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Effect of Some Controlled Release Nitrogen Fertilizer (Coated Urea) on Growth, Yield, and Nitrogen Uptake of Corn Plants.

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ABSTRACT

Nitrogen fertilization plays an important roles for improving corn yield but it was easily lost after addition of N-fertilizers. This study was conducted during the season of 2015 for comparing five slow release N fertilizers namely, urea formaldehyde (UF), sulfur coated urea (UFS), sulfur& inhibitors coated urea (UFS_{IN}). Cement coated urea (U Cement) and cement & inhibitors coated urea (U Cement $_{in}$) and tow adding rates (recommended and 1.5 recommended) by soil application under a complete randomize design, with three replicates for each treatment. The results indicated that the best values of fresh and dry weight of shoot yield and flag leaf of maize (g) as well as plant height (cm), ear weights (g), 100-seed weight (g), protein of grain (%) and grain yield (g)of maize were at(UFS_{IN}) treatment . Also, the values of nitrogen, phosphorus, potassium, contents in shoot and flag leaf of maize were evaluated under the effect of different types of coated urea.

Keywords: N fertilizers; urea; formaldehyde; inhibitors; sulfur

INTRODUCTION

The efficiency of classical mineral NPK fertilizers is usually low because a major part of these fertilizers does not reach plant roots and ends up polluting ground waters with nitrates and phosphates. (El-Ghamry *et al*., (2010).

With the exponential growth of the global population, the agricultural sector is bound to use ever larger quantities of fertilizers to augment the food supply, which consequently increases food production costs. Urea, when applied to crops is vulnerable to losses from volatilization and leaching. Current methods also reduce nitrogen use efficiency (NUE) by plants which limit crop yields and, moreover, contributes towards environmental pollution in terms of hazardous gaseous emissions and water eutrophication. An approach that offsets this pollution whilealso enhancing NUeis the use of controlled releaseurea (CRU) for which several methods and materials haveben reported. The physical intromission of urea granules in an appropriatecoating material is onesuch techniquethat produces controlled releasecoated urea (CRCU) El-Naggar, *et al.*, (2002).

The development of CRCU is a green technology that not only reduces nitrogen loss caused by volatilization and leaching, but also alters the kinetics of nitrogen release, which, in turn, provides nutrients to plants at a pace that is more compatible with their metabolic needs (El-Ghamry et al., (2010).

It is well established that the use of fertilizers is necessary for crop yield, but it can cause environmental problems such as increase of nitrate concentration in the groundwater, contribution to the formation of acid rain, ozone layer depletion due to release of nitrous oxides by de-nitrification, etc. By reducing these N losses in the field, it is possible to reduce rate of application and avoid N-pollution of the environment (Patra *et al.*, 2002).

Urea is the most widely used fertilizer globally because of its high nitrogen content (46%), low cost, and ease of application. Therefore, the development of CRCU has been a subject of interest for decades. When applied to the soil, urea undergoes a series of biological, chemical and physical transformations to produce plant available nutrients as follows.

$(NH_2)_2CO_3 + 2H_2O$ ((Urease))$\rightarrow (NH_4)_2CO_3 + 2H^+ \rightarrow 2NH^+_4 + CO_2 + H_2O$

$2NH_4^+ + 3O_2$ ((Nitrosomonas/nitrosococus bacteria)) $\rightarrow 2NO_2^- + 2H_2O + 4H^+$ +Energy

$2NO_2^- + O_2$ ((Nitrobacter bacterium/nitrification)) $\rightarrow 2NO_3^-$ + Energy

NO_3^- ((Microorganisms/O2deficient soil)) $\rightarrow N_2 + N_2O$

NH_4^+ ((Urease enzyme/Basic soil pH))$\rightarrow NH_3(g) + H^+$

Fertilizer urea, when applied to soil, is hydrolysed by urease to $NH4^+$ which is then oxidized to $NO3^-$ which can be leached or denitrified. To ensure a continuous and optimal supply of N, and to decrease losses, chemicals that retard either urea hydrolysis, or nitrification or both have been extensively tested. In this context, slow-release urea forms such as sulfur-coated urea, polymer-coated urea, and urea super granules have been extensively investigated (Prasad *et al.,* 1971; Prasad 1998); urease inhibitors retarding urea hydrolysis have been also studied (Gould et al., 1986). In order to improve nitrogen use efficiency of crops, several synthetic chemicals such as N-serve (nitrapyrin), DCD (dicynadiamide), CS2 (carbon disulphide), sodium chlorate, BHC (benzene hexachloride) etc. have been examined for inhibition of urea hydrolysis or nitrification or both in soils (Zaman *et al.,* 2008). However, the use of many of these chemicals has been restricted to academic experimental studies because of high cost, lack of availability, and adverse effects on soil microflora (Purakayastha 1997).

Controlled release fertilizer (CRF) is a purposely designed manure that releases active fertilizing nutrients in a controlled, delayed manner in synchrony with the sequential needs of plants for nutrients, thus, they provide enhanced nutrient use efficiency along with enhanced yields . An ideal controlled releases fertilizer is coated with a natural or semi-natural, environmentally friendly macromolecule material that retards fertilizer release to such a slow pace that a single application to the soil can meet nutrient requirements for model crop growth. The terms, controlled release fertilizer (CRF), and slow release fertilizer (SRF), are generally considered analogous.

So, the aim of this investigation was to study the effects of five controlled release N fertilizers urea formaldehyde, cement coated urea , sulphur coated urea, cement& inhibitors coated urea and sulphur & inhibitors coated urea compared to fast release (urea) on growth, nutritional status of maize plants grown on an alluvial .

MATERIALS AND METHODS

To achie ve the goal of this study, a field expe rime nt was carried out at the gre n house of Soils Dept. Faculty of Agriculture, Mansoura University,during the season of 2015 to investigate the use efficiency of different levels of some modern slow –re lease nitrogen fe rtilizers on maize *(Zea mays L. Var. S. C.10)* plants grown in a alluvial soil and nutrients uptake. The different effects of some modern slow –release nitrogen fertilize rs on growth and yie ld of maize plants were inve stigated by combining five urea type s and tow adding rate s (recommende d and 1.5 recommended) by soil application under a complete randomize design, with three replicates for each treatment. The expe rimental plots were pre pare d with dimensions $3.0{\times}4.0m^2$ .The urea type s were: (UF) urea formaldehyde, (UFS) sulfur coated urea, (UFS_{IN}) sulfur& inhibitors coated ure a, (U Cement) cement coated urea and (U $Cement_{IN}$) cement&inhibitors coated urea. Three maize seeds we re sown; planting date was the 15th of Jun 2015.

Super phosphate (7 % P_2o_5) was added at 3 days be fore planting, it was applied at a rate of 200 kg fe d^{-1} and all the agricultural operations we re performed according to the usual local agriculture management.

Nitrogen fe rtilization was applied in two equal doses at 30 and 45 (DAS) using urea fertilizer (46%N) at the rate of 120 kg N Fe $d^{-1}$for maize planted.

The recommended of UF (38.3 %N), UFS (41%N), UFS_{IN} (41%N), U cement (37.2%N) and U Ceme nt $_{IN}$ (36.3%N) Was 313.3, 292.6, 292.6, 322.5 and 330.5 kg fed^{-1}, respe ctive ly.

Potassium sulphate (50 % K_2O) was applied at a rate of 50 kg fed^{-1} at 60 days from planting in both soils.

Irrigation was carried out every 7 days to reach the soil moisture to field capacity by weight .

Plants were harvested after 120 (DAS), after harvesting, shoot samples were cleaned, weighed for fresh weight dried at $70^{\circ}C$ until the constant weight, weighed for dry weight, ground and saved for chemical analysis.

Particle size distribution of the soil was carrie d out using the pipe tte method (Dewis and Fertias, 1970). Soil field capacity was determined by the method de scribed by Richards, (1954). Soil re action (pH), and soil e le ctrical conductivity (EC) was de termined in the saturate d soil paste, and the saturated soil paste extract, respectively, according to Richards, (1954). Total carbonate was e stimated gasometrically using Collin's Calcimeter and calculate d as calcium carbonate according to Dewis and Fertias, (1970). The amounts of soluble ions meq L^{-1} in the soil were determined in saturation extract by method according to (Hesse, 1971). Available soil B was de te rmined by hot water e xtract method as described by Dewis and Freitas, (1970). To determine the concentrations of nutrients in plant tissues, 0.2 g from each sample (shoot or root) was digested using 5 cm^3 from the mixture of sulphuric (H_2SO_4) and perchloric ($HClO_4$) acids (1:1) as described by Peterburgski,(1968). Nitrogen was de te rmined by micro-Kjeldahl me thod as explained by Hesse,(1971). Phosphorus was determined colorimetrically at wavelength 680 nm using Spekol spectrophotometer as de scribe d by Jackson,(1967). Potassium was de te rmined by using Gallen Kamp flame photometer as me ntioned by Jackson,(1967).

Table 1 some Soil physical and chemical characteristics of the experimental soil .

Soil characteristics			Alluvial soil
Sand (%)		C	1.7
		F	19.8
Silt (%)			28.4
Clay (%)			50.1
Soil texture			Clay
Field capacity (%)			35
Saturation (%)			70
Calcium carbonate (%)			3.55
OM(%)			1.10
pH*			7.80
EC** (dSm-1)			1.50
Soluble ions**	Soluble cations (meq L^{-1})	Ca^{++}	2.5
		Mg^{++}	1.0
		Na^{+}	3.4
		K^{+}	1.0
	Soluble anions (meq L^{-1})	CO_3^{--}	NS
		HCO_3^{-}	0.7
		Cl^{-}	3.7
		SO_4^{--}	3.5
Available nutrient (mg Kg^{-1}		N	80.3
		p	15
		K	220

***Soil pH was determined in soil paste.**
****Soil Electrical Conductivity (EC) and soluble ions were determined in soil paste extract.**

RESULTS AND DISCUSSION

1-Shoots and flag leaf of maize as affected by different types of coated urea.

Data illustrated in Table 2 show the effect of different types of coated urea on the values of fresh and dry weight (g) of maize shoots and flag leaf grown on alluvial soil.

Data in Table 2 show that the application of nitrogen significantly increased the dry matter production in maize at all the growth stages and at maturity. The best values of shoot fresh & dry weight and flag leaf fresh & dry weight were at $U.S_{IN}$ (sulfur&inhibitor coated urea) treatment with using1.5 recommended**.** It were 342.70, 240.70, 48.40 and 44.50, respectively, While the less values were at control treatment .it were256.80, 152.46, 30.56 and 28.28, respectively.

Under recommended rate, the shoot fresh weight of maize grown on alluvial soil was increased from 256.8 at control treatment (without application) to

308.76, 330.26, 336.703.16.43 and 322.36 at (UF), (UFS), (UFS_{IN}), (U Cement) and (U Cement $_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS_{IN}), is (31%).Also, the shoot dry weight of maize grown on alluvial soil was increased from 152.46 at control treatment (without application) to 201.80, 227.80, 234.60, 213.86 and 220.26 at (UF), (UFS), (UFS_{IN}), (U Cement) and (U Cement $_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS_{IN}), is (53.87%).

Table 2: Shoots yield (g) of maize as affected by application of different doses (1 and 1.5 and Recommended) of some modern slow –release nitrogen fertilizers

Char .	Shoots yield		flag leaf	
Type of urea	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
Recommended				
Control (without application)	256.8 i	152.46 k	30.56 i	28.28 h
U.F (urea formaldehyde)	308.76 h	201.80 j	34.13 h	32.00 g
U.FS (sulphur-coated urea)	330.26 e	227.80 g	40.20 e	38.16 d
UFSIN (sulphur&inhibitor coated urea)	336.70 c	234.60 e	42.23 d	38.43 d
U.Cem (Cement - coated urea)	316.43 g	213.86 i	36.10 g	34.33 f
U.Cem $_{IN}$ (Cement & inhibitor coated urea)	322.36 f	220.26 h	38.30 f	36.03 e
1.5 Recommended				
U.F (urea formaldehyde)	333.96 d	230.50 f	40.36 e	36.43 e
U.FS (sulphur-coated urea)	338.9 b	238.96 b	46.33 b	42.33 b
UFSIN (sulphur&inhibitor coated urea)	342.70 a	240.70 a	48.4 a	44.50 a
U.Cem (Cement - coated urea)	335.60 c	235.90 d	42.50 d	38.20 d
$U.S_{IN}$ (sulphur&inhibitor coated urea)	338.60 b	237.50 c	44.23 c	40.30 c
L.S.D $_{(5\%)}$	1.43	1.28	0.73	0.50

Under 1.5 recommended rates, the shoot fresh weight of maize grown on alluvial soil was increased from 256.8 at control treatment (without application) to 333.96, 338.90, 342.70, 335.60 and 338.60 at (UF), (UFS), (UFS_{IN}), (U Cement) and (U Cement $_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS_{IN}), is (33.45%). Also, the shoot dry weight of maize grown on alluvial soil was increased from 152.46 at control treatment (without application) to 230.50, 238.96, 240.70, 235.90 and 237.50 at (UF), (UFS), (UFS_{IN}), (U Cement) and (U Cement $_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS_{IN}), is (57.87%). Thus the data indicate That 1.5 recommended rate gave the best results than 1.5 recommended rate. This trend was the same for fresh and dry weight of flag leaf.

Generally, the improving effects of slow release N fertilizer UF, UCem, $UCem_{IN}$ UFS and UFS_{IN} on vegetative growth of might be attributed to their effect on regulating the release of N according to the plants needed. Also they gave the highest values of residual N in soil due to their low activity index, compared fast release (urea) which gave the lowest values of available N left in the soil (Mikkelsen et al. 1994). In addition, the role of nitrogen in plants,which increase growth and development of all living tissue, also N considered to be an important constituent of chlorophyll, protoplasm, protein and nucleic acid, so that it resulted in an increase in cell number and cell size with an increase (Said, 1998 and El- Naggar *et al*. 2002). The obtained results are in agreement with those obtained by Zaman *et al.*,(2008).

2- Plant height (cm), ear weights (g), 100-seed weight (g), Protein of grain (%) and grain yield (g) of maize as affected by different types of coated urea.

It is clear from Table 3 that the application of the slow release N fertilizers, urea formaldehyde (UF), sulfur coated urea (UFS), sulfur& inhibitors coated urea (UFS_{IN}). cement coated urea (U Cement) and cement& inhibitors coated urea (U Cement $_{IN}$) were have high positive effective and significantly improved, plant height (cm), ear weights (g), 100-seed weight (g), protein of grain (%) and grain yield (g) of maize grown on alluvial soil compared to application of fast release N fertilizer (Urea) .

Data in Table 3 indicate that the best values of plant height (cm), ear weights (g), 100-seed weight (g), Protein of grain (%) and grain yield (g) of maize were at U.SIN (sulfur&inhibitor coated urea) treatment with using1.5 recommended. It were 198.36, 184.50, 45.80, 10.50 and 428.50, respectively, While the less values were at control treatment .it were131.0, 100.8, 28.73, 6.36 and 300.2, respectively.

Under recommended rate, the plant height (cm) of maize grown on alluvial soil was increased from 131.00 at control treatment (without application) to 170.00, 186.03, 190.43, 175.60 and 180.86 at (UF), (UFS), (UFS_{IN}), (U Cement) and (U Cement $_{in}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS_{IN}), is (38%). Also, the grain yield (g/line) of maize grown on alluvial soil was increased from 300.20 at control treatment (without application) to 354.96, 401.26, 422.5, 366.96 and 386.46 at (UF), (UFS), (UFS_{IN}), (U Cement) and (U Cement $_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS_{IN}) is (28.73%).

Table 3 : Plant height (cm),ear weights (g), 100-seed weight (g), protein of grain (%) and grain yield (g)of maize as affected by application of different doses (1 and 1.5 and recommended) of some modern slow –release nitrogen fertilizers

Char. / Type of urea	Plant growth parameters: Plant height (cm)	Ear weights (g)	100-seed weight (g)	Protein of grain (%)	Grain yield (g/line)
Recommended					
Control (without application)	131.00 j	100.8 i	28.73 j	6.36 g	300.20 i
U.F (urea formaldehyde)	170.16 i	160.43 h	34.36 i	7.90 f	354.96 h
U.FS (sulphur-coated urea)	186.03 e	178.26 e	41.53 e	9.86 b	401.26 e
UFSIN (sulphur&inhibitor coated urea)	190.43 c	183.76 ab	43.90 bc	10.28 a	422.5 c
U.Cem (Cement - coated urea)	175.60 h	168.63 g	36.05 h	8.46 e	366.96 f
U.Cem $_{IN}$ (Cement&inhibitor coated urea)	180.86 g	172.43 f	38.66 g	9.30 cd	386.46 f
1.5 Recommended					
U.F (urea formaldehyde)	184.13 f	180.76 d	40.76 f	9.00 d	418.9 d
U.FS (sulphur-coated urea)	194.48 b	182.9 bc	44.46 b	9.96 b	425.06 b
UFSIN (sulphur&inhibitor coated urea)	198.36 a	184.5 a	45.80 a	10.50 a	428.5 a
U.Cem (Cement - coated urea)	188.50 d	181.2 d	42.20 d	9.10 cd	420.4 d
U.Cem $_{IN}$ (Cement &inhibitor coated urea	190.06 c	182.2 c	43.50 c	9.40 c	422.5 c
L.S.D $_{(5\%)}$	1.013	0.94	0.59	0.24	1.53

Under 1.5 recommended rate, the plant height (cm) of maize grown on alluvial soil was increased from 131.00 at control treatment (without application) to 184.13, 194.48, 198.36, 188.50 and 190.06 at (UF), (UFS), (UFS$_{IN}$), (U Cement) and (U Cement$_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS$_{IN}$), is (51.41%). Also, the grain yield (g/line) of maize grown on alluvial soil was increased from 300.20 at control treatment (without application) to 418.9, 425.06, 428.5, 420.4 and 422.5 at (UF), (UFS), (UFS$_{IN}$), (U Cement) and (U Cement $_{IN}$) treatments, respectively. Where the increasing rate from control at the best treatment (UFS$_{IN}$) is (42.73%). This trend was found for ear weights (g), 100-seed weight (g), protein of grain (%).

Application of UFS$_{IN}$ was a considerable effect on increasing growth parameters, while, (UF), (UFS), (U Cement) and (U Cement$_{IN}$) recorded the intermediate values., In addition, the substantially improved the vegetative growth trails due to sulpher – coated urea may be attributed to acidification resulted from S oxidation that decreasing soil pH that enhanced the solubility of nutrients and increases the activity of micro-organisms. These effects increase the nutrients availability uptake and translocation and increase the vegetative growth (Yousry et al 1984). Similar results were investigated by El- Naggar *et al*., (2002) and Jibiao *et al*., (2016).

3- : Nitrogen, phosphorus and potassium percentages in shoot and flag leaf of maize as affected by different types of coated urea.

Data in Table 4 show the values of N, P and K percentages in shoot and flag leaf of maize as affected by application of different doses (1 and 1.5 and Recommended) of some modern slow –release nitrogen fertilizers.

Data in Table 3 show that the best values of N percentages in shoot and flag leaf of maize were at U.S$_{IN}$ (sulfur& inhibitor coated urea) treatment with using 1.5 recommended. It were 4.86 and 4.36, respectively. While the less values were at control treatment .it were1.6 and 1.23, respectively.

Data of the same Table reveal that the best values of P and K percentages in shoot and flag leaf of maize were at U.SIN (sulfur-coated urea inhibitor) treatment with using1.5 recommended. It were 0.50, 3.56, 0.28 and 3.68, respectively. While the less values were at control treatment .it were 0.38, 2.20, 0.20 and 2.41. respectively

Table 4: N, P and K percentages in shoot and flag leaf of maize as affected by application of different doses (1 and 1.5 and Recommended) of some modern slow –release nitrogen fertilizers.

Element percent.	Shoot			Flag leaf		
Type of urea	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Recommended						
Control (without application)	1.60 i	0.38 cd	2.20 c	1.23 h	0.20 a	2.41 d
U.F (urea formaldehyde)	3.16 h	0.36 d	3.23 b	3.03 g	0.21 a	3.10 c
U.FS (sulphur-coated urea)	4.03 e	0.5 ab	3.40 ab	3.70 de	0.27 a	3.46 b
UFSIN (sulphur&inhibitor coated urea)	4.20 d	0.53 a	3.55 a	3.90 cd	0.28 a	3.70 a
U.Cem (Cement - coated urea)	3.58 g	0.40 bcd	3.45 ab	3.28 f	0.21 a	3.16 c
U.Cem $_{IN}$ (Cement& inhibitor coated urea)	3.86 f	0.43 abcd	3.41 ab	3.61 e	0.23 a	3.40 b
1.5 Recommended						
U.F (urea formaldehyde)	4.00 e	0.41 bcd	3.46 ab	3.43 f	0.21 a	3.45 b
U.FS (sulphur-coated urea)	4.63 b	0.48 abc	3.45 ab	4.15 b	0.25 a	3.58 ab
UFSIN (sulphur&inhibitor coated urea)	4.86 a	0.50 ab	3.56 a	4.36 a	0.28 a	3.68 a
U.Cem (Cement - coated urea)	4.30 d	0.38 cd	3.36 ab	4.06 bc	0.21 a	3.55 ab
U.Cem $_{IN}$ (Cement& inhibitor coated urea)	4.50 c	0.40 bcd	3.46 ab	3.80 de	0.23 a	3.58 ab
L.S.D $_{(5\%)}$	0.1	0.07	0.15	0.16	0.05	0.12

Results indicated that increasing the dose of (UF), (UFS), (UFS_{IN}). (U Cement) and (U Cement $_{IN}$) from recommended to 1.5 recommended were followed by a gradual increase in leaf N, P and K percentage. Similar results were obtained by Wassel *et al.,* (2000).

CONCLUSION

Based on the obtained results of this study it could be concluded that slow –release nitrogen fertilizers decreased losses of added nitrogen, especially in soils that have high pH. Therefore, it is recommended to use sulfur coated urea inhibitors (UFS_{IN}).

Increase the absorption of nutrients from the soil, due to the presence of sulfur which reduces soil acidity.

Reduce environmental pollution because these fertilizers working to decreased losses of added nitrogen.

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تأثير بعض الأسمده النيترووجينيه بطيئه الزوبان (اليوريا المغلفه) علي كل من النمو ومحصول الأذره وكذلك تثبيت النيتروجين

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علي الرغم من الدور الحيوي الذي يلعبه التسميد النيتروجيني في تحسين محصول الحبوب للذره الا انه يكون معرض دائما للفقد بالتطاير خصوصا في أراضينا المصريه القلويه . ومن ثم أقيمت تجربه حقليه بالمزرعه الخاصه بكليه الزراعه –جامعه المنصوره في الموسم الصيفي 2015 بهدف تقييم استخدام(الجرعه الموصي بها وكذلك 1.5 من هده الجرعه) من 5 انواع مختلفه من الاسمده النيتروجينيه بطيئه الزوبان وهي (يوريافورمالدهيد)و(يوريا مغلفه بالكبريت)و(يوريا مغلفه بالكبريت+مثبطات)و(يوريا مغلفه بالاسمنت)و (يويا مغلفه بالاسمنت + مثبطات) ومدي تأثيرها علي محصول الذره . ولقد اوضحت النتائج ان افضل قيم لكل من الوزن الجاف والطازج للمجموع الخضري وكذلك طول النبات ووزن الكوز ووزن 100 حبه و% للبروتين ومحصول الذره كانت عند المعامله (اليوريا المغلفه بالكبريت +المثبطات). ايضا تم تقدير المحتوي المعدني للمجموع الخضري وكدلك ورقه العلم تحت المعاملات المختلفه. وقد استنتج ان افضل المعاملات علي الاطلاق عند استخدام سماد اليوريا المغلفه بالكبريت حيث انها تقلل من فقد النيتروجين خاصه من التربه مما يقلل من التلوث البيئي كذلك فهذه المعامله تزيد من امتصاص النبات من خلال اعطاء النبات احتياجه من العنصر المغذي طوال فتره الزراعه كما انها تزيد من جوده المحصول وانتاجيته .