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The effects of different plant densities and nitrogen levels on some macro and micro element contents of okra

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ABSRACT

Field trials were conducted in two locations: the training fields of the Ege University Odemis Vocational High School and Ege University, Menemen Research, Application and Production Farm, where the effects of different plant densities and nitrogen levels on macro and micro element contents of okra (*Abelmoschus esculentus* L.) were investigated. The experiments were conducted using a split-plot design with three replicates, where the main plots consisted of nitrogen applications and sub-plots of plant densities. Nitrogen fertilizers were applied in the form of urea and ammonium nitrate. Five different nitrogen levels (0, 40, 80, 120 and 160 kg N ha^{-1}) and two different distances between rows (15 cm * 70 cm and 25 cm * 70 cm) were tested. Macro and micro nutrients in fruits and leaves were determined. The N content of the leaves increased with higher nitrogen levels in the Odemis location. The maximum nitrogen content in leaves was determined at the 80 kg N ha^{-1} application in this location. Additionally, the content of Mg, Zn, and Mn in the leaves and P, Ca, Mg, Fe, and Zn in fruits significantly affected nitrogen doses at the Odemis location. The Mg, Cu and Zn uptake of leaves and Zn content in fruit when compared to the control parcel significantly affected nitrogen doses at Menemen.

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1. Introduction

Okra belongs to Malvaceae family. The production of okra is generally close to canneries. Turkey's annual okra production is 33,103 tonnes (Anonymous 2015). The demand for both fresh and canned okra is only increasing, and okra farming can yield high profits.

Yield and quality in crop production were improved by cultural practices. Fertilization is a key cultural practice in production. Fertilizers are often used unconsciously without a soil analysis. Fertilizers used in high doses will negatively affect both human health and the environment (Ikemoto et al. 2002). Investigation and assessment of the health impacts of fertilizer in order to determine the appropriate dose are becoming increasingly important.

Nitrogen (N) is an essential nutrient for plant growth, and in the desire to produce more food, farmers apply it intensively and often in excessive quantities in the form of nitrogen-based fertilizers. If fertilizer application exceeds plant demands and the denitrification capacity of the soil, nitrate not taken up by the crop may potentially contribute to ground and surface water pollution through nitrate leaching and soil erosion (Gastal and Lemaire, 2002; Wang et al. 2002; Chen et al. 2004; Almasri and Kaluarachchi, 2007 and references therein), possibly raising the nitrate concentrations in groundwater above the maximum allowed level of 50 mg L^{-1} set by the European Commission Nitrate Directive (91/676/EEC).

Nitrogen uptake by the aboveground biomass of plants is a crucial point of information. This parameter shows variations in yield as well as variations in N concentration in plants (Balík et al. 2003; Martina Šturmet et al. 2010). Nitrate is often the major source of nitrogen available to higher plants (Marschner 1995).

High N rates may lead to the increase of nitrate pollution; thus, the more efficient use of N fertilizer must be considered (Campell et al. 1995; Luo et al. 2000; Horvat et al. 2004).

Nitrogen uptake and distribution in plants are of major importance with respect to both environmental concerns and the quality of plant products (Gastal and Lemaire 2002). Fertilizer N taken up by the plant affects not only the yield but also the quality of the plant (Turan and Sevimli 2005). It can cause high nitrate accumulation in plants, especially in most leafy vegetables (Chen et al. 2004), and as reported in Commission Regulation (EC) No. 1881/2006. Vegetables are the major source of nitrate in the human diet. Nitrate is relatively non-toxic but its metabolites (nitrite) may produce a number of deleterious health effects (e.g., methaemoglobinaemia, carcinogenesis) (Santamaria 2006), so care should be taken, especially for pregnant women and babies, not to exceed the acceptable daily intake of 3.65 mg nitrate per kg body weight.

Hence, in order to reduce the burden on the natural environment caused by excessive N fertilization, optimal crop cultivation methods are sought to diminish the negative effect of N compounds on the environment while simultaneously ensuring high and quality yields (Rahn 2002). While it is not possible to prevent nitrate leaching, improved management practices leading to increased efficiency in the use of fertilizer N can reduce the potential for nitrate contamination of groundwater (Bijay-Sighn et al. 1995; Cassman et al. 2002). The utilization of N can be increased by the balanced application of N, P and K and lighter and more frequent irrigation (Bijay-Singh and Sekhon 1979; Bijay-Singh et al. 1995).

Küçük Menderes and the Gediz basin play an important role in vegetable production in Turkey. Their ecology and product designs are representative of the very best in the Odemis and Menemen districts. In these locations, the determination of the effect of distance between rows on okra plants with different doses of nitrogen fertilizer on the macro and micro elements contents are planned.

In the experiments carried out in this study, nitrogen doses were examined in the main plots (F1: 0, F2: 40, F3: 80, F4: 120 and F5: 160 kg N ha-1), while in the sub-plots, planting densities (PD1: 15 cm and PD2: 25 cm were used as inter-rows) were examined. Each row is 70 cm long.

2. 2. Material and Methods

2.1. Material

The study was conducted at two locations (Ege University Odemis Vocational High School, and Ege University Faculty of Agriculture, Menemen Research, Application and Production Farm). The altitude of the research field at the Odemis Location is 136 m (Anonymous 2010a), and 22 m for Menemen Location (Anonymous 2010b). In the study, the Sultana type okra variety, which is a high-yielding variety, was used as a trial plant. This variety is typically grown for canning.

2.1.1. Field (vegetation) establishment of the experiment and applications

The vegetation experiment was set up using the split-plot experimental design with three replications. All procedures were carried out in parallel at both locations. In the experiments; nitrogen doses were administered in the main plots (F1: 0, F2: 40, F3: 80, F4: 120 and F5: 160 kg N ha^{-1}), while in the sub-plots, planting densities (PD1: 15 cm and PD2: 25 cm were used as inter-rows) were located. The row is 70 cm long. The area of the parcel to which nitrogen was applied is 1.26 m^2, and the trial areas consisted of 30 plots.

In the experiments, ammonium nitrate (NH_4NO_3, 26 %N), urea (46 %N), 80 kg ha^{-1} triple superphosphate (TSP, 52 %P_2O_5) and 120 kg ha^{-1} potassium sulfate (K_2SO_4, 50 %K) was used.

2.1.2. Soil properties of the research site

The physical and chemical properties of experimental the soils are shown in Table 1.

Table 1
Some physical and chemical properties and N, P, K content of the experimental soil.

Sample Location	pH	%					Texture	Organic Matter (%)	Total N (%)	Available (mg kg^{-1})	
		Total salt	$CaCO_3$	Sand	Mil	Clay				P	K
Odemis	7.09	< 0.03	0.61	76.04	20.28	3.68	Sandy-loam	0.99	0.06	14	140
Menemen	7.88	0.051	6.58	50.40	37.28	12.32	Sandy-loam	1.29	0.034	0.23	127.4

Table 1 shows various properties of the soil: neutral pH, total soluble salts % in terms of seamless, and textured sandy-loam soil features in Odemis Location (0-20 cm). This soil is low in lime content, and its organic matter is poor. The soil's total N and available K contents are low (Güneş et al. 2000) but there is abundant P (Chapman and Pratt 1961).

In Menemen Location, the soil has a moderate alkaline reaction and sandy-loam texture. It is rich in lime, poor in organic matter, and the total N, available P and

K amounts are low (Chapman and Pratt 1961; Güneş et al. 2000).

2.2. Methods

Basic fertilizer as P_2O_5 in the form of the TSP to 80 kg ha-1 and 120 kg ha^{-1} K_2O fertilizers were given in the form of K_2SO_4. All of the phosphorus, 60 % of potassium and 25 % of nitrogen was applied with sowing. second doses of the remaining nitrogen and potassium were applied after 20 days from the emergence. third dose was applied after 40 days. Nitrogen was applied as urea (46 %) form (0, 40, 80, 120 and 160 kg ha^{-1}) in plantation and the other part was applied as Ammonium nitrate (26 %). Nitrogen fertilizer has been applied to band. To determine the nutrient content of the leaves, from each parcel during the period of flowering, 20-30 sample were taken from young, developed leaves. To determine the amount of nutrients in fruits, 250-gram samples were taken from mature fruits grown in each plot. The fruits were harvested three times weekly on a regular schedule.

2.2.1. Physical and chemical analysis

2.2.1.1. Analysis of soil's physical and chemical properties, total N, available P and K methods

Soil samples (0-20 cm depth) were taken from all treatments, and pH (Jackson, 1967), total soluble salt (Anonymous, 1951), CaCO3 (Kacar 1995), organic matter content (Reuterberg and Kremkurs 1951) and texture (Bouyoucos 1962) were determined. The total N was determined according to Bremner (1965), and the available K+ was determined after extraction with 1 N NH4OAc using a flame photometer (Jackson 1967; Atalay et al. 1986). The available P was measured using a colorimeter after extracting with distilled water (Bingham 1962).

2.2.1.2. Analysis of macro and micro elements of the leaves and fruit

Leaf and fruit samples were dried at 65°C and N was analysed according to the modified Kjeldahl method (Bremner 1965), and P was determined using a colorimeter after wet digestion with mixed acid (1 part $HClO_4$ + 4 parts HNO_3) (Lott et al., 1956). Potassium and Ca were determined using a flame photometer, and Mg, Fe, Cu, Mn and Zn were determined using an Atomic Absorption Spectrophotometer (AAS) (Slawin 1968; Kacar 1984).

The amount of sample dry matter that was milled was determined after drying at 105°C (Kacar 1984).

The data from the locations where we conducted the experiments are discussed separately. Two factors, including fertilizer doses and plant densities, were statistically analysed according to the split-plot experimental design. Data were analysed using the SPSS 13.0 statistical package programme, and findings were determined based on differences between the mean Duncan multivariate analyses (Düzgüneş et al. 1993).

3. Results

Properties of soil samples are given Table 1. The soil was a sandy-loam, notral pH and no problem total soluble salts, low in organic matter and lime in Odemis Location (0-20 cm). Total N, available K content of soil was low (Güneş et al. 2000). Available P was rich (Chapman and Pratt 1961).

In Menemen Location, the soil has a moderate alkaline reaction and sandy-loam texture. It is rich in lime, poor in organic matter, and the total N, available P and K amounts are low (Chapman and Pratt 1961; Güneş et al. 2000).

3.1. Macro and micro nutrient content of okra leaves in Odemis location.

The macro and micro nutrient content of leaf samples taken during the blooming period are shown in Table 2.

Table 2
Macro and micro nutrient content in okra leaves (Odemis).

Fertilizer Doses	%										mg kg^{-1}							
(kg N ha^{-1})	N		P		K		Ca		Mg		Fe		Cu		Zn		Mn	
Control	2,90	c	0,24		1,57		5,63		1,37	ab	219		12		14	b	85	b
40	3,03	bc	0,26		1,40		5,90		1,37	ab	276		12		17	ab	77	b
80	3,37	a	0,34		2,27		5,50		1,30	b	274		13		15	b	87	b
120	3,03	bc	0,28		1,30		6,57		1,43	a	362		12		20	a	126	a
160	3,17	ab	0,25		1,10		6,17		1,30	b	355		12		19	a	136	a
Minimum	2,90		0,24		1,10		5,50		1,30		219		12		14		77	
Maximum	3,37		0,34		2,27		6,57		1,43		362		13		20		136	
Average	3,10	*	0,27	ns	1,53	ns	5,95	ns	1,35	**	297	ns	12	ns	17	*	102	**

x= Duncan's multiple classification test
**: p≤ 0.01, *: p≤0.05', ns: no signification
ns: not significantly

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Fertilizer doses as shown significantly increased N content in leaves ($p\leq0.05$). 80 kg N ha^{-1} dose caused the highest N content (3.37 %). The lowest N content (2.90 %) was recorded in the control plot. The nitrogen application significantly increased Mg, Zn ve Mn content in leaves. The highest contents were obtained from 120 kg ha-1 doses. But in Mg content in leaves, control, 40, 80, 120 kg N ha^{-1}; Zn content in leaves 40, 120 kg N ha^{-1} and Mn content in leaves 120, 160 kg N ha^{-1} doses were statistically the same group.

The lowest Mg values (1.30 %) were recorded for the 80 kg N ha-1 and 160 kg N ha^{-1} applications. The Zn and Mn content of the leaves at those fertilizer doses were significantly different between the confidence levels of $p\leq0.05$ and $p\leq0.01$.

The highest Zn content (20 mg kg^{-1}) was found at a dose of 120 kg N ha^{-1}, followed doses at 160 kg N ha^{-1} and 40 kg N ha^{-1} and were located in the same significance groups. The highest Mn content was observed at the 160 kg N ha^{-1} dose, followed by the 120 kg N ha^{-1}. Contents of P, K. Fe, Cu in leaves were not significantly affected by N rates.

3.2.Macro and micro nutrient content in okra fruit at Odemis location

The macro and micro nutrient content of the okra fruit samples collected during harvest are shown in Table 3.

Table 3
Macro and micro nutrient content in okra fruit (Odemis).

Fertilizer Doses (kg N ha^{-1})	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		Fe (mg kg^{-1})		Cu (mg kg^{-1})		Zn (mg kg^{-1})		Mn (mg kg^{-1})	
PD1																		
Control	3,17		0,55	a	2,90		2,37	a	0,60	a	85	cd	9		48	cd	33	
40	3,15		0,49	bc	2,10		1,90	bc	0,56	a	100	a-d	8		45	d	25	
80	3,10		0,55	a	2,80		2,20	ab	0,59	a	94	b-d	7		56	ab	29	
120	3,43		0,53	ab	3,07		2,37	a	0,58	a	111	a-c	8		53	bc	32	
160	3,27		0,54	ab	2,93		2,30	a	0,59	a	120	ab	7		59	ab	31	
PD2																		
Control	3,27		0,54	ab	3,07		2,37	a	0,60	a	90	cd	8		55	ab	33	
40	3,20		0,49	bc	2,53		2,17	ab	0,57	a	94	b-d	8		44	d	24	
80	3,07		0,47	c	2,37		1,80	c	0,51	b	125	a	7		46	cd	29	
120	3,37		0,51	a-c	2,17		2,20	ab	0,59	a	81	d	7		48	cd	35	
160	3,40		0,51	a-c	2,60		2,17	ab	0,56	a	109	a-c	8		60	a	32	
Minimum	3.07		0.47		2.10		1.80		0.51		81		7		44		24	
Maximum	3.43		0.55		3.07		2.37		0.60		125		9		60		33	
Average	3,24	ns	0,52	*	2,65	ns	2,18	*	0,58	*	101	*	8	ns	51	**	30	ns

x= Duncan's multiple classification test
**: p=0.01 important, *: p=0.05 important, ns: no signification
ns: not significantly

The effect of fertilizer applications on the amount of P, Ca, Mg, Fe and Zn measured in the fruit were found to be statistically significant. The effect of applications on the quantity of the N, K, Cu and Mn was not significant. P (%) content was determined to have a significant impact at the $p\leq0.05$ level. In the first plant density (15 cm) application, 0 and 80 kg N ha-1 were the first statistical group with 0.55 % values. The lowest phosphorus content (0.47 %) was found in the second plant density (25 cm) and in 80 kg N ha-1 applications. The percentage of Ca in fruit showed differences between practices significant at the $p\leq0.05$ level. Accordingly, 0 and 120 kg N ha^{-1} doses with the greatest plant density and 0 and 160 kg N ha^{-1} with the second greatest plant density combinations were included in the first and the same statistical group. The lowest Ca value was recorded as 1.80 % in 0 and 80 kg N ha^{-1} doses with the second greatest plant density. The Mg (%) value ranged from 0.51 to 0.60 percent. The highest value of magnesium (0.60 %) in okra fruit in both plant density applications was recorded in the control parcels. Iron (Fe) content (mg kg^{-1}) was statistically significant ($p\leq0.05$). The 80 kg N ha-1 application created the first set of statistical values of 125 mg kg^{-1} in the second greatest density. The lowest iron content (81 mg kg^{-1}) was determined in the second greatest plant density and 80 kg N ha-1 combination. Fertilizer applications were an important influence on the amount of Zn in fruit ($p\leq0.01$ level). The second greatest density group with 160 kg N ha-1 application (60 mg kg^{-1}) created the first statistical group. The lowest zinc content (45 mg kg^{-1}) was recorded in 40 kg N ha^{-1} with the greatest plant density application.

3.3. Macro and micro nutrient content of okra leaves in Menemen location

The macro and micro nutrient content of plant leaf samples taken during the blooming period are shown in Tables 4-5. The treatment of okra leaves had no significant effect on the amount of N, P, K, Ca, Fe and Mn measured in the leaves. The Mg, Cu and Zn contents were affected in a statistically significant way by treatments (Tables 4-5).

The effect of Mg content in the leaves was found to be statistically significant ($p \le 0.05$). The maximum value (0.80 %) was obtained from the application of 40 kg N ha-1 and greatest plant density combination. It was also in the first statistical group. The lowest value (0.53 %) was identified in 120 kg N ha^{-1} with greatest plant density combination and 80 kg N ha^{-1} with second greatest plant density combination. The Cu content of the leaves showed significant differences between applications safely ($p \le 0.01$). The highest value (16 mg kg^{-1}) was obtained from 160 kg N ha^{-1} and the greatest plant density application, followed by the application of 120 kg N ha-1 and greatest plant density combination (13 mg kg^{-1}). The lowest value (6 mg kg^{-1}) was recorded in the 40 kg N ha^{-1} and greatest plant density combination. The average Cu content of the leaves was 10 mg kg^{-1}. Significant changes in the amount of zinc between applications were observed (safely $p \le 0.05$). The highest Zn content was recorded in the 40 kg N ha^{-1} and greatest plant density combination (108 mg kg^{-1}) and included in the first statistical group. The lowest value (70 mg kg-1) was found in leaves of the 120 kg N ha^{-1} and second greatest plant density combination.

Table 4
Macro and micro nutrient content in okra leaves (Menemen).

Fertilizer Doses (kg N ha^{-1})	N		P		K		Ca		Mg		Fe		Cu		Zn		Mn	
PD1																		
	%										mg kg^{-1}							
Control	1,27		0,45		2,00		5,50		0,55	c	289		7	cd	94	a-d	36	
40	1,60		0,45		2,00		5,53		0,80	a	286		6	d	108	a	38	
80	1,47		0,44		1,80		5,57		0,57	c	345		11	a-d	100	a-c	41	
120	1,40		0,44		2,20		5,30		0,53	c	287		13	ab	76	cd	39	
160	1,47		0,34		1,77		5,47		0,57	c	328		16	a	81	b-d	47	
PD2																		
	%										mg kg^{-1}							
	N		P		K		Ca		Mg		Fe		Cu		Zn		Mn	
Control	1,37		0,51		2,30		5,70		0,77	ab	296		7	cd	79	b-d	31	
40	1,55		0,59		2,30		5,35		0,75	ab	210		9	b-d	98	a-c	35	
80	1,40		0,35		1,87		5,60		0,53	c	288		9	b-d	84	a-d	36	
120	1,47		0,39		2,03		5,30		0,60	bc	266		10	b-d	102	ab	37	
160	1,63		0,39		2,00		5,80		0,63	a-c	304		12	a-c	70	d	39	
Average	1,46	ns	0,44	ns	2,03	ns	5,51	ns	0,63	*	290	ns	10	**	89	*	38	ns

x= Duncan's multiple classification test
**: p=0.01 important, *: p=0.05 important, ns: no signification
ns: not significantly

Table 5
Macro and micro nutrient content in okra leaves (Menemen).

Fertilizer Doses (kg N ha^{-1})	N		P		K		Ca		Mg		Fe		Cu		Zn		Mn
	%										mg kg^{-1}						
Control	1,32		0,48		2,15		5,60		0,66		293,00		7,00		85,67		33,33
40	1,58		0,52		2,15		5,44		0,78		248,33		7,42		103,33		36,17
80	1,43		0,40		1,83		5,58		0,55		316,67		10,00		92,00		38,33
120	1,43		0,42		2,12		5,30		0,57		277,00		11,50		89,33		38,00
160	1,55		0,37		1,88		5,63		0,60		316,33		14,00		75,67		42,83
Average	1,46	ns	0,44	ns	2,03	ns	5,51	ns	0,63	*	290,27	ns	9,98	*	89,20	ns	37,73 ns

x= Duncan's multiple classification test
**: $p \le 0.01$, *: $p \le 0.05$', ns: no signification
ns: not significantly

3.4. Macro and micro nutrient content in okra fruit in the Menemen location

The macro and micro plant nutrient content of the okra fruit (samples collected during harvest) are shown in Table 6. According to Table 6, in the Menemen location, applications and other nutrients except for zinc of okra fruit, had no statistically significant effect on meaning. Regarding the total nitrogen content of okra fruit, the highest value was recorded in the 80 kg N ha^{-1} and greatest plant density combination (2.80 %), while the lowest value was recorded in the 80 kg N ha-1 and second greatest plant density combination (2.10 %).

The effect of the treatments on the Zn content of fruits was determined to be statistically significant (p≤0.01). The 120 kg N ha^{-1} and second greatest plant density combination (90 mg kg^{-1}) and 40 kg N ha^{-1} and second greatest plant density combination (88 mg kg^{-1}) shared the first statistical group with high zinc content. The control parcels and greatest plant density combination, in addition to the 160 kg N ha^{-1} and greatest plant density combination (63 mg kg^{-1}), are grouped in the last statistical group with low zinc content of the sampled fruit.

Table 6
Macro and micro nutrient content in okra fruit (Menemen).

Fertilizer Doses (kg N ha^{-1})	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})		Mn (mg kg^{-1})
PD1										
Control	2,60	0,56	2,87	2,80	0,48	46	9	63	c	20
40	2,57	0,54	2,30	2,50	0,65	37	11	72	bc	19
80	2,80	0,51	2,15	3,10	0,49	42	10	87	a	19
120	2,60	0,51	2,33	3,37	0,59	40	9	78	ab	19
160	2,37	0,46	2,20	2,70	0,67	31	11	63	c	21
PD2										
Control	2,75	0,61	2,35	3,20	0,58	33	10	84	ab	20
40	2,60	0,70	2,60	2,90	0,64	39	13	88	a	24
80	2,10	0,50	2,50	2,90	0,57	33	12	80	ab	19
120	2,77	0,53	1,97	3,03	0,59	40	9	90	a	21
160	2,67	0,51	2,30	3,23	0,56	39	9	78	ab	24
Average	2,58 ns	0,54 ns	2,36 ns	2,97 ns	0,58 ns	38 ns	10 ns	78	**	21 ns

x= Duncan's multiple classification test
**: p=0.01 important, *: p=0.05 important, ns: no significion
ns: not significantly

4.Discussion

Plant population density had no effect on plant height or number of fruits per plant (Wu et al. 2003). The number of marketable fruits per plant was generally unaffected by the plant population. The plant population can significantly influence plant architecture. There are several reports of okra plant morphology being affected by fertilizer, row spacing and plant arrangement.

Fatokun and Chheda (1981) have recorded a decrease in he increase of nitrogen uptake with P application in okra.

Verma et al. (1970) and Majanbu et al. (1986) have reported difficulties in okra production at the rate of 120 kg N ha^{-1} and above. Fruit yield was reduced in the extreme N ratio. Nitrogen rates of 0 kg ha^{-1} and 100 kg ha^{-1} observed okra fruits with increased N concentrations. Similar results to those obtained in our study were reported in a study in Nigeria by Fatokun and Chheda (1981).

In this study, the high nitrogen content in the fruit was achieved with the highest nitrogen application in the Odemis location. High N content was also determined at high doses (120 kg N ha^{-1}) in the Menemen location. Similar results in the nutrient content of fruit were reported by Majanbu et al. (1986). In that study, the effects of nutrient concentrations subsequent to nitrogen and phosphorous application were studied in the growth of okra. Similar results have also been reported for Nigerian conditions by Fatokun and Chheda (1981). The nitrogen uptake of fruits is increased by nitrogen applications. These increases have been noted in various studies (Ahmad and Tullock-Reid 1968; Asif and Greig 1972).

Elmacı et al. (2013) suggested that the N, K, Zn and Mn of leaves were below adequate levels. In this study, similar results were obtained regarding the level of N, P, Fe, Ca, Zn and Mn.

The lowest N value in the nutrient content in leaves for both locations was recorded in the control applications. Similar results were reported by Majanbu et al. (1986), when the lowest value (3.44 %) was obtained in the 0 kg N ha-1 application, while the highest value (4.13 %) was obtained in the 100 kg N ha-1 treatment. The same researchers found that the production of leaves and the first branch and plant height were affected by N application (100 kg ha^{-1}), but not by phosphorus treatment.

Nitrogen has rarely been exploited for improving onion growth under sandy-soil conditions. These results show that the application of nitrogen to onions was effective for increasing the yield. We found that improved growth with applied N was a major element in increasing plant growth.

With increasing nitrogen application, the N, P, K and Mg concentrations in plant leaves increased, while having no effect on Ca concentration. Nitrogen applied to the soil has been effective for the N, P, K and Mg concentrations in okra fruits. Plant analysis is useful in determining fertilizer needs, here, for okra.

5.Recommendations

Fertilizer is necessary for okra cultivation given the ecological conditions of the region studied. Considering the highest values of efficiency and quality and soil, 80 kg ha^{-1} and 120 kg ha^{-1} may be specified as suitable doses of fertilizer.

Finally, nitrogen fertilizer increases the zinc concentration, in particular, which is important in human nutrition, in okra fruit. The maximum zinc content in fruit is obtained at the 80 kg N ha^{-1} nitrogen application. The N (%) content of okra fruit was determined to be higher in the greatest plant density in both locations.

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6. References

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