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EFFECT OF UREA WITH OR WITHOUT UREASE INHIBITOR (NBPT) AND HERBICIDE ON MAIZE YIELD

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ABSTRACT

Improving nitrogen (N) use-efficiency of applied urea is critical to maximise its uptake and decrease environmental impact. A field experiment was conducted to investigate the effect of urease inhibitor N- (n-butyl) thiophosphoric triamide (NBPT - "Agrotain") and herbicide on fertilizer use-efficiency and yield of maize. The application of both urea with herbicide and urea with urease inhibitor significantly increased grain yield and plant biomass compared with urea alone treatment. Agrotain treated urea with herbicide increased grain yield by 38% compared with urea alone treatment. Similarly, Agrotain treated urea with herbicide produced significantly higher plant biomass by 52% compared with urea alone or other treatments. These results suggested that both Agrotain and herbicide together performed better than urea alone, by increasing fertilizer use-efficiency through controlled urea hydrolysis and weeds competition. Treating urea with Agrotain and herbicide thus has the potential to increase N use-efficiency, grain and biomass yields.

Key words: Urea, urease inhibitor, maize, weeds, herbicide.

INTRODUCTION

Nitrogen is an essential nutrient for plant growth and development (Simpson, 1987) as it plays a key role in the synthesis of protein and chlorophyll, which are essential for plant development, yield, post-grazing re-growth and reproduction (Vickery, 1981). In response to high agricultural commodity prices, World N fertilizer demand is projected to grow steadily. From average N fertilizer consumption in 2004/05 and 2006/07 of 97.9 and 100.1 Mt, global demand in 2011/12 is predicted to increase to 107.5 Mt by 2011/12 the International Fertilizer Industry Association (IFIA, 2007).

Urea not only accounts for 50 % of the total world N-consumption (IFIA, 2007), but it is also the predominant form (80%)

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of the chemical fertilizer applied to both arable crops and pasture in New Zealand. Maize is the most commonly grown cereal crop in the world, ahead of wheat and rice production in developed countries, such as New Zealand, maize is used primarily as stock feed. In 2008, the livestock feed sector consumed 58% of maize grain production in which most enters the poultry and ruminant sectors (Statistics New Zealand, 2009). Food and industrial processors consumed the remaining 42% (Statistics New Zealand, 2009). In New Zealand, maize is grown in the Northern regions as well as in the Canterbury plains around mid October until early November. Maize receives about 100-200 kg N ha^{-1} which is applied in spilt applications mainly as urea at different growth stage to meet crop demand and increase productivity. Urea application has been associated with relatively poor N-use efficiency due to heavy N losses via ammonia (NH_3) emission, especially when applied under hot and dry soil conditions, high pH and high wind (Cabrera *et al*., 2001; Gioacchini *et al*., 2002; Khalil *et al*., 2002; Kissel *et al*., 2004; Ahmed *et al*., 2006; Pacholski. *et al*., 2006; Zaman *et al*., 2008; Rochette *et al*., 2009).

A number of options have been proposed to improve urea use-efficiency. These include physical (altering the rate, timing and method of application and producing large-granule urea) and chemical (coating urea with different materials and with chemicals) approaches. The application of urease inhibitors has been considered a promising way to reduce N losses and enhance urea N use efficiency. Several urease inhibitors have been identified and tested but N-(n-butyl) thiophosphoric triamide (NBPT - "Agrotain") has the potential to reduce N losses at low concentration and improved crop productivity (Watson *et al*., 2008; Zaman *et al*., 2008; Dawar *et al*., 2010; 2011).

Although maize is a vigorous and tall growing plant, it is susceptible to competition from weeds, with losses greater than 30% commonly reported (Rahman, 1985). Therefore, weed control is pre-requisite for higher yield and quality crops. The present study was planned to evaluate the effect of urea with or without urease inhibitor and herbicides application together to enhance fertilizer use-efficiency and yield of maize.

MATERIALS AND METHODS

A field experiment was conducted on irrigated (spray irrigation) arable site near Lincoln, Canterbury, New Zealand. The soil used was Paparua silt loam, Typic Haplustepts (Soil Survey Staff, 1998). About 20 plots each of 2 x 2 m with a buffer zone of 1 m were set up on 30 October 2010. Before the application of treatments, 4 composite soil samples (0–10 cm depth), each composite soil sample comprised of 10 randomly collected soil cores, were collected from the experimental site and passed through a 2 mm sieve to remove visible plant litter and roots. Sieved soil samples were analyzed (Hill laboratories Ltd, Hamilton, New Zealand) for key soil properties (Table-1). Each plot received phosphorus (P) at 90 kg ha^{-1}using single superphosphate (SSP) and potassium (K) at 60 kg ha^{-1} using potassium sulphate before sowing the maize crop.

Maize (cv. Pioneer 3527) was sown at rate of 100 kg ha^{-1} in rows (row to row distance of 60 cm and plant to plant distance 20 cm). The 5 treatments (urea only, urea + herbicide, urea with Agrotain, urea with Agrotain + herbicide) were applied at 120 kg N $ha^{-}1$ in three split doses to appropriate plots in a 4x5 randomized block design. Each treatment had four replicates. The control treatment received no N and no herbicide.

The 1st fertilizer application was broadcast at sowing time, 2nd 40 days after sowing and the 3rd after 70 days after sowing. Herbicide (Primextra-Gold) was applied three times @ 1 L ha^{-1} 4 days before each fertilizer application. The maize crop was harvested at maturity for assessment of grain yield and plant biomass. Analysis of variance (ANOVA) was carried out to determine if the different treatments had any significant effect on corn grain yield and plant biomass using Minitab (Version 12, Minitab Inc. USA). Least significant Differences (LSD) were calculated only when the treatment effect was significant at ($p \leq 0.05$).

RESULTS AND DISCUSSION

Biomass yield

Biomass yield of maize showed significant variations when urea was applied with herbicide and with urease inhibitor (Table-2). Urea + herbicide produced significantly ($p \leq 0.05$) greater biomass compared with urea alone treatment (Table-2). The maximum biomass was recorded in urea + Agrotain + herbicide treatment compared with other treatments (Table-2). These results showed that biomass yield obtained in urea with Agrotain and herbicide treated plots were significantly higher than that obtained without Agrotan and herbicide application. Other researchers also found an improvement in crop productivity after applying urea with Agrotain in different environmental conditions (Yang *et al*., 2007; Zaman *et al*., 2008; Mattain *et al*., 2008; Dawar *et al*., 2010). Galzina *et al.* (2008) also reported that the biomass of maize plants was more than 40% lower in weedy check than herbicide treated plots.

Grain yield

Grain yield in response to urea (applied with or without Agrotain and herbicide) were significantly ($p \leq 0.05$) higher than that of the control treatments. Urea + herbicide produced significantly ($p \leq 0.05$) greater grain yield of 6003 kg ha^{-1} compared with 5339 kg

ha^{-1} in comparison to when urea was used alone (Table-2).These results suggested that herbicide could reduce weeds growth by competing with maize for available N and other nutrients and may result in improved N bioavailability by providing maize plant an extra-opportunity to take more N.

However, grain yield of maize was even greater when urea applied with Agrotain + herbicide compared with urea alone, Urea + herbicide and urea + Agrotain treatments (Table-2). These results suggested that Agrotain delayed urea hydrolysis (Sanz-Cobena *et al*., 2008; Dawar *et al*., 2011) and allowed more time for irrigation or rain fall to move added urea from the surface layer to the rooting zone which could reduce the concentration of NH_4^+ present in the surface soil layer and the potential for NH_3 volatilization (Grant *et al*., 1996; Dawar *et al*., 2011).

Table-1. Physical and chemical properties of the soil used in experiments.

Soil properties	Values
pH	5.65
Total N (%)	0.38
Organic matter (%)	7.0
Olsen P (µg/ml)	20
CEC (me/100g)	14
Ca_2^+ (me/100g)	6.7
K^+ (me/100g)	0.45
Mg^{++} (me/100g)	1.74

Apart from NH_3 losses such increases in grain yield could be related to other benefits of Agrotain like delayed urea hydrolysis (Watson 2000; Chen *et al*., 2008; Dawar *et al*., 2011) and improvement of bioavailability (i.e., easier N uptake and metabolism) of applied urea (Blennerhassett *et al*., 2006; Zaman *et al*., 2008; Dawar *et al*., 2010).

Slow urea hydrolysis by Agrotain enable maize crop to taken up N in urea form by the plant roots as an intact molecule which may be incorporated into organic compounds and finally into plant protein at less energy cost compared to NO_3^- or NH_4^+, suggesting that the maize plant may be left with extra energy to allocate to growth and increase grain yield.

Table-2. Effect of urea with or without urease inhibitor and herbicide on grain yield and biomass of maize crop.

Treatments	Grain yield (kg ha^{-1})	% difference to urea-only	Biomass yield (kg ha^{-1})	% difference to urea-only
Control	4412[a]		709a	
Urea-only	5339[b]		9562[b]	
Urea+ Herbicide	6003[c]	16	11160[c]	17
Urea+ Agrotain	6359[d]	27	12440[d]	30
Urea+Agrotain +Herbicide	6731[e]	38	14531[e]	52

Within columns, means with the same letters are not significantly different at the P<0.05 level where n = 4.

CONCLUSIONS

This field study has provided us significant insights into how maize productivity is influenced by urea with or without Agrotain and herbicides. Agrotain and herbicide improved bio availability of the applied urea and resulted in higher grain yield and biomass than those of urea alone suggesting that applying urea with Agrotain and herbicide has the potential to improve maize crop productivity.

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