INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
10–210/HNB/2010/12–5–773–776
http://www.fspublishers.org

Full Length Article

Maize Response to Biodegradable Polymer and Urease Inhibitor Coated Urea

NASIMA JUNEJO[1], M.Y. KHANIF, M.M. HANFI† MD Z.W.Y. WAN‡ AND K.A. DHAREJO
Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Selangor, Malaysia
†*Institute of Tropical Agriculture, Universiti Putra Malaysia, Serdang, Selangor, Malaysia*
‡*Department of Chemistry, Faculty of Science, Universiti Putra Malaysia, Serdang, Selangor, Malaysia*
[1]Corresponding author's e-mail: neelum85@hotmail.com

ABSTRACT

One possible approach to improve the nitrogen losses from the surface applied urea is to coat it with biodegradable materials and urease inhibitors. The pot experiment was carried out to compare the effects of newly developed urea on plant yield and nutrient uptake. Their relative residual effects were also investigated on plant and soil by repeating the same experiment without urea application. The treatments were prepared by using fluidized bed coating machine as urea alone, palm stearin +Cu coated urea, agar + Cu coated urea, gelatin +cu coated urea, Cu coated Urea, micronutrient coated urea. The treatments were added at a dose of 100 kg ha^{-1} by surface application on the pots filled by Munchong soil series. The soil was analyzed for physical and chemical properties and plant samples were analyzed for yield, nutrient uptake and total N. The outcome of the first pot experiment indicated that the application of coated urea increased dry matter yield from 60 to 20% pot^{-1} and enhanced N uptake up to77% as compare to urea alone. The results of the second experiment indicated improvement in N uptake (80%) of the plant, when it treated by coated urea. The investigation proved that the natural biodegradable polymer and Cu coated urea can reduce N loss; enhance the nutrient uptake and improve the plant production.

Key Words: Cu; Urea; Maize; Natural polymer

INTRODUCTION

Poor nutrient utilization and nitrogen (N) losses from urea applications have been reported for many years (Khalil *et al.*, 2009). The N losses from applied urea were estimated 30 to 60% in tropical soil (Freney *et al.*, 1981). The main reason of these losses is the immediate increase in pH and NH_4 concentration around the fertilizer micro site due to the activity of enzyme urease (Ahmed *et al.*, 2008; Mohsina *et al.*, 2004).

When urea is applied to the soil, the soil pH and urea concentration increases immediately on the fertilizer micro site and urease enzymes start their activity to hydrolyse the applied urea (Krajewska, 2009). The rapid hydrolyses process of urea caused N losses and accumulation of NH_4, which can be resulted in seedling damage and restricted germination (Watson, 2000). Various approaches have been adopted to inhibit the urease activity and to delay the hydrolysis process of urea. The coating of urea with biodegradable material and use of urease inhibitors are two possible remedies to reduce N loss and enhance urea efficiency (Shaviv, 2001).

Urease inhibitors are compounds, which are used to inhibit the urease enzyme activity in soil and slow down the hydrolysis process of urea in soil (Bolan *et al.*, 2004). The investigations on various urease inhibitors and polymer coatings have been done to improve urea efficiency. A number of chemical compounds were tested as urease inhibitors but their toxic effects were poorly documented (Krogmeier *et al.*, 1989; Bremner, 1995; Watson, 2000). The uses of these chemical compounds and synthetic coating materials have not practical applications due to high cost, lack of availability and phototoxic effects (Purkayastha, 2009). The use of environmental friendly biodegradable polymer coating and micronutrient as urease inhibitors can be beneficial as two in one. They can provisionally retard the urease activity in soil and have effect as essential nutrient on plant and soil.

It is reported by Bremner (1975) that some micronutrient can work as competent urease inhibitors. On the other hand, 50% of agriculture land of world is deficient in micronutrients and there is need to provide sufficient fertilization of micronutrient. The acidity of soils in tropical regions influences on the availability of micronutrient due to high liming rate and iron content, which make these nutrient insoluble in soil solution (Gupta, 2008). Cu and Zn considered as limiting nutrients in tropical soil (Shamsuddin *et al.*, 1979). Cu and zinc were found deficient in acidic

To cite this paper: Junejo, N., M.Y. Khanif, M.M. Hanfi M.Z.W.Y. Wan and K.A. Dharejo, 2010. Maize response to biodegradable polymer and urease inhibitor coated urea. *Int. J. Agric. Biol.*, 12: 773–776

clayey soils due to accumulation in root zone. The movement of Zn and Cu was observed downward in acidic sandy soils with low organic matter. The availability of both micronutrients is very low to plant (John, 1983). In addition, the interaction studied of Nitrogen and Cu proved that addition of these nutrients together increase the nutrient uptake and nutritional quality of plant used as food (Rongli *et al.*, 2010). The various forms of Cu have been considered as urease inhibitor. The urea amended with $CuSO_4$ can reduce NH_3 losses from 24 to 30% in cultivated soil and increased nutrient uptake of plant (Khanif, 1986; Reddy & Sharma, 2000; Leong, 2002). This technique can be extended to other micronutrients such as Zn, B or a combination of relevant micronutrients.

There is no comprehensive research was conducted and published on this aspect of Cu. In addition the use of Agar, gelatins and palm stearin as coating of urea was not considered previously. Even though, the applications of these materials as coating of medicine and vitamins (especially gelatin) are well known. These materials are easily available, biodegradable and low in cost. The use of these natural materials as the adhesive agent keeps together nitrogen and added micronutrient on the micro site. Therefore, the urease inhibitory effects and acidifying properties of $CuSO_4$ will control the increase in pH and urea concentration on the applied soil surface. The addition of Zn will improve the nutrient deficiency and the growth of plant as micronutrient.

These coatings have been tested previously in laboratory studies for reduction in ammonia volatilization loss. The outcomes indicated that use of Cu coated urea can reduce 50% of the ammonia volatilization losses from sandy loam acidic soils (Junejo, 2009a). This study was carried out to determine the effects of these coatings on dry matter yield and nutrient uptake of maize plant.

MATERIALS AND METHODS

The experiment was conducted at the glass house, Universiti Putra Malaysia. Pots were filled with 20 kg of air dry Munchong soil series (Typic Hapludox). The size of pot was 50×50 cm and arranged in a randomized complete block design with four replications. The soil was characterized for physical and chemical properties after sampling (Table I). The coated urea treatments were prepared according to the method has been described by Junejo (2009b). Six treatments *viz.*, uncoated urea, Palm stearin+Cu coated urea, Agar+Cu coated urea, gelatin+Cu coated urea, Cu coated urea and micronutrient coated urea were used in the experiment (Table II).

The fertilizers were applied 100 kg N ha^{-1}, 50 kg P ha^{-1} and 100 kg K ha^{-1}, 24 h before sowing, according to the recommended dose for maize in Malaysia. Six treatments of coated and uncoated urea, Triple super phosphate (TSP) and KCl were used as sources of N, P and K, respectively. Three seeds of J-58 maize variety were planted per pot. First planting was harvested after 8 weeks to determine dry matter yield and nutrient concentration in plant. The plant samples were separated into stem and leaves and analyzed for total N (Bremner & Mulvaney, 1982) and Cu, Mn and Zn concentration was calculated by multiplying total content of nutrients with total dry-matter weight, as suggested by Panda *et al*. (1995). The soil samples were analyzed for micronutrients content (Cu, Zn & Mn) by double acid method and plant samples by dry ash method (Benton, 2001). The nutrient content in extracts was measured at atomic absorption spectrophotometer (AAS).

Table I: Properties of soil used in the experiments

Soil	Typic Hapludox
pH	4.3
Texture (%)	clayey
Sand %	20
Silt%	10
Clay %	70
Organic C %	2.5
Total N %	0.2
Cu mg kg^{-1}	0.005
K $cmol^+ kg^{-1}$	0.06
Ca $cmol^+ kg^{-1}$	0.0
Mg $cmol^+ kg^{-1}$	0.2
Urease activity (NH_4 - N ug kg^{-1})	18

Table II: Fertilizer treatments used for experiment

Polymer coated treatment	Rate of fertilizer g/pot	Treatments labels	N %
Urea	2.80	T1	46
Palm stearin + Cu	3.00	T2	42
Ag (0.3g) +Cu (5ug/100 g urea)	3.00	T3	42
Gelatin (0.3g) + Cu (5ug/100 g urea)	3.00	T4	42
Urea + Cu	3.00	T5	42
Micronutrient coated urea	3.00	T6	42

The experiment was repeated without N fertilizer application to examine the residual effects of coated and uncoated urea treatments. Plant samples were analyzed as described above. The N loss of soil was calculated as:

N-loss (%) = 100– (Np % +Ns %).

Analysis of variance (ANOVA) was conducted to test the treatment effects, followed by Tukey's test, comparing the treatment means using Statistical Analysis System, version 9.1 (SAS Institute Inc. 2006).

RESULTS AND DISCUSSION

Soil analysis: The soil was clayey in texture and low in organic matter, Cu, Zn and N (Tisdale *et al*., 1993). The soil pH was 4.3, indicating medium acidity of soil (Table I).

Dry matter yield and N uptake (first planting): Application of coated urea treatments increased maize yield and nutrient uptake of plant as compared to urea alone (Table III). Among all the treatments, the highest dry matter yield (29.25 g pot^{-1}) was obtained from gelatin+Cu coated urea and (26.50 g pot^{-1}) micronutrient coated urea treated pots, closely followed by (25.5 g pot^{-1}) Palm stearin+Cu

Table III: Effect of coated urea on dry matter yield, nutrient content and nutrient-uptake of maize plant

Treatments	TDMY (g pot^{-1})	Total N (%)	Cu content (mg kg^{-1})	Zn content (mg kg^{-1})	N uptake (mg pot^{-1})	Cu uptake (mg pot^{-1})	Zn content (mg pot^{-1})
Uncoated urea	18.00c	1.50b	0.5b	0.3b	270d	9.00e	5.4d
Palm stearin+Cu coated urea	25.50b	1.96b	0.8a	0.4b	500b	20.4c	10.2c
Agar + Cu coated urea	26.00b	1.89b	0.6b	0.4b	491c	15.6d	10.4c
Gelatin + Cu coated urea	29.25a	2.31a	0.9a	0.5a	676a	26.3b	14.6b
Cu coated urea	20.75c	2.52a	0.8a	0.5a	523b	16.6d	10.3c
Micronutrient coated urea	26.50b	2.65a	1.1a	0.6a	702a	30.3a	16.5a

Table IV: Residual effect of urea treatments on dry matter yield, nutrient content and nutrient uptake of maize plant

Treatments	TDMY (g pot^{-1})	Total N (%)	Cu content (mg kg^{-1})	Zn content (mg kg^{-1})	N uptake (mg pot^{-1})	Cu uptake (mg pot^{-1})	Zn content (mg pot^{-1})
Uncoated urea	12.50d	1.25c	0.2c	0.02c	156d	2.50d	0.25d
Palm stearin+Cu coated urea	20.15c	1.84b	0.8b	0.4a	371c	16.0c	8.00b
Agar + Cu coated urea	26.50a	1.75b	0.7b	0.2b	464b	18.5c	5.30c
Gelatin + Cu coated urea	22.00b	1.76b	0.8b	0.3a	387c	17.6c	6.60bc
Cu coated urea	22.00b	1.62b	1.2a	0.3a	356c	26.4b	6.60bc
Micronutrient coated urea	23.00b	2.20a	1.5a	0.5a	506a	34.5a	11.50a

Table V: Total dry matter yield (g/pot) and micronutrient contents (mg kg^{-1}) and uptake (mg pot^{-1}) by plants

Treatment	TDMY (leaves + stem)	Contents		Uptake	
		Cu	Zn	Cu	Zn
			First harvest		
Uncoated urea	18.00	0.5	0.3	9.0e	5.4d
Palm stearin+Cu coated urea	25.5	0.8	0.4	20.4c	10.2c
Agar + Cu coated urea	26.00	0.6	0.4	15.6d	10.4c
gelatin + Cu coated urea	29.25	0.9	0.5	26.3b	14.6b
Cu coated urea	20.75	0.8	0.5	16.6d	10.3c
micronutrient coated urea	27.50	1.1	0.6	30.3a	16.5a
			Second harvest		
Uncoated urea	12.5	0.2c	0.02c	2.50d	0.25d
Palm stearin+Cu coated urea	20.0	0.8b	0.4a	16.0c	8.00b
Agar + Cu coated urea	26.5	0.7b	0.2b	18.5c	5.30c
gelatin + Cu coated urea	22.0	0.8b	0.3a	17.6c	6.60bc
Cu coated urea	22.0	1.2a	0.3a	26.4b	6.60bc
micronutrient coated urea	23.0	1.5a	0.5a	34.5a	11.5a

Means with different letters are significantly different (significant at P=0.05)

coated urea, (26 g pot^{-1}), Agar+Cu coated urea and (20.75 g pot^{-1}) Cu coated urea. The uncoated urea produced the least dry matter yield (19 g pot^{-1}) at the same level of N application. The dry matter yield of maize planted under coated urea, Palm stearin+Cu coated urea, Agar+Cu coated urea, gelatin+Cu coated urea, Cu coated urea and micronutrient coated urea increased by 40, 15, 45, 8 and 45%, respectively compared to uncoated urea (Table III). The highest dry matter yield obtained from coated urea treated soil may be attributed to the increased N availability due to reduced ammonia loss as reported earlier (Junejo *et al.*, 2009b). Total N uptake in plants was obtained highest to lowest: micronutrient coated urea > gelatin+Cu coated urea > Palm stearin+Cu coated urea > Cu coated urea > Agar+Cu coated urea > uncoated urea, which which were 762, 676, 523, 491, 324 mg pot^{-1}, respectively (Table III)

Dry matter yield and N uptake at second planting: The second experiment was conducted on the same soil with same parameters to determine the residual effect of coated and uncoated urea treatments without application of fertilizers. The highest dry matter yield was obtained from Agar+Cu coated urea (26.5 g pot^{-1}), followed by micronutrient coated urea (23 g pot^{-1}), Cu coated urea (22 g pot^{-1}), gelatin+Cu coated urea (22 g pot^{-1}), Palm stearin+Cu coated urea (20 g pot^{-1}) in descending order. Lowest dry matter yield was recorded 12.5 g pot^{-1} for uncoated urea (Table IV). The dry matter yield was slightly decreased as compare to first harvest due to absence of N fertilization except Agar+Cu coated urea, which indicated a slight increase in dry matter weight (26.5 g pot^{-1}).

Micronutrient uptake of plant: The concentration of Cu and Zn with their uptake by plant was significantly higher than uncoated urea (Table V). Cu and Zn concentrations in maize ranges from 0.5 to 1.1and 0.36 to 0.59 mg kg^{-1}, respectively and were below critical levels (Tisdale *et al.*, 1993). The response of maize plant towards Cu application indicates that Cu and Zn are limiting nutrient in the soil and their addition enhanced plant yield significantly (P<0.05).

In addition, The N content of plants was decreased in comparison to first harvest, because of limited % of N in soil, which was affected on dry matter yield and nutrient uptake of plant. In coated urea treatments the N-uptake ranged from 156 to 506 mg pot^{-1}. In addition, uncoated urea obtained the least N-uptake i.e., 156 mg pot^{-1} (Table IV).

Micronutrient uptake of plant: The second planting was done on the same soil with same parameters to determine the residual affect of coated and uncoated urea treatments without application of fertilizers. Nutrients (Cu & Zn) uptakes were found in coated urea than urea alone, due to the dilution effect as a result of increase in dry matter yield. The N uptake of plant obtained highest to lowest Cu coated urea > micronutrient coated urea > gelatin+Cu coated urea > Agar+Cu coated urea > Palm stearin+Cu coated urea > uncoated urea (Table V).

In this glass house study, we investigate the effect of natural material and Cu coated urea at 100 kg ha^{-1} rate of N on dry mater yield, N-uptake and residual effects on maize plant. The increase in nutrient uptake and dry matter yield was due to addition of micronutrient and coating, which was not only reduced N loss but left a positive impact on the physiological phenomenon of plant. The coated urea reduced 98% to 35% N loss as compare to uncoated urea. The results of the second experiment showed beneficial residual effects of coated urea on nutrient uptake of plant as compare to urea alone without further N application.

The dry matter yield remained same as first experiment and response of maize was not significantly influenced by the absence of N application. However, the plant yield of pots treated by urea alone decreased 35% in repeated pot experiment. These results suggested that N rate can be adjusted in a cropping system to take advantage of residual N in soil. Increase in dry matter yield and nutrient uptake by the application of coated urea treatments could be attributed both to its physiological effect on the plant and its inhibition to urea hydrolysis in soils and nitrogen loss.

CONCLUSION

The urea coated with biodegradeable polymer and micronutrient was significantly reduced ammonia loss and increased plant production.

Acknowledgement: The author is thankful to Asian Development Bank for financial support and University Putra Malaysia to provide me laboratory and glass house facility at campus to conduct this research.

REFERENCES

Ahmed, O.H., A. Hussain and H.M.H. Ahmad, 2008. Ammonia volatilization and ammonium accumulation from urea mixed with zeolite and triple super phosphate. *Acta Agric. Scandinavia*, 58: 182–186

Benton Jones, J.J., 2001. *Laboratory Guide for Conducting Soil Tests and Plant Analysis*. CRC Press LLC, New York

Bolan, N., S. Saggar and J. Singh, 2004. The role of inhibitors in mitigating nitrogen losses in grazed pasture. *New Zealand Soil News*, 52: 52–58

Bremner, J.M. and C.S. Mulvaney, 1982. Nitrogen Total. *In:* Page, A.L., R.H. Miller and D.R. Keeney (eds.), *Methods of Soils Analysis, Part 2*, 2nd edition, pp: 1149–1178. ASA and SSSA, Madison, Wisconsin

Bremner, J.M., 1995. Recent research on problems in the use of urea as a nitrogen fertilizer. *Fert. Res.*, 42: 321–329

Freney, J.R., J.R. Simpson and O.T. Denmead, 1981. Ammonia volatilization. *In:* Clark, F.E. and T. Roswell (eds.), *Terrestrial Nitrogen Cycles*: *Processes, Ecosystem Strategies and Management Impacts*, pp: 291–302

Gupta, U.C., W.U. Kening and L. Siyuan, 2008. Micronutrients in Soils, Crops and Livestock. *Earth Sci. Fron.*, 15: 110–125

Junejo, N., Y.M. Khanif and M.M. Hanafi, 2009a. Effect of Cu and palm stearin coating on ammonia volatilization of Urea. *Res. J. Agric. Biol. Sci.*, 5: 608–612

Junejo, N., S. Sagar and M.Y. Khanif, 2009b. Reducing NH_3 emission loss from urea fertilizer: urease inhibitors, polymer coatings and micronutrient. *New Zealand Soil News*, 57: 193–199

John, J.M., 1983. Impacts of acid deposition on micronutrient cycling in agro ecosystems. *Envoi. Environ. Bot.*, 23: 243–249

Khalil, I.M., R. Gutser and U. Schmidhalter, 2009. Effects of urease and nitrification inhibitors added to urea on nitrous oxide emission from a loess soil. *J. Plant Nutr. Soil Sci.*, 172: 651–660

Khanif, Y.M., 1986. *Effect of Calcium, Copper and Hydroquinone on Urea Volatilization Loss*, pp: 49–60. Workshop of Soil Science Department, Serdang, Malaysia

Krajewska, B., 2009 Urease I. Functional, catalytic and kinetic properties: *A review. J. Mol. Catal. B: Enzymatic*, 59: 9–21

Krogmeier, M.J., G.W. McCarty and J.M. Bremner, 1989. *Proc. Natl. Acad. Sci. USA*, 86: 1110–1112

Leong, T.K., 2002. The development of cooper-coated urea for rice production. *Master and Agric. Sci. Thesis*, UPM, Serdang, Malaysia

Mohsina, H., R. Khalil, A.S. Muneer and M.A. Shahzad, 2004. Effect of substrate concentrations, temperature and cropping system on hydrolysis of urea in soils. *Int. J. Agric. Biol*., 6: 964–966

Panda, M.M., A.R. Mosier, S.K. Mohanty, S.P. Chakravorti, A.B. Chalam and M.D. Reddy, 1995. Nitrogen utilization by lowland rice as affected by fertilization with urea and green manure. *Fert. Res.*, 40: 215–223

Purkayastha, T.J., 1997. Evaluation of some modified urea fertilizers applied to rice. *Fert. News*, 42: 53–56

Reddy, D. and K. Sharma, 2000. Effect of amending urea fertilizer with chemical additives on ammonia volatilization loss and nitrogen-use efficiency. *Biol. Fert. Soil*, 32*:* 24–27

Rongli, S., Y. Zhang, X. Cheng, Q. Sun, F. Zhang, V. Romheld and C. Zou, 2010. Influence of long-term nitrogen fertilization on micronutrient density in grain of winter wheat (*Tritium aestivum* L.). *J. Cer. Sci.*, 51: 165–170

SAS Institute Inc., 2006. *SAS/STAT Guide for Personal Computers, Version 9.1*. SAS Institute, Cary, North Carolina

Shaviv, A., 2001. Improvement of fertilizer efficiency Product processing, positioning and application methods. *Proc. Int. Fert. Soc.*, 469: 1–23

Tisdale, L.S., N.L. Werner and J.D. Beaten, 1993. *Soil Fertility and Fertilisers*. Prentice Hall, Upper Saddle River, New Jersey

Watson, C.J., 2000. Urease activity and inhibitions Principle and practice. *Int. Fert. Soc., Proceed. No*. 454

(Received 10 May 2010; Accepted 17 June 2010)