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Effect Of different Forms and Rates of Slow Release Urea Fertilizers on Growth, Yield and Quality of Maize Plants (*Zea mays* L.)

Eman H. Abd El-Azeiz[2*]; Rania F. El Mantawy[1] and Alaa F. Albakry[2]

[1]Crop Physiology Res. Dep. - Field Crops Res. Inst. - Agric. Res. Center, Giza-Egypt.
[2]Soil Fertility and Pl. Nut. Dep., Soil, Water and Environ. Res. Inst. ARC. Giza- Egypt.

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ABSTRACT

An experiment was conducted at the Experimental Farm of Sakha Agricultural Research Station, Kafr-Elsheikh, Egypt, during 2019 and 2020 to study the effect of different forms and rates of slow release urea nitrogen fertilizers; sulfur (SCU), formaldehyde (FCU) and dolomite (DCU), coated urea with fast release (un coated) urea fertilizers (UCU) on growth, yield and grain quality of maize yellow hybrid Single Cross168. The experiment was laid out in completely randomized blocks design with four replicates. The treatments were (UCU at 120, SCU, FCU and DCU at 60, 80 and 100 kg N fad.$^{-1}$). Results showed that, using slow release nitrogen fertilizers caused significant increase on most growth parameters, yield and grain quality. The highest values were obtained by SCU followed by FCU and then DCU at 100 kg N fad.$^{-1}$ except chlorophyll a, b and carbohydrates content which increased with DCU at 100 kg N fad.$^{-1}$. Using slow release nitrogen fertilizers can lead to saving mineral fertilizers, reduces nitrogen loss in the soil, reduced environmental pollution and also, provides the plant with the nutrients it needs throughout its growth.

Keywords: maize, slow release urea nitrogen fertilizers, growth, yield, grain quality, soil properties.

INTRODUCTION

Maize (*Zea mays* L.) is the third most important crop worldwide following rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.). Maize kernel is composed of approximately 72% starch, 10% protein, 5% oil, 2% sugar and 1% ash with the remainder being water Perry (1988).

Urea fertilizer is the famous important source of nitrogen that is used widely, but more than 30% of it is lost as a result of leaching, decomposition and volatilization Shaviv and Mikkelsen (1993).

Slow release fertilizers are promising alternatives to conventional fertilizers, as both reduce losses by leaching, volatilization and problems of toxicity and/or salinity to plants. Slow release fertilizers are one of new specific fertilizer types that releases its nutrients over a specific period of time. Rarely, searches reported that, coated fertilizers amended nitrification inhibitor to increase crop growth Ayyer (1992). In this respect, Fageria and Baligar (2005) recorded a significant increase in maize yield by 10.35% after using slow release nitrogen fertilizer compared with conventional fertilizer. Abu Zied *et al*., (2014) studied the effect of different slow release nitrogen fertilizer forms on yield and chemical constituents of maize and soybean and they found that, all forms of coated urea increased grain yield by 4-10% for maize and 3-16% for soybean. Also it can be noticed that application of SCU at 80 kg fad.$^{-1}$ to maize could effectively produce similar or more than that obtained by 100 kg N fad.$^{-1}$ applied in the form of uncoated urea. Also, Khaveh *et al.*, (2015) showed that polymer trapping of urea fertilizers led to improvement in morphological traits of corn such as stem diameter, plant height, corn length, diameter and weight of corn stalk, number of kernels per ear, seed weight, 1000- seed weight, biological yield, seed yield and harvest index.

The advantages of slow release fertilizers are that the nutrients are available gradually over time which means that, the farmers can work less often. Most slow release fertilizers (organic and synthetic) are being available at specific (warm) soil temperatures. The benefit of such fertilizers is that plant roots generally are most active in warm soil and therefore the slow release fertilizer will start to make fertilizer available as soon as the plants actually needs them. As the plant roots become more active (in warmer soil) more fertilizer will automatically be released Gagnon *et al*., (2012). Additionally, if slow-release fertilizers can be applied as a pre-planting, production costs can be reduced, eliminating the need for multiple applications of soluble nitrogen fertilizers.

Sulfur-coated urea (SCU) contains about 30-40% nitrogen and 20% sulfur. Urea granules coated by sulfur as a cheap coating and control nitrogen nutrient release. Releasing of N nutrient occur as a result of sulfur coat oxidation by microorganisms in soil Rindt *et al*., (1968).

Formaldehyde coated urea (FCU 38%N) is the first developed group of slow release nitrogen fertilizer, it is formed by a reaction between formaldehyde and excess of urea under controlled conditions *i.e.* pH, temperature, mole proportion, reaction time, *etc.*, Watson (2013). It is a good slow release nitrogen fertilizer for most crops, where it has a low solubility. On the other hand, it's used widely in warmer climates as in the mediterranean region where its more effective in case of higher temperatures than cold ones Trenkel (2010).

Dolomite coated urea (DCU) is a fertilizer of urea granules that coated by dolomite Ca Mg $(CO_3)_2$, it contain

*** Corresponding author.**
E-mail address: dremhamdy@gmail.com
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about 22% Ca and 12% Mg. Dolomite coated urea control nitrogen nutrient release , raising pH of soil and act as a source of Ca and Mg Ibrahim *et al*., (2014).

So, the aim of this investigation was to compare the response of maize plants using slow release N fertilizers; sulfur, formaldehyde and dolomite coated urea with fast release (un coated urea) on growth, yield, NPK uptake and grain quality.

MATERIALS AND METHODS

Experimental sites

The present study was established at the Experimental Farm of Sakha Agricultural Research Station, (31°07\\ N latitude and 30°57\\ E longitude) Kafr- Elsheikh, ARC, Egypt during the two successive summer seasons 2019 and 2020 to compare three types and rates of slow release urea nitrogen fertilizers with conventional urea fertilizers on growth, yield and yield components and grain quality of maize.

Each plot area was 19.2 m^2 included four rows 6.00 m long and 0.80 m apart between rows. Maize grains (SC168) were sown at rate of 10 kg of grains fad^{-1} in 14^{th} and 16^{th} May at the first and second seasons, respectively. The experiment was irrigated eight times, where the first one was applied 15d after sowing and the others were every 10-12 d. The plants were thinned to one plant/ hill before the first irrigation producing 22000 plants $fad.^{-1}$. The other mineral fertilizers were applied at the recommended levels, *i.e.*30 kg P_2O_5 fad^{-1}. Superphosphate forms of calcium superphosphate (15.5% P_2O_5) was added before planting. Potassium was added as (potassium sulphate 48 % K_2O at the rate of 50 kg K_2O fad^{-1} in once dose.

Random disturbed soil samples from 0-30 cm surface soil were collected before planting. Soil physical, chemical, and nutrients status of the experimental sites were determined according to Page *et al*., (1982) and Klute (1986) as shown in Table (1).

Table 1. Physical and chemical analysis of the experimental site during the two seasons of study (2019 and 2020).

Soil characteristics	The average of two growing seasons 2019 and 2020	
I. Physical properties:	2019	2020
Particle size distribution		
Sand	24.00	25.28
Silt	34.80	33.22
Clay	41.20	41.50
Soil Texture Class	Clay	Clay
II. Chemical properties:		
pH, [1:2.5 soil suspension] *	8.06	8.12
EC, [soil past, dS m^{-1}] **	3.40	3.45
Soluble cations, meq 100 g soil $^{-1}$)		
Ca^{2+}	0.60	0.66
Mg^{2+}	0.52	0.56
Na^{+}	2.26	2.21
K^{+}	0.02	0.02
Soluble anions, meq 100 g soil $^{-1}$)		
CO_3^{2-}	-	-
HCO_3^{-}	0.28	0.32
Cl^{-}	2.26	2.30
SO_4^{2-}	0.86	0.83
$CaCO_3$, %	4.80	4.84
OM, %	1.63	1.66
III. Nutritional properties:		
KCl extractable N, mg kg^{-1}	47.39	47.42
$NaHCO_3$ Extractable P, mg kg^{-1}	15.00	15.31
Amm. Acetate Extractable K, mg kg^{-1}	225.72	225.75

Experimental description:

The experiment was set in a randomized complete block design (RCBD) with four replications. This experiment included the following 10 treatments as follows:

1. Application of un-coated urea (46.5% N) at 120 kg N fad^{-1} (normal recommended dose).
2. Application of sulfur coated urea (SCU40 % N) at 60 kg N fad^{-1}.
3. Application of sulfur coated urea (SCU40 % N) at 80 kg N fad^{-1}.
4. Application of sulfur coated urea (SCU 40 % N) at 100 kg N fad^{-1}.

5- Application of formaldehyde coated urea (FCU 38% N) at 60 kg N fad^{-1}.

6- Application of formaldehyde coated urea (FCU 38 % N) at 80 kg N fad^{-1}.

7- Application of formaldehyde coated urea (FCU 38 % N) at 100 kg N fad^{-1}.

8- Application of dolomite coated urea (DCU 32 % N) at 60 kg N fad^{-1}.

9- Application of dolomite coated urea (DCU 32 % N) at 80 kg N fad^{-1}.

10- Application of dolomite coated urea (DCU 32 % N) at 100 kg N fad^{-1}.

The slow release N fertilizers at the prementioned amounts were applied once at the start of planting, while the fast release N fertilizers (urea) was added in two equal split doses at first and second irrigations.

The following parameters were recorded in both seasons:

Growth parameters:

- Number of green leaves $plants^{-1}$ at 90 days after sowing.
- Plant height (cm) was measured at 90 days from sowing.
- Ear height (cm) was recorded after flowering from 10 guarded plants per plot.
- Stem diameter (cm).

Yield and its components:

- Ear length (cm) measured as an average of five ears from five guarded plants.
- Ear diameter.
- Number of kernels / row was measured on five ears from five guarded plants.
- 100-kernel weight (g).
- Grain yield (ton $fad.^{-1}$).

Chemical analysis:

- **Photosynthetic pigment content in leaves**:

The total chlorophyll pigments were determined by reading the absorbance on spectrophotometer at 664 and 647 nm and concentration of photosynthetic pigments were calculated according to the equation mentioned by (Metzener *et al*., 1965). The following equations were applied to calculate the chlorophyll content of the leaf samples as mg/g fresh weight after 50 days after sowing (DAS).

$$\text{Chlorophyll a (Chl. a)} = 11.79\ E_{663} - 2.29\ E_{647}$$

$$\text{Chlorophyll b (Chl. b)} = 20.05\ E_{647} - 4.77\ E_{663}$$

- **Total Nitrogen in grains:** was determined by Kjeldahl method as described by A.O.A.C (**1990).** Protein content in the grains was calculated by multiplying N% by 5.85 factors.

- **Grain Phosphorus (%):** was determined calorimetrically according to Chapman and Pratt (1978).
- **Grain Potassium (%)**: was determined by flam photometer according to Chapman and Pratt (1978).
- **Grain oil (%):** was determined by soxhelt apparatus using petroleum ether as a solvent as described by A.O.A.C. (1995).
- **Grain carbohydrate (%):** was determined according to Dubois *et al.,* (1956).
- **NPK uptake:** was calculated using the following equation according Rosecrance *et al*.,(1995)

NPK uptake (kg fad^{-1}) = NPK (%) X yield (kg fad^{-1}) /100.

Economics evaluation:

The total cost of cultivation as well as the gross return was calculated on the basis of prevailing market rates for different practices and produces. Net profit was calculated treatment wise. The total cost of cultivation per hectare was subtracted from the gross income for computing net retunes from each treatment.

Net profit (£.fad^{-1}) = Gross return – Cost of cultivation.

The benefit-cost ratio (BCR) was calculated for every treatment wise as below:

Benefit cost ratio (BCR) = Gross return / Cost of cultivation.

Statistical analysis:

All data were subjected to statistical analysis according to Snedecor and Cochran (1980). Means were compared using least significant difference at 5% level. Appropriate analyses of variance was performed for the two experiments according to Steel and Torrie (1984).

RESULTS AND DISCUSSION

Growth characteristics

It is obvious from Table (2) that, number of green leaves plant $^{-1}$, plant height, ear height and stem diameter were significantly affected by forms and rates of slow release nitrogen urea fertilizer treatments during 2019 and 2020 season, respectively. The results showed that, slow release nitrogen fertilizers have significant effects on growth parameters as SCU at 100 kg N fad.$^{-1}$ recorded the highest values in plant height (265.55 & 263.42 cm), ear height (168.33 & 165.16 cm) and stem diameter (2.42 &2.37cm) during the two seasons, respectively followed by FCU and then DCU at 100 kg N fad.$^{-1}$ as compared with UCU at 120 kg Nfad^{-1}. This increase is probably due to the application of urea fertilizer without incorpation caused losses of N element as NH_3 Flower and Brydon (1989).Positive increase with SCU may be due to it act as a source of both major macronutrients (N and S) which were needed for plant growth and cell elongation Abou- Zied *et al.,* (2014) and Jadon *et al., (*2018). The "S" element is used as a secondary element, fungicide and has acidic properties that neutralized the soil alkalinity Azeem *et al.,* (2014).

Table 2. Growth parameters as affected by different forms and rates of coated urea nitrogen fertilizers during 2019 and 2020 seasons.

Treatments	No. of green leaves plant^{-1}		Plant height (cm)		Ear height (cm)		Stem diameter (cm)	
	2019	2020	2019	2020	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	13.26 c	12.15 c	258.52 d	255.27 d	155.33 d	150.36 f	2.10 b	2.06 c
SCU at 60 kg N fad^{-1}	11.14 f	10.36 e	235.00 h	232.33 h	145.33 h	143.26 h	1.89 c	1.82 e
SCU at 80 kg N fad^{-1}	12.13 e	11.22 d	251.50 e	250.44 e	153. 82 e	151.33 d	2.08 b	2.04 cd
SCU at 100 kg N fad^{-1}	15.10 a	14.92 a	265.55 a	263.42 a	168.33 a	165.16 a	2.42 a	2.37 a
FCU at 60 kg N fad^{-1}	10.15 h	10.25 e	233.33 i	230.25 i	142.40 i	140.22 i	1.85 d	1.74 ef
FCU at 80 kg N fad^{-1}	12.32 d	11.33 d	246.15 f	241.15 f	150.25 g	151.18 e	2.06 b	2.03 cd
FCU at 100 kg N fad^{-1}	15.10 a	14.92 a	263.52 b	261.58 b	165.50 b	164.18 b	2.35 a	2.28 b
DCU at 60 kg N fad^{-1}	10.33 g	10.26 e	231.00 j	228.33 j	141.01 j	140.10 j	1.74 d	1.71 f
DCU at 80 kg N fad^{-1}	12.2 de	11.33 d	244.66 g	240.26 g	150.66 f	148.28 g	2.04 b	1.97 d
DCU at 100 kg N fad^{-1}	14.26 b	13.26 b	260.50 c	258.66 c	157.13 c	155.25 c	2.13 b	2.11 c
LSD at 0.05	0.157	0.161	0.085	0.085	0.134	0.085	0.090	0.085

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea.

Yield and yield components:

Data presented in Table 3 indicated that, slow release urea nitrogen fertilizers showed significant effects on yield and yield components of maize plants during the two studied seasons 2019 and 2020, respectively. SCU at 100kg N fad.$^{-1}$ recorded the highest values where, ear length (26.42& 26.48 cm), no. of kernel / ear (661.62&654.33), eat diameter (4.05&4.11), 100-grain wt. (51.44&52.14 g) and grain yield (4.25&4.13ton fad.$^{-1}$) during the two growing seasons, respectively. followed by FCU and DCU at 100kg N fad.$^{-1}$. These recorded results were due to the availability of needed N during reproductive and grain filling stages Gagnon *et al*., (2012). These results are in matching with that obtained by Noellsch *et al.,* (2009). Also, Amany *et al*., (2006) and Signor and Barbiani (2013) also found that, slow-release nitrogen fertilizer gave the highest 100 grain weight of wheat and maize. An observation also shared by Jadon *et al*., (2018) who concluded that, coated urea fertilizer application enhance yield and yield attributes of maize compared with un coated urea. Slow or controlled-release fertilizers have been designed to ensure that the delayed nutrient release is synchronized in time with the nutritional requirements of plants Drury *et al*., (2017).

Chlorophyll content

Data in Table (4) showed that, coated urea with sulfur and coated urea with dolomite recorded the highest values of chl. a (0.249 & 0.254mg/g F.W.) and chl. b (0.159 & 0.162 mg/g F.W) for SCU and chl. a (0.250&0.2255 mg/g F.W.) and chl. b (0.160 & 0.163 mg/g F.W) for DCU as caused an enhancement of chl. a and chl. b during the two successive summer seasons. This improving effect of coated urea because their ability to regulate N releasing according to needs of plant Mikkelsen *et al*., (1994).

Table 3. Yield and yield components as affected by different forms and rates of coated urea nitrogen fertilizers during 2019 and 2020 seasons.

Treatments	Ear length (cm)		No. of kernel/ear		Ear diameter (cm)		100-kernel wt. (g)		Grain yield (ton fad.$^{-1}$)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	24.33 d	23.97 bc	635.68 d	623.36 d	3.72 bc	3.43 d	48.22 d	46.24 d	3.64 c	3.47 c
SCU at 60 kg N fad^{-1}	21.55 h	21.60 d	597.42 h	582.55 h	3.12 f	3.08 f	42.55 h	41.34 h	2.91 f	2.94 f
SCU at 80 kg N fad^{-1}	23.51 e	23.55 c	630.52 e	621.62 e	3.64 cd	3.60 c	46.31 e	44.32 e	3.35 d	3.24 d
SCU at 100 kg N fad^{-1}	26.42 a	26.48 a	661.62 a	654.33 a	4.05 a	4.11 a	51.44 a	52.14 a	4.25 a	4.13 a
FCU at 60 kg N fad^{-1}	20.52 i	20.55 e	584.33 i	581.22 h	3.05 f	3.10 f	41.35 i	40.34 i	2.82 g	2.85 g
FCU at 80 kg N fad^{-1}	23.10 f	23.15 c	624.33 f	618.18 f	3.58 d	3.42 d	45.11 f	43.36 f	3.21 e	3.11 e
FCU at 100 kg N fad^{-1}	25.88 b	24.50 b	658.33 b	650.42 b	3.98 a	3.84 b	50.66 b	51.23 b	4.17 a	4.11 a
DCU at 60 kg N fad^{-1}	20.30 j	20.28 e	576.25 j	571.21 i	3.03 f	2.91 f	40.21 j	39.87 j	2.73 h	2.54 h
DCU at 80 kg N fad^{-1}	22.86 g	21.80 d	618.14 g	609.18 g	3.42 e	3.31 e	44.32 g	42.31 g	3.18 e	3.02 f
DCU at 100 kg N fad^{-1}	24.66 c	25.72 a	642.88 c	637.45 c	3.85 b	3.63 c	49.85 c	48.21 c	3.92 b	3.74 b
LSD at 0.05	3.40	3.40	8.52	8.50	0.090	0.085	8.51	8.50	0.090	0.090

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea.

Dolomite coated urea (DCU) caused increase on chl. a and chl. b as it contain Mg that an important element for synthesis of chlorophyll and /or urea coated dolomite had rapid nitrogen release than the other coated urea forms used which gave nitrogen to plants during the growth period Eghbali *et al*., (2015). In addition to the effective role of nitrogen in meristematic activity that increasing cells numbers leading to cell elongation Zaman *et al.*, (2008). This results in agreement with that obtained by Hatfield and Parkin (2014). Results are confined with Zong *et al*, (2010) who found that SCU significantly enhanced the maize chlorophyll concentration and grain yield.

Table 4. Chlorophyll content as affected by different forms and rates of coated urea nitrogen fertilizers during 2019 and 2020 seasons.

Treatments	Chl. a (mg/g F.W.)		Chl. b (mg/g F.W.)		Chl.a+b (mg/g F.W.)	
	2019	2020	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	0.245 abc	0.250 abc	0.155 abc	0.160 ab	0.400 abc	0.410 abc
SCU at 60 kg N fad^{-1}	0.235 d	0.237 de	0.140 ef	0.143 de	0.375 de	0.380 e
SCU at 80 kg N fad^{-1}	0.238cd	0.242 cde	0.147 cde	0.151 cd	0.385 cde	0.393 cde
SCU at 100 kg N fad^{-1}	0.249 a	0.254 a	0.159 a	0.162 ab	0.408 a	0.416 ab
FCU at 60 kg N fad^{-1}	0.232 d	0.236 e	0.137 f	0.142 e	0.369 e	0.378 e
FCU at 80 kg N fad^{-1}	0.237 cd	0.240 de	0.145 def	0.148 cde	0.382 de	0.388 de
FCU at 100 kg N fad^{-1}	0.248 ab	0.252 ab	0.158 ab	0.160 ab	0.406 ab	0.412 ab
DCU at 60 kg N fad^{-1}	0.237 cd	0.240 de	0.144 ef	0.150 cde	0.381 de	0.390 de
DCU at 80 kg N fad^{-1}	0.240 bcd	0.245 abc	0.150 bcd	0.154 bc	0.390 bcd	0.399 bcd
DCU at 100 kg fad^{-1}	0.250 a	0.255 a	0.160 a	0.163 a	0.410 a	0.418 a
LSD at 0.05	0.0085	0.0085	0.009	0.0085	0.016	0.017

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea.

Protein, carbohydrate and oil % in grains:

Data presented in Table (5) demonstrated that, slow release nitrogen fertilizers caused increase on protein and carbohydrate % as the highest values of protein (14.15& 14.27%) were obtained with SCU at 100 kg N fad.$^{-1}$ in comparison to UCU at 120 kg N fad^{-1}.These results are in harmony with Amany *et al*., (2006) whom reported an increase in grain protein content of about 0.5 % with application of slow-release nitrogen fertilizer compared with uncoated urea. These results may be due to the effective role of coating material in regulation availability of nitrogen for longer duration Nash *et al*., (2013). The highest values of carbohydrate (74.56 &74.59 %) were obtained with DCU at 100 kg N fad.$^{-1}$ during the two growing seasons. This increase in grain carbohydrate as required Mg which found in dolomite. These results are in accordance with that reported by Ibrahim *et al*., (2014) and Eghbali *et al*., (2015). On the other hand, the highest values of oil % were recorded with SCU at 60 kg N fad.$^{-1}$ (4.32&4.36%).These results are similar to the those of Signor and Barbiani (2013).

Table 5. Protein, carbohydrate and oil % as affected by different forms and rates of coated urea nitrogen fertilizers during 2019 and 2020 seasons.

Treatments	Oil (%)		Protein (%)		Carbohydrates (%)	
	2019	2020	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	4.06 e	4.08 ef	13.63 bcd	13.92 abc	74.44 bcd	74.46 bcd
SCU at 60 kg N fad^{-1}	4.32 a	4.36 a	12.75 fg	12.98 ef	74.32 fg	74.36 ef
SCU at 80 kg N fad^{-1}	4.20 bcd	4.25 bc	13.45 cde	13.74 bc	74.41 cde	74.46 bcd
SCU at 100 kg N fad^{-1}	4.08 e	4.10 e	14.15 a	14.27 a	74.50 ab	74.52 ab
FCU at 60 kg N fad^{-1}	4.28 ab	4.33 ab	12.63 fg	12.87 ef	74.28 g	74.33 f
FCU at 80 kg N fad^{-1}	4.18 cd	4.22 cd	13.33 de	13.63 cd	74.38 def	74.42 cd
FCU at 100 kg N fad^{-1}	3.94 f	4.0 fg	14.04 ab	14.15 ab	74.52 ab	74.54 ab
DCU at 60 kg N fad^{-1}	4.25 abc	4.28 abc	12.28 g	12.57 f	74.35 efg	74.40 def
DCU at 80 kg N fad^{-1}	4.12 de	4.15 de	13.04 ef	13.16 de	74.47 bc	74.50 bc
DCU at 100 kg N fad^{-1}	3.87 f	3.96 g	13.86 abc	14.04 abc	74.56 a	74.59 a
LSD at 0.05	0.085	0.09	0.498	0.498	0.085	0.085

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea

Nitrogen, Phosphorus and potassium in grains (NPK %):

The percentages of N, P and K nutrients were significantly affected by coated urea especially SCU and values increases by increasing rates of all nitrogen fertilizer forms as appear in Fig. (1&2). Similar results were obtained by Abou-Zied *et al.*, (2014). Also, Signor and Barbiani (2013) reported that application of slow release fertilizers increased the phosphorus percentage in grains of maize. However, slow release fertilizers in general can increase the absorption of K^+ to a certain extent and also increased yield and yield components. Sulfur oxidation in soil reducing pH, improving soil water relation and increasing availability of nutrients leading to increase nutrient uptake by plant El-Ghamry *et al.*, (2016).

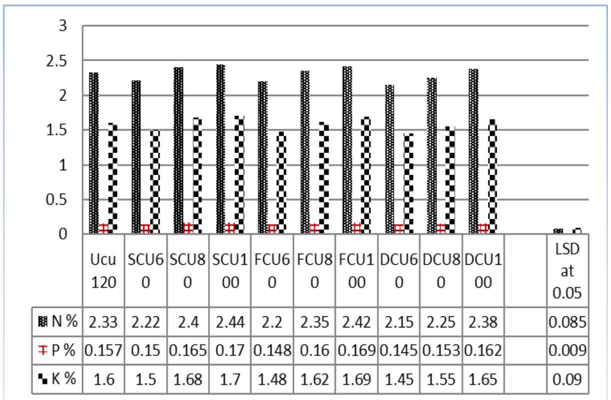

Fig. 1. NPK % as affected by different forms and rates of coated urea nitrogen fertilizers during 2019 seasons.

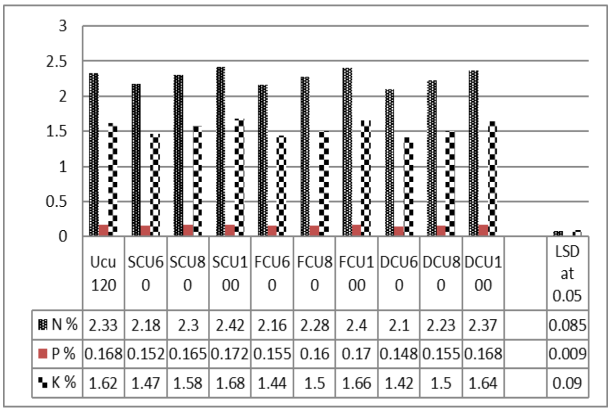

Fig. 2. NPK % as affected by different forms and rates of coated urea nitrogen fertilizers during 2020 seasons.

Nitrogen, Phosphorus and potassium (NPK) uptake

The obtained results in Table (6) indicated that, SCU and FCU at 100 kg N fad^{-1}. recorded the highest values of NPK uptake during the two growing seasons, respectively. In the same way Pokhrel *et al.*, (2009) found that more nitrogen applied produces a larger nitrogen intake per grain due to higher dry matter yield.

Table 6. NPK uptake as affected by different forms and rates of coated urea nitrogen fertilizers during 2019 and 2020 seasons.

Treatments	N uptake(kg fad^{-1})		P uptake(kg fad^{-1})		K uptake(kg fad^{-1})	
	2019	2020	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	80.86 c	82.56 c	5.62 c	5.82 c	56.23 c	57.23 c
SCU at 60 kg N fad^{-1}	63.52 fg	64.69 ef	4.35 f	4.41 fg	42.35 f	43.52 fg
SCU at 80 kg N fad^{-1}	74.53 d	76.12 d	5.18 d	5.34 d	51.17 d	52.50 d
SCU at 100 kg N fad^{-1}	99.96 a	100.78 a	7.02 a	7.10 a	69.40 a	70.22 a
FCU at 60 kg N fad^{-1}	62.11 g	63.25 f	4.27 f	4.33 g	41.91 f	42.73 g
FCU at 80 kg N fad^{-1}	70.89 de	72.47 d	4.88 de	4.97 e	48.18 de	49.77 de
FCU at 100 kg N fad^{-1}	98.65 a	99.47 a	6.94 a	6.98 a	68.20 a	69.47 a
DCU at 60 kg N fad^{-1}	53.35 h	54.62 g	3.68 g	3.76 h	36.08 g	36.81 h
DCU at 80 kg N fad^{-1}	67.36 ef	67.96 e	4.62 ef	4.67 ef	45.31 ef	46.82 ef
DCU at 100 kg fad^{-1}	88.65 b	89.77 b	6.16 b	6.28 b	61.35 b	62.81 b
LSD at 0.05	4.36	4.09	0.382	0.346	3.54	3.45

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea

Also, Shrestha *et al.*, (2018) found that, the nitrogen uptake in grain increases with application of increased level of nitrogen up to 150 kg N/ha applied in soil and its affected by availability of N in later growth stages.

Soil N content

Table (7) showed available nitrogen content in soil at maximum vegetative growth stage and residual N after harvesting. Obtained data cleared that, nitrogen at maximum vegetative growth stage as well as residual nitrogen were significantly increased in soil under all slow releases nitrogen fertilizers treatments. However, sulfur coated urea fertilizers recorded the highest values of soil nitrogen content followed by FCU and DCU treatments.

UCU hydrolyzed just applied to soil through a series of biological, chemical and physical reactions to NH4+ which is then oxidized to NO-3 that loss by leached or denitrified El-Ghamery *et al.*,(2016).

Table 7. Nitrogen in soil (mg kg^{-1}) after fertilizers addition and residual after harvesting during 2019 and 2020 seasons.

Treatments	N soil at max vegetative growth stage		N soil after harvesting	
	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	89.42 d	90.16 d	79.16 c	82.22 c
SCU at 60 kg N fad^{-1}	57.45 h	59.45 h	42.07 i	47.19 h
SCU at 80 kg N fad^{-1}	76.86 e	79.12 e	60.36 f	63.13 e
SCU at 100 kg N fad^{-1}	95.90 a	97.66 a	85.36 a	88.82 a
FCU at 60 kg N fad^{-1}	52.46 i	53.82 i	45.82 h	46.25 i
FCU at 80 kg N fad^{-1}	73.12 f	75.14 f	60.42 e	62.39 f
FCU at 100 kg N fad^{-1}	95.34 b	92.92 b	80.33 b	85.34 b
DCU at 60 kg N fad^{-1}	50.28 j	52.28 j	47.18 g	50.36 g
DCU at 80 kg N fad^{-1}	70.33 g	70.34 g	63.92 d	65.42 d
DCU at 100 kg fad^{-1}	90.60 c	92.82 c	79.16 c	82.22 c
LSD at 0.05	0.085	0.090	0.085	0.344

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea

Releasing time of nutrients from slow release fertilizers ranging between 3-12 months where it depends on different factors *i.e*: coating solubility, rate of hydrolysis, moisture, temperature of soil, coating thickness, microcracks number in coating surface and granule size of fertilizer Pereira (2009). Mello *et al*., (2017) and Noellsch *et al.,* (2009) indicated that, losses of nitrogen through volatilization reduced by approximately 50% in case of coated urea application.

Gross return, net return and benefit- cost ratio (BCR) of maize:

Data in Table (8) recorded economic of maize production that affected by different forms and rates of slow release nitrogen fertilizer during the two seasons. Results showed a significant variation in gross return, net return and benefit cost ratio among all treatments. The highest cost of cultivation (11265 and 11245 £.fad^{-1}) in two seasons was obtained by DCU at 100 Kg fad^{-1} followed by FCU at 100 kg fad^{-1} (10530 and 10515 £.fad^{-1}). SCU treatments achieved the lowest total cost of cultivation compared with other coated urea treatments where sulfur is the cheapest coating. The cost of cultivation on uncoated urea (UCU) at 120 Kg N fad^{-1} applied treatment was 7875 £.fad^{-1} in both seasons. It is clear that coated urea showed more costs of cultivation than that of uncoated urea and this may be due to high price of coating and production. The maximum gross return of maize crop (21250 and 20650 £.fad^{-1} in two seasons, respectively) was achieved in case of SCU at rate 100 kg Nfad^{-1} applied treatment followed by FCU and lately DCU at 100 kg N fad^{-1} . The gross return of UCU applied treatment was 18200 and 17350 £.fad^{-1} in both seasons. Coated urea *i.e.* SCU, FCU and DCU at 100 Kg N fad^{-1} treatments enhanced maize grain yield more than that of uncoated urea (UCU) at 120 Kg N fad^{-1}. Highest net return of 12750 and 12350 £.fad^{-1} were obtained by SCU at 100 kg N fad^{-1} in both seasons followed by UCU at 120 Kg N fad^{-1} with net return 10825 and 9475 £.fad^{-1} in 2019 and 2020, respectively.

The highest BCR (2.50 and 2.48) in both seasons was achieved from SCU at 100 Kg N fad^{-1} applied treatment followed by UCU at 120 Kg N fad^{-1} applied treatment with BCR (2.46 and 2.20) in the two seasons . It is clear that SCU at 100 Kg N fad^{-1} applied treatment recorded highest net return as well as BCR and it could be a good alternative to UCU.

Table 8. Economic criteria for the different treatments during the two seasons under study.

Treatments	Total cost of cultivation (£.fad^{-1})		Gross return (£.fad^{-1})		Net return (£.fad^{-1})		Benefit cost ratio (BCR)	
	2019	2020	2019	2020	2019	2020	2019	2020
UCU at 120 kg N fad^{-1}	7875	7875	18200	17350	10825	9475	2.46	2.20
SCU at 60 kg N fad^{-1}	7500	7300	14550	14700	7050	7400	1.94	2.01
SCU at 80 kg N fad^{-1}	8000	7800	16750	16200	8750	8400	2.09	2.07
SCU at 100 kg N fad^{-1}	8500	8300	21250	20650	12750	12350	2.50	2.48
FCU at 60 kg N fad^{-1}	8940	8920	14100	14250	5160	5330	1.57	1.59
FCU at 80 kg N fad^{-1}	9735	9715	16050	15550	6815	5835	1.73	1.60
FCU at 100 kg N fad^{-1}	10530	10515	20850	20550	10820	10035	2.07	1.95
DCU at 60 kg N fad^{-1}	9405	9494	13650	12700	4745	3206	1.53	1.33
DCU at 80 kg N fad^{-1}	10335	10315	15900	15100	6065	4785	1.61	1.46
DCU at 100 kg fad^{-1}	11265	11245	19600	18700	8835	7455	1.82	1.66

Where UCU; uncoated urea, SCU; sulfur coated urea, FCU; formaldehyde coated urea DCU; dolomite coated urea

CONCLUSION

Based on the obtained results of this study, it could be concluded that slow release nitrogen fertilizers decreases losses of added nitrogen . As well as, it can be noticed that application of SCU at 100 kg N fad^{-1} could effectively produce the highest values of most studied characters. Also, other benefits such as reduced N leaching and decreased production cost must be demonstrated coupled with the ability to extend N availability over a growing season. The coated urea fertilizers inhibited nitrification and volatilization processes and increased N availability in the soil for plant consumption.

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تأثيرصور ومعدلات مختلفه من اسمدة اليوريا بطيئة الذوبان على نمو ومحصول وجودة الذرة الشامية

ايمان حمدى عبدالعزيز[2]، رانيا فاروق المنطاوى[1] و الاء فتحى البكرى[2]

[1]قسم بحوث فسيولوجيا المحاصيل – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية.

[2]قسم تغذية النبات-معهد الاراضى والمياه والبيئة- مركز البحوث الزراعية.

تم إجراء تجربة حقلية بمزرعة محطة البحوث الزراعية بسخا – محافظة كفر الشيخ خلال موسمى الزراعة 2019،2020 لدراسة تأثيرصور ومعدلات مختلفة من اسمدة اليوريا بطيئة الذوبان (يوريا مغلفه بالكبريت ويوريا مغلفه بالفورمالدهيد ويوريا مغلفه بالدولوميت) ومقارنتها باسمدة اليوريا الغير مغلفه على نمو وانتاجية وجودة محصول الذرة الشامية صنف هجين فردى 168 . وقد صممت التجربة في قطاعات كاملة العشوائيه فى أربعة مكررات وكانت المعاملات كالاتي (اليوريا الغير مغلفه بمعدل 120 واليوريا المغلفه بالكبريت واليوريا مغلفه بالفورمالدهيد واليوريا المغلفه بالدولوميت بمعدل 120،100،80 كجم نيتروجين للفدان). وقد أظهرت النتائج أن استخدام الاسمدة بطيئة الذوبان أدى الى زيادة معنويه فى معظم صفات النمو الخضرى والمحصول وكذلك جودة الحبوب وكانت افضل النتائج عند استخدام اليوريا المغلفه بالكبريت ويليها اليوريا المغلفه بالفورمالدهيد ثم اليوريا المغلفه بالدولوميت بمعدل 100كجم نيتروجين للفدان فيما عدا كلوروفيل ا، ب ونسبه الكربوهيدرات التى سجلت زيادة مع استخدام اليوريا المغلفه بالدولوميت بمعدل 100 كجم نيتروجين للفدانو هذا يعنى أن استخدام اليوريا بطيئه الذوبان أدى الي توفير الاسمدة المعدنيه وتقليل فقد النيتروجين فى التربه مما يحد من التلوث البيئى وايضا توفر للنبات احتياجاته من العنصر المغذى طوال فترة النمو .