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Effect of Nitrogen Source and Rates on Grain Yield, Morphological and Physiological Traits of some Maize Hybrids

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ABSTRACT

A field experiment was carried out in old newly reclaimed calcareous soils at Nubaria Agricultural Research Station, during 2015 and 2016 summer seasons. The aim of the investigation was to study the effect of nitrogen fertilizer sources (solid and gaseous) under different nitrogen rates (80, 100, 120 and 140 kg N fed^{-1}) on yield, yield components, NPK concentrations and N use efficiency for some maize hybrids (SC 131, SC 168 and SC 176). Experimental design was strip-split plot design with four replications where nitrogen sources distribute in the vertical- plots while, nitrogen rates assigned to the horizontal- plots within N sources. Hybrids were randomly distributed in the sub - plots. Injection ammonia gas gave the lower significant averages value of number days from planting to 50% tasseling (DTT) and number of days from planting to 50% silking (DTS), but increased significantly in plant height (PHT), leaf area index (LAI), chlorophyll content (CHL), No. of ears per plot (EAR), grain yield (GY) and ear length (EL) in the two successive seasons as compared to those obtained with ammonium nitrate (AN) form. Results revealed that the application of AA was associated with significantly higher in kernel per row (KPR) and weight of 100-grains (KWT) than AN. No significant difference between the nitrogen sources was found in ear diameter (CD) in both seasons. Increasing N rates from 80 to 140 kg fed^{-1} caused a significant increase in DTT, DTS and EAR traits in 2016 only. However, increasing N rate significantly effect on PHT, LAI, CHL, GY, EL, KPR and KWT traits. Significant differences were found among maize single crosses for all tested growth characters and grain yield. Single cross 176 was the earliest hybrid while SC 168 was the latest concerning DTT and DTS in both seasons. Single cross 131 gave the highest value in GY, while SC 176 was the lowest value. Anhydrous ammonia (AA) had higher GY productive under all NR than AN with linear positive significant increase during the growing season of 2015. The highest grain yield was 36.9 ard fed^{-1} under 140 kg N fed^{-1} of AA while the lowest value was 24.0 ard fed^{-1} for AN at 80 kg N fed^{-1}. Single cross 131 had the highest significant value in grain yield under AA, while SC 176 was the lowest value under AN fertilizer. Concentration of grain nitrogen (N^{conc}), phosphorus (P^{conc}), potassium (K^{conc}), their uptake (NPK^{uptake}) and nitrogen use efficiency (NUE) were affected positively by the sources of N fertilizers applied in the two successive seasons. Ammonia gas (AA) enhanced all nutritional parameters comparing with AN. Three way interactions of the tested NS, NR and maize HB agreed with all previous results of main. In general SC 131 followed by SC 168 respond efficiently more than SC 176 to AA comparing with AN under all four N rates up to 140 kg N fed^{-1}. Regression coefficient between grain yield and the nineteen variables showed that there was a highly significant relation between grain yield and ten of the independent variables including (N uptake, N concentration, K uptake, K concentration, ear length, NUE, chlorophyll content, ear, no. of days to sillking, leaf area index). It was included that injection of AA to maize crop remarkably positively affect maize growth and N, P and K, compared with AN in calcareous soils.

Keywords: Maize, ammonia gas, ammonium nitrate, N fertilizer rate, grain yield, N use efficiency.

INTRODUCTION

Nitrogen fertilization is very essential to cereal crops due to its vigorous role in photosynthetic activity, cell building and protein assimilation rate (King *et al.*, 2003). Anhydrous ammonia (NH_3) is generally readily available and is the least expensive source of N fertilizer, has the most concentrated analysis at 82% N, and is more slowly converted to nitrate than other N fertilizers (Fernández *et al.,* 2009). Injecting of AA at depth reduces the potential for volatilization loss and generally presents the lowest risk of yield-limiting denitrification loss compared to other conventional N fertilizers. Anhydrous ammonia (82 % N) and ammonium nitrate (33.5% N) are the common N fertilizers and these sources are similarly effective when properly applied to maize .They vary in their susceptibility to volatilization or gaseous loss as ammonia to the atmosphere and they can pollute soils and groundwater as nitrate. Therefore, management of N fertilizers is very important for soil fertility and productivity (Siam *el al.*, 2012). Ammonium nitrate (AN fertilizer is important for plant nutrition. In recent years, AN use has declined for the following causes (1) high expensive, (2) difficulty of store and maintain under the right conditions, (3) a potential source of environmental pollution and (4) it is also, considered to be a hazardous material because of its combustible and explosive properties (Dana *el al.,* 2013). In soil, ammonia reacts with water to form the ammonium (NH_3) ion, which is held on organic matter. Moreover, Berry (2011) reported that AA has lower labor requirements for application predisposes to mechanize the agricultural operations like planting, foliar fertilization, herbicides and insecticides spraying and harvest. It has also been shown that ammonia has nematicidal and fungicidal properties.

Total amount of nitrogen utilized by maize plants was higher in the AA than AN forms (Hamissa *et al*., 1971), as also was by grain sorghum (Abdou *et al*., 2011). Yield and its components increased by using AA as compared with urea or other nitrogen fertilizer sources (Darwish, 2003 and Siam *et al*., 2008). The highest averages values of yield and its components and the highest averages of N, P and K concentration in maize plants and their uptake in grains were resulted from injection of ammonia gas (Abdou *et al.* 2017). Application of AA gave the highest recorded values of NPK concentrations in grain, stover yields and also its uptake by plants than urea fertilizer (Siam *et al*., 2008 and Abd El-Hafeez *et al*., 2013). Plants can assimilate ammonium more readily than nitrate, possibly because plants lack a completely functional nitrate- redacted system (Abdel Wahab *et al.,* 2017).

Applying the right N source, at the right rate, in the right place, at the right time becomes key management for optimizing maize yields and economic returns while obtaining most efficient use of the N applied (Roberts, 2007). The highest response of Egyptian maize hybrids to N-levels was recorded by Gouda (1997) and Faisal *et al.* (2012). They reported that increasing N-levels up to 135kg/Fed was accompanied by a significant increase in growth, yield and yield components and decrease number of days to 50% tasseling and silking.

The major problems of soil under calcareous conditions are poor in physical properties, deficient in organic matter and characterized by relative high pH, thus their content of N was limited and availability of phosphorus and micronutrients are low.

The main objective of this study was investigated the effect of nitrogen source (Ammonium nitrate, AN 33.5% N and Anhydrous ammonia, AA 82%N) and N rates (80, 100, 120 and 140 kg N fed^{-1}) on grain yield as well as morphological and physiological traits of some maize hybrids (SC 131, SC 168 and SC 176) in calcareous soil.

MATERIALS AND METHODS

Experimental site:

A field experiment was conducted in old newly reclaimed calcareous soils of North Tahrir area. The study was conducted on 15 and 20 June in the two successive seasons of 2015 and 2016 in the experimental farm of Nubaria Agricultural Research Station, Agricultural Research Center (ARC), Egypt. The station is located at 30° 54´ N, 29° 57´ E, and 25m above sea level.

Disturbed soil samples from three depths (0-20, 20-40, and 40-60 cm) were collected before planting. The soil physical, chemical, and nutritional properties of the experimental site were determined according to Page *et al.* (1982) and Klute (1986) these data were presented in Table 1.

Experiment description:

The experimental design was strip-split plot design with four replications. Nitrogen sources (anhydrous ammonia 82% N and ammonium nitrate, 33.5% N) distribute in the vertical- plots while, nitrogen rates (80, 100, 120 and 140 kg fed^{-1}) assigned to the horizontal- plots within N sources. Hybrids (SC131, SC 168 and SC 176) were randomly distributed in the sub- plots.

Thirty kg P_2O_5 in the form Calcium Superphosphate (15.5% P_2O_5) and 24 kg K_2O/fed in the form of Potassium sulphate (48% K_2O) were added during soil preparation. Anhydrous ammonia was injected 20 cm under the soil surface for the tested 4 rates (80, 100, 120 and 140 kg N fed^{-1}) 5 days before planting. Ammonium nitrate rates (80, 100, 120 and 140 kg N fed^{-1}) were splited to 3 equal doses started at germination and ended before 60 days after planting. Experimental units included 6 ridges, 80 cm in width, 4.5 m in length, and 20 cm between hills. The previous crop was wheat in both seasons. All other farming practices (i.e., irrigation, weeding, diseases control and others) were done according to technical recommendation for maize production.

Data recorded were number of days from planting to 50% tasseling (DTT), number of days from planting to 50% silking (DTS), plant height (PHT). Leaf area index (LAI) is the ratio of plant leaves area to corresponding ground surface area.

The leaf area index was determined as follows: LAI = LA/GA

Where: GA = ground area (cm^2)/plant.

Chlorophyll content was measured in units by a Chlorophyll Metter (SPAD-502). This unit was transformed to mg/gm as described by Monge and Bugbe, (1972) as follow:

Chl. = 80.05+10.4 (SPAD-502).

At harvest time, the three inner ridges in each experimental unit (plot) were harvested. Ears per plot were weighted and random sample of 5 kg was taken from each plot to measure shelling percentage and moisture content in grains. Grain yield (GY) was adjusted to 15.5% moisture content. Number of ears (EAR), ear length (EL) cm, ear diameter (ED); cm, number of kernels per row (KPR) and weight of 100-grain (KWT) were recorded.

Nutrient uptake and N use efficiency:

At harvest, grain samples were collected, air-dried, crushed, and prepared for laboratory analysis. Samples were wet-digested using concentrated sulfuric acid hydrogen peroxide (H_2O_2) according to FAO method (FAO, 1970). Macro-elements (N, P, K) were determined in grains (Westerman, 1990). As well as, protein content (%) and uptake of nitrogen (N^{uptake}), phosphorus (P^{uptake}) and potassium (K^{uptake}) in grains (kg fed^{-1}) were assessed. Nitrogen use efficiency NUE (kg grain kg^{-1} N) was calculated according to Huggins and Pan (1993). Protein content was estimated by multiplying N Concentration (%) with 6.25 (FAO, 2003).

Table 1. Physical, chemical and nutritional properties of the experimental field during years of 2015 and 2016, (average of the two seasons).

Soil Characteristics	Soil depth, cm 0-20	20-40	40-60
I. Physical properties:			
Particle size distribution			
Sand	53.36	46.40	49.06
Silt	10.00	12.00	10.00
Clay	33.64	41.60	40.94
Soil Texture Class	Sandy Clay	Clay Loam	Clay Loam
II. Chemical properties:			
pH, 1:2.5 soil suspension	8.21	8.18	8.15
EC, soil past, dS m^{-1}	1.37	1.24	1.41
Soluble cations, meq l^{-1}			
Ca^{2+}	20.00	20.00	20.33
Mg^{2+}	17.00	14.00	13.00
Na^+	5.64	6.94	10.83
K^+	1.07	1.02	0.33
Soluble anions, meq l^{-1}			
CO_3^{2-}	-	-	-
HCO_3^-	4.00	4.00	3.33
Cl^-	9.66	6.50	4.00
SO_4^{2-}	30.05	31.46	37.16
$CaCO_3$, %	22.99	26.08	26.20
OM, %	0.46	-	-
III. Nutritional properties:			
KCl extractable N, μg g^{-1}	73.00	50.26	34.13
$NaHCO_3$ Extractable P, μg g^{-1}	15.60	17.36	10.26
Amm. Acetate Extractable K, μg g^{-1}	216.66	176.66	210.00

Statistical analysis:

All data were subjected to statistical analysis according to Snedecor and Cochran (1980) and the means were compared using least significant difference at 5% level were carried out; using Duncan's multiple range tests as presented by Steel and Torrie (1984). Appropriate analyses of variance and regression were performed for the two experiments according to Steel and Torrie (1984).

RESULTS AND DISCUSSION

Agronomic Traits, Grain Yield and Yield Components:

Effect of Nitrogen Sources (NS):

Data in Table 2 showed that AA gave the lower significant number of DTT and DTS, but increased significantly PHT, LAI, CHL, EAR, GY and EL in the two successive seasons compared to AN. Results revealed that the application of ammonia gas fertilizer significantly increased values of KPR and 100 KWT in 2016 compared to AN (Table 2).

These results are in harmony with results found by Zohry and Farghaly (2003) and Hanan *et al.* (2008) where they showed that, the addition of ammonia gas fertilizer significantly increased plant height, fresh and dry weights of leaves, ear weight, and weight of grains and straw yields of maize as compared with other fertilizers.

Grain yield was increased by 3.55 ardab fed^{-1} averaged over the two growing seasons as compared to ammonium nitrate (AN) fertilizer treatments.

Metwally (2009) found that AA was associated with higher grain yield and, minerals uptake than other nitrogen sources. Ismail *el al.*, (2013) found that the application of AA at high rate led to increase of plant characters. Abdou *et al.* (2017) concluded that the highest mean values of maize grain yield and its components were linked to AA, which increased grain yield by 4-6% in the two successive seasons, respectively, compared to those obtained by AN.

The superiority of ammonia gas fertilizer than the traditional nitrogen fertilizers is the addition of ammonia under the surface of the soil to the depths save the fertilizer from being lost, increase the efficiency of nitrogen fertilization and thus produce higher grain yield. Moreover, the proper source of ammonia gas up to 140 kg N/fed augmented soil nutrition, its uptake, N use efficiency, maize growth and production (quantity and quality), (Siam, *et al.* 2008). Ammonia gas is reported to reduce the soil pH leading to an increase in the availability of macro nutrients such as nitrogen, phosphorus and potassium. Increased availability on nutrients in soil improved their uptake by maize (Darwish, 2003; King *et al.*, 2003; Siam *et al.*, 2008 and strip-split plot design Abd El-Hafeez *et al.*, 2013).

Table 2. Effect of N source (NS) on DTT, DTS, PHT, LAI, CHL, GY, EL, ED, KPR and KWT during 2015 and 2016 growing seasons.

N sources	DTT days	DTS days	PHT cm	LAI cm^2	CHL mg g^{-1}	EAR no	GY ard fed^{-}	EL cm	ED cm	KPR cm	KWT, g
					2015						
AA	54.6	57.3	252	5.6	523	59.7	32.8	21.5	5.19	46.3	49.0
AN	57.7	60.7	233	5.1	502	57.1	31.0	22.4	5.24	46.5	49.0
$LSD_{0.05}$	0.38	1.59	4.09	NS	8.07	1.00	0.75	0.34	NS	NS	NS
CV	1.6	5.6	3.0	2.9	0.3	4.3	6.1	34.	23.	5.9	10.4
					2016						
AA	55.0	57.0	257	5.6	519	65.7	37.3	22.3	5.03	45.2	44.1
AN	57.3	59.3	249	5.2	500	63.7	31.7	21.8	6.03	43.2	41.3
$LSD_{0.05}$	0.37	0.35	3.93	NS	13.92	1.65	1.13	0.344	NS	1.21	0.745
CV	1.5	1.2	3.6	5.8	3.7	3.4	5.3	4.1	4.1	6.1	4.8

No. of days to 50% tasseling (DTT), number of days to 50% silking (DTS), plant height (PHT), leaf area index (LAI), chlorophyll content(CHL), Grain yield (GY), Ear length (EL), ear diameter (ED), number of kernel per row (KPR), and 100 kernel weight (KWT).

Metwally (2009) found that the anhydrous ammonia injected before planting gave higher grain yield and, minerals uptake than other nitrogen sources. Ismail *el al.* (2013) found that the application of anhydrous ammonia at high rate led to increase of plant characters.

Effect of Nitrogen Rates (NR):

Data in Table 3 showed that increasing N rates from 80 to 140 kg fed^{-1} caused a significant increase in DTT and DTS traits in 2016 only. However, increasing N rate significantly increased PHT, LAI, CHL, GY, EL, KPR, and KWT traits in both seasons.

Table 3. Effect of nitrogen rates (NR) on DTT, DTS, PHT, LAI, CHL, GY, EL, ED, KPR and KWT during 2015 and 2016 growing seasons.

NR	DTT, Days	DTS, days	PHT, cm	LAI, Cm^2	CHL, mg g^{-1}	EAR, no.	GY, ard/fed	EL, cm	ED, cm	KPR, cm	KWT, g
						2015					
80	55.7	58.3	230	4.50	396	58.3	25.5	21.4	5.18	43.7	46.0
100	55.4	57.9	242	5.01	502	58.1	30.7	22.0	5.18	45.2	47.9
120	56.1	58.8	244	5.68	537	58.0	33.9	22.1	5.25	47.8	50.0
140	57.5	60.8	253	6.28	617	59.2	36.3	22.4	5.24	49.0	51.9
$LSD_{0.05}$	NS	NS	4.81*	0.010*	0.54*	NS	1.56*	0.277*	NS	1.63*	2.56*
CV	1.5	5.7	3.0	2.9	0.3	4.3	6.1	4.3	3.2	5.9	10.4
						2016					
80	55.7	57.5	242	4.53	421	62.5	29.2	20.5	4.99	40.4	38.2
100	56.0	58.0	249	5.03	451	63.7	33.5	21.8	5.04	43.9	41.9
120	56.7	59.0	259	5.66	542	66.0	36.6	22.7	5.03	45.0	44.1
140	56.3	58.2	262	6.32	624	66.7	38.7	23.3	5.12	47.3	46.7
$LSD_{0.05}$	0.53	0.55*	5.29*	0.239*	9.91*	1.50*	1.12*	0.48*	NS	1.45*	1.22*
CV	1.5	1.2	3.6	5.8	3.7	3.4	5.3	4.1	4.1	6.1	4.8

No. of days to 50% tasseling (DTT), number of days to 50% silking (DTS), plant height (PHT), leaf area index (LAI), chlorophyll content (CHL), Grain yield (GY) , Ear length (EL), ear diameter (ED), kernel per row (KPR), and 100-kernel weight (KWT).

These increases could be due to the amount of metabolic synthesized by plants as a result of increasing nitrogen levels and the favorable effect of nitrogen fertilizer levels on the metabolic processes and physiological activities of meristimatic tissues, which are responsible for cell division and elongation in addition to formation of plant organs (Zohry and Farghaly, 2003 and Gouda *et al.*, 2009). El-Gizawy (2009) demonstrated that chlorophyll (SPAD-units), growth characters, yield and yield components of maize significantly increased with increasing N rate to 120 kg/fed. Gouda *et al.,* (2009) found that yield of maize increased with increasing rate of nitrogen application. Saeid *et al*. (2010) reported that increasing nitrogen levels significantly decreased N use efficiency. In addition, increasing of nitrogen levels led to significant increase in number of kernels per row, number of kernels per ear and 100-kernels weight.

Results are in agree with those reported by Sharifi and Namvar (2016) they showed that a positive response and significant effect of nitrogen application rate on maize plant height, dry weight and grain yield, also, increased kernels weight and1000 grain weight.

Ali and Anjum (2017) reported that an increase in plant height, a maximum growth and yield traits and quality of maize due to increasing nitrogen. Abd El-Hafeez *et al*. (2013) showed that 120 kg N/fed as ammonia gas gave the highest values of plant height, dry weight/plant. Amanullah and Shah (2011) showed that nitrogen rates and nitrogen timings management improve maize growth and yield components. Mohamoud and Sharnappa (2002) stated that maximum growth, yield traits, and quality increased with increasing N-level. Biswas and Ma (2016) stated that the increasing trend of chlorophyll content with raising N dose indicated better nitrogen uptake by the maize plants. Nitrogen uptake in maize to a large extent depends on the rate of N applied.

Effect of maize Hybrids (HR):

Significant differences were found among maize single crosses for all tested growth characters and grain yield, except for DTS in 2015 (Table 4). Single cross 176 was the earliest hybrid in both seasons while SC 168 was the latest concerning DTT and DTS in both seasons. Single cross 176 was the tallest hybrid in 2015 and the SC 131in 2016. In contrast, SC 168 had the shortest plants in both seasons.

Hybrid SC 131 in total chlorophyll and grain yield (ard/fed) showed the highest significant values, while SC 176 was the lowest in both seasons. Significant differences were detected among maize hybrids for yield components (EAR, EL, ED, KPR and KWT) in both seasons. The SC 131 showed the highest significant values in EAR, EL, ED, KPR and KWT during the two successive seasons compared to the SC 168 and SC 176.

Differences in hybrids growth, yield and its components may be due to differences in their genetic makeup, which affected their response to environmental factors affecting developmental processes and ability to thrive and benefit from available nutrients. These results are in harmony with those obtained by Nofal *et al.* (2005) and Gouda *et al.* (1992 and 2009) mentioned that single crosses of maize significantly surpassed in yield components.

According to Lopes *et al.* (2007) the relationships between ear characteristics are dependent on the genotypes. For Cruz and Carneiro (2003) the hybrid is responsible for 50% of the final grain yield. In this way, for the hybrid to express all its genetic potential, the factors such as nutrients and temperature are fundamental.

Table 4. Effect of Maize hybrid (HB) on DDT, DTS, PHT, LAI, CHL, GY, EAR, EL, ED, KPR and KWT during 2015 and 2016 growing seasons.

HB	DDT, days	DTS, days	PHT, cm	LAI, cm^2	CHL, mg g^{-1}	EAR, no	GY, ard fed^{-1}	EL, cm	ED, cm	KPR, No	KWT, g
						2015					
SC 131	56.00	58.30	237	5.6	598	59.2	35.60	23.20	5.23	49.70	53.00
SC 168	57.30	59.90	236	5.3	503	58.3	31.70	22.40	5.33	46.10	47.70
SC 176	55.10	58.60	2530	5.2	439	57.7	27.50	20.30	5.08	43.50	46.30
$LSD_{0.05}$	0.43*	NS	3.68*	0.08*	0.67*	1.27*	0.972*	0.473*	0.084*	1.39*	2.56*
CV	1.6	5.6	3.0	2.9	0.3	4.3	6.1	4.3	3.2	5.9	10.4
						2016					
SC 131	55.80	57.70	254	5.7	559	64.0	38.20	23.00	5.10	46.90	45.70
SC 168	57.40	59.40	251	5.3	518	63.9	34.10	22.30	5.03	43.80	41.70
SC 176	55.20	57.40	254	5.2	453	66.2	31.10	20.80	5.01	41.90	40.80
$LSD_{0.05}$	0.43*	0.336*	4.52*	0.16*	9.48*	1.12*	0.92*	0.45*	0.105*	1.36*	1.03*
CV	1.5	1.2	3.6	5.8	3.7	3.4	5.3	4.1	4.1	6.1	4.8

No. of days to 50% tasseling (DTT), number of days to 50% silking (DTS), plant height (PHT), leaf area index (LAI), chlorophyll content(CHL), Grain yield (GY), Ear length (EL), ear diameter (ED), kernel per row (KPR), and 100-kernel weight (KWT).

Nitrogen sources (NS) × Nitrogen rates (NR) interaction:

Data in Table 5 indicated that anhydrous ammonia (AA) was superior in GY under all NR than AN with linear positive significant increase during the growing season of 2015.

Applying the right N source, at the right rate, in the right place, at the right time becomes key management for optimizing maize yields and economic returns (Roberts, 2007). Ammonia gas fertilizer at 140 kg N fed^{-1} gave the highest grain yield, while the smallest value was for ammonium nitrate at 80 kg N fed^{-1}. Ammonia gas is reported to reduce the soil pH leading to an increase inthe availability of macro nutrients such as nitrogen, which increased availability of nutrients in soil and improved nutrients uptake by maize (Siam *et al*., 2008; Abd El-Hafeez *et al*., 2013).

Nitrogen sources (NS) × hybrids (HB) interaction:

Results in Table 6 showed that the interactions between NS and HB was significant for DTT, CHL and EL traits in both 2015 and 2016 seasons, while this effect was significant in EAR, GY and KPR traits in 2015. Single cross 176 was significantly earlier in DTT under AA application recorded low value in both seasons, while SC 168 was the latest concerning DTT under AN application recorded the highest value of DTT in two seasons. In the same trend the SC 131 showed the highest significant value in LAI, EAR, EL and KPR under AA application, in the two seasons.

Table 5. Effect of the interaction between NS and NR on grain yield (GY) in 2015 growing season.

NS	NR	grain yield (GY)
AA	80	27.04
	100	32.27
	120	34.57
	140	36.90
AN	80	24.00
	100	29.04
	120	33.30
	140	35.65
$LSD_{0.05}$		1.83
CV		6.1

The CHL content was significantly higher for SC 131 under AN in 2015 and was significantly higher under AA in 2016 as compared to other hybrids. Grain yield recorded the highest value under AA for SC 131, while the

SC 176 recoded the lowest value under AN in 2015. Results are in harmony with those reported by Gouda (1997), Akmal, *et al.* (2010) and Hafez and Abdelaal (2015).

Table 6. Effect of the interaction between nitrogen sources (NS) and hybrids (HB) on DTT, CHL, LAI, EAR, GY, EL and KPR in 2015 season and DTT, PHT, CHL and EL in 2016.

Interaction		DTT No	CHL mg m^2	LAI %	EAR No	GY ard fed^{-1}	EL cm	KPR No	DTT No	PHT cm	CHL mg m^2	EL cm
NS	HB				2015					2016		
AA	131	54.5	574	5.97	61.4	37.0	22.9	51.0	54.6	249	571	22.9
	168	55.4	528	5.55	58.7	33.2	21.3	45.2	56.6	246	520	21.3
	176	53.9	469	5.40	58.9	27.9	20.4	42.9	53.8	261	467	20.4
AN	131	57.6	622	5.27	57.0	34.1	23.6	48.4	56.9	227	546	23.6
	168	59.1	477	5.07	57.9	30.2	23.5	47.0	58.3	227	516	23.5
	176	56.3	408	4.95	56.5	27.1	20.2	44.1	56.6	246	439	20.2
$LSD_{0.05}$		1.08	99.6	0.22	2.99	2.11	2.03	3.90	0.93	19.5	21.2	1.37
CV		1.5	0.3	2.9	4.3	6.1	4.3	5.9	1.5	3.6	3.7	4.1

No. of days to 50% tasseling (DTT), plant height (PHT), chlorophyll content (CHL), leaf area index (LAI), Grain yield (GY), Ear length (EL) and kernel per row (KPR).

Nitrogen rates (NR) and Hybrids (HB) interaction:

Results presented in Table 7 show significant interactions for DTT, CHL, GY and KPR in 2015 growing season and DTT, DTS, CHL, LAI, EAR and EL, in 2016 growing season. Single cross 176 was significantly earlier in DTT trait under100 kg N/fed, while SC 168 was the latest concerning DTT trait under 120 kg N fed-1 recorded the highest value of DTT in terms of DTS. Hybrid SC 176 was earliest in DTS trait under 80 kg N fed-1, while the SC 168 was latest in DTS under 120 kg N fed-1. During 2015 growing season the SC 176 hybrid under 80 kg N fed-1recorded the lowest significant values for KPR and CHL traits and in same trend for EL, CHL and LAI in 2016 growing season. On the other hand SC 131 recorded the highest significant values under 140 kg N fed-1 for the pervious traits in both seasons. The grain yield recorded the highest value for SC 131 under 140 kg N/fed, while SC 176 showed the lowest value under 80 kg N/fed in 2015 growing season.

According to Lopes *et al*. (2007) the relationships between the ear characteristics are dependent on the genotypes. For Cruz and Carneiro (2003) the hybrid is responsible for 50% of the final grain yield. In this way, for the hybrid to express all its genetic potential, factors such as nutrients are fundamental. The increase of N doses allowed better development of rows and grains due to the tendency of higher N accumulation, with positive reflection on the nutritional state of the plant, allowing the genetic expression of the material in number of rows and grain per ear.

Table 7. Effect of the interaction between NR and HB on DTT, KPR, CHL and GY in 2015 growing season and DTT, DTS, CHL, LAI EAR and EL in 2016 growing season.

Interaction		DTT no	CHL mg m^2	GY ard fed^{-1}	KPR no	DTT no	DTS no	CHL mg m^2	LAI %	EAR no	EL cm
NR	HB		2015					2016			
80	131	56.9	429	28.2	44.9	55.1	57.1	447.0	4.88	63.6	21.5
	168	55.8	407	25.7	44.2	56.9	58.8	419.8	4.49	61.6	21.3
	176	54.4	352	22.7	42.0	54.8	56.8	397.5	4.22	62.1	18.6
100	131	54.9	652	33.9	46.5	55.6	57.4	495.8	5.14	62.5	23.0
	168	57.3	449	30.6	45.7	57.8	59.5	456.6	5.20	62.6	22.3
	176	54.0	406	27.4	43.5	54.5	57.1	403.3	4.77	66.0	20.1
120	131	55.1	617	37.7	52.4	56.3	58.4	604.8	5.87	64.5	23.1
	168	58.1	544	34.6	46.4	58.3	60.8	562.8	5.56	66.3	22.9
	176	55.0	452	29.6	44.7	55.5	57.9	458.6	5.54	67.1	22.1
140	131	57.3	694	42.5	55.0	56.1	57.9	688.0	6.83	65.3	24.4
	168	58.0	611	35.9	48.2	56.8	58.8	634.0	5.88	65.3	22.9
	176	57.1	546	30.5	43.8	56.1	58.0	552.8	6.24	69.5	22.5
$LSD_{0.05}$		2.35	100.14	3.45	5.04	1.34	1.08	54.72	0.537	3.34	1.43
CV		1.5	0.3	6.1	5.9	1.5	1.2	3.7	5.8	3.4	4.1

No. of days to 50% tasseling (DTT), number of days to 50% silking, chlorophyll content (CHL), leaf area index (LAI), Grain yield (GY), Ear length (EL), and number of kernel per row (KPR).

Grain NPK Concentration, Uptake, NUE and protein content:

Increased productivity of maize genotypes is due to their ability to accumulate nitrate in their leaves during vegetative growth and to efficiently remobilize this stored nitrogen during grain filling.

Effect of N source (NS):

Concentration of grain nitrogen (N^{conc}), phosphorus (P^{conc}) and potassium (K^{conc}) and their uptake (NPK^{uptake}) and nitrogen use efficiency (NUE) were affected positively by the sources of N fertilizers applied in the two successive seasons. Data presented in Table 8 indicated that anhydrous ammonia (AA) enhanced NPK concentration to 1.81%, 0.66% and 0.67 %, respectively when compare to 1.74%, 0.66% and 0.638% for AN fertilizer, average values are the over the two growing seasons. The same trends of results were detected for NPK uptake (NPK^{uptake}). Table 8 shows significant differences in quantity of kernels nitrogen uptake, phosphorus and potassium (N^{uptake}, P^{uptake}, K^{uptake}) in case of applying under surface injected gaseous fertilizer comparing with surface application of solid fertilizer.

Ammonia gas is reported to reduce the soil pH leading to an increase in the availability of macro nutrients such as nitrogen, phosphorus and potassium. Such increased availability on nutrients in soil improved their uptake by maize (Darwish, 2003; Siam *et al*., 2008 and Abd El-Hafeez *et al*., 2013).

Table 8. Effect of N source (NS) on grain N^{conc}, P^{conc}, K^{conc}, N^{uptake}, P^{uptake}, K^{uptake} and NUE during 2015 and 2016 growing seasons.

NS	N^{conc}, %	P^{conc}, %	K^{conc}, %	N^{uptake}, kg fed-1	P^{uptake}, kg fed-1	K^{uptake}, kg fed-1	NUE	Protn, %
				2015				
AA	1.753	0.590	0.616	81.84	27.97	28.83	42.44	10.96
AN	1.665	0.581	0.595	72.53	25.71	25.84	39.29	10.41
$LSD_{0.05}$	NS	NS	NS	6.18*	1.87*	2.29*	1.55*	0.743
CV	15.38	12.90	14.85	16.16	14.08	16.54	6.17	15.38
				2016				
AA	1.865	0.736	0.734	98.78	39.43	38.80	48.75	11.66
AN	1.813	0.708	0.682	82.10	32.15	30.76	40.91	11.33
$LSD_{0.05}$	NS	NS	0.045*	1.97*	7.79	5.80*	1.92*	0.923
CV	13.64	14.65	17.54	14.96	13.17	19.15	3.67	13.73

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}), Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake(K^{uptake}), Nitrogen use efficiency (NUE), and Protein content (Protn).

Nitrogen use efficiency (NUE) values clearly demonstrated increasing productivity from each gases N unite comparing with AN fertilizer. Each AA N unite produced 45.6 kg grains comparing with 40.1 kg in case of fertilizing using AN which translated to 13.71% increase in maize grains production under the experiment conditions at Nubaria calcareous soils. These underline the importance of providing optimum source of N to improve the NUE which also helps in improving water and soil unite productivity. Also protein content increased with 0.45% in case of AA over AN. Reham *et al.* (2018) concluded that applying anhydrous ammonia increased NUE and protein % positively comparing with AN fertilizer under calcareous soils conditions.

Effect of N fertilization rate (NR):

Results in Table 9 showed that increasing nitrogen rates improved maize kernels concentration of nitrogen (N^{conc}), phosphorus (P^{conc}) and potassium (K^{conc}) and their uptake (NPK^{uptake}). All concentrations were improved linearly, positively and significantly with increasing NR from 80 to 140 kg N fed^{-1}. Application of nitrogen with increasing increments led to increase phosphorus and potassium content of maize kernels and increased the accumulation on grains of NPK nutrients (N^{uptake}, P^{uptake}, and K^{uptake} kg fed^{-1}). Results are in line with those reported by Knight (2013) who stated that maize exposed to greater nitrogen rates will have greater nitrogen uptake in the plant species.

Nitrogen use efficiency (NUE) was significantly affected conversely by increasing N fertilizers application rate in the two successive seasons. Ma and Biswas (2015) started that the adoption of improved N management practices in maize production can increase both grain yield and N use efficiency (NUE) as well as minimize N loading of the environment. Also protein content increased linearly with increasing N rates.

Effect of maize hybrids (HB):

Different responses from maize hybrids (HB) to nitrogen fertilization under calcareous soils conditions are represented in Table 10. SC 131 followed by SC 168 recorded highest kernels Nconc , Pconc, Kconc comparing with SC 176. Values averaged over the two growing seasons were 1.86%, 0.75% and 0.68% for NPK concentrations, respectively for SC 131 whereas SC 176 values were 1.66%, 0.60% and 0.64% respectively. The same trend of results were found for NPK uptake (Nuptake, Puptake, Kuptake) with the same order of HB response, with superiority of SC 131 in NUE reflected in producing more grains with each N fertilizer unit applied. Production of 48.97, 44.17 and 38.14 kg grains per kg N applied for the three HB of 131, 168 and 176, respectively were recorded with 10.87% and 28.40% increase in grain production by SC 131 averaged over the growing seasons. Protein contents in the grain of three single crosses were increased in order 131> 168> 176 during the two growing seasons. The productive characteristics of different maize hybrids have been studied by several investigators (Gouda *et al*., 1992 and Shafshak *et al*., 1995).

Table 9. Effect of N rates (NR) on grain N^{conc}, P^{conc}, K^{conc}, N^{uptake}, P^{uptake}, K^{uptake}, NUE and protn during 2015 and 2016 growing seasons.

NR	N^{conc}, %	P^{conc}, %	K^{conc}, %	N^{uptake}, kg fed-1	P^{uptake}, kg fed-1	K^{uptake}, kg fed-1	NUE	Protn, %
				2015				
80	1.41	0.415	0.514	50.7	15.3	18.4	44.7	8.8
100	1.66	0.543	0.555	71.4	23.5	23.8	42.9	10.4
120	1.78	0.653	0.640	84.8	31.3	30.5	39.6	11.1
140	1.99	0.729	0.713	102.0	37.5	36.6	36.3	12.4
$LSD_{0.05}$	0.133*	0.046*	0.047*	6.65*	2.34*	2.60*	1.96*	0.83*
CV	15.38	12.9	14.9	16.2	14.1	16.5	6.2	15.4
				2016				
80	1.53	0.576	0.585	62.63	23.8	24.1	51.0	9.5
100	1.78	0.648	0.672	83.90	30.5	21.3	46.9	11.1
120	1.95	0.782	0.776	100.70	40.6	39.8	42.7	12.2
140	2.10	0.881	0.800	114.55	48.4	43.5	38.7	13.1
$LSD_{0.05}$	0.143*	0.060*	0.065*	8.14*	4.06*	3.88*	2.13*	0.87*
CV	13.6	14.7	17.5	15.0	13.2	19.2	3.7	13.7

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}) , Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake (K^{uptake}), Nitrogen use efficiency (NUE), and Protein content (Protn).

Table 10. Effect of maize hybrids (HB) on grain N^{conc}, P^{conc}, K^{conc}, N^{uptake}, P^{uptake}, K^{uptake}, NUE and protn during 2015 and 2016 growing seasons.

HB	N^{conc}, %	P^{conc}, %	K^{conc}, %	N^{uptake}, kg fed-1	P^{uptake}, kg fed-1	K^{uptake}, kg fed-1	NUE	Protn, %
				2015				
SC131	1.78	0.683	0.622	90.9	35.0	31.7	45.8	11.1
SC168	1.73	0.527	0.613	77.4	23.9	27.6	41.0	10.8
SC176	1.62	0.547	0.583	63.3	21.6	22.8	35.8	10.1
$LSD_{0.05}$	0.13	0.038	0.045	6.27*	1.9*	2.27*	1.27*	0.826*
CV	15.38	12.90	14.85	16.2	14.1	16.5	6.2	15.4
				2016				
SC131	1.94	0.812	0.732	105.4	44.7	39.9	49.6	12.2
SC168	1.87	0.707	0.704	90.4	34.1	34.1	44.4	11.7
SC176	1.70	0.647	0.687	75.6	28.6	30.3	40.5	10.6
$LSD_{0.05}$	0.13	0.053	0.062	6.8*	2.37*	3.35*	0.83*	0.79*
CV	13.64	14.65	17.54	15.0	13.2	19.2	3. 7	13.7

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}) , Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake(K^{uptake}), Nitrogen use efficiency (NUE) and Protein content (Protn).

Interaction effects of NS, NR and HB on NPK concentration, uptake, NUE and protein content:

Nitrogen sources (NS) and Nitrogen rates (NR) interaction:

Effect of interaction between NS and NR was clearly reflected in concentrations of NPK nutrients in maize grains during the two growing seasons (Table 11). The results showed linear increase in concentrations with increase NR on both of N fertilizer sources with superiority to AA. The same trends of data were recorded for uptake (Nuptake, Puptake, Kuptake) and protein (protn) content, the highest values were located for AA over AN fertilizer even with increasing application rate (NR). Results are in agreement with those reported by Knight (2013) who stated that maize exposed to greater nitrogen rates will have greater nitrogen uptake. In revers trend NUE decreased with increase NR meaning decreased productivity from each N unit applied. The results indicated that grain production from each N fertilizer unit of AA superior AN it may be due to minimize losses of N fertilizer when injected under soil surface comparing with proud casting.

Table 11. Interaction effects between NS and NR on grain N^{conc} , P^{conc}, K^{conc} , N^{uptake}, P^{uptake}, K^{uptake}, NUE and protn during 2015 and 2016 growing seasons.

NS	NR	N^{conc}., %	P^{conc}., %	K^{conc}., %	N^{uptak} kg fed-1	P^{uptak} kg fed-1	K^{uptak} kg fed-1	NUE	Protn, %
					2015				
AA	80	1.49	0.415	0.513	56.7	15.9	19.6	47.3	9.3
	100	1.65	0.553	0.557	75.1	25.3	25.3	45.2	10.3
	120	1.83	0.652	0.662	89.1	32.0	32.0	40.3	11.5
	140	2.04	0.737	0.732	106.4	39.7	38.5	36.9	12.7
AN	80	1.33	0.415	0.515	44.7	14.1	17.3	42.0	8.3
	100	1.67	0.533	0.553	67.6	21.8	22.4	40.7	10.4
	120	1.73	0.654	0.618	80.4	30.7	29.0	38.8	10.8
	140	1.94	0.721	0.694	97.5	36.3	34.7	35.7	12.1
$LSD_{0.05}$		0.150	0.052	0.053	7.39	2.6	2.93	2.21	0.94
CV		15.38	12.89	14.85	16.2	14.08	16.54	6.17	15.4
					2016				
AA	80	1.53	0.598	0.603	71.1	27.6	27.9	57.6	9.6
	100	1.79	0.622	0.709	92.5	32.3	36.7	51.3	11.2
	120	2.02	0.800	0.794	109.8	44.3	43.0	45.1	12.6
	140	2.11	0.920	0.829	121.6	53.3	47.5	40.7	13.1
AN	80	1.51	0.553	0.567	54.1	19.8	20.2	44.3	9.4
	100	1.76	0.674	0.635	75.2	28.7	26.9	42.4	11.0
	120	1.88	0.763	0.757	91.5	36.7	36.5	40.2	11.7
	140	2.09	0.841	0.765	107.4	43.3	39.3	36.5	13.0
$LSD_{0.05}$		0.686	0.067	0.073	9.17	4.58*	4.37	2.40**	0.98
CV		13.64	14.64	17.54	14.96	13.17	19.15	3.67	13.7

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}) , Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake (K^{uptake}), Nitrogen use efficiency (NUE) and Protein content (Protn).

Nitrogen sources (NS) and hybrids (HB) interaction:

Data presented in Table 12 indicated that maize hybrids (HB) respond with different feature to NS during the two growing seasons. Mainly SC131 under 0fertilization by AA was superb performance the other two HB in all studded nutritional features (Nconc , Pconc, Kconc , Nuptake, Puptake, Kuptak, NUE and protein content). Under calcareous soils conditions solid N fertilizers were subjected to volatilization to air causing low N uptake and use efficiency. Zhou *et al*. (2016) concluded that unreasonable application of nitrogen fertilizer to crop land decreases nitrogen use efficiency of crop. It may be by reducing the application rate of chemical nitrogen fertilizers, applying deep placement fertilizing method, are effective practices for reducing nitrogen loss and improving nitrogen use efficiency.

Nitrogen rates (NR) and hybrids (HB) interaction:

Different responses from maize hybrids (HB) to Nitrogen fertilization rate (NR) under calcareous soils conditions (Table 13) were found. SC 131 followed by SC 168 recorded highest grain N^{conc} , P^{conc}, K^{conc} comparing with SC 176 for all tested NR. The same trend of responses was found in N^{uptake}, P^{uptake}, K^{uptake}.

Table 12. Interaction effects between NS and HB on grain N^{conc} , P^{conc}, K^{conc} , N^{uptake}, P^{uptake}, K^{uptake}, NUE and protn during 2015 and 2016 growing seasons.

NS	HB	N^{conc}. %	P^{conc}., %	K^{conc}., %	N^{uptak} kg fed-1	P^{uptak} kg fed-1	K^{uptak} kg fed-1	NUE	Protn, %
				2015					
AA	SC131	1.88	0.71	0.66	99.0	37.67	35.1	47.7	11.7
	SC168	1.76	0.52	0.60	82.4	24.51	28.3	43.2	11.0
	SC173	1.63	0.54	0.59	64.1	21.73	23.1	36.4	10.2
AN	SC131	1.69	0.66	0.58	82.8	32.25	28.2	43.9	10.6
	SC168	1.69	0.54	0.62	72.3	23.34	26.8	38.8	10.6
	SC173	1.61	0.55	0.58	62.5	21.54	22.5	35.1	10.1
$LSD_{0.05}$		0.985	0.067	0.097	7.7	2.34*	2.80*	1.56*	1.01
CV		15.38	12.90	14.85	16.2	14.08	16.5	6.2	15.4
				2016					
AA	SC131	1.97	0.56	0.80	114.7	52.3	46.5	53.6	12.3
	SC168	1.88	0.70	0.70	97.7	36.3	36.6	48.4	11.7
	SC173	1.75	0.62	0.70	83.7	29.7	33.4	44.3	10.9
AN	SC131	1.91	0.74	0.66	96.1	37.2	33.4	45.5	12.0
	SC168	1.87	0.71	0.71	82.8	31.9	31.7	40.4	11.7
	SC173	1.66	0.67	0.67	67.4	27.4	27.2	36.8	10.4
$LSD_{0.05}$		0.985	0.67	0.186**	8.37	2.92**	4.12*	1.02	0.98
CV		15.4	13.5	14.6	15.0	13.2	19.2	3.7	13.7

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}), Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake (K^{uptake}), Nitrogen use efficiency (NUE) and Protein content (Protn).

Table 13. Interaction effects between NR and HB on grain N^{conc} , P^{conc}, K^{conc} , N^{uptake}, P^{uptake}, K^{uptake}, NUE and protn during 2015 and 2016 growing seasons.

NR	HB	N^{conc}. %	P^{conc}, %	K^{conc}, %	N^{uptak} kg fed-1	P^{uptak} kg fed-1	K^{uptak} kg fed-1	NUE	Protn, %
				2015					
80	SC131	1.47	0.493	0.544	58.0	19.4	21.5	49.4	9.2
	SC168	1.50	0.395	0.534	53.9	14.3	19.2	45.0	9.4
	SC173	1.26	0.359	0.465	40.0	11.4	14.6	39.7	7.9
100	SC131	1.69	0.630	0.530	80.5	30.0	25.2	47.4	10.6
	SC168	1.69	0.494	0.579	72.4	21.2	24.8	42.8	10.6
	SC173	1.60	0.506	0.558	72.4	19.4	21.4	38.5	10.0
120	SC131	1.82	0.760	0.640	61.2	40.2	33.7	43.9	11.4
	SC168	1.78	0.565	0.641	96.3	27.5	31.2	40.4	11.1
	SC173	1.74	0.635	0.640	85.9	26.4	26.6	34.5	10.9
140	SC131	2.15	0.848	0.773	72.0	50.2	46.2	42.5	13.5
	SC168	1.93	0.653	0.698	128.8	32.8	35.0	35.9	12.1
	SC173	1.88	0.688	0.670	79.8	29.4	28.6	30.5	11.7
$LSD_{0.05}$		0.174	0.068	0.086	10.26*	3.11**	3.72**	2.07	1.4
CV		15.38	12..90	14.85	16.2	14.1	16.5	6.17	15.4
				2016					
80	SC131	1.67	0.561	0.629	75.0	25.1	28.6	56.1	10.4
	SC168	1.58	0.700	0.574	63.5	29.0	23.2	50.8	9.9
	SC173	1.33	0.466	0.554	49.5	17.2	20.6	46.1	8.3
100	SC131	1.84	0.723	0.701	94.5	37.3	36.5	51.4	11.5
	SC168	1.82	0.586	0.681	83.8	26.8	31.5	46.1	11.4
	SC173	1.68	0.636	0.634	73.3	27.5	27.5	43.3	10.5
120	SC131	1.98	0.939	0.780	113.9	54.1	44.9	47.7	12.4
	SC168	1.98	0.688	0.763	101.3	35.0	38.8	42.5	12.4
	SC173	1.90	0.720	0.785	86.8	32.6	35.6	37.9	11.8
140	SC131	2.29	1.025	0.818	138.1	62.5	49.7	43.2	14.3
	SC168	2.11	0.854	0.799	112.9	45.6	43.1	38.2	13.2
	SC173	1.90	0.765	0.776	92.6	37.0	37.6	34.6	11.9
$LSD_{0.05}$		0.181	0.233	0.050	11.13	3.88**	5.48	1.35	1.30
CV		13.6	**14.7	17.5	15.0	13.2	19.2	3.7	13.7

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}) , Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake (K^{uptake}), Nitrogen use efficiency (NUE) and Protein content (Protn).

The results showed that increasing N fertilization rate was caused increase in nutrients concentrations, their uptake and protein content. Revers trend were found for NUE with increasing N fertilization rate NUE was decreased. Zeinab *et al*. (2015) concluded that nitrogen levels exhibited significant effect for all studied traits of maize.

Nitrogen sources (NS) and Nitrogen rates (NR) hybrids and (HB) interaction:

Three way interactions of the tested NS, NR and maize HB agreed with all previous results of main and two way interaction effect (Table 14). In general SC 131 followed by SC168 respond efficiently more than SC176 to ammonia gas fertilizer (AA) comparing with solid ammonium nitrate fertilizer under all four N rates up to 140 kg N fed-1 during the two growing seasons of 2015 and 2016, respectively.

It is suggested that developing new high efficiency maize hybrids in use and utilize nitrogen fertilizers, enhancing nitrogen management, and strengthening minimizing nitrogen rates with using sources are the powerful tools to decrease nitrogen application rate and increase efficiency of crop land (Tisdale *et al.*, 1999).

Table 14. Interaction effects among NS, NR and HB on grain N^{conc} , P^{conc}, K^{conc} , N^{uptake}, P^{uptake}, K^{uptake}, NUE and protn during 2015 and 2016 growing seasons.

NS	NR	HB	N^{conc}. %	P^{conc}., %	K^{conc}., %	N^{uptak} kg fed-1	P^{uptak} kg fed-1	K^{uptak} kg fed-1	NUE	Protn, %	N^{conc}. %	P^{conc}., %	K^{conc}., %	N^{uptak} kg fed-1	P^{uptak} kg fed-1	K^{uptak} kg fed-1	NUE	Protn, %
			2015								2016							
AA	80	SC131	1.61	0.518	0.575	65.93	21.13	23.59	51.39	10.08	1.71	0.522	0.680	85.45	26.27	34.21	62.78	10.65
	80	SC168	1.52	0.395	0.520	59.65	15.47	20.39	48.91	9.46	1.50	0.812	0.550	69.02	37.50	25.41	57.84	9.34
	80	SC173	1.34	0.335	0.445	44.42	11.22	14.66	41.68	8.36	1.41	0.460	0.580	58.82	19.25	24.32	52.38	8.77
	100	SC131	1.77	0.668	0.560	88.65	33.39	28.09	49.95	11.07	1.83	0.747	0.797	103.36	42.06	44.90	56.22	11.46
	100	SC168	1.70	0.505	0.573	77.10	22.97	26.10	45.48	10.60	1.88	0.522	0.697	94.51	26.39	35.22	50.36	11.76
	100	SC173	1.49	0.488	0.540	59.66	19.55	21.64	40.09	9.32	1.67	0.597	0.632	79.77	28.45	30.02	47.57	10.43
	120	SC131	1.89	0.770	0.663	103.05	42.18	35.87	45.29	11.78	2.04	1.122	0.840	122.52	67.24	50.57	50.03	12.75
	120	SC168	1.84	0.543	0.625	92.08	27.58	31.65	42.00	11.44	1.99	0.632	0.745	108.08	34.35	40.19	45.25	12.40
	120	SC173	1.78	0.645	0.700	72.18	26.17	28.43	33.72	11.14	2.04	0.647	0.797	98.98	31.54	38.24	40.20	12.76
AN	140	SC131	2.24	0.880	0.855	138.52	53.96	52.82	44.04	13.99	2.31	1.150	0.877	147.41	73.42	56.10	45.53	14.45
	140	SC168	1.98	0.628	0.685	100.85	32.03	34.92	36.39	12.36	2.15	0.840	0.812	120.21	47.03	45.50	39.96	13.43
	140	SC173	1.90	0.705	0.658	79.92	29.94	27.75	30.25	11.83	1.87	0.772	0.797	97.20	47.03	41.01	36.87	11.68
	80	SC131	1.32	0.468	0.513	50.06	17.75	19.36	47.30	8.24	1.63	0.600	0.577	64.46	23.84	22.88	49.42	11.68
	80	SC168	1.48	0.398	0.548	48.23	13.08	18.02	41.05	9.25	1.66	0.587	0.597	57.92	20.54	20.91	43.72	10.36
	80	SC173	1.19	0.383	0.485	35.63	11.57	14.59	37.65	7.43	1.26	0.472	0.527	40.10	15.05	16.81	39.89	7.83
	100	SC131	1.61	0.593	0.500	72.42	26.57	22.38	44.90	10.07	1.84	0.697	0.605	85.70	32.49	28.15	46.57	11.49
	100	SC168	1.69	0.483	0.585	67.67	19.41	23.54	40.18	10.57	1.75	0.650	0.665	73.18	27.18	27.69	41.79	10.95
	100	SC173	1.71	0.525	0.575	62.75	19.25	21.20	36.87	10.65	1.70	0.675	0.635	66.84	26.54	24.92	39.11	10.61
	120	SC131	1.76	0.750	0.618	89.59	38.17	31.48	42.58	10.96	192	0.7550	0.720	105.31	40.86	39.19	45.40	12.01
	120	SC168	1.72	0.588	0.658	79.77	27.33	30.77	38.71	10.74	1.98	0.742	0.780	94.59	35.55	37.41	39.82	12.39
	120	SC173	1.70	0.625	0.580	71.87	26.55	24.72	35.24	10.63	1.75	0.792	0.772	74.69	33.74	32.97	35.58	10.93
	140	SC131	2.07	0.815	0.690	119.04	46.52	39.63	40.88	12.93	2.26	0.900	0.757	128.85	51.53	43.26	40.79	10.93
	140	SC168	1.89	0.678	0.710	93.63	33.55	35.01	35.39	11.78	2.07	0.867	0.785	105.53	44.15	40.65	36.38	12.95
	140	SC173	1.86	0.670	0.683	79.70	28.77	29.34	30.67	11.59	1.94	0.757	0.755	88.07	34.33	34.26	32.41	12.11
$LSD_{0.05}$			0.159	0.068	0.106	14.5	4.40	5.26	2.93	1.91	0.238	0.308**	0.065	15.74	5.48**	7.75	1.92	1.84
CV%			15.38	12.90	14.85	16.16	14.08	16.54	6.17	15.38	13.64	14.65	17.54	14.96	13.17	19.14	3.67	13.73

Nitrogen concentration (N^{conc}), Phosphorus concentration (P^{conc}), Potassium concentration (K^{conc}) , Nitrogen uptake (N^{uptake}), Phosphorus uptake (P^{uptake}), potassium uptake (K^{uptake}), Nitrogen use efficiency (NUE) and Protein content (Protn).

IV. Parameters affected grain yield

The regression coefficient between grain yield (GY) and the nineteen variables showed that there is a highly significant relation between grain yield and ten of the independent variables including (N uptake, N concentration, K uptake, K concentration, ear length, NUE, chlorophyll content, EAR, no. of days to sillking, leaf area index) and the rest of variables not effected the grain yield under the experiment conditions.

Stepwise regression analysis was made to explain the regression coefficient between grain yield as dependent variable and the most effective parameters (Table 15). The analysis indicated that there was a statistical model contains all the sixteen independent variables explain 819 % (R-square = 0.819) of grain yield differences, at the same time there were four variables explained 96.3% (R-square=0.9626) of yield variations including (N uptake, N concentration, K uptake and K concentration).

It is suggested that developing new high efficiency nitrogen fertilizers, enhancing nitrogen management, and strengthening the monitoring and use of environmental nitrogen sources are the powerful tools to decrease nitrogen application rate and increase efficiency of cropland.

Table 15. Regression coefficient of grain yield, as dependent variable with the 10 effective attributes averaged over the two growing seasons

Step	Variable entered	Partial R^{**2}	Model R^{**2}	Prop > f
1	N^{uptake}	0.8191	0.8191	0.0001
2	N^{conc}	0.1414	0.9605	0.0001
3	K^{uptake}	0.0022	0.9626	0.0011
4	K^{conc}	0.0045	0.9672	0.0001
5	EL	0.0013	0.9685	0.0060
6	NUE	0.0013	0.9697	0.0060
7	CHL	0.0020	0.9718	0.0004
8	EAR	0.0006	0.9724	0.0466
9	DTS	0.0006	0.9730	0.0410
10	LAI	0.0006	0.9736	0.0434

CONCLUSION

The major problems of soil under calcareous conditions are poor in physical properties, deficient in organic matter and characterized by relative high pH, thus their content of N was limited and availability of phosphorus and micronutrients were low. Therefore, applying ammonia gas fertilizer on calcareous soil is recommended for maize crop. The superiority of ammonia gas fertilizer than the traditional nitrogen fertilizers is the addition of ammonia under the surface of the soil to the depths save the fertilizer of the loss, increase the efficiency of nitrogen fertilization and thus producing abundant crops. Also, anhydrous ammonia (NH3) is generally readily available and is the least expensive source of N fertilizer and is more slowly converted to nitrate than other N fertilizers. Ammonia gas is reported to reduce the soil pH leading to an increase in the availability of macro nutrients such as nitrogen, phosphorus and potassium. Such increased availability on nutrients in soil improved their uptake by maize.

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تأثير مصادر ومعدلات النيتروجين علي المحصول والصفات المرفولوجية والفسيولوجية لبعض هجن الذرة الشامية

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اقيمت تجربة حقلية بمزرعة محطة بحوث النوبارية الممثلة للاراضي الكلسية خلال موسمي 2015، 2016 علي التوالي وذلك بهدف دراسة تأثير مصدرين مختلفين من الاسمدة النيتروجينية (الحقن بالامونيا الغازية 82% ونترات الامونيوم 33.5% بمعدلات 80، 100، 120، 140 كجم نيتروجين/ فدان لكل منهما علي المحصول ومكوناته وبعض الصفات المرفولوجية والفسيولوجية وكذلك تركيز وامتصاص عناصر النتروجين ، الفوسفور و البوتاسيوم NPK^{conc} وكفاءة استخدام النيتروجين لبعض هجن الذرة الشامية هجين فردى 131 ، هجين فردى 168 وهجين فردى 176. اوضحت النتائج المتحصل عليها ان تأثير الحقن بالامونيا الغازية ادي الي خفض عدد الايام حتي خروج 50% من اللقاح (DTT) و50% خروج الحريرة (DTS) بينما زاد معنوياً ارتفاع النبات (PHT) ومساحة الورقة (LAI) ومحتوي الكلورفيل (CHL) وعدد الكيزان (EAR) ومحصول الحبوب (GY) ومكوناته ما عدا قطر الكوز في كلا موسمي النمو بالمقارنة بالتسميد بنترات النشادر (AN). اوضحت النتائج ايضا زيادة معدل التسميد (NR) من80 كجم الي 140 كجم نيتروجين/ فدان ادي الى زيادة معنوية في عدد الايام حتي خروج 50% من اللقاح و 50% خروج الحريرة وعدد الكيزان فى عام 2016 بينما أدت الزيادة فى معدل التسميد الى تأثير ايجابى معنوي فى صفات الكلورفيل والمساحة الورقية وارتفاع النبات والمحصول ومكوناته فى كلا موسمي الزراعة. واظهرت هجن الذرة الشامية اختلافات معنوية في كل من صفات النمو والمحصول ومكوناته. وكان هجين فردي 176 ابكر الهجن في التزهير بينما كان هجين فردي 168 اكثرهم تأخيرا في كلا موسمي النمو. اعطي هجين فردي 131 اعلي محصول اردب للفدان بينما كان هجين فردي 176 الاقل في المحصول في كلا موسمي النمو. اظهرت النتائج ان هناك زيادة منعوية وايجابية للمحصول عند التسميد بالامونيا الغازية تحت كل معدلات التسميد مقارنا بنترات الامونيوم وكان اعلي محصول هو 36.9 اردب للفدان عند التسميد بالامونيا الغازية بمعدل 140كجم للفدان بينما كان اقل محصول هو 24.0 اردب للفدان عند التسميد بنترات الامونيوم بمعدل 80كجم للفدان في موسم 2015. اوضحت النتائج ان استجابة الهجن بالتسميد الامونيا الغازية كانت افضل من التسميد بنترات الامونيوم وكان الهجين 131 افضلهم معنويا في المحصول. اما بالنسبة لتركيز عناصر النتروجين ، الفوسفور و البوتاسيوم NPK^{conc} و امتصاصها فى محصول الحبوب NPKuptake وكذلك كفاءة استخدام السماد النتروجيني NUE و نسبة البروتين فقد اوضحت النتائج ان الحقن بالامونيا الغازية ادت الي رفع كفاءة استخدام التسميد النتروجيني وزيادة تركيز وامتصاص كل من النتروجين والفسفور والبوتاسيوم وكذلك نسبة البروتين زيادة ايجابية عن التسميد بنترات الامونيوم. اوضح التفاعل الثلاثي بين العوامل المختبرة (HB, NR, NS) أن الهجين 131 ثم الهجين 168 قد أستجابت بكفاءة اكبر من الصنف 176 لسماد الأمونيا الغازية بالمقارنة بسماد نترات الامونيوم الصلب تحت كل معدلات التسميد الأربعة حتى مستوي 140 كجم ن/فدان . اشارت النتائج الي ان معامل الانحدار بين محصول الحبوب وعدد 19 عامل مستقل أظهرت وجود علاقة معنوية عالية فقط بين المحصول و10 من العوامل المستقلة شملت تركيز عناصر النتروجين و البوتاسيوم NK^{conc} وامتصاصها وكذلك طول الكوز وكفاءة استخدام النتروجين ومحتوي الكلورفيل وعدد الايام حتي 50% خروج الحريرة ومساحة الورقة وعدد الكيزان. لذلك توصي الدراسة باستخدام الامونيا الغازية للتسميد في الاراضي الكلسية لتحسين امتصاص العناصر وبالتالي زيادة انتاجية محصول الذرة الشامية.