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STUDY OF NITROGEN FERTILIZATION MANAGEMENT ON CORN YIELD AND NITROGEN USE EFFICIENCY IN THE SOUTHERN CASPIAN SEA REGION

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ABSTRACT

Research was conducted at the Mazandaran Agricultural Research Center (Gharakhil) from 2016 to 2018 on the effect of nitrogen consumption time and amount on the yield and efficiency of nitrogen consumption in corn. A complete block design with four replications was used. Treatments include N1: no fertilizer application (control); N2: 60 kg ha^{-1} nitrogen fertilizer application in pre-plant; N3: 120 kg ha^{-1} nitrogen fertilizer application in pre-plant; N4: 180 kg ha^{-1} nitrogen fertilization in pre-plant; N5: 60 kg ha^{-1} nitrogen application in two stages [50% in pre-plant + 50% in R1(silking)]; N6: 120 kg ha^{-1} nitrogen fertilizer in two stages [50% in pre-plant + 50% in R1(silking)]; N7: 180 kg ha^{-1} nitrogen fertilization in two stages [50% in pre-plant + 50% in R1(silking)]; N8: 60 kg ha^{-1} nitrogen in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]; N9: 120 kg ha^{-1} nitrogen fertilizer in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]; N10: 180 kg ha^{-1} in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]. The agricultural activities were conducted according to regional customs. Based on the results, different levels and times of consumption affected the chlorophyll index yield and nitrogen use efficiency significantly. The highest grain yields were obtained by applying 120 kg ha^{-1} of nitrogen before planting, and the chlorophyll index was found to be positively related to grain yield.

Keywords: corn, nitrogen use efficiency, chlorophyll, yield.

INTRODUCTION

Corn can provide a useful amount of carbohydrates and edible oils to many countries because it yields a large amount of grain and dry matter (Singh et al., 2017). A lot of foreign inputs are required in order for this function. According to the evidence, indiscriminately applying chemical fertilizers has reduced soil fertility, hardened arable land, and increased pollution of the environment. Therefore, an improved development program that addresses the plant's fertilizer needs and avoids negative influences on the environment is essential for soil health (Samuhel and Siska, 2007). Despite improvements in resource management, conventional farming has yet to prove successful in today's world because over-reliance on artificial institutions and injection of auxiliary energy such as fertilizers and chemical pesticides has created unsustainable agricultural ecosystems (Roberts, 2008). Achieving efficient fertilizer use and improved crop quality requires a particular effort to ensure that nutrients are absorbed more readily from the soil and transferred to the crop. It is important to manage nitrogen consumption properly for success in increasing grain production, as nitrogen plays a critical role in corn production. The amount, frequency, source, time, and manner of nitrogen consumption all affect the effectiveness and large amount of nitrogen used. In addition to causing groundwater pollution, immediate consumption of nitrogen causes its efficiency to decline and its availability to decrease. Among the enzymes and proteins found in leaves, Rubio makes up more than 50% of them, and nitrogen plays an essential role in their

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structure as well (Cheng and Fuchigami, 2000). Increased photosynthetic material is being transferred from corn leaves to cob as a result of the nitrogen use in corn crops (Peng et al., 2014). Additionally, maize grows slower and yields less during nitrogen deficiency, but consuming nitrogen increases its nitrogen use efficiency. As great amounts of nitrogen fertilizer are required in cereals to obtain maximum yield, improving NUE is viewed as a tough task, as NUE is estimated to be lower than 50% under these conditions. (Raun and Johnson, 1999; Zhu et al., 2010). NUE is measured in two ways: (i) nitrogen uptake efficiency, how well a plant takes in nitrogen from the soil, and (ii) nitrogen utilization efficiency, how well a plant uses nitrogen to produce grain. In order to improve nitrogen utilization efficiency while reducing excess application of fertilizers while maintaining acceptable yields and environmental quality, it is paramount to gain a better understanding of physiological mechanisms controlling nitrogen utilization in plants under different N management practices (Ciampitti and Vyn, 2011). There is a close relationship between chlorophyll and nitrogen content of the leaf, since the most of the nitrogen in the leaf is contained in chlorophyll molecules (Yoder and Pettigrew-Crosby, 1995). However, accurate real-time diagnosis of plant N status on a field is essential to precision nitrogen management in corn (Bausch and Duke, 1996; Ma et al., 2005, 2007, 2010). There has long been research using canopy reflectance indices such as the normalized difference vegetation index (NDVI) and simple ratio (SR) to detect N status of crops as well as forecast crop growth and yield (Bausch and Duke, 1996). An evaluation of the yield and some features of maize plants was conducted in the present study as well as an assessment of different nitrogen management conditions.

MATERIAL AND METHODS

An investigation was undertaken by Mazandaran Agricultural Research Farm in Gharakhil to determine how nitrogen fertilizer management affects yield and some agronomic traits in corn plants. A complete block design with four replications was used for the experimental design during 2016 to 2018. Treatments include N1: no fertilizer application (control); N2: 60 kg ha^{-1} nitrogen fertilizer application in pre-plant; N3: 120 kg ha^{-1} nitrogen fertilizer application in pre-plant; N4: 180 kg ha^{-1} nitrogen fertilization in pre-plant; N5: 60 kg ha^{-1} nitrogen application in two stages [50% in pre-plant + 50% in R1(silking)]; N6: 120 kg ha^{-1} nitrogen fertilizer in two stages [50% in pre-plant + 50% in R1(silking)]; N7: 180 kg ha^{-1} nitrogen fertilization in two stages [50% in pre-plant + 50% in R1(silking)]; N8: 60 kg ha^{-1} nitrogen in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]; N9: 120 kg ha^{-1} nitrogen fertilizer in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]; N10: 180 kg ha^{-1} in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]. The climatic conditions in the research area during the research period are shown in Table 1. For this experiment, samples from 0-30 cm depth were collected in several locations to determine soil properties. The sampled soil's physical and chemical properties are shown in Table 2. Corn hybrid variety 704 single cross was used. Three lines of five meters were planted for each treatment. There were 75 cm of spacing between plant rows and 16 cm between the plant rows. Each treatment was grown in four rows with a two-meter distance between replicates. During the coding stage, a chlorophyll meter device was used to determine the chlorophyll index. An average chlorophyll index was determined for each plot by taking 30 measurements from the middle leaves of ten plants in the middle of a plot. The final yield was calculated by harvesting two square meters from each experimental plot in the middle and bottom rows after removing half a meter from the top and bottom rows and calculating the grain yield from that. In the relevant measurement, nitrogen content for stems, leaves, roots, and seeds was determined by Kjeldahl method. By applying Equations 1 and 2, agronomic nitrogen efficiency (ANE) and nitrogen uptake efficiency (NUE) were calculated. Data was analyzed using SAS 9.2 software and graphs were drawn using Excel software.

Table 1. Monthly total rainfall, temperature and sunshine hours during 2016-2018

Year	Month	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	Sun shine (h)
2016	April	10.3	20.1	0.3	5.2
	May	17.3	25.5	0.1	7.1
	June	19.4	28.2	0.6	8.1
	July	21.6	28.6	1.3	3.2
	August	21.8	33.1	1.4	8.6
2017	April	8.9	19.6	0.2	4.8
	May	14.5	21	0.4	3.1
	June	20	27.4	1	5.4
	July	21.6	30.2	0.2	6
	August	22.4	31.8	2.0	5
2018	April	9.9	19.8	0.3	4.9
	May	15.9	24	0.25	5.1
	June	19.7	26.5	0.9	7
	July	21.6	29	0.7	4.8
	August	44.2	31.5	1.2	6.9

Table 2. Soil physical and chemical properties of the experiment field

Year	Soil texture	PH	Clay (%)	Silt (%)	Sand (%)	Exch. K (mg kg^{-1})	Exch. P (mg kg^{-1})	Total Nitrogen (%)	Organic C (%)
2016	Loam	6.63	24	49	27	150	20	1.65	2.2
2017	Loam	6.76	30.33	48.46	21	147.33	13.16	1.69	2.83
2018	Loam	6.55	31.43	48.7	19.87	148.25	14.8	1.66	2.69

(1) Agronomic Nitrogen use Efficiency (ANE) = (Grain yield in fertilizer treatment/Amount of Nitrogen Applied) × 100

(2) Nitrogen Uptake efficiency (NUE) = (Nitrogen adsorbed in fertilizer treatment/Amount of Nitrogen Applied) × 100

RESULTS AND DISCUSSION

Chlorophyll index (SPAD)

Based on the variance analysis of the measured data, it can be determined that the different treatment variables used in this design have significant effects on chlorophyll index (Table 3). This study evidentiated the highest chlorophyll index to be in the N5 treatment and low chlorophyll index to be in the N8 treatment during research (Table 4). Chlorophyll index values decreasing trend indicates the aging of the leaves. Nitrogen fertilizer usage is linked to an increase in chlorophyll content, according to researchers. Additionally, this delay of leaf aging results in increased grain yield and biomass. This resulted in the use of soil nitrogen being utilized more efficiently, leading to more chlorophyll and a reduction of chlorophyll because nitrogen is required during plant growth.

Table 3. Tests of fixed effects on corn grain yield, Chlorophyll Index (SPAD), Agronomic Nitrogen use Efficiency (ANE), Nitrogen Uptake efficiency (NUE)

Fixed effect	Yield	Chlorophyll Index (SPAD)	Agronomic Nitrogen use Efficiency (ANE)	Nitrogen Uptake efficiency (NUE)
	P>F			
Year	< .0001	< .0001	< .0001	< .0001
Treatment	< .0001	< .0001	< .0001	< .0001
Year×Treatment	< .0001	< .0001	< .0001	0.32

Grain yield

An analysis of variance of grain yield data showed that nitrogen significantly affected grain yield at 1% probability (Table 3). By applying 120 kg ha^{-1} of nitrogen fertilizer in preplant, the maximum yield was achieved (8960, 8910, 9610 kg ha^{-1} in 2016, 2017 and 2018, respectively). In the N8 and N9 treatment methods, nitrogen consumption led to the lowest yield (Table 4). A broad leaf area and a higher rate of photosynthesis are two factors associated with increased yield in response to nitrogen consumption (Peng et al., 2014). An experiment comparing commercial hybrid corn at different stages of emergence showed that an increase in nitrogen supply led to a greater leaf area index, more photosynthesis, and a higher activity of the Rubisco and PEP carboxylase enzymes in both hybrids (Uribelarrea et al., 2009). According to Peng et al. (2014) the application of 300 kg ha^{-1} nitrogen increased corn grain yield significantly when compared to the application of 150 kg ha^{-1} nitrogen, and compared to control treatment, both nitrogen levels showed improved performance.

Table 4. Corn grain Yield, Chlorophyll Index (SPAD), Agronomic Nitrogen use Efficiency (ANE), Nitrogen Uptake efficiency (NUE)

Treatment*	Grain Yield			Chlorophyll Index (SPAD)			Agronomic Nitrogen use Efficiency (ANE)			Nitrogen Uptake efficiency (NUE)		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
	Kg ha^{-1}			SPAD			Kg ha^{-1}			Kg ha^{-1}		
N_1	7910d	8211cd	8360c	43.53c	43.91c	44.5b	39.67b	38.24bc	36.01b	45.06a	46.16a	41.95abc
N_2	8960c	8910b	9610b	46.17b	46.12b	46.51a	30.12d	31.15d	35.46b	34.64bc	35.12bc	39.16cd
N_3	10960a	9564a	10091a	47.26b	48.21a	47.19a	45.12a	44.12a	41.52a	47.74a	48.15a	44a
N_4	9750b	9550a	9326b	46.1b	46.81b	47.64	35.22c	36.12c	37.39b	36.12b	37.32b	40.41bc
N_5	8680c	8694bc	8174c	49.21a	49.01a	47a	40.73b	39.72b	37b	47.78a	48.22a	43.59ab
N_6	7150f	7232e	6934e	42.78cd	43.23cd	42.96c	30.57d	31.61d	30.03c	34.78bc	35.91bc	33.97e
N_7	6420g	6654f	6931e	42.88cd	42.91cde	42.56c	27.91d	28.12d	29.12c	31.24c	32.12c	33.49e
N_8	7720de	7920d	7786cd	42.91e	41.78e	41.71c	31.32cd	31.12d	30.41c	37.12b	38.21b	35.74de
N_9	7220ef	7264e	7391de	41.43e	42.12de	41.85c	28.78d	29.23d	30.23c	31.91c	32.09c	33.96e
N_{10}	7691def	7921d	7524d	42.01de	41.92e	41.92c	30.88d	31.12d	29.69c	37.88b	38.15b	34.73e

*N1: no fertilizer application (control); N2: 60 kg ha^{-1} nitrogen fertilizer application in pre-plant; N3: 120 kg ha^{-1} nitrogen fertilizer application in pre-plant; N4: 180 kg ha^{-1} nitrogen fertilization in pre-plant; N5: 60 kg ha^{-1} nitrogen application in two stages [50% in pre-plant + 50% in R1(silking)]; N6: 120 kg ha^{-1} nitrogen fertilizer in two stages [50% in pre-plant + 50% in R1(silking)]; N7: 180 kg ha^{-1} nitrogen fertilization in two stages [50% in pre-plant + 50% in R1(silking)]; N8: 60 kg ha^{-1} nitrogen in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]; N9: 120 kg ha^{-1} nitrogen fertilizer in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)]; N10: 180 kg ha^{-1} in three stages [33.33% pre-plant + 33.33% in R1 (silking) + 33.33% in R3 (milk)].

Nitrogen use efficiency

As shown in the results, the highest ANE (agronomic nitrogen efficiency) in the years 2016 to 2018 was obtained from fertilizer N3 having values of 45.12, 44.12 and 41.53, respectively (Table 4). There was a significant impact of nitrogen on crop yield at the 1% probability level (Table 3). The least nitrogen uptake efficiency were produced in N_7 and N_6 treatment due to the increased nitrogen consumption in this fertilizer, crop yields decreased (Table 4). There was a greater impact of fertilizer in the initial application units on yield. The efficiency of nitrogen decreases as the amount consumed increases. According to the researchers, 330 kg ha^{-1} of nitrogen slightly enhanced yield compared to 165 kg ha^{-1} (Ciampitti and Vyn, 2011). It has been shown in another study that nitrogen application led to 26 and 35 kg of grain with 300 and 150 kg ha^{-1}, respectively. It has been reported that grain yields per kilogram of nitrogen applied were 26 and 35 kg, respectively, with 300 kg and 150 kg ha^{-1}.

Table 5. Correlations between Corn grain Yield, Chlorophyll Index (SPAD), Agronomic Nitrogen use Efficiency (ANE), Nitrogen Uptake efficiency (NUE)

	Yield	Chlorophyll Index (SPAD)	Agronomic Nitrogen use Efficiency (ANE)	Nitrogen Uptake efficiency (NUE)
Yield	1			
Chlorophyll Index (SPAD)	0.47*	1		
Agronomic Nitrogen use Efficiency (ANE)	0.72**	0.35	1	
Nitrogen Uptake efficiency (NUE)	0.63**	0.56*	0.87**	1

CONCLUSIONS

A positive and significant relationships were found between the chlorophyll index and the nitrogen uptake efficiency, chlorophyll content and agronomic nitrogen efficiency, which confirms the results obtained by other researchers that using nitrogen fertilizer increases biomass and grain production, due to delay in aging caused by the increased chlorophyll content of the leaves.

Using 120 kg ha^{-1} of nitrogen provided the highest yield at 10960, 9564 and 10091 kg ha^{-1} in 2016, 2017 and 2018 respectively, whereas using 100 kg ha^{-1} of nitrogen caused a 40% decrease in yield, which led to a decline in leaf area index and chlorophyll index.

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