018**	**2018-2019**	**2018**	**2019**	**2018-2019**
N0	108 f†	116 g	112 g	7.48 b	7.30 b	7.39 b
N4	151 ef	158 f	154 f	8.03 ab	7.95 ab	7.99 ab
N8	170 e	176 f	173 f	8.20 ab	8.03 ab	8.11 ab
N12	231 d	251 e	241 e	8.23 ab	8.10 ab	8.16 ab
N16	308 c	324 d	316 d	8.28 ab	8.13 ab	8.20 ab
N20	416 b	457 b	436 b	8.70 ab	8.20 ab	8.45 ab
N24	547 a	566 a	557 a	8.85 ab	8.35 ab	8.60 a
N28	613 a	629 a	621 a	8.88 a	8.80 a	8.84 a
N32	370 b	400 c	385 c	8.83 ab	8.43 ab	8.63 a
N36	227 d	244 e	236 e	8.73 ab	8.38 ab	8.55 a
Mean	314	332	323	8.42	8.17	8.29
CV	3.91	2.31	3.22	4.00	4.00	4.00

†: There is no significant difference at 0.05 level between the averages shown in the same letter according to Duncan test, **: denotes P≤0.01

According to the combined analysis results of two years, it was observed that the leaf area per plant varied between 112 cm^2 plant^{-1} (N0) and 621 cm^2 plant^{-1} (N28). Leaf area values increased in parallel with the increase in nitrogen (*Fig. 8*). Supporting our research findings, some researchers reported that leaf area values increased with increasing nitrogen doses (Yururdurmaz, 2007; Hokmalipour et al., 2011; Tunalı et al., 2012).

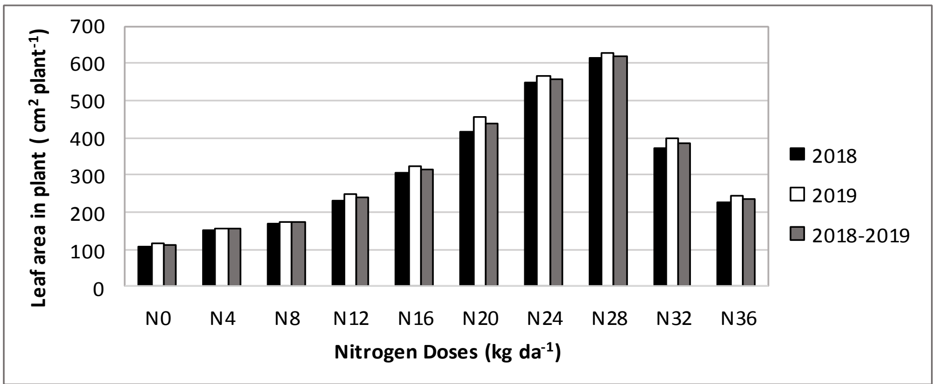

Figure 8. *Leaf area in plant values at different nitrogen doses given by fertigation method*

Protein content of kernel (%)

According to analysis of variance, the effect of different nitrogen amount on kernel protein content was found to be statistically significant (P≤0.01). According to the combined analysis results of two years it was observed that the protein content in the kernel varied between 7.39% and 8.84% in different N applications (*Fig. 9*).

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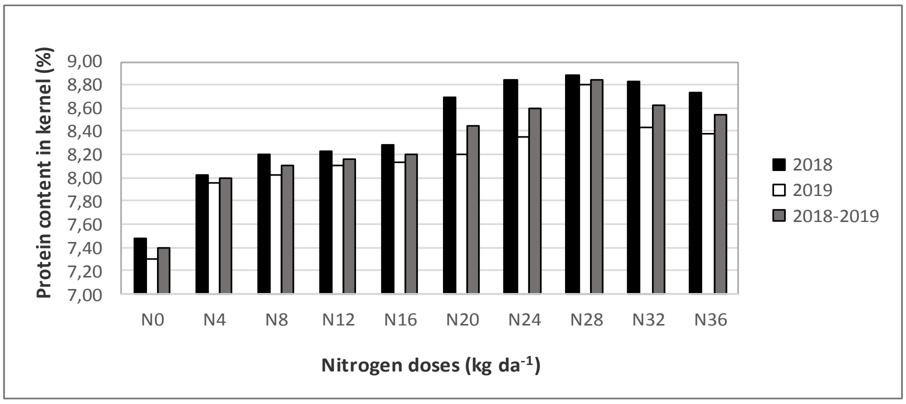

Figure 9. *Protein content of kernel values at different nitrogen doses given by fertigation*

The lowest kernel protein content was obtained from N0 application, and the highest kernel protein content (8.84%) was obtained from N28 application (*Table 6*). Parallel to our findings, some researchers stated that the protein ratio increased as the nitrogen dose increased (Patricio Soto et al., 2004; Oktem, 2008c; Oktem et al., 2010; Ullah et al., 2015; Avsar et al., 2018; Kılınc et al., 2018; Kahriman et al., 2020). Ozsisli (2010), on the other hand, reported higher protein content values than our findings.

Starch content of kernel (%)

The effect of different nitrogen amount applied by fertigation method on starch content in kernel was not found statistically significant. According to the combined analysis results of two years; the starch content in kernels varied between 70.90% and 71.62%. The lowest starch content in the kernel was obtained from the N36 application (70.90%), and the highest starch content in the kernel (71.62%) was obtained from the N8 application (*Table 7*).

Table 7. *Starch and oil content of kernel values at different nitrogen doses given by fertigation method*

N Doses	Starch content** (%)			Oil content** (%)		
(kg da^{-1})	2018	2019	2018-2019	2018	2019	2018-2019
N0	69.68	72.80	71.24	4.15 b†	4.25 b	4.20 c
N4	70.58	72.08	71.33	4.25 ab	4.35 ab	4.30 bc
N8	70.95	72.28	71.62	4.35 ab	4.40 ab	4.38 abc
N12	70.85	72.05	71.45	4.43 ab	4.48 ab	4.45 abc
N16	70.85	72.25	71.55	4.45 ab	4.48 ab	4.46 abc
N20	70.48	72.15	71.32	4.48 ab	4.50 ab	4.49 ab
N24	70.48	71.60	71.04	4.55 a	4.60 ab	4.58 ab
N28	69.90	72.05	70.98	4.59 a	4.73 a	4.66 a
N32	70.88	71.95	71.42	4.48 ab	4.55 ab	4.51 ab
N36	70.45	71.35	70.90	4.48 ab	4.55 ab	4.51 ab
Mean	70.51	72.06	71.28	4.42	4.49	4.45
CV	0.97	1.16	1.06	7.65	4.23	6.36

†: There is no significant difference at 0.05 level between the averages shown in the same letter according to Duncan test, **: denotes P≤0.01

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In parallel with our findings, similar starch content values in maize have been reported by some researchers (Ignjatovic-Micic et al., 2014; Kahriman et al., 2020). Some other researchers reported lower starch content values than our findings (Ozsisli, 2010; Kılınc et al., 2018).

Oil content of kernel (%)

According to the analysis of variance, it was determined that the effect of different nitrogen amounts applied by fertigation method on the oil content in the grain was statistically significant (P≤0.01). According to the values of the first year of the study, the lowest oil content in the grain was obtained from the N0 application (4.15%), and the highest oil content in the grain (4.59%) was obtained from the N28 application.

It was observed that the oil content in the grain varied between 4.25% (N0) and 4.73% (N28) in the 2019 growing season (*Table 7*). According to the combined analysis results of two years; the lowest oil content in the kernel was taken from the N0 application (4.20%), and the highest kernel oil content (4.66%) was taken from the N28 application. It has been reported that the oil content of the corn kernel is 4.3% (Watson, 2003). Josipovic et al. (2014) reported that grain oil ratios ranged from 3.50 to 4.17%.

The oil content in the kernel increased from N0 application to N28 application (*Fig. 10*). Increasing nitrogen doses had a positive effect on grain oil content. It has also been stated in previous studies that nitrogen doses have a positive effect on grain oil content (Paiva et al., 2011; Ignjatovic-Micic et al., 2014; Ozata and Kapar, 2014; Avsar et al., 2018; Kahriman et al., 2020).

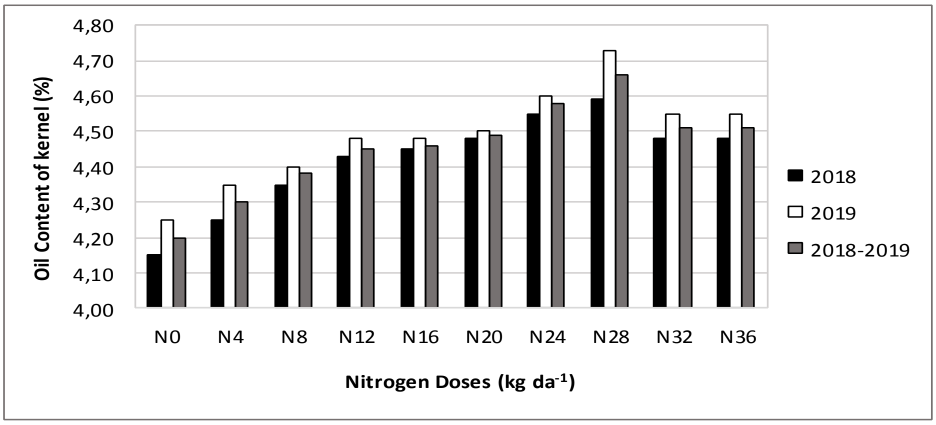

Figure 10. *Oil content of kernel values at different nitrogen doses given by fertigation*

Conclusion

As a result of this study which was carried out to determine the most appropriate nitrogen amount by fertigation method, according to the average of two years; plant height ranged from 175.18 to 277.49 cm, stem diameter 10.75 to 20.28 mm. Ear length varied from 6.99 to 21.17 mm, ear thickness 34.22 to 50.67 mm. Thousand kernel weight ranged from 309 to 373 g, grain yield from 434 to 1594 kg da^{-1}. The leaf area per plant was between 112 cm^2 plant^{-1} and 621 cm^2 plant^{-1}, the protein content in the kernel was between 7.39% and 8.84%. The starch content was found between 70.90% and 71.62%, and the oil content in the kernel varied between 4.20% and 4.66%. The analyzed parameters were found to be statistically significant (P<0.01). In general, an increase was

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recorded in the properties examined from the N0 application to the N28 application, but a decrease was observed after N28 nitrogen dose. The nitrogen doses applied by the fertigation method had a positive effect on the investigated properties. According to two-years average, the highest grain yield was determined in 28 kg da^{-1} nitrogen application with fertigation system. But there were no statistical differences between N24 and N28 applications. When factors such as economic factors, protection of natural resources, environmental pollution, sustainable agriculture, and regression analysis (*Fig. 7*) are taken into consideration, 24 kg da^{-1} of nitrogen given by fertigation method seems more appropriate for corn. It is useful to repeat similar fertigation studies with nitrogen for different corn varieties and different locations in the world.

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