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Foliar nitrogen fertilizers compound with nitrification inhibitors on growth and yield of corn plant

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Abstract: Foliar fertilization is the most important and very effective method of fertilizer application. This study was conducted to determine the effects of different nitrogen fertilizers such as urea (46%N), ammonium sulphate $(NH_4)_2SO_4$ (21% N) and ammonium nitrate (NH_4NO_3) 33%N beside nitrification inhibitors (AM and DCD) on the growth and yield of corn. Field experiment was conducted at Al Sharkia Governorate, Egypt in a private farm through a project of soil and water Dept. of the National Research Center. The corn plants cultivar as Giza10 were sprayed with nitrogen fertilizers solution at two N levels and the nitrification inhibitors were applied at 5% of the added nitrogen. The important detected results are as follow:1.Foliar urea fertilization at 200 Kgfed^{-1}reflected increases in vegetative growth, yield and its components and nutrient concentration of corn plant compared with control, ammonium sulphate and ammonium nitrite after 60, 90 days from planting and at harvest. 2. The application of (DCD) to urea at 200Kgfed^{-1}as sparing gave the higher values of vegetative growth, yield components and nutrient concentrations compared with (AM). The results of this study explain that foliar urea fertilization with nitrification inhibitors (DCD) may have a possibility role for increasing corn yield.
Keywords: Corn, Foliar fertilization, nitrogen fertilizers, nitrification inhibitors.

Introduction

In Egypt, maize (*Zea mays* L.) is very important plant as a cereal crop. It is cultivated after wheat and rice and its very important as human food, animal feed and raw material source of large number of industrial products **(**Mutuc et al[1]**)**. It has been supposed that corn is more nutritious than rice and a better source of energy. When of rice deficiency, used flour corn or corn grits combination with rice is used as staple food. Maize is staple food in most part of the world and has third position after wheat and rice (Zaman et al[2]).

The macronutrients as nitrogen, phosphorus and potassium are very important to plant and its increased the plant growth. Especially, nitrogen is very important element which includes in many essential metabolic processes in plants as building amino acids, proteins, activity, enzymes, regulators, nucleic acids, pigments, alkaloids and many other metabolites involve nitrogen for their biosynthesis and inter conversions (Srivastava and Singh[3]).

Nitrogen is one of the important plant nutrients, its increased the crop production. N in the soil can be leached, volatilized, denitrified, or fixed in the organic fraction of the soil (Rolston et al [4]). Nitrogen use efficiency is of significant importance in crop production system due to its effects on farmer economic outcomes and environmental impact. Nitrogen use efficiency also, may be reduced in crop production due to many factors such as losses of soil nitrogen by volatilization, leaching and denitrification.

Conducted a study of the effects of N application rate on residual NO_3-N in non-irrigated corn and concluded that when N rate was increased, soil NO_3 -N was also higher (Jokela and Randall[5]).

Nitrogen fertilizer as urea is theme to ammonia volatilization through the activity of the urease enzyme found ubiquitously in soil (Kissel et al [6]). Nitrogen as ammonium forms can be fixed (Kissel et al[6]), or can be transformed to nitrate through the activities of specific soil bacteria (Parvez et al[7]).

Recently, many studies have included the loss of nitrogen in soil, and show that the foliar application is very important method for macronutrients and micronutrient **(**Epstein and Bloom[8]).

Foliar fertilization is addition the fertilizers as liquid to leaves of plant (Kovacevic[9]). The foliar application is more used to correct nutritional deficiencies in plants caused by incorrect supply of nutrients to roots (Silberbushl[10]). Also, the foliar application method increased the plant growth, translocation of nutrients to economic parts and ultimately improve the productivity of the crops (Mohamed et al[11]).The foliar application improved of plant growth and chemical constituents (Majeed and Ali[12]).

The leaf area, fresh and dry weight and leaf content of chlorophyll, N, P and K increased by foliar fertilization. The effectiveness of foliar fertilization effected by the holding capacity of leaf surface area for the liquid fertilizer. It was concluded that foliar application may partially restitution for deficient uptake by the roots, but requires sufficient leaf area to become effective (Ling and Silberbus[13]).

If the micronutrient deficiencies do occur during the growing season, the most effective method for overcoming these deficiencies is through foliar fertilizer applications (Camberto et al[14]).The foliar spray can significantly improve the growth and yield of corn (Stephen et al[15]). Method of foliar feeding has been proved as an effective tool for increasing of grain yield in both cultivars (Mandić et a [16]).

The application of nitrogen fertilizers such as urea, ammonium sulphate and ammonium nitrite as spring to leaves is very important to increase the quality and yield corn plant. Foliar application of urea is the most appropriate way for nitrogen source, because urea is low salt index and high solubility in comparison to other nitrogen sources. Urea has been shown to stimulate absorption of other nutrients by increasing the permeability of leaf tissue. However, the urea utilized in foliar sprays should be low in biuret content (Kowal[17]). Other sources of nitrogen can be obtained from ammonium sulphate and ammonium nitrite its exposed to loses. These sources, when utilized at low foliar rates.

Nitrification is an important part of the nitrogen cycle and counting for significant loss of nitrogen from agricultural process as leaching of nitrate and as gaseous forms of nitrogen, evaluated as about 70% of annual 100 kg N fertilizer input. When ammonia or ammonium N is added to the soil, it is exposed to a process called nitrification. Soil bacteria called nitrosomonas transform the ammonia or ammonium to nitrate. Using a nitrification inhibitor with spring applications of ammonia or ammonium nitrogen will slow the transformation to nitrate until it can be available to used by crops (Ranking[18]**)**.

Nitrification inhibitors means that the transformation of ammonium to nitrate by temporarily deactivating the activity of the bacteria *Nitrosomonas* and *Nitrobacter*. These species of bacteria are responsible for transforming ammonium to nitrate. The interests of inhibiting nitrification is that ammonium has a positive charge and is attracted to the cation exchange sites in the soil and is therefore less prone to leaching than the negatively charged nitrate molecule. Higher corn yield with nitrification inhibitors fall-applied N was also reported by (Randall et al [19]andRandall and Vetsch[20]).

It is clear from former studies that foliar application of nitrogen fertilizers with nitrification inhibitors increased the plant growth, yield and improved the quality in maize crop. Nonetheless, to best of our knowledge, some information is available on combined use of foliar nitrogen fertilizers as urea, ammonium sulphate and ammonium nitrite with nitrification inhibitors on maize plants. This study was, therefore, obtained to evaluate the most foliar nitrogen application with nitrification inhibitors for crop growth and yield of maize.

Material and Methods

This study was conducted under field conditions at the district, Sharkia Governorate, Egypt 2014 to study the efficiency of foliar fertilization by nitrogenous fertilizers beside nitrification inhibitors were used for foliar fertilization. The seeds were obtained from Agricultural Research Center. Some physical – chemical characteristics of the studied soil are presented in Table 1.

Table (1). Physical and chemical properties of the studied soil

Soil characteristics	Soil content
Fine sand%	24.66
Coarse sand%	9.92
Silt%	12.80
Clay%	52.62
Organic matter%	1.88
pH *	8.01
EC (dS m^{-1})**	0.15
$CaCO_3$ g kg^{-1}	0.22
Ca^{++}	0.46
Mg^{++}	0.28
Na^{+}	0.84
K^{+}	0.08
CO^{-}_3	-
HCO^{--}_3	0.56
Cl^{-}	0.40
SO^{--}_4	0.70
*A*vailable-N (g kg^{-1})	3.61
Available-P (g kg^{-1})	1.62
Available-K (g kg^{-1})	0.81

Soil- water suspension 1:2.5 ** Soil water extract 1:5

Table (2): chemical properties of the studied fertilizers.

Material	Formula	N%
Urea	$O{=}C(NH_2)_2$	46
Ammonium sulphate	$(NH_4)_2SO_4$	20.5
Ammonium nitrite	NH_4NO_3	33
Nitrification inhibitor "AM"	2-amino-4-cholro-6-methyl-pyrimidene	
Nitrification inhibitor "DCD"	Dicyandiamide	

Samples of the commonly used nitrogen fertilizers urea, ammonium sulphate (AS) and ammonium nitrite (AN) were added as foliar application beside nitrification inhibitors (AM and DCD) were applied at 5% of the added nitrogen. Corn plants cultivar (Single-cross 10) were sprayed with nitrogen fertilizers solution at two N levels (100 and 200 $Kgfed^{-1}$). Corn seeds were sown on the 15^{th} of June, 2014. The recommended dose of corn plants (130 N + 60 P_2O_5 + 60 K_2O) done following the guidelines given by Ministry of Agriculture. Treatments were arranged in a complete randomized block design with three replicates. Nitrogenous fertilizers were applied on maize foliage at 5^{th} leaf stage and split after 15 days before irrigation. Treatments were as follows:

1- Urea $100Kgfed^{-1}$
2- Urea $200Kgfed^{-1}$
3- Urea 100Kg/fed+ DCD

4- Urea 200Kgfed^{-1}+ DCD
5- Urea 100Kgfed^{-1}+ AM
6- Urea 200Kg/fed+ AM
7- AS 100Kgfed^{-1}
8- AS 200Kgfed^{-1}
9- AS 100Kgfed^{-1}+ DCD
10- AS 200Kgfed^{-1}+ DCD
11- AS 100Kgfed^{-1}+ AM
12- AS 200Kgfed^{-1}+ AM
13-AN 100Kgfed^{-1}
14-AN 200Kgfed^{-1}
15-AN 100Kgfed^{-1}+ DCD
16-AN 200Kgfed^{-1}+ DCD
17-AN 100Kgfed^{-1}+ AM
18-AN 200Kgfed^{-1}+ AM
19- Control

After 60 and 90 days from planting, three plants were randomly chosen from each plot and taken for determinations:- Leaf area (cm^2), fresh and dry weight of leaves (g plot^{-1}), plant height (cm plant^{-1}). Also, samples of corn plants were collected after 120 days from planting and the following parameters were recorded: grain yield (ton fed^{-1}), weight of 100 grains (g), number of rows in ear, ear length (cm). A random sample of 6 plants from each treatment (two plants from each replicate at each sampling date) was chosen after 60 and 90 days from planting. The samples were directly transferred to the laboratory, cleaned with tap water to get them free from any adherent dust or clay, then at harvest, the vegetative samples were separated into two parts; leaves and grains, where nutrients concentrations were determined and recorded: total nitrogen (%), total phosphorus (%), total potassium (%).

Methods of Analysis

Mechanical analysis was determined according to the international Pipette method and calcium carbonate content of the soil was determined volumetrically using Calcimeter as described by (Piper[21]).

- The electrical conductivity (EC) of soil water extract was determined by using the bridge (Jackson[22]).
- Calcium carbonate content of the soil was determined volumetrically using Collins calcimeteras described by (Piper[21]).
- Soil pH was measured using a glass electrode pH meter in a 1: 2.5 soil water suspension (Cottenie et al [23]).
- Organic matter was determined by Walkley and Black's method as described by (Jackson[22]).
- Soluble cations and anions were determined in (1:5) soil water extract according to (Black[24]).
- Sodium and potassium were determined by using flame photometer as described by (Cottenie et al [23]).
- Calcium and magnesium were determined following the versenate method (Jackson[22]).
- Total nitrogen in soil was determined using microKjeldahl method (Jackson[22]).
- Total potassium in soil was determined by flame photometer according (Jackson[22]).
- Total phosphorus in soil was determined colourmetrically using ascorbic acid method (Watanabe and Olsen[25]).

The data obtained was subjected to analysis variance procedure using Duncan's Multiple Range Test was adopted for the means comparison among treatments showing significant difference. Effect of N and P fertilizer was partitioned into linear and quadratic components and regressions were calculated for effects significant at 0.05 level of probability (Duncan[26]).

The values obtained from spectroradiometer can be used to predict the N, P, K, Mg and Mn contents of orchard leaves in field. However, predictions of Ca, Fe, Zn and Cu contents are not adequate for use. The fore-optic may be used for determination of macronutrients, while plant probe may be useful for micronutrients determination (Levent and Huseyin[27]). A new, simple and selective spectrophotometric method was developed for the analysis amino acids which used in nitrification inhibitors this method obtained by (Patel et al [28]).

Results and Discussion

Vegetative growth

Data in Table (3) show that there are significant differences between average leaf area, plant height and fresh and dry weight as affected by foliar application with nitrogen fertilizers beside nitrification inhibitors at 60, 90 days after planting (DAP) and at harvest, respectively.

1- Effect of foliar nitrogenous fertilizers:

Data in the same Table, indicated that the foliar nitrogen fertilization increased the plant growth compared with control it is more advantageous in absorption compared with control. From the data, it can be recognized that the leaf area, plant height and fresh and dry weight increased with the foliar nitrogen fertilizers with 100 or 200 $Kgfed^{-1}$compared with control.

This increase in plant growth might be due to the more nutrient availability which increased photosynthetic rates and the meristemic activities when applied fertilizers to leaves and due to the effect of foliar application on corn stomatal conductance and transpiration. These results obtained by Khan et al[30] obtained that the foliar application with nitrogen fertilizers increased the photosynthetic rates, stomatal conductance and transpiration in corn.Norton[29] who revealed that foliar application for nitrogen fertilizers significantly increased plant height. The foliar application of nitrogen fertilizers improved the plant growth and important method to increase the yield of corn (Madison[31]**)**.

There is a direct effect between foliar nitrogen fertilizers and the improving of the enzymatic systems of the plant. The timeliness and ready availability of nutrients increased by foliar application stimulate enzymatic cycle to greater efficiency and high response (Dixon[32]). It may be also attributed to the increasing of photosynthesis rate as a result of more absorption of available nutrients, which cause increasing in growth and photosynthesis efficiency. Instant effect can be obtained using foliar feeding, because using that way, fertilizer is collected directly and used instantly. In general for foliar feeding every nitrogen form dissolved in water can be applied. This result confirm that obtained by (Kowal[17]).

Concerning foliar nitrogenous fertilizers (Urea, Ammonium sulphate and Ammonium nitrite) data indicated that the application of nitrogen fertilizers as spraying, urea gave the greatest values of leaf area, plant height and fresh and dry weight compared with AS and AN with the addition 200 $Kgfed^{-1}$. It was observed that the application of urea with 200 $Kgfed^{-1}$ gave the maximum values of leaf area, plant growth and fresh and dry weight. However the least values were obtained with ammonium nitrite at the two rates of N applied.Kowal[17] reported that as a nitrogen source in fertilizers it is often to use urea. In water it is easy soluble, and its granules has 46% of nitrogen in amid form, which in soil is changed into ammonium form, then nitrate form. Nitrate form is stopped by the soil, and thanks to its loss of the nitrogen due to the elution is small. (Khan et al[30]), (Dinnes et al [33]) and (Rolston et al [4]) also supported the same theory that foliar application of urea significantly increased plant height, spike length and number of grains $spike^{-1}$.

The application of nitrogen fertilizers as spraying increased the plant growth these result due to that application to leaves decreased the ammonia volatilization when nitrogen fertilizer in the form of urea (Kissel et al [6]) and decreased the leaching (Vetsch[20]) or denitrification (Coyne[34]) when nitrogen fertilizer in the form of nitrate and ammonium forms of N can be fixed (Kissel et al [6]), or can be transformed to nitrate through the activities of specific soil bacteria. Because of these and other processes, nitrogen use efficiency is low.

The interaction between foliar nitrogen fertilizers and nitrification inhibitors: According to interaction effects between nitrogen fertilizers application spray and nitrification inhibitors, as shown in the same Table, the maximum mean values of leaf area, plant height and fresh and dry weight were obtained with urea +DCD at 200$Kgfed^{-1}$compared with ammonium sulphate and ammonium nitrite. These result reported by Randall et al [19]andVetsch[20].Also, the application of urea + DCD increased the plant growth compared with urea + AM with high level. These result may be due to the application of DCD with urea fertilizers, reducing the N losses in forms of nitrous oxide (N_2O) emission and NO^{-3} leaching while increasing the plant growth and use efficiency of fertilizer N compared with AM (Weiske et al [35],Majumdar et al [36],Zaman et al [2],Cui et al [37],Di et al [38],Moir et al [39]andPatel et al [28]).

The role of DCD application play in plant growth, Patel et al[28] indicated that the application of nitrification inhibitors (DCD) decreased nitrogen losses and stimulated nitrogen utilization by plants grown. DCD proved to be more effective in controlling nitrification process than AM and the effectiveness of both inhibitors were found to be much higher in the spraying application. Dicyandiamide (DCD) is the most frequently used commercial nitrification inhibitors in agriculture (Patel et al[28]).

Table (3): Effect of foliar nitrogen fertilizers with nitrification inhibitors on leaf area, plant height, fresh and dry weight after 60,90DAPand at harvest.

Treatments		60 DAP				90 DAP				At harvest		
Sources	Rate of N	leaf area $(cm)^2$	plant height (cm)	F.W (g)	D.W (g)	leaf area $(cm)^2$	plant height (cm)	F.W (g)	D.W (g)	plant height (cm)	F.W (g)	D.W (g)
Urea	100	415.14	168.00	174.21	88.24	514.36	183.00	241.23	114.21	214.00	264.01	127.52
	200	428.27	172.00	181.00	92.47	543.11	197.00	253.14	101.24	221.00	268.12	134.24
Urea+ DCD	100	432.01	179.00	189.14	94.27	547.28	236.00	257.21	123.41	247.00	268.45	135.62
	200	445.33	181.00	194.25	98.16	561.23	248.00	268.14	129.31	253.00	269.24	138.11
Urea+ AM	100	420.65	165.00	187.22	87.26	479.48	197.00	196.45	97.47	217.00	247.25	99.45
	200	425.47	169.00	185.35	86.39	482.74	211.00	214.54	98.26	226.00	249.14	104.25
A.S	100	368.12	150.00	167.25	79.24	489.36	196.00	223.01	110.39	243.00	236.21	124.22
	200	398.28	157.00	168.12	84.15	510.24	206.00	239.23	114.10	249.00	241.25	126.14
A.S+ DCD	100	401.14	159.00	171.28	77.58	542.23	210.00	237.16	102.34	241.00	241.36	128.41
	200	411.36	162.00	169.17	89.36	558.79	224.00	243.19	115.01	246.00	249.14	129.22
A.S+ AM	100	367.24	146.00	175.36	68.35	514.23	178.00	227.16	96.47	224.00	234.28	106.21
	200	386.16	152.00	178.01	74.29	523.68	185.00	232.22	101.45	228.00	239.14	107.24
A.N	100	346.32	137.00	169.25	75.41	489.65	184.00	214.69	114.02	216.00	225.16	124.11
	200	377.24	146.00	168.14	79.58	475.63	194.00	234.13	108.47	220.00	237.62	130.36
A.N+ DCD	100	359.13	139.00	175.69	82.22	526.14	196.00	219.24	120.86	224.00	221.46	125.14
	200	367.01	141.00	184.25	86.24	538.12	235.00	228.29	100.14	238.00	234.69	112.01
A.N+ AM	100	347.12	137.00	175.36	74.28	469.24	112.00	211.28	92.47	241.00	224.71	97.45
	200	359.00	140.00	178.14	80.14	481.25	221.00	224.20	95.73	245.00	228.34	101.24
L.S.D. 5%		15.14	12.48	11.45	8.45	15.49	20.14	25.16	10.25	16.59	9.45	14.26
Control		214.12	127.00	136.12	68.58	364.29	150.00	141.30	75.49	154.00	149.27	84.15

Yield and its components

Data in Table (4) show that there are significant differences between the averages of ear weight, 100 grains weight, number of rows, ear length, ear yield and weight of straw at harvest stage under experimental conditions straw as affected by foliar nitrogen application with nitrification inhibitors.

1- Effect of foliar nitrogenous fertilizers:

The maximum values of ear weight, 100 grains weight, number of rows, ear length, ear yield and weight of straw were produced from foliar nitrogen application with 200 Kgfed^{-1}during the growing season. While, the minimum mean value of aforementioned attribute were occurred with control (no foliar nitrogen application). It is due to the fact that foliar nitrogen application not only enhance the grain yields but also improve of the quality. These results are in harmony with those obtained by Gooding and Davies[40]show that when applied nitrogen as foliar application it can be reduced nitrogen losses as denitrification and leaching compared with nitrogen fertilizer application to the soil; the ability to provide nitrogen when root activity is impaired in saline or dry condition, and uptake late in the season to increase grain nitrogen concentration.

Foliar nitrogen fertilizers may also hinder crop productivity although the explanation for this vary, and include desiccation of leaf cells and the disruption of carbohydrate metabolism. When damage has not been severe, foliar application have increased ear yield, particularly when applied before flag leaf emergence and when nitrogen availability is limiting. (Parvez et al [7]) found that foliar nitrogen application significantly increased plant height, spike length, number of grains^{-1}, hundred grain weight, biological yield, grain yield and N uptake by the crop. Antonio and Mallarino[41]results showed that foliar nitrogen fertilization increased yield. These increasing may be attributed to increasing various physiological processes, as better uptake nutrients, better plant growth, higher rates of photosynthesis and hence, higher dry matter accumulation as indicated by (Khater et al [42]).

Concerning foliar nitrogenous fertilizers (Urea, Ammonium sulphate and Ammonium nitrite) data in the same Table, indicate that the maximum mean values of ear weight, 100 grains weight, number of rows, ear length, ear yield and weight of straw were obtained with foliar urea application with 200 Kgfed^{-1} compared with ammonium sulphate and ammonium nitrite. On the other hand, the lowest mean values of yield and its component were obtained with ammonium nitrite with 100Kgfed^{-1}.These result may be due to the solubility of urea compared with ammonium sulphate and ammonium nitrite. These results are in harmony with those obtained by (Kowal[17]) reported that as a nitrogen source in fertilizers it is often to use urea. In water it is easy soluble, and its granules has 46% of nitrogen in amid form, which in soil is changed into ammonium form, then nitrate form. (Khan et al [30]),(Dinnes et al[33]) and (Rolston et al [4]) also supported the same theory that foliar application of urea significantly increased 100 grain weight, grain yield.

It was noticed that the best results of ear weight, 100 grains weight, number of rows, ear length, ear yield and weight of straw were observed with foliar urea application at 200 Kgfed^{-1}. These results are in conformity with those obtained byIbrahim[43]who found the foliar urea application could be considered as the best way to reduce the salt accumulation and maintain necessary fertility levels in plant root zone and consequently improve plant growth particularly under saline conditions. (Tea et al [44]) reported that foliar nitrogen fertilization increased the remobilization of urea to grain and increased yield. The results also are in agreement with (Mosluh et al[45]) and (Swenson et al[46]).

2-The interaction between foliar nitrogen fertilizers and nitrification inhibitors:

According to interaction effects between foliar nitrogen fertilizers and nitrification inhibitors, as shown in the same Table, the maximum mean values of ear weight, 100 grains weight, number of rows, ear length, ear yield and weight of straw were produced from foliar urea application with DCD at 200 Kgfed^{-1} compared with urea with AM. Also, the application of ammonium sulphate and ammonium nitrite with DCD gave the greatest values of ear weight, 100 grains weight, ear length, ear yield and weight of straw compared with nitrification inhibitor (AM). On the other hand, the lowest values of ear weight, 100 grains weight, number of rows, ear length, ear yield and weight of straw were obtained with urea, ammonium sulphate and ammonium nitrite with AM at 100Kgfed^{-1}. These results may be due to effect of the nitrification inhibitors to reducing the N losses and increasing the use efficiency of fertilizer N compared with control. These results reported by (Randall et al [19]) and (Vetsch[20]).The application of nitrification inhibitors (DCD) decreased nitrogen losses and stimulated nitrogen utilization by plants grown. DCD proved to be more effective in controlling nitrification process than AM and the effectiveness of both inhibitors were found to be much higher in the spraying application. These results were confirmed with those obtained by (Patel et al [28]) showed that the Dicyandiamide (DCD) is the most frequently used commercial nitrification inhibitors in agriculture.

Table (4): Effect of foliar nitrogen fertilizers with nitrification inhibitors on ear weight (g), weight of 100 grain(g), number of rows, ear length (cm), ear yield(ton fed^{-1}) and weight of straw (ton fed^{-1}) at harvest.

Treatments		Ear weight (g)	Weight of 100 grain(g)	Number of rows	Ear length (cm)	ear yield (ton fed^{-1})	weight of straw (ton fed^{-1})
Urea	**100**	312.14	13.25	14.00	19.35	3.22	5.14
	200	325.01	13.46	14.00	19.55	3.41	5.32
Urea+ DCD	**100**	329.36	13.41	14.00	20.31	3.45	6.04
	200	361.12	13.46	14.00	20.14	3.51	6.12
Urea+ AM	**100**	317.13	12.47	14.00	19.34	3.20	5.43
	200	321.03	13.25	14.00	20.41	3.26	5.32
A.S	**100**	297.15	12.57	13.00	18.47	2.87	5.11
	200	268.00	12.71	14.00	18.60	2.89	5.21
A.S+ DCD	**100**	274.12	12.64	13.00	18.68	3.12	5.42
	200	279.36	13.24	14.00	19.32	3.22	5.53
A.S+ AM	**100**	254.16	12.52	13.00	17.14	2.85	5.13
	200	248.31	12.64	13.00	18.15	2.74	5.22
A.N	**100**	285.69	12.36	12.00	17.26	2.94	4.46
	200	289.36	12.42	13.00	17.35	2.96	4.52
A.N+ DCD	**100**	293.65	12.60	13.00	18.26	3.21	4.78
	200	286.12	12.84	13.00	18.33	3.11	4.68
A.N+ AM	**100**	267.25	12.07	11.00	18.00	3.10	4.55
	200	284.36	12.12	12.00	18.21	3.14	4.62
L.S.D. 5%		5.14	--	--	0.64	0.21	0.91
Control		189.25	11.24	11.00	13.05	1.78	2.45

Chemical composition

1- Nitrogen

Data presented in the Tables (5) revealed that the effect of foliar application of nitrogen fertilizers with nitrification inhibitors on nitrogen concentration (%). The results of Table show that there are significantly differences between N concentration at 45 and 90 DAP. The highest mean value of N concentration observed with foliar nitrogen application at 200 Kgfed^{-1} at 45 and 90 DAP and at harvest, respectively. On the other hand, the lower mean value of N concentration observed with control at 45 and 90 DAP. These results were obtained with those showed by Gooding and Davies[40] who reported that the foliar application of NPK reduced nitrogen losses as denitrification and leaching compared with nitrogen fertilizer applications to the soil. And the ability to provide nitrogen when root activity is impaired in saline or dry conditions, and uptake late in the season to increase grain nitrogen concentration. Factors that influence the degree of foliar absorption in field conditions have not, however, been clearly defined and losses to the atmosphere and soil can occur. (Afza et al [47]) who reveal that the foliar application of nitrogen fertilizers significantly reduced the amount of N2 fixed.

Also, from the Table, data show that the foliar application with urea at 200Kgfed^{-1}increased the N concentration compared with ammonium sulphate and ammonium nitrite at 200 or 100Kgfed^{-1}. These increased due to the solubility of urea in water compared with ammonium sulphate and ammonium nitrite. These results were confirmed with those obtained by (Kowal[17]).

Regarding with the effect of nitrogen fertilizers with nitrification inhibitors DCD and AM data in the Table (5) indicate that there are significantly differences between N concentrations as affected by nitrogen fertilizers with nitrification inhibitors. Also, the highest mean values of N concentration were observed with foliar urea fertilizers with DCD at 200Kgfed^{-1} at 45, 90 DAP and harvest compared with ammonium sulphate and ammonium nitrite. Meanwhile, the lowest mean values of N concentration occurred with ammonium nitrite fertilizer with AM at 100Kgfed^{-1} at 45, 90 DAP and harvest. These results were confirmed with those obtained by(Patel et al [28]) showed that the Dicyandiamide (DCD) is the most frequently used commercial nitrification inhibitors in agriculture. Data show that the nitrification inhibitors have potential to reduce nitrate leaching and increase nitrogen use efficiency.

So, the foliar urea application with DCD increased the N concentration that the nitrification inhibitors decreased the nitrogen loess. These results were confirmed with those obtained by (Ranking[18]**)** obtained that using a nitrification inhibitor with spring applications of ammonia or ammonium nitrogen will slow the conversion to nitrate until it can be readily used by crops.

2- Phosphorus

Data in Table (5) show the effect of foliar nitrogen application with nitrification inhibitors on phosphorus concentration (%). The results reveal that there are no significant differences between P concentration at 45 and 90 DAP and at harvest. The highest mean values of P concentration were observed with foliar nitrogen application at 45 and 90 DAP, respectively. Also, the mean values of P concentration at harvest were found with foliar nitrogen application. These results are in agreement with the finding of (Thalooth et al [48]) who found that the application foliar nitrogen fertilization increased P concentration indicating that phosphorus was absorbed poorly by the roots, but was well absorbed by the leaves. Also, the P use efficiency as applied to the soil is very low because more than 80% of the applied P becomes immobile and unusable by the plant because of adsorption, precipitation or conversion to organic form. (Yuncai et al [49]) reported that the application of foliar nitrogen fertilization increased the uptake of P which may be attributed to decreased transpiration. From the Table, data show that the foliar application with urea at 200Kgfed^{-1} increased the P concentration compared with ammonium sulphate and ammonium nitrite at 200 or 100Kgfed^{-1}. These increased due to the solubility of urea in water compared with ammonium sulphate and ammonium nitrite. These results were confirmed with those obtained by (Kowal[17]).

Concerning the effect of foliar nitrogen fertilizer with nitrification inhibitors, data in Table (5) indicate that there are significantly differences between P concentrations as affected by foliar nitrogen fertilizers with nitrification inhibitors. Also, the highest mean values of P concentration were observed with foliar urea fertilizer with DCD at 200 Kgfed^{-1} at 45, 90 and at harvest. The lowest mean values of P concentration were obtained with ammonium nitrite with AM at 100 Kgfed^{-1}.These results are in harmony with those obtained by (Ranking[18]) using a nitrification inhibitor with spring applications of ammonia or ammonium nitrogen will slow the conversion to nitrate until it can be readily used by crops. These result may be due to that nitrification inhibitor decreased the loses of nitrogen this increased to plant growth and efficiency of plant to absorbed the nutrients as P, Ca, K and Mg by the leaves. These results are in agreement with the finding of (Thalooth et al [48]).Data from the Table show that the foliar urea application with DCD at 200 Kgfed^{-1} increased the P concentration compared with all treatments with AM. These results may be due to that the nitrification inhibitors have potential to reduce nitrate leaching and increase nitrogen use efficiency. These results were confirmed with those obtained by (Patel et al [28]) showed that the Dicyandiamide (DCD) is the most frequently used commercial nitrification inhibitors in agriculture. (Ranking[18]) reported that using a nitrification inhibitor with spring applications of ammonia or ammonium nitrogen will slow the conversion to nitrate until it can be readily used by crops.

3- Potassium

Data in Table (5) show the effect of foliar application of nitrogen fertilizers with nitrification inhibitors on potassium concentration (%). The results of Table show that there are significantly differences between K concentration at 45 and 90 DAP and at harvest. Also, in the same Table, the maximum mean values of K concentration were occurred with foliar nitrogen application at 45, 90 DAP and at harvest, respectively. Also, the lowest mean values of K concentration were observed with control. These results are in agreement with the results obtained by (Kolota and Osinska[50]) who found that the foliar nitrogen application increased the K concentration and results showed that the benefits of foliar applied plant nutrients in treatments with half rates of preplant fertilization. Kelly et al [51] found that potassium availability in agronomic crops has recently decreased due to periodic drought conditions, soil compacting, reduced K applications, lower frequency of soil testing, and higher K fertilizer requirements because of increasing corn yield. Also, from the Table, data show that the foliar application with urea at 200Kgfed^{-1} increased the K concentration compared with ammonium sulphate and ammonium nitrite at 200 or 100Kgfed^{-1}. These increased due to the solubility of urea in water compared with ammonium sulphate and ammonium nitrite. These results were confirmed with those obtained by (Kowal[17]).

Data in the same Table, show that the effect of foliar nitrogen fertilizers with nitrification inhibitor, the results indicate that there are significantly differences between K concentration as affected by foliar nitrogen fertilizers with nitrification inhibitors. Also, the highest mean values of K concentration were observed with foliar urea fertilizer with DCD at 200 Kgfed^{-1} at 45, 90 and at harvest. The lowest mean values of K concentration were obtained with ammonium nitrite with AM at 100 Kgfed^{-1}. (Ranking[18]) who found that using a nitrification inhibitor with spring applications of ammonia or ammonium nitrogen will slow the conversion to nitrate until it can be readily used by crops. This result may be due to that nitrification inhibitor increased the plant growth and efficiency of plant to absorbed the nutrients as P, Ca, K and Mg by the leaves. These results are in agreement with the finding of (Dinnes et al [33]) who show that the nitrogen-use efficiency has vital economic and ecological importance and application of nitrification inhibitors is used to mitigate nitrogen loss from the ecosystem. Also, Dicyandiamide (DCD) is the most frequently used commercial nitrification inhibitors in agriculture.

Table (5): Effect of foliar nitrogen fertilizers with nitrification inhibitors on N, K and P after 60,90 DAP and at harvest.

Treatments		**60 DAP**			**90 DAP**			**At harvest**		
Sources	**Rate**	**N%**	**P%**	**K%**	**N%**	**P%**	**K%**	**N%**	**P%**	**K%**
Urea	**100**	2.10	0.23	1.64	1.92	0.32	1.77	1.23	0.21	2.14
	200	2.15	0.27	1.66	1.98	0.33	1.79	1.28	0.26	2.25
Urea+ DCD	**100**	2.42	0.28	1.78	2.23	0.34	1.84	1.31	0.25	1.97
	200	2.44	0.29	1.84	2.25	0.36	1.86	1.36	0.31	2.32
Urea+ AM	**100**	2.13	0.24	1.46	1.86	0.35	1.57	1.24	0.18	2.11
	200	2.21	0.25	1.59	1.88	0.36	1.61	1.28	0.19	2.19
A.S	**100**	1.88	0.21	1.45	1.74	0.31	1.55	1.54	0.19	1.89
	200	1.89	0.23	1.52	1.83	0.33	1.69	1.62	0.21	1.96
A.S+ DCD	**100**	1.95	0.22	1.61	1.65	0.34	1.72	1.22	0.24	1.88
	200	2.11	0.25	1.74	1.77	0.37	1.79	1.26	0.26	1.98
A.S+ AM	**100**	1.67	0.21	1.58	1.45	0.30	1.66	1.12	0.22	1.85
	200	1.69	0.22	1.59	1.36	0.31	1.75	1.24	0.24	1.87
A.N	**100**	1.85	0.19	1.34	1.71	0.31	1.46	1.15	0.17	1.78
	200	1.89	0.21	1.46	1.69	0.32	1.53	1.21	0.18	1.82
A.N+ DCD	**100**	2.04	0.22	1.56	1.78	0.33	1.69	1.26	0.16	1.77
	200	2.19	0.26	1.62	2.01	0.34	1.71	1.28	0.19	1.79
A.N+ AM	**100**	1.99	0.21	1.45	1.58	0.34	1.55	1.11	0.14	1.69
	200	2.06	0.23	1.48	1.67	0.36	1.64	1.17	0.15	1.73
L.S.D. 5%		0.11	0.06	0.12	0.21	0.04	0.11	0.07	0.04	0.14
Control		1.44	0.21	0.27	1.23	0.22	0.31	0.87	0.17	0.45

Conclusion

The results of this study indicated that further research on the use of foliar urea fertilization at 200 Kgfed^{-1} increased the vegetative growth, yield and its components and nutrient concentration of corn plant compared with control, ammonium sulphate and ammonium nitrite after 60, 90 from planting and at harvest. Furthermore, this technique is very useful for plant to increase the adsorption of macro and micro nutrients. In order to use this method is necessary. The application of (DCD) as nitrification inhibitors to urea at 200Kgfed^{-1} as sparing gave the higher values of vegetative growth, yield components and nutrient concentrations compared with (AM). The study results explain that foliar urea fertilization with nitrification inhibitors (DCD) may have a possibility role for increasing corn yield.

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