J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 4 (11): 1313 - 1328, 2013

INFLUENCE OF DIFFERENT SOURCES AND LEVELS OF NITROGEN AND ROCK PHOSPHATE ADDITION ON MAIZE PRODUCTIVITY AND SOIL FERTILITY

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ABSTRACT

Two field experiments were conducted at Sids Agricultural Research Station Farm during 2010 and 2011 seasons to investigate the effect of two nitrogen fertilizer sources, namely ammonia gas (83% N) and urea (46.5% N) with three levels, i.e. 60, 90 and 120 kg N/fed as well as rock phosphate as phosphorus source under two levels (0.0 and 300 kg rock P/fed) on growth characters ,yield and its components,net income and N, P and K concentrations and uptake of maize (*Zea mays* L.) as well as soil fertility. The results show that 120 kg N/fed as ammonia gas recorded the highest values of plant height, dry weight/plant, ear length and diameter, 100-seed weight, grain and stover yields, net income, N, P and K concentrations and uptake and nitrogen availability, while number of rows and kernels/ear and P and K availability not affected by either nitrogen sources or levels. Application of rock phosphate significantly increased plant height, dry weight/plant, 100-seed weight, grain and stover yields, net income, N and P concentrations and N, P and K uptake as well as P availability, while ear length and diameter, number of rows and kernels, K concentration and the availability of N and K in soil after harvesting not affected. Phosphorus concentrations in both grains or stover and N and P availability in soil after harvesting were affected by increasing nitrogen levels only under ammonia gas application.

Keywords: Maize, growth characters, yield and its components, net income, NPK concentration and uptake, ammonia gas, urea, soil fertility.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops grown principally during the summer season in Egypt. Maize grain is widely used for human and animal feeding. Grain yield could be increased by increasing new high yielding hybrids which will be adapted to different cultural practices such as nitrogen and phosphorus.

Nitrogen is the most important nutrient for plant production, which represents a vital element in all biological processes in plant life. Among the great number of nitrogenous fertilizers, ammonium sulphate, ammonium nitrate and urea used in Egypt. Recently, nitrogen added to plants, especially maize, as ammonia gas by injected in the soil before planting using especial apparatus. The influence of inorganic nitrogen fertilizer sources on plant growth is mainly due to its effect on soil reaction and nutrients availability. Some fertilizer materials leave an acid residue in soil, others are of basic, and still others seemingly have no influence on soil pH (Tisdale and Nelson, 1975; Kanwar, 1978; Stecker *et al.* (1993) and Hassanein, 1996). The superiority of ammonia gas as nitrogen source than others especially urea were reported by many workers such as Abdel- Aziz *et al.* (1986), Morsy (1994) and Abd El-Hameid *et al.* (1996). On the other hand maize responded to great extent to increasing N-fertilization level because of its nature as a heavy N feeder crop, as well as the deficit in soil-N. (Genaidy *et al*., 1992*;* Ismail *et al*., 2006*;Mansour,2009;* Sadik *et al*., 2009 and Ali *et al*., 2012).

Supply of adequate phosphorus is an essential factor for plant growth. Quite high rates of soluble P fertilizers are required to increase soil P levels to sufficiency for economic crop production. The use of high rates of such fertilizer increase the costs of agricultural production. Rock phosphate may be desirable alternative to high cost of soluble P fertilizers. In this respect Jena *et al*. (2004), Kifuko *et al*. (2007), Franzini *et al*. (2009), Phiri *et al*. (2010) and El Sheref (2012) stated that maize growth and yields responded to rock phosphate application.

The objective of the present investigation is to evaluate the effect of nitrogen sources and levels as well as using some natural P fertilizer, namely rock phosphate on maize productivity and some soil properties.

MATERIALS AND METHODS

Two field experiments were conducted at Sids Agric. Res. Station (Beni-Swif Governorate) during the two successive growing seasons 2010 and 2011 to study the effect of two nitrogen fertilizer sources, i.e. ammonia gas (83% N) and urea (46.5% N) under three levels (60, 90 and 120 kg/fed) as well as rock phosphate application under two levels (zero and 300 kg rock P/fed) on growth characters, yield and its components and NPK concentrations and uptake of maize (*Zea mays* L.) as well as soil fertility.

Soil samples:

A representative soil sample was collected from the experimental site at the depth of 0.0-30 cm before planting. Also, representative soil samples were collected after harvesting from each experimental plots to determine soil available N, P and K. Some chemical and physical properties of experimental soil before planting are determined according to Jackson (1973) and listed in Table (1).

Table (1): Chemical and physical properties of experimental soil before planting.

Soil properties	First season	Second season
Particle size distribution:		
Clay (%)	55.16	57.73
Silt (%)	26.67	30.11
Sand (%)	18.17	12.16
Texture grade	Clay loam	Clay loam
pH (1:2.5 soil water suspension)	8.06	8.21
EC, dSm^{-1} (soil paste)	0.83	0.92
Organic matter (%)	1.72	1.79
$CaCO_3$ (%)	3.11	2.83
Available N (mg kg^{-1})	25.3	26.8
Available P (mg kg^{-1})	13.3	12.5
Available K (mg kg^{-1})	169	173

Fertilizer treatments:

1. Nitrogen: ammonia gas (83% N) at rate of 60, 90 and 120 kg N/fed were applied in the main split plot which injected directly into moderately moisture soil at 15 cm depth with 30 cm spacing between points of injection before sowing. While, urea (46.5% N) was applied at the above mentioned levels to the soil in two equal doses, one dose was applied after the thinning and the second after one month later.
2. Rock phosphate (about 8.7-9.6% P) at two rates (without and 300 kg rock phosphate) were added to experimental plots before sowing.

Experimental design:

The experimental design was split-split in completely randomized blocks with four replication. Nitrogen sources were located in the main plot and its levels were randomized distributed in sub plots, while rock phosphate treatments were added in the sub-sub plots. The experiment included 12 treatments and 48 plots in both seasons.

Field experiment:

Maize grains c.v. Three Way Cross 310 were sown in ridges during the first week of June in the two seasons. The plot area was (3.0 x 4.5 m = 1/267 fed). Each plot consisted of five rows, 4.5 meters along and 70 cm apart. Planting was done in hills, 30 cm apart using two kernels for each. Thinning was done before first irrigation to get one plant/hill resulting a plant population of 20000 plant/fed. The plants were harvested at maturity at 120 days after planting in both seasons. All other agronomic practices without nitrogen and superphosphate fertilizers application were followed using the technical package of growing mage in district

Plant samples:

Two plant samples were taking from each plot. The first sample was taken during tasseling-silking stage (about 60 days age) from the inner rows to measure plant height (cm) and plant dry weight (g/plant). The second sample was taken at harvesting time to estimate some yield components [ear length (cm), ear diameter (cm), number of rows/ear, number of kernels/row and 100-seed weight (g)]. Finally, each grain and stover yields were determined and recorded as ardab/fed and ton/fed, respectively for each plot. N, P and K concentrations in both grains and stover were determined according to Chapman and Pratt (1961) and its uptake by both grains and stover were calculated.

Net income (L.E.):

The net income of yielded maize grain due only to the cost of the studied treatments, where other agronomic practices were constant, was calculated as: Net income (NI) in Egyptian pound (L.E.) = Price of the weight of grains – price of added fertilizer treatments in kg/fed.

Where, the average price of grains/ardab was 250 L.E. in the two seasons and the average price of the fertilizer treatments were 3.66 and 3.25 L.E./kg N for urea and ammonia gas, respectively and 120 L.E./300 kg rock phosphate.

Statistical analysis:

The data were subjected to statistical analysis according to Snedecor and Cochran (1980). Significant of differences among treatment were compared using the least significant differences.

RESULTS AND DISCUSSION

1- The growth characters:

Data in Table (2) show that both plant height and dry weight/plant were significantly affected by nitrogen sources. The tallest and heaviest plants were recorded with the addition of N as ammonia gas in both seasons. The increasing percentage in plant height and dry weight due to ammonia gas comparing with urea were 3.4 and 5.0%, respectively in the first season.

Table (2): Effect of nitrogen sources and levels and rock phosphate application on some maize growth at tasseling stage.

N sources (A)	N levels (B)	Rock P (C)	Plant height (cm) 2010	Plant height (cm) 2011	Dry weight (g/plant) 2010	Dry weight (g/plant) 2011
Urea	60	without	165.5	167.5	66.1	66.9
		with	168.6	169.9	69.0	69.3
	Mean		**166.9**	**168.7**	**67.6**	**68.1**
	90	without	**171.2**	**173.7**	**71.7**	**72.0**
		with	**175.7**	**178.2**	**75.1**	**75.6**
	Mean		**173.5**	**176.0**	**73.4**	**73.8**
	120	without	177.6	180.1	77.3	78.1
		with	180.3	182.5	80.9	81.5
	Mean		**179.0**	**181.3**	**79.1**	**79.8**
Mean			**173.1**	**175.3**	**73.4**	**73.9**
Ammonia gas	60	without	170.2	172.9	70.8	71.2
		with	173.9	175.7	72.6	73.4
	Mean		**172.1**	**174.3**	**71.7**	**72.3**
	90	without	177.3	180.3	76.1	76.7
		with	181.6	184.1	80.3	80.9
	Mean		**179.5**	**182.2**	**78.2**	**78.8**
	120	without	180.2	183.5	79.6	80.2
		with	184.3	188.6	82.9	83.3
	Mean		**182.3**	**186.1**	**81.3**	**81.8**
Mean			**178.0**	**180.9**	**77.1**	**77.6**
Mean of levels	60		168.6	171.5	69.7	70.2
	90		176.5	179.1	75.8	76.3
	120		180.7	183.7	80.2	80.8
Mean of rock P		without	**173.7**	**176.3**	**73.8**	**74.2**
		with	**177.4**	**179.8**	**76.8**	**77.3**
L.S.D at 0.05	A		**3.35**	**3.13**	**1.72**	**1.91**
	B		**4.11**	**4.26**	**4.23**	**3.01**
	C		**2.07**	**2.10**	**2.19**	**2.35**
	AB		**NS**	**NS**	**NS**	**NS**
	AC		**NS**	**NS**	**NS**	**NS**
	BC		**NS**	**NS**	**NS**	**NS**
	ABC		**NS**	**NS**	**NS**	**NS**

The same trend was obtained in the second one. The superiority of ammonia gas on the vegetative growth may be due to continuous and slow release of N beginning of sowing to maize plants. These results are in conformity with the findings of Abd El-Hameid *et al*. (1996) and Ismail *et al*. (1996). On the other hand, El-Sayed (2001) and Sarhan (2006) stated that the hydrolysis of urea was more rapid than other nitrogen fertilizers resulted in more loss by leaching.

As for nitrogen levels, the data in the same Table show that plant height and dry weight were significantly increased as increasing nitrogen levels from 60, 90 and 120 kg/fed. These results are mainly due the vital role of nitrogen in plant growth, as it necessary for protoplasm formation and photosynthesis in all plants, it also necessary for cell deviation and merestimatic activity in plant organs. These results are similar to those obtained by Ismail *et al*. (1999), Oraby and Sarhan (2002), Sarhan (2006) and Sadik *et al*. (2009).

With regard to rock phosphate fertilization, the data show that maize plant height and dry weight were significantly responded to application of 300 kg/fed rock phosphate in both seasons. Hence the highest and heaviest maize plants were achieved by plants received rock phosphate (177.4 cm and 77.3 g/plant) in the first growth season, respectively. On the other hand, the plants without rock phosphate fertilization recorded 173.7 cm and 73.8 g/ plant in the second one, respectively. This may be due to the role of application of natural elemental materials as source of phosphorus which enhancing the metabolic process. These results are in harmony with those obtained by Aknade *et al*. (2005), Hellal *et al*. (2009) and El-Sheref (2012).

As for the interaction between treatments, the data show that the growth characters not responded to the interactions between any of two treatments or to the interaction among them. Those means that the greatest values for maize plant height and dry weight were obtained for the plants received 120 kg N/fed as ammonia gas and supplied with 300 kg/fed rock phosphate. While, the plants fertilized with 60kg N/fed as urea and without rock phosphate application recorded the shortest and lightest maize plants.

2- The yield components:

The results reported in Table (3)clearly indicate that all studied maize yield components except number of rows/ear and number of kernels/row were significantly affected by nitrogen sources. The application of nitrogen as ammonia gas produced the highest ear length and diameter as well as seed index in both seasons. The increments of ear length and diameter and seed index due to ammonia gas application as comparing with urea are mainly due to the effect of ammonia gas on growth parameters as mentioned before (Table, 2) which in turn improved ear length, ear diameter and 100-seed weight. On the other hand, both number of rows/ear and number of kernels/row were not affected by nitrogen sources which mainly due to these parameters have a gentic affect. Similar results were obtained by Mansour (2009).

As for nitrogen level, the data show that increasing nitrogen level up to 120 kg/fed was significantly increased maize yield components, except number of rows/ear and number of kernels/row in the two seasons. The relative increasing of ear length, ear diameter and seed index yielded by adding 120 kg N/fed were 4.1, 4.6 and 3.3% as compared with adding 60 kg N/fed in the first season, respectively. Similar trends were obtained in the second season. It is quite evident from the results that, nitrogen fertilization is required for optimum or better building up of vegetative growth and reproductive plant organs. These results are in harmony with those obtained by Gebraiel *et al*. (2005) and Abd El-Lattif (2012).

Table (3): Effect of nitrogen sources and levels as well as rock phosphate application on some yield components.

N sources (A)	N levels (B)	Rock P (C)	Ear length (cm)		Ear Diameter(cm)		Number of rows/ear		Number of kernels/ear		100-seed weight (g)	
			2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Urea	60	without	20.11	20.21	5.01	5.05	12.61	12.62	35.12	35.11	33.16	33.21
		with	20.15	20.26	5.03	5.05	12.60	12.63	35.17	35.10	33.51	33.58
	Mean		**20.13**	**20.24**	**5.02**	**5.05**	**12.61**	**12.63**	**35.15**	**35.10**	**33.34**	**33.40**
	90	without	21.32	21.41	5.16	5.19	12.62	12.61	35.07	35.09	34.00	34.07
		with	24.29	21.35	5.16	5.18	12.61	12.62	35.11	35.10	34.62	34.69
	Mean		**21.31**	**21.38**	**5.16**	**5.19**	**12.62**	**12.62**	**35.09**	**35.10**	**34.31**	**34.38**
	120	without	22.41	22.47	5.24	5.29	12.61	12.63	35.01	35.08	35.31	35.40
		with	22.45	22.63	5.23	5.28	12.62	12.61	35.00	35.13	35.90	35.99
	Mean		**22.43**	**22.55**	**5.24**	**5.29**	**12.62**	**12.62**	**35.01**	**35.11**	**35.61**	**35.70**
Mean			**21.29**	**21.39**	**5.14**	**5.18**	**12.62**	**12.62**	**35.08**	**35.10**	**34.42**	**34.49**
Ammonia gas	60	without	20.22	20.31	5.07	5.10	12.60	12.61	35.11	35.14	34.32	34.37
		with	20.26	20.33	5.06	5.11	12.62	12.61	35.07	35.08	34.76	34.98
	Mean		**20.22**	**20.32**	**5.06**	**5.11**	**12.61**	**12.61**	**35.09**	**35.11**	**34.54**	**34.68**
	90	without	21.35	21.46	5.21	5.27	12.61	12.62	35.12	35.13	34.60	34.71
		with	21.40	21.47	5.20	5.27	12.61	12.62	35.11	35.13	34.91	35.00
	Mean		**21.38**	**21.47**	**5.21**	**5.27**	**12.61**	**12.62**	**35.12**	**35.13**	**34.76**	**34.86**
	120	without	22.39	22.42	5.29	5.31	12.63	12.60	35.11	35.11	35.82	35.89
		with	22.42	22.40	5.30	5.31	12.61	12.60	35.09	35.12	36.07	36.10
	Mean		**22.41**	**22.41**	**5.30**	**5.31**	**12.62**	**12.60**	**35.10**	**35.12**	**35.95**	**36.00**
Mean			21.34	22.40	5.19	5.23	12.61	12.61	35.10	35.12	35.08	35.18
Mean of levels	60		20.18	20.28	5.04	5.08	12.61	12.62	35.11	35.11	33.99	34.04
	90		21.35	21.43	5.19	5.23	12.62	12.62	35.11	35.12	34.54	34.62
	120		22.42	22.48	5.27	5.30	12.62	12.61	35.06	35.12	35.78	35.85
Mean of rock P		without	**21.30**	**21.38**	**5.16**	**5.20**	**12.61**	**12.62**	**35.09**	**35.11**	**34.54**	**34.61**
		with	**21.33**	**21.41**	**5.16**	**5.20**	**12.61**	**12.62**	**35.09**	**35.11**	**34.96**	**35.06**
L.S.D at 0.05		A	0.03	0.03	0.05	0.07	N.S	N.S	N.S	N.S	0.43	0.40
		B	0.98	1.03	0.08	0.07	N.S	N.S	N.S	N.S	0.50	0.48
		C	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.05	0.06
		AB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
		AC	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
		BC	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
		ABC	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Regarding rock phosphate fertilization, the data revealed that the natural fertilizer, namely, rock phosphate had a markedly effect only on 100-seed weight in both seasons, While other maize yield components were not affected by rock phosphate application. The plants supplied with rock phosphate yielded 34.96 and 35.06 grams of 100-seed weight of maize grains compared with 34.54 and 34.61 grams without rock phosphate application in the two seasons, respectively. These results agree with those obtained by Rajput *et al*. (2007).

Concerning the interaction between treatments, the results clearly show that, all studied maize yield components were not affected by the interaction between treatments or among them. These results means that combined 120 kg N/fed as ammonia gas with 300 kg rock phosphate/fed produce better yield components for maize.

3- Grain and stover yields and net income:

The results reported in Table (4) indicate that, there were significant differences between maize grain and stover yields as affected by nitrogen sources, i.e. urea and ammonia gas in the two studied seasons. The data indicate that ammonia gas exceeded urea fertilizer in its effect on both grain and stover yields by about 10.0 and 6.6%, respectively in the first season. The same trend was obtained in the second season. The positive effect of ammonia gas on maize grain and stover yields is mainly due to the enhancement of ammonia gas on both growth and yield components as mentioned before (Tables 2 and 3). These results are in harmony with those obtained by Abdel-Aziz *et al*. (1986), Morsy (1994) and Abd El-Hameid *et al*. (1996). Concerning the effect of nitrogen sources on net income, the data obtained show that the net income resulted from added ammonia gas surpassed that gained due to urea by about 264.4 and 339.0 Egyptian pounds in the two studied seasons, respectively. The superiority of ammonia gas on grain net income than urea is mainly due to not only its effect on increasing grain yield but also to the cheaper price of nitrogen unit than that of urea

As for nitrogen level, data in Table (4) show that irrespective of nitrogen sources, increasing nitrogen level from 60 to 90 and 120 kg/fed were accompanied by a significant increases in both grain and stover yields in both seasons. The relative increasing of grain yield due to 120 kg N/fed as comparing to 60 and 90 kg N/fed were 10.2 and 4.6% in the first season, respectively in the first season. Similar trends were obtained for the second season and straw yield in the two seasons. The promotive effect of the high nitrogen fertilization on maize grain and stover yields could be explained by the fact that maize plant responded to great extent to N-fertilization because its nature as a heavy N feeder crop, as well as the deficit in soil-N (Genaidy *et al.*, 1992). Similar results were obtained by many workers such as Mansour (2009) and Sadik *et al*. (2009). Also, the data in Table (4) clearly show that increasing nitrogen level up to 120 kg/fed had a positive effect on net income of grain yield in both seasons. The net income gained from grain yield due to added 120 kg N/fed exceeded that yielded from 60 and 90 kg N/fed by about 317.7 and 120.7 in the first season and 325.9 and 114.0 L.E in the second one, respectively. These results are in agreement with those obtained by Ismail *et al*. (2006) and Mansour (2009).

With regard to rock phosphate application the data clearly reveal that adding rock phosphate as phosphorus source was significantly increased both grain and stover yields of maize in the two studied seasons. The maize plants received 300 kg rock phosphate resulted grain yield exceeded that without rock phosphate application by about 6.6 and 6.0% in the two seasons, respectively. Similar trends were obtained for stover yield in both seasons. This may be due to good phosphorus nutrition which increased maize growth and yield components (Tables 2 and 3). These results are similar to those obtained by El-Hefny and Yousef (2011) and El Sheref (2012). The data in Table (4), also indicate that using rock phosphate as a source of phosphorus significantly increased maize grain net income in both seasons. The net income of grains resulted from plants supplied with rock phosphate exceeded that not treated by about 191.7 and 183.0 L.E in both seasons, respectively.

Table (4): Effect of nitrogen sources and levels and rock phosphate application on grain and stover yields as well as net income due to treatments.

N sources (A)	N levels (B)	Rock P (C)	Grain yield (ardab/fed)		Stover yield (t/fed)		Net income (L.E.)	
			2010	2011	2010	2011	2010	2011
Urea	60	without	17.39	18.11	2.56	2.61	4122.9	4307.9
		with	18.85	19.52	2.85	2.88	4372.9	4540.4
	Mean		**18.12**	**18.82**	**2.71**	**2.75**	**4247.9**	**4424.2**
	90	without	18.39	19.42	2.81	2.86	4287.1	4535.6
		with	19.80	20.81	2.98	2.98	4510.6	4763.1
	Mean		**19.1**	**20.12**	**2.90**	**2.92**	**4394.4**	**4649.4**
	120	without	19.86	20.70	2.92	2.96	4525.8	4735.8
		with	20.76	21.69	3.12	3.17	4630.8	4853.3
	Mean		20.31	21.18	3.02	3.07	4578.3	4794.6
Mean			**19.18**	**20.04**	**2.88**	**2.91**	**4406.9**	**4622.7**
Ammonia gas	60	without	18.61	19.91	2.81	2.85	4457.5	4782.5
		with	19.80	20.85	2.97	2.99	4635.0	4897.5
	Mean		**19.21**	**20.38**	**2.89**	**2.92**	**4546.3**	**4840.0**
	90	without	19.73	20.90	2.96	3.00	4640.0	4932.5
		with	20.73	21.77	3.11	3.15	4770.0	5030.0
	Mean		**20.73**	**21.34**	**3.04**	**3.08**	**4705.0**	**4981.2**
	120	without	20.10	21.20	3.20	3.26	4635.0	4910.0
		with	21.60	22.91	3.35	3.39	4890.0	5217.7
	Mean		**20.85**	**22.05**	**3.28**	**3.33**	**4762.5**	**5063.9**
Mean			**20.10**	**21.26**	**3.07**	**3.11**	**4671.3**	**4961.7**
Mean of levels	60		18.67	19.60	2.80	2.84	4352.7	4603.4
	90		19.67	20.73	2.97	3.00	4549.7	4815.3
	120		20.58	21.62	3.15	3.20	4670.4	4929.3
Mean of rock P		without	**19.01**	**20.04**	**2.88**	**2.92**	**4443.2**	**4700.7**
		with	**20.26**	**21.25**	**3.06**	**3.09**	**4634.9**	**4883.7**
L.S.Dat0.05	A		0.65	0.69	0.11	0.20	65.1	52.6
	B		0.81	0.85	0.08	0.06	74.9	75.9
	C		0.46	0.55	0.09	0.07	86.7	89.3
	AB		NS	NS	NS	NS	NS	NS
	AC		NS	NS	NS	NS	NS	NS
	BC		NS	NS	NS	NS	NS	NS
	ABC		NS	NS	NS	NS	NS	NS

Concerning the interaction between treatments, the data clearly reveal that grain and stover yields as well as net income of maize grain not affected by the interactions between treatments. This means that the main factors were independed from each other. It is worthy to notice that maize plants received 120 kg N/fed as ammonia gas and supplied with rock phosphate recorded highest values of grain and stover yields as well as net income of maize grain. On the other hand, plants supplied with 60 kg N/fed as urea and not treated with rock phosphate showed the lowest grain and stover yields and net income of maize grain.

4- Nutrient concentration:

The statistical analysis of the obtained data listed in Table (5) indicate that nitrogen concentration in grains and stover of maize plants were significantly affected by nitrogen sources, where ammonia gas gave the highest values of N, P and K in grains and stover than urea in both seasons, except K in stover in the first one. This result could be explained by the promotive effect of ammonia gas on maize growth (Table, 2) consequently enhanced its ability to nutrients uptake.

Table (5): Effect of nitrogen sources and levels and rock phosphate on N, P and K concentration in maize grains and stover (%).

N sources (A)	N levels (B)	Rock P (C)	N				P				K			
			2010		2011		2010		2011		2010		2011	
			grains	stover	grains	stover	grains	stover	grains	stover	grains	stover	grains	stover
Urea	60	without	1.12	0.88	1.10	0.86	0.27	0.18	0.25	0.17	0.74	1.19	0.73	1.17
		with	1.16	0.90	1.14	0.90	0.32	0.21	0.31	0.21	0.75	1.21	0.74	1.17
	Mean		**1.14**	**0.99**	**1.12**	**0.88**	**0.30**	**0.20**	**0.28**	**0.19**	**0.75**	**1.20**	**0.74**	**1.17**
	90	without	1.25	0.98	1.23	0.96	0.28	0.18	0.28	0.18	0.74	1.18	0.74	1.17
		with	1.28	1.00	1.27	1.02	0.33	0.22	0.32	0.22	0.75	1.20	0.74	1.17
	Mean		**1.27**	**0.99**	**1.25**	**0.99**	**0.31**	**0.19**	**0.30**	**0.20**	**0.75**	**1.19**	**0.74**	**1.17**
	120	without	1.32	1.03	1.30	1.00	0.29	0.19	0.27	0.18	0.76	1.21	0.74	1.16
		with	1.35	1.07	1.34	1.07	0.35	0.23	0.34	0.23	0.77	1.24	0.76	1.20
	Mean		**1.34**	**1.05**	**1.32**	**1.04**	**0.32**	**0.21**	**0.31**	**0.21**	**0.77**	**1.23**	**0.75**	**1.18**
Mean			1.25	1.01	1.23	0.97	0.31	0.20	0.30	0.20	0.76	1.21	0.74	1.17
Ammonia gas	60	without	1.18	0.92	1.16	0.93	0.28	0.20	0.27	0.20	0.75	1.21	0.73	1.16
		with	1.28	1.00	1.26	1.01	0.36	0.23	0.34	0.22	0.75	1.20	0.74	1.15
	Mean		**1.23**	**0.96**	**1.21**	**0.97**	**0.32**	**0.22**	**0.31**	**0.21**	**0.75**	**1.21**	**0.74**	**1.16**
	90	without	1.27	1.00	1.25	1.00	0.28	0.17	0.26	0.16	0.75	1.21	0.75	1.20
		with	1.29	1.02	1.27	1.02	0.37	0.24	0.36	0.24	0.77	1.22	0.76	1.21
	Mean		**1.28**	**1.01**	**1.26**	**1.01**	**0.33**	**0.20**	**0.31**	**0.20**	**0.76**	**1.21**	**0.76**	**1.21**
	120	without	1.36	1.07	1.30	1.03	0.30	0.20	0.30	0.19	0.77	1.23	0.76	1.21
		with	1.39	1.10	1.33	1.06	0.39	0.24	0.37	0.25	0.79	1.25	0.78	1.24
	Mean		**1.38**	**1.09**	**1.32**	**1.05**	**0.35**	**0.22**	**0.34**	**0.22**	**0.78**	**1.24**	**0.77**	**1.23**
Mean			1.30	1.02	1.26	1.01	0.33	0.21	0.32	0.21	0.76	1.22	0.76	1.20
Mean of levels	60		1.19	0.98	1.14	0.93	0.31	0.21	0.28	0.20	0.75	1.21	0.74	1.17
	90		1.28	1.00	1.26	1.00	0.32	0.20	0.31	0.20	0.76	1.21	0.75	1.19
	120		1.36	1.07	1.32	1.05	0.34	0.22	0.33	0.22	0.78	1.24	0.76	1.21
Mean of rock P		without	**1.25**	**0.98**	**1.22**	**0.96**	**0.28**	**0.19**	**0.27**	**0.18**	**0.75**	**1.21**	**0.75**	**1.18**
		with	**1.29**	**1.02**	**1.27**	**1.01**	**0.35**	**0.23**	**0.34**	**0.23**	**0.76**	**1.22**	**0.75**	**1.19**
L.S.Dat 0.05		A	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	NS	NS	0.01	0.01
		B	0.05	0.04	0.04	0.03	0.02	0.03	0.02	0.01	0.02	0.02	0.02	0.02
		C	0.02	0.02	0.03	0.03	0.04	0.03	0.03	0.02	NS	NS	NS	NS
		AB	NS	NS	NS	NS	0.02	0.02	0.02	0.02	NS	NS	NS	NS
		AC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
		BC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
		ABC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

With regard to nitrogen levels, the results reveal that, irrespective of nitrogen sources, increasing nitrogen levels up to 120 kg/fed had a markedly increasing in N, P and K concentrations in both grains and stover. The increase of nutrients in maize grains and stover may be due to the increase in root surface per unit soil volume caused by increasing nitrogen level and accordingly increased the rate of nutrients uptake. Similar results were obtained by Murillo *et al*. (1992) and Mansour (2009).

As for rock phosphate, the data clearly show that rock phosphate had a positive action on N and P content in maize grains and stover in both seasons, while K content not affected. Using rock phosphate as a source of phosphorus led to increasing N and P in grains by about 3.2 and 25% in the first season, respectively. Similar trends were obtained for the second season and stover. It is worthy to notice that the effect of rock phosphate is more pronounced on P than N, which mainly due to beside the effect of rock phosphate on maize growth, it is a good source of phosphorus for plant. These results are similar to the finding of El-Sheref (2012).

Regarding the interaction effect, it is evident to notice that N, P and K concentration in grains and stover were not affected by the interactions between treatments, except the effect of the interaction between nitrogen sources and levels on P concentration in the two seasons, where the differences of P content in grains and stover between 90 and 120 kg N/fed are significant under using ammonia gas only. In general, the highest values of N, P and K are recorded for maize plants supplied with 120 kg N/fed as ammonia gas and applied with rock phosphate.

5- Nutrients uptake:

The results presented in Table (6) indicate that total N, P and K uptake by maize grains and stover were significantly affected by nitrogen sources in both seasons. The highest values of total N, P and K uptake were recorded for ammonia gas than urea. The relative increasing of N, P and K uptake due to ammonia gas over urea were 8.2, 16.9 and 7.9% in the first season, respectively. The same trends were obtained for the second season. The increment in total nutrients uptake due to ammonia gas application is mainly due to its effect on maize growth (Table, 2) which in turn adsorbed more nutrients.

Regarding nitrogen level, the data show that increasing nitrogen doses significantly increased total N, P and K in the two studied seasons. The plants supplied with 60, 90 and 120 kg N/fed uptaked 64.4, 72.4 and 81.3 kg N, P and K/fed in the first season, respectively. The corresponding values of the second season were 64.9, 73.8 and 82.2. Such increments were mainly due to these nutrients are considered the most important nutrients for plant growth (Table,2).consequently its application increased both grain and stover yields (Table, 4), which in turn increased nutrients uptake, since it calculated as multiplying nutrient concentration in grains or straw by its yield. Similar results were obtained by Ismail *et al*. (2006) and El-Sheref (2012).

Considering rock phosphate, the data in Table (6) pointed out that using rock phosphate as a source of phosphorus led to increasing N, P and K uptake by about 8.1, 32.9 and 7.8% over without rock phosphate application, respectively in the first season. The corresponding values for the second season were 9.9, 31.3 and 7.6% in the abovementioned order. The positive effect of rock phosphate fertilizer on nutrients uptake is mostly due to its effect of increasing grain and stover yields.

As for the interaction effect, the data in Table (6) clearly reveal that N, P and K uptake were not affected by the interaction between treatments or among the three treatments in both seasons. This means that the maize plants received 120 Kg N/fed as ammonia gas and supplied with 300 kg rock phosphate/fed uptaked the highest values of the studied nutrients, while the plants supplied with 60 kg N/fed as urea without rock phosphate application showed the lowest values.

Table (6): Effect of nitrogen sources and levels as well as rock phosphate application on total N, P and K uptake (kg/fed).

N sources (A)	N levels (B)	Rock P (C)	N uptake		P uptake		K uptake	
			2010	2011	2010	2011	2010	2011
Urea	60	without	56.94	56.35	13.60	13.15	36.76	37.06
		with	63.97	63.15	17.91	16.95	40.86	41.45
	Mean		**60.46**	**59.75**	**15.67**	**15.05**	**38.81**	**39.26**
	90	without	67.91	67.90	14.85	15.37	93.72	41.11
		with	72.69	74.26	18.62	19.21	42.87	43.25
	Mean		**70.30**	**71.08**	**16.74**	**17.29**	**41.30**	**42.18**
	120	without	76.28	76.31	16.61	16.09	43.45	43.31
		with	81.17	83.25	20.65	20.86	46.72	46.89
	Mean		**78.73**	**79.78**	**18.63**	**18.48**	**45.09**	**45.10**
Mean			**69.83**	**70.21**	**17.04**	**16.94**	**41.73**	**42.18**
Ammonia gas	60	without	63.96	64.89	15.78	15.82	41.36	41.35
		with	79.52	75.03	21.21	20.35	42.89	43.51
	Mean		**68.24**	**96.26**	**18.50**	**18.09**	**42.13**	**42.43**
	90	without	72.16	74.31	15.85	15.68	42.76	44.41
		with	76.99	78.56	22.69	21.98	46.61	47.31
	Mean		74.58	76.44	19.27	18.83	44.96	45.86
	120	without	81.91	81.11	18.61	18.32	46.51	47.03
		with	85.72	88.25	25.50	24.66	50.10	51.15
	Mean		**83.82**	**84.68**	**22.06**	**21.49**	**48.31**	**49.09**
Mean			**75.55**	**77.03**	**19.94**	**19.47**	**45.04**	**45.79**
Mean of levels	60		64.35	64.86	17.13	16.57	40.47	40.85
	90		72.44	73.76	18.01	18.06	43.00	44.02
	120		81.28	82.23	20.35	19.99	46.70	47.10
Mean of rock P		without	**96.86**	**70.15**	**15.88**	**15.74**	**41.76**	**42.38**
		with	**75.51**	**77.08**	**21.10**	**20.67**	**45.01**	**45.89**
L.S.Dat0.05	A		3.12	3.98	1.18	2.05	2.31	2.06
	B		5.36	5.81	0.66	1.13	2.17	2.19
	C		2.79	3.12	2.95	3.15	2.56	2.06
	AB		NS	NS	NS	NS	NS	NS
	AC		NS	NS	NS	NS	NS	NS
	BC		NS	NS	NS	NS	NS	NS
	ABC		NS	NS	NS	NS	NS	NS

6- Soil fertility:

With respect to the effect of treatments on soil fertility after harvesting, the data in Table (7) show that nitrogen sources affected only soil available nitrogen in both seasons. It is worthy to notice that ammonia gas yielded the highest values of soil available nitrogen than urea. The relative increasing in soil available N due to ammonia gas fertilization reached to75.6 and 65.7% over urea in two studied seasons, respectively. The superiority of ammonia gas to increasing nitrogen availability than urea after harvesting is mainly due to the ammonia cations are temporarily retained by colloidal factions of the soil, whether clay or organic matter, while a part of urea is leached down to ground water.

As for nitrogen levels, the data obtained reveal that, only available nitrogen was positively responded to increasing nitrogen levels in both seasons. Added 120 kg N/fed was increased nitrogen availability by about 35.3 and 13.4% over 60 and 90 kg N/fed, respectively in the first season. The same trend was obtained in the second season. It is worthy to observe that the main effect of nitrogen fertilization on the nitrogen availability is mainly due to ammonia gas fertilizer than urea as discussed before.

Table (7):Effect of nitrogen sources and levels as well as rock phosphate application on the availability of N, P and K (ppm) in soil.

N sources (A)	N levels (B)	Rock P (C)	N		P		K	
			2010	2011	2010	2011	2010	2011
Urea	60	without	19.21	21.13	16.19	17.75	181.3	184.7
		with	19.09	20.95	25.31	27.31	182.5	183.9
	Mean		**19.15**	**21.04**	**20.75**	**22.53**	**181.9**	**184.3**
	90	without	19.35	20.36	16.15	17.33	182.6	184.1
		with	19.16	20.71	25.09	26.92	183.7	182.5
	Mean		**19.26**	**20.54**	**20.62**	**22.13**	**183.2**	**183.3**
	120	without	19.61	20.66	16.81	18.03	181.9	183.9
		with	19.53	20.31	25.19	26.71	181.2	182.3
	Mean		**19.57**	**20.49**	**21.00**	**22.81**	**181.6**	**183.1**
Mean			**19.33**	**20.65**	**20.79**	**22.51**	**181.2**	**183.6**
Ammonia gas	60	without	25.11	27.51	16.19	17.55	195.1	197.3
		with	25.05	26.97	25.91	26.65	195.6	196.9
	Mean		**25.07**	**27.24**	**21.05**	**22.09**	**195.4**	**197.1**
	90	without	33.36	34.15	15.88	18.03	205.5	207.7
		with	33.61	34.61	25.19	27.11	206.1	208.1
	Mean		**33.49**	**34.36**	**20.54**	**22.57**	**205.3**	**207.9**
	120	without	40.15	41.09	16.26	17.65	210.9	211.9
		with	40.34	41.00	24.30	26.87	211.3	213.0
	Mean		**40.25**	**41.05**	**20.28**	**22.26**	**211.1**	**213.0**
Mean			**33.94**	**34.22**	**21.96**	**22.07**	**203.9**	**206.0**
Mean of levels	60		22.11	24.14	20.90	22.31	188.7	190.7
	90		26.38	27.45	20.58	22.35	194.3	195.5
	120		29.91	30.77	20.64	22.57	196.4	198.1
Mean of rock P		without	**26.13**	**27.48**	**16.25**	**17.72**	**192.9**	**195.1**
		with	**26.12**	**27.42**	**25.18**	**26.92**	**193.4**	**194.5**
L.S.Dat0.05	A		4.13	6.92	NS	NS	NS	NS
	B		2.72	2.96	NS	NS	NS	NS
	C		NS	NS	3.11	4.65	NS	NS
	AB		3.65	4.35	NS	NS	3.61	4.11
	AC		NS	NS	NS	NS	NS	NS
	BC		NS	NS	NS	NS	NS	NS
	ABC		NS	NS	NS	NS	NS	NS

Regarding rock phosphate, the data in Table (7) clearly show that the phosphorus availability only is responded to rock phosphate application, while N and K availability were not affected. The relative increasing of available P caused by added rock phosphate were 55.0 and 51.9% over without application in the two seasons, respectively. These results may be due to rock phosphate consider as a source of P through its mineralization in soil

(Gowda *et al.*, 2011). These results are in harmony with those obtained by Hellal *et al.* (2009) and El-Sheref (2012).

Considering the interaction effect, the data obtained reveal that only N and K availability were affected by the interaction between nitrogen sources and nitrogen levels (A X B). It is obvious to notice that N or K availability were affected by nitrogen levels only when added as ammonia gas, while increasing urea doses not affected the available N or K in soil after harvesting.

CONCLUSION

The benefits of using natural and ammonia gas as a sources of phosphorus and nitrogen, respectively demonstrated the validity and possibility of sustain agronomic performance of maize and reduce the cost of its production. Therefore, it could be recommend to increasing maize productivity and improving soil fertility fertilized maize the plants with 120 kg N/fed as ammonia gas + 300 kg rock phosphate/fed.

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تـأثير مصـادر ومسـتويات مختلفـة مـن النتـروجين واضـافة صـخر الفوسـفات علـى أنتاجية الذرة وخصوبة التربة

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أقيمت تجرتبان حقليتان بالمزرعة البحثية بمحطة البحوث الزراعية بسدس لدراسة تأثير مصادر مختلفة من الأسمدة النتروجينية (الحقن بالأمونيا الغازية، اليوريا) تحت مستويات مختلفة (٦٠، ٩٠، ١٢٠ كجم نتروجين/فدان) وكذلك أستخدام صخر الفوسفات كمصدر للفوسفور تحت مستويان (صفر، ٣٠٠ كجم صخر فوسفات للفدان) على خصائص النمو (طول ووزن النبات الجاف)، مكونات المحصول (طول وقطر الكوز، عدد الصفوف والحبوب فى الكوز ووزن المائة حبة)، محصول الحبوب والقش وكذلك صافى الدخل، وتركيز وأمتصاص عناصر النتروجين والفوسفور والبوتاسيوم فى الحبوب والقش وكذلك صلاحية عناصر النتروجين والفوسفور والبوتاسيوم فى التربة بعد الحصاد.

ويمكن تلخيص أهم النتائج فيما يلى:

- أدى أضافة ١٢٠ كجم نتروجين للفدان على صورة أمونيا غازية إلى الحصول على أعلى القيم لكل من طول النبات ووزنه الجاف وطول وقطر الكوز ووزن المائة حبة ومحصول الحبوب والقش وصافى الدخل وتركيز وأمتصاص الحبوب والقش للنتروجين والفوسفور والبوتاسيوم وصلاحية عنصر النتروجين فى التربة بعد الحصاد، بينما لم يتأثر كلاً من عدد الصفوف والحبوب فى الكوز وصلاحية الفوسفور والبوتاسيوم.
- أدى أضافة ٣٠٠ كجم/للفدان من صخر الفوسفات إلى زيادة طول الوزن الجاف للنبات ووزن المائة حبة ومحصول الحبوب والقش وصافى الدخل وصلاحية عنصر الفوسفور فى التربة بعد الحصاد، بينما لم يتأثر طول وقطر الكوز وعدد الصفوف والحبوب فى الكوز وتركيز البوتاسيوم فى الحبوب والقش وكذلك صلاحية النتروجين والبوتاسيوم فى التربة بعد الحصاد بأضافة صخر الفوسفات.
- تركيز الفوسفور فى كلاً من الحبوب والقش وكذلك صلاحية النتروجين والفوسفور فى التربة بعد الحصاد أستجاب لزيادة مستويات النتروجين فقط عندما يضاف النتروجين على صورة أمونيا غازية.

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