10.7251/AGSY1303493A

EFFECT OF SLOW-RELEASE NITOGEN FERTILIZERS ON MAIZE PLANTS GROWN ON NEW RECLAIMED SOIL

Mohamed S. Awaad

Soil, Water & Environment. Res. Inst., Agric. Res. Center. Giza, Egypt
(Corresponding author: moayamai@yahoo.com)

Abstract

A field experiments was done in summer 2009 season at private farm, located at El-Sadat district, Minufiya Governorate, Egypt to evaluate the effect of ureaform or urea+hmic acid as slow release nitrogen fertilizers at a rate of 60 and 100 kg fed-1 compared to urea at rate of 120 kg fed-1 on maize (Zea mays L.) (Single-cross 10) grown on sandy soil. The obtained results indicated that ear length, plant high, 100-grain weight, shoot and grain yields and biological yield were markedly significantly higher when application of ureaform at rate of 100 kg N/fed followed urea at rate of 100 kg N/fed + humic acid. Application of ureaform at high rate increased the values of nitrogen uptake by both shoot and grain of maize plant, while urea at high rate + humic acid induced the highest values of both phosphorus and potassium uptake for the same mentioned organs. Also, the results indicated that, maize plants received urea+humic acid or ureaform registed the highest values of fertilizer use efficiency, i.e., highest Agronomic efficiency and Apparent N recovery were obtained due to application of 60 kg N/fed urea+humic acid, while ureaform at rate of 100 kg N/fed gave the highest value of Physiological efficiency.

Key words: Slow release fertilizers, Sandy soils, Maize yield, Efficiency

Introduction

Maize (Zea mays L.) is one of the most strategically cereal crop grown in Egypt. Maize is the most widely cultivated cereal in the world after wheat and rice. It has a great significance as human food, animal feed and raw material source of large number of industrial products. Growing maize on newly reclaimed soils of Egypt is faced by many problems, the most important of these is the leaching of the applied N led to reduce the uptake efficiency of the addition nitrogen fertilizers by crops and is an agricultural and environmental problem.

Nitrogen is one of the most important mineral nutrient elements for existence and maintenance of higher plants life on this planet. Its main functions are serving as the constituents of many important organic compounds and participating in many essential metabolic processes in plants. Building amino acids, proteins, carriers, enzymes, regulators, nucleic acids, pigments, alkaloids and many other metabolites involve nitrogen for their biosynthesis and interconversions (Marschne 1997; Srivastava & Singh, 1999).

Nitrogen use efficiency is of significant importance in crop production system due to its impact on farmer economic outcomes and environmental impact. Nitrogen use efficiency also, may be reduced in crop production due to many factors including losses of soil nitrogen by volatilization, leaching and denitification. Jokela and Randall (1989) conducted a study of the effects of N application rate on residual NO3-N in non-irrigated corn and concluded that when N rate was increased, soil NO3 -N was also higher. Another study showed no significant differences in soil NO3 -N among several N fertilizer rates, although there was a clear trend of higher soil NO3 -N levels with the highest fertilizer N application which may cause accumulation in the soil profile and leaching into groundwater in the long term (Elmi et al., 2002). Wang and Alva (1996) observed that up to 30% of N applied as slow release can be leached as compared to more 88% N leaching after readily soluble ammonium nitrate application in sandy soils. Acidic materials alone, organic and inorganic additives, mixture of acidic materials and additives could reduce N loss by 60, 38.5 and 49%, respectively (Zaman et al., 2007). Generally, the main concerns for the above mixtures are that they create an acidic environment from acidic materials used and inhibit ureolytic microorganism's activities which in effect slows down the release of NH4+ into the soil and indirectly reduces N loss (Cheftetz, et al., 1996).

Controlled or slow-release fertilizers can be classified in two basic groups: compounds of low solubility and coated water-soluble fertilizers. Other products, known as N stabilizers or bio-inhibitors, are not true slow-release products, but reduce N losses by slowing N transformations. Polymer-coated controlled-release fertilizers look promising for widespread use in agriculture because they can be designed to release nutrients in a more controlled manner. The polymers are generally durable and exhibit consistent release rates that are predictable when average temperature and moisture conditions can be estimated. Nutrient release rate is altered by manipulating properties of the polymer coating. A more detailed review was provided in (Hauck, 1985). Ureaform fertilizer has the following characteristics: Consists essentially of chemically combined urea with greatly reduced solubility. Nitrogen is released through action of soil microorganisms. Biological reactions are dependent on temperature - require same conditions as growing plants. Quality is indicated by combination of WIN and AI. Other slowly available fertilizers require data such as coating thickness, particle size, soil moisture, and permanganate values to indicate quality. Nitrification studies in soil indicate 30-40% release in 4 weeks, 60-75% in 24 weeks, with a portion being carried over for utilization in the following season. Many rehearses stated that nitrogen application increased grain yield and its components of maize. Torbert et al. (2001) found that yield and yield component of maize were increased by increasing the rate of applied nitrogen. El-Sheikh (1998) reported that applying N 160 kg/ha significantly increased ear characters and grain yield of maize. El-Kramany (2001) found that the use of slow release nitrogen fertilizer gave the highest 1000-grain weight, grain yield/plant, grain yield /fed. and nitrogen and protein content of wheat plants compared to the other nitrogen sources. Scott Perin et al. (1998) showed that amending sandy soil with slow release N can reduce N leaching, increase plant growth and increase nitrogen concentration in sweet corn.

Therefore the present research was conducted to evaluate the effect of slow-release nitrogen fertilizers and levels on yield and some nutrients uptake of maize plants.

Materials And Methods

A field experiment was conducted at private farm in located at El-Khatatba, district, Menofia Governorate, Egypt, in summer season of 2009 to evaluate the effect of slow release nitrogen fertilizers at two levels on maize (Zea mays L.) (Single – cross 10) grown on new reclaimed sandy soil. Some physical and chemical properties of studied soil are revealing in Table (1).

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

Soil properties	**Value**
Particle size distribution %	
sand	84.00
Silt	10.00
Clay	6.00
Soil Texture	Loamy sandy
Soil pH (saturated soil paste)	8.10
EC(dS/m) in soil paste extract	2.02
$CaCO_3$ %	8.89

The experiment was conducted in a factorial split plot design with three replicates for each treatment, nitrogen sources (urea, ureaform and urea + humic acid) were in the main plots. N levels were represented the sub plot. Each plot was 3x3.5 m. Calcium super phosphate (15% P2O5) and potassium sulphate (48%K2O) were applied to the all of plots during papering the soil at the rate of 50 and 24 kg fed-1, respectively.
Nitrogen fertilizers treatments as follows: control, 120 kg N fed-1 as urea (46.5%N), 60 kg N fed-1 as ureaform (38%N), 100 kg N fed-1 as ureaform (38%N), 60 kg N fed-1 as urea (46.5% N) + humic acid at rate of 20 kg fed-1 and 100 kg N fed-1 as urea (46% N) + humic acid at rate of 20 kg fed-1. Ureaform was applied at sowing; however urea or urea + humic acid were applied into three equal doses, which applied at 15, 45 and 60 days from sowing.
Plant samples were taken at harvest stage. Plant high (cm), ear weight (g), ear grain weight, shoot and grain yields as well as 100-grain weight were recorded and grains were also subjected to chemical analysis. Whereas, at harvest time (120 days after planting) grain weight kg/plot were measured. Grain yield per feddan was obtained. Total-N in shoots and grains were determined by the kjdhal method described by (Bremner and Mulvaney, 1972). Phosphorus, potassium and micronutrients (Fe, Zn and Mn) were determined according to the method described by Cottenie.
Beneficial effects use of different nitrogen sources and levels on maize growth and N uptake were assessed by calculating following parameters according to Mengel and Kirkby (2001).
- Agronomic efficiency= Yield F- Yield C/Fertilizer N applied
- Apparent N Recovery = N uptake F – N uptake C/Fertilizer N applied
- Physiological Efficiency = Yield F – Yield C /N uptake F – N uptake C

Were: F= Fertilizer C= Control (without fertilizer) N=Nitrogen
The obtained data were subjected to statistical analyses according to Snedecor and Cochran (1980) using L.S.D. at the level of 5%.

Results and Discussion

Effect of different N-sources on some growth parameters, shoot, grain and biological yields of maize plant:
Data presented in Table 2 reveal that ear length, plant high (cm), 100-grain weight, shoot, grain and biological yield (ton/fed) of maize plants were significantly affected by increasing levels of different nitrogen sources. It was noticed that the application of different nitrogen sources increased ear length, Plant high (cm), 100-grain weight, shoot, grain and biological yield (ton/fed) of maize plants compared with the control treatment. Results also indicated that the application of ureaform or urea+humic acid increased the abovementioned parameters of maize plants compared with urea as source of nitrogen fertilizer. Also obtained data in

Table 2 show that increasing nitrogen fertilization levels led to a significant increase in all studied traits compared with the control treatment. These increases of the parameters under investigated may be due to the amount of metabolites synthesized by plants as a result of increasing nitrogen levels. This may be attributed to the favorable effect of nitrogen fertilizer levels on the metabolic processes and physiological activates of meristimatic tissues, which are responsible for cell division and elongation in addition to formation of plant organs this lead to more vigorous growth and consequently accumulation of more photosynthesis assimilates. Similar results were reported by (El-Naggar & Amer, 1999; El-Bana & Goomaa, 2000). Generally, the application of ureaform at rate of 100 kg N/fed followed by urea at rate of 100 kg N/fed +humic acid caused the highest values of ear length, plant high (cm), 100-grain weight, shoot, grain and biological yield when compared with other N treatment as urea application at rate of 120kgN/fed. The relative increases were (80.00, 99.05, 30.88, 318.25, 332.22 and 323.78%) and (56.80, 88.78, 23.55, 247.44, 251.11 and 249.78%) for both treatment ureaform at rate of 100 kg N/fed or urea at rate of 100kgN/fed +humic acid, respectively compared to the control treatment. These results may be due to that sandy soil is very low water holding capacity and high nutrient leaching losses. Also application of urea as slow release nitrogen fertilizer or combined of urea with humic acid maintained the nitrogen losses as volatilization or leaching.

Table 2: Effect of different nitrogen sources and levels on ear length (cm), plant high (cm), 100 grains weight (g), shoots, grains and biological yields (ton/fed) of maize plant.

Treatments		Ear length(cm)	Plant high (cm)	100 grains (g)	Shoots ton/fed.	Grain yield (ton/fed.)	Biological yield (ton/fed.)
Sources	**Rates of Kg/fed.**						
Control	**0**	**11.90**	**107.00**	**25.9**	**1.37**	**0.90**	**2.27**
Urea	**120**	**17.88**	**150.00**	**29.8**	**3.94**	**3.11**	**7.05**
Urea+humic acid	**60**	**16.70**	**139.00**	**28.0**	**3.34**	**2.98**	**6.32**
Urea+humic acid	**100**	**18.66**	**202.00**	**32.00**	**4.76**	**3.16**	**7.94**
Ureaform	**60**	**15.00**	**128.00**	**27.06**	**3.07**	**2.56**	**5.63**
Ureaform	**100**	**21.42**	**213.00**	**33.9**	**5.73**	**3.89**	**9.62**
L.S.D.at,0.05		**2.303**	**3.837**	**N.S**	**0.070**	**0.099**	**0.090**

Hanafi et al. (2002) reported that uncoated compound fertilizer such as urea gave significantly higher amounts of nutrients loss compared to slow release N fertilizer. Concerning the effect of urea + humic acid the obtained results could be due to the urea + humic acid mixtures are that create an acidic environment from acidic materials used and inhibit ureolytic microorganisms activities which in effect slows down the release of NH4+ into the soil and indirectly reduces N loss (Cheftetz et al 1996). El-Kramany (2001) found that slow-release nitrogen fertilizer gave the highest 1000-grain weight, grain and biological yield /fed of wheat. Yerokun (1997) reported that increasing nitrogen supply up to 134 kg N ha-1 improved maize yield. El-Naggar and Amer (1999) found that maize grain yield was significantly increases N rate increased and maximum figure was obtained due to addition of 140 kg N/fed.

Effect of different N-sources on macronutrients uptake by shoot and grain of maize plant:

Data in Table (3) revealed that the effect of different nitrogen sources and levels on N, P and K uptake by shoot and grain of maize plant. It is clear from data that application of all nitrogen sources and levels increase N, P and K uptake of shoot, grain and total uptake of their nutrients compared to the control treatment.

Table 3: Effect of different nitrogen sources and rates on N, P and K uptake (kg/fed) by shoot and grain of maize plant

Treatments		Shoot uptake (kg/fed)			Grain uptake (kg/fed)			Total nutrient uptake (kg/fed.)		
Sources	Rates of N Kg/fed.	N	P	K	N	P	K	N	P	K
Control	0	11.76	5.69	16.13	19.15	9.83	11.62	30.81	15.52	27.75
Urea	120	31.23	8.00	30.90	46.21	14.44	19.54	77.44	22.44	50.44
Urea+humic acid	60	24.03	14.92	36.05	38.76	19.21	25.00	62.79	34.13	61.05
Urea+humic acid	100	38.75	18.11	44.67	51.36	26.00	31.08	90.11	44.11	75.75
Ureaform	60	29.45	11.03	38.65	42.90	16.70	23.62	72.25	27.73	62.27
Ureaform	100	43.21	15.54	41.91	67.49	21.56	27.67	110.70	37.10	69.58
L.S.D.at,0.05		2.386	0.907	2.303	5.288	2.301	2.440	2.289	1.819	2.301

The maximum total N uptake of 110.0 kg/fed by maize crop were obtained in treatment (ureaform at rate of 100 kg N/ fed.). While the treatment (urea + humic acid at rate of 100kg N/fed) caused the highest values of both total P and K uptake by maize crop. These results may be due to the use of slow release nitrogen fertilizer or urea combined with humic acid improving of dry matter and grain yield of maize plant and consequently alternative the macronutrients uptake and produced excellent results when compared to urea. Raina and Goswami (1988) stated that the increase in P uptake may be due to the prevention of P fixation in the soil and the formation of humophospho complexes, which are easily assimilable by the plants. Randhawa and Broadbent (1965) reported that HA produces ligands capable of complexing nutrient elements and the complexed elements remain more available to plant roots as complexation shields them against immobilisation in soil. Inhibition of urease activity by HA led to reduced losses of N by volatilization, as described by Flaig (1984) could have also contributed to increased availability of nitrogen. Heng (1989) reported that HA reduces P fixing capacity of the soil, which closely corroborate with the present study where HA enhanced the P availability. The increased N uptake was supposed to be due to the better use efficiency of applied N fertilizers in the presence of humic acid coupled with retarded nitrification process enabling the slow availability of applied N (Guminiski, 1968). Samson and Visser (1989) found that application of humic acid induced increase in permeability of biomembranes for electrolytes accounted for increased uptake of K. Dou and

Alva (1998) conducted a study to measure the growth and N uptake of two citrus rootstock seedlings after application of two controlled-release N fertilizers (polyolefin resin-coated (PRC), sulfur-coated urea (SCU)), and traditional urea. The study demonstrated that the total N uptake by seedlings was greater for the controlled release fertilizers compared to traditional urea.

Effect of different nitrogen sources and levels on Agronomic efficiency, Apparent N recovery and Physiological efficiency:

Figure (1) demonstrated that the effect of different nitrogen sources and levels on Agronomic efficiency, Apparent N recovery and Physiological efficiency of maize plant.

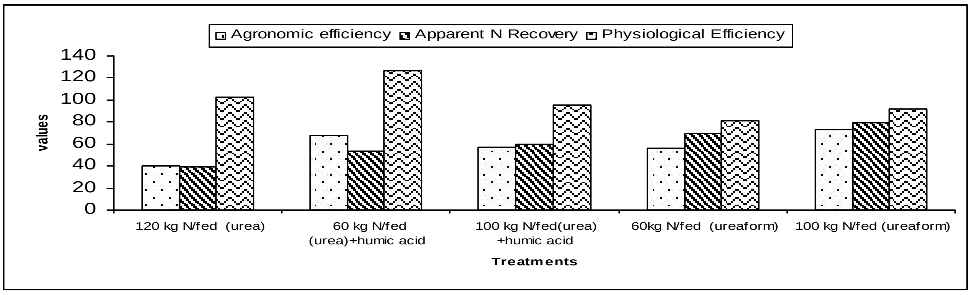

Figure 1. Effect of different treatments on Agronomic efficiency, Apparent N recovery and Physiological efficiency of maize plant.

Results in the Fig 1 suggested that the highest values of Agronomic efficiency and Apparent N recovery could be obtained due to application of (100 kg N/fed as ureaform), while (urea at rate of 60 kg N/fed+humic acid) gave the highest values of Physiological efficiency. This effect may be due to higher utilization of nitrogen by the crop as a result of retardation of losses of fertilizer by the regulation of urea hydrolysis and nitrification and subsequently higher N use efficiency due to regulation of urea-N transformation. Susilawat et al (2009) reported that the amount or rate of humic molecules was enhanced NH4 and NO3 recovery in soil which can indirectly promote plant growth. Zhu and Chen (2002) suggest for China that emphasis be placed on optimization of N application rates, deep placement of N, matching N application with crop demands, balanced fertilizer application, and use of controlled release N fertilizer of nitrification inhibitors. KANETA et al. (1994) compared coated urea with a conventional compound fertilizer in one single application in a nursery box of non-tillage rice. In his experiment the absorption of N from coated urea was greater than that from the conventional fertilizer (recovery of 79% of N from coated urea at maturity). This also resulted in a greater number of grains and a higher yield. Perrin et al. (1998) showed that amending sandy soils with slow-release N can reduced leaching, increase plant growth and increase N concentration compared with sweet corn grown in soil amended with ammonium nitrate. Amal et al (2007) concluded that Slow-release N fertilizer has long – term effects including reduced leaching losses and enhanced N uptake, as well as positive effects on both health and soil nutrient levels. Therefore amending poor soil with slow-release N fertilizer could be effective in eliminating mid-season N deficiency. (FUJITA, 1996a) showing the possible reduction of the amount of nutrients applied by use of controlled-release fertilizers without affecting the grain yield. Gauer et al. (1992) reports that NUE is generally the greatest with low levels of applied N and decreases as the amount of N applied increases.

Conclusion

Slow release nitrogen fertilizers can be applied as a preplant application. It reduces production costs, eliminates the need for multiple applications of soluble nitrogen fertilizers. Also slow release nitrogen fertilizers were able to increase nitrogen use efficiency by reduce nitrogen leashate and volatilization from soils.

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