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

Awaad, M.S. G. F. El-Shiekh and S. E. M. Elsisi
Soil, Water & Environment Res. Inst., Agric. Res. Center. Giza, Egypt

ABSTRACT

A field experiment was conducted in summer season of 2009 at a private farm, with loamy sand soil located at El-Sadat district, Minufiya Governorate, Egypt to evaluate the effect of urea+hmic acid as well as ureaform, as a slow release nitrogen fertilizer applied at the rates of 60 and 100 kg fed^{-1} compared to urea at rate of 120 kg fed^{-1} on the yield, some yield components and nutrients uptake by maize (*Zea mays* L.) (Single-cross 10) grown on a sandy soil.

Obtained results indicated that ear length, plant height, shoot and grain yields and biological yield were significantly higher with the application of ureaform at rate of 100 kg N/fed followed by urea at rate of 100 kg N/fed + humic acid. Application of ureaform at high rate (100 kg/fed) increased the values of nitrogen uptake by shoots, grain and both shoot and grain of maize plant. While urea at high rate + humic acid induced the influence of the highest values of both phosphorus and potassium uptake for the same components. Results indicated also that, maize plants received urea+humic acid or ureaform had the highest values of fertilizer use efficiency, i.e., the highest ratio of agronomic efficiency (34.67) and physiological efficiency (106.07) were obtained the application of 60 kg N/fed urea+humic acid, while ureaform at the rate of 100 kg N/fed resulted in the highest value of apparent N recovery percent (48.34%). Results of this work emphasized the beneficial effects of the slow release fertilizer urea form followed by urea + humic acid in comparison with urea on maize plant growth, yield, yield components and nitrogen recovery percentage.

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

INTERODUCTION

Maize (*Zea mays* L.) is one of the most strategic 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 them are the leaching of applied N that reduces the uptake efficiency of added nitrogen fertilizers by crops and corresponding agricultural and environmental problems.

Nitrogen is one of essential macro-nutrients, its mean functions are 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. (**Marschner 1997; Srivastava and 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, may be reduced due to many factors among which are losses of soil nitrogen by volatilization, leaching and de-nitrification in the form of slow release fertilizer. **Wang and Alva (1996)** observed that up to 30% of applied N 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 that inhibit ureolytic microorganism activities, and slows down the release of NH_4^+ into the soil and indirectly reduces N loss. (**Cheftetz, et al., 1996**).

Controlled or slow-release fertilizers can be classified into 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 down bio-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 by **Hauck,(1985).**

Ureaform fertilizer has the following characteristics: Essentially consists 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 indicated 30-40% release in 4 weeks, 60-75% in 24 weeks, with a portion being carried over for utilization in the following season. Many researchers stated that nitrogen application increases maize grain yield and its component (**Torbert et al. 2001); (El-Sheikh 1998). 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 applied 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.

Randhawa and Broadbent (1965) reported that humic acid (HA) produces ligands capable of complexing nutrient elements and the complexed elements remain more available to plant roots against immobilisation in soil. Inhibition of urease activity by humic acid (HA) 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. 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).**

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 yield.

The present work was conducted to evaluate the effect of urea form as a slow-release nitrogen fertilizer on yield, yield component, and uptake of some nutrients by maize plants in comparison with urea or urea+humic acid at different N levels..

MATERIAILS AND METHODS

A field experiment was conducted at a private farm located at El-Sadat, district, Menofia Governorate, Egypt, during the summer season of 2009 to evaluate the effect of slow release nitrogen fertilizers on maize (*Zea mays* L.) (Single–cross 10) grown on a new reclaimed loamy sand soil. Some properties of the studied soil are given in Table (1).

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

Particle size distribution %		Soluble ions (me/L) in soil paste extract:		Available Soil nutrient (mg/kg)	
sand	84.00	CO_3^{2-}	0.00	N	12.850
Silt	10.00	HCO_3^-	1.30	P	4.44
Clay	6.00	Cl^-	14.26	K	171.60
Soil Texture	Loamy sand	SO_4^{2-}	6.59	Fe	3.03
Soil pH (soil paste)	8.10	Ca^{2+}	2.84	Zn	1.62
EC(dS/m)(soil paste extract)	2.02	Mg^{2+}	4.41	Mn	0.92
$CaCO_3$ %	8.89	Na^+	14.34		
		K^+	0.76		

The experimental plots were distributed in a complete randomized block design with three replicates. Each plot area was 1/400 feddan (3 x 3.5m). Calcium super phosphate (15% P_2O_5) and potassium sulphate (48%K_2O) were applied to all plots before cultivation at the rate of 50 and 24 kg fed^{-1}, respectively. Treatments of nitrogen fertilizers were;

(1) control, (zero N/fed)
(2) 120 kg N fed^{-1} as urea (46.5%N),
(3) 60 kg N fed^{-1} as urea (46.5% N) + humic acid at the rate 20 kg fed^{-1},
(4) 100 kg N fed^{-1} as urea (46% N) + humic acid at the rate 20 kg fed^{-1},
(5) 60 kg N fed^{-1} as ureaform (38%N) and
(6) 100 kg N fed^{-1} as ureaform (38%N).

Ureaform was applied at sowing; however urea or urea + humic acid rates were divided into three equal doses, applied at 15, 45 and 60 days from sowing.

Plant samples were collected at harvest of maize plants (120 days after planting). Plant height (cm), ear weight (g), ear length, shoot and grain yields were recorded. Grain weight kg/plot was measured and grain yield per feddan was calculated. Plant shoot and grains were subjected to wet digestion and chemical analysis. Total-N in shoots and grains were determined by the microkjeldahl method described by **(Bremner and Mulvaney, 1972).** Phosphorus, potassium and micronutrients (Fe, Zn and Mn) were determined according to the method described by **(Cottenie et al,).**

The following parameters were calculated as described by **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

Where: 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 and levels on some growth parameters, shoot, grain and biological yields of maize plant:

Data presented in Table 2 reveal that ear length, plant height (cm), shoot, grain and biological yield (ton/fed) of maize plants were significantly affected by different nitrogen treatments, while the 100-grain weight values were not significantly affected. It was noticed that the application of different nitrogen sources increased ear length, Plant height (cm), shoot, grain and biological yield as 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. Ureaform treatment had the best effect on all the studied parameters. Also, data in Table 2 show that increasing nitrogen fertilization level led to significant increases in all studied traits compared with the control treatment. Increases of parameters under investigation 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 that lead to more vigorous growth and consequently accumulation of more photosynthesis assimilates. Similar results were reported by **(El-Naggar and Amer, 1999 and El-Bana and Goomaa, 2000).**

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 height (cm), 100-grain weight, shoot, grain and biological yields when compared with other N treatments as urea application at rate of 120kgN/fed. The relative increases as percent of control treatment, 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 the treatments; ureaform at rate of 100 kg N/fed or urea at rate of 100kgN/fed +humic acid, respectively. These results may be due to that sandy soil has 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. **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.

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

Treatments		Ear length (cm)	Plant height (cm)	100 grains weight	Shoots yield ton/fed.	Grain yield (ton/fed.)	Biological yield (ton/fed.)
N Sources	Rate of N Kg/fed.						
Control	0	11.90	107	25.9	1.37	0.90	2.27
Urea	120	17.88	150	29.8	3.94	3.11	7.05
Urea + humic acid	60	16.70	139	28.0	3.34	2.98	6.32
Urea + humic acid	100	18.66	202	32.00	4.76	3.16	7.94
Urea form	60	15.00	128	27.06	3.07	2.56	5.63
Urea form	100	21.42	213	33.9	5.73	3.89	9.62
L.S.D.at,0.05		2.30	3.84	N.S	0.07	0.10	0.09

Concerning the effect of urea + humic acid, the obtained results could be due to the improving effect of humic acid on soil physical properties in addition to the acidic environment caused by humic acid that may inhibit ureolytic microorganisms activities which slows down the release of NH_4^+ 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 increased as N rate increased and the maximum value was obtained due to addition of 140 kg N/fed.

Effect of different N-sources and levels on macronutrients uptake by maize shoot and grains:

Data given in Table (3) show the effect of the studied nitrogen sources and levels on N, P and K uptake by shoot and grain of maize plant. It is clear from data that the application of all nitrogen sources and levels increased 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.)		
N Sources	Rate 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		2.39	0.91	2.30	5.29	2.30	2.44	2.29	1.82	2.30

The maximum total N uptake of about 110.0 kg/fed by maize crop was obtained with ureaform application at rate of 100 kg N/fed. While the treatment of urea + humic acid at rate of 100kg N/fed caused the highest values of both P and K total uptake by maize crop, where the values were 44.11 and 75.45 kg/fed respectively. These results may be due to increased dry matter and grain yield of maize plant with the application of ureaform or urea+ humic acid 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 sandy soil and the formation of humophospho complexes, which are easily absorbed at assimilable by plants.

Effect of nitrogen source and level on Agronomic efficiency, Apparent N recovery and Physiological efficiency:

The values listed in table 4 and depicted in fig. 1 presents the values of agronomic efficiency expressed as yield of one kilogram grain per every kilogram nitrogen fertilizer for the studied treatments. The application of 60 kg N/fed as urea+humic acid resulted in the greatest value of grain yield (34.67 kg) for every one kilogram N fertilizer among other N treatments. The greatest physiological efficiency as value (106 kg/kg N uptake was found with the treatment 60 kg N/fed in the form as compared to all other treatments.

The greatest apparent N recovery presented as the percentage of total N uptake relative to the rate of N fertilizer was obtained with the application of 100 kg N in the form of ureaform. However the rate of 100 kg N/fed in the form of urea+ humic acid resulted in lower efficiency than the 60 kg as ureaform.

The calculated values of agronomic efficiency ratio and physiological efficiency ratio indicate that the grain yield was more dependent on N uptake instead of N fertilizer rate since the 60 kg/fed was the most efficient for both.

Table 4. Agronomic efficiency, Physiological efficiency and Apparent N recovery of maize grain yield.

N kg fertilizers/fed	Agronomic efficiency (Ratio) (Kg grain yield/kg N fertilizer)	Physiological efficiency (Ratio) (kg grain yield/kg N uptake)	Apparent N recovery (%) (kg N uptake/kg N fertilizer)
120 kg urea	18.42	81.67	22.25
60 kg urea+humic	34.67	106.07	32.68
100 kg urea+humic	22.60	70.16	32.21
60 kg ureaform	27.67	69.89	39.58
100 kg ureaform	29.90	61.85	48.34

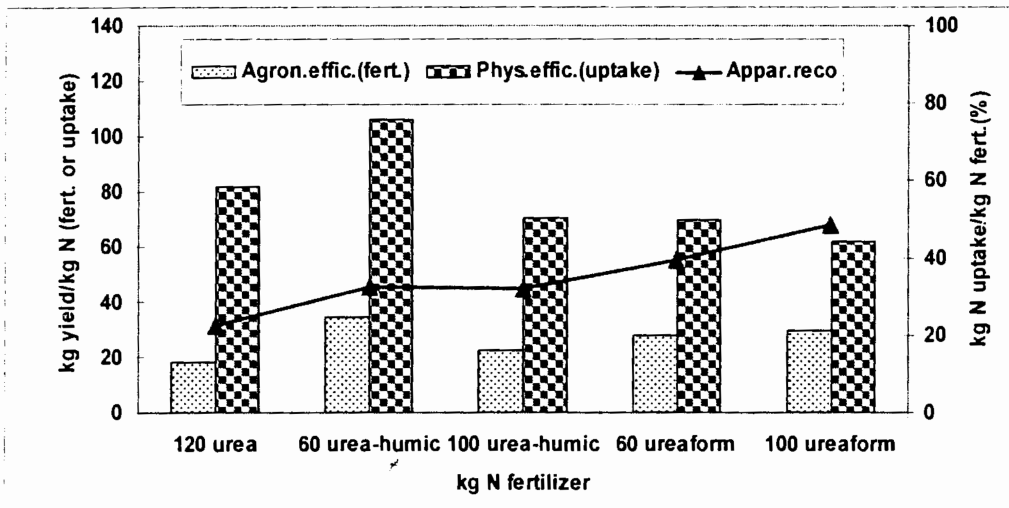

Fig 1. Effect of different treatments on Agronomic efficiency, Physiological efficiency and Apparent N recovery for maize grain yield.

Perrin et al. (1998) showed that amending sandy soils with slow-release N can reduce 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 reduction of leaching losses and enhancing 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.

Results of the present study emphasized the beneficial effect of slow release fertilizer ureaform followed by urea+humic acid on maize plant growth, yield, yield components and the apparent recovery percentage. The most effective rate was 100 kg N/feddan.

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أثر الأسمدة النتروجينية بطيئة الانطلاق على نباتات الذرة النامية فى أرض مستصلحه حديثا

محمد سعيد عواد، جمال فريد الشيخ وصلاح الدين محمد عويس السيسى
معهد بحوث الاراضى والمياه والبيئة ، مركز البحوث الزراعيه، الجيزه– مصر

اجريت تجربه حقليه فى موسم ٢٠٠٩ فىمزرعه خاصه تقع فى منطقه السادات بمحافظة المنوفيه وذلك لتقييم تاثير اضافة سماد اليوريا فورم وايضا اضافة اليوريا بمصاحبة حمض الهيوميك باعتبارها اسمده بطيئه و ذلك بالمعدلين ٦٠ و١٠٠ كجم نيتروجين للفدان مقارنه بسماد اليوريا كسماد سريع الذوبان بالمعدل الموصى به وهو ١٢٠ كجم نيتروجين للفدان على الذرهالشاميه صنف هجين فردى عشره المنزرعفى ارض رمليه.

وقد اشارت النتائج الى الآتي:

أن اضافة السماد النيتروجينىفى صوره اليوريا فورم أو اليوريا بمصاحبه حمض الهيوميك بمعدل ١٠٠ كجم نيتروجين للفدان ادى الى الحصول على زياده ملحوظه فى طول الكوز وطول النبات وايضا محصول السيقان والحبوب والمحصول البيولوجى مقارنه بالكنترول ومعامله اضافة اليوريا بالمعدل الموصى به (١٢٠كجم نيتروجين للفدان).

أدت اضافه معاملة اليوريافورم بالمعدل العالى الى زياده قيم النيتروجين الممتص بواسطه كلا منالسيقان والحبوب مقارنه بالمعاملات الاخرى، بينما معامله اليوريا بالمعدل العالى بمصاحبة حمض الهيوميك أعطت قيم عاليه للفوسفور والبوتاسيوم الممتص بواسطه السيقان والحبوب.

كما اوضحت النتائج ان اعلى قيم لمعدل الكفاءهالمحصولية وأيضا لمعدل الكفاءهالفسيولوجيهقد وجدت نتيجه اضافة اليوريا بمعدل ٦٠ كجم للفدان بمصاحبة حمض الهيوميكومن جهة اخرى وجد ان معاملة اليوريافورمالدهيد بمعدل ١٠٠ كجم للفدان فقد اعطت اعلى قيمه للنسبة المئوية للنيتروجين المسترجع.