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Quantitative field evaluation of Malaysian-made formaldehyde treated granular urea for *Nicotiana tabacum* L., using ^{15}N isotope aided technique

(Penilaian kuantitatif pada peringkat ladang tentang keupayaan baja urea berbutir dengan rawatan 'formaldehyde' buatan Malaysia untuk tanaman tembakau menggunakan kaedah isotop ^{15}N)

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Key words: formaldehyde – treated granular urea, ^{15}N technique, *Nicotiana tabacum* L., ^{15}N fertilizer equivalent, % N uptake

Abstrak

Dengan menggunakan teknik isotop ^{15}N, tindakbalas pokok tembakau terhadap dua jenis butiran urea yang mengandungi formaldehid [urea dengan garis pusat 2.0–2.8 mm (SGU) dan 6.0–8.0 mm (LGU)] dan ammonium nitrat (NH_4NO_3) telah dibandingkan bagi dua kaedah pengurusan iaitu secara tradisional untuk dua musim (tanah siri Rusila) dan penyiraman dengan sprinkler secara teratur (tanah siri Rhu Tapai).

Perlakuan yang menerima baja urea butiran memberikan hasil N yang lebih tinggi dan peratus kelebihan atom ^{15}N yang lebih rendah. Ini menunjukkan kecekapan urea berbutir yang lebih tinggi berbanding dengan NH_4NO_3 walaupun tidak memberi perbezaan bererti (p =0.05) pada semua tempat. Kesemua baja N dagangan yang diuji tidak menunjukkan kesan bererti terhadap hasil bahan kering.

Apabila kecekapan baja yang diuji dikira semula dalam unit piawaian baja ^{15}N, didapati baja urea butiran membekalkan jumlah nitrogen lebih tinggi berbanding dengan baja NH_4NO_3. Walau bagaimanapun secara statistik, perbezaan bererti (p =0.05) hanya didapati di Bachok pada tahun 1986 iaitu kedua-dua saiz urea berbutir membekalkan N lebih kurang 1.3 kali ganda lebih tinggi berbanding dengan NH_4NO_3.

Pengukuran terhadap penggunaan sumber-sumber baja N dagangan pada pokok bahagian atas menunjukkan paling tinggi dengan LGU dan paling rendah dengan NH_4NO_3 pada kedua-dua keadaan pengurusan walaupun perbezaan-perbezaan ini tidak bererti (p =0.05).

Kesemua sumber baja N dagangan tidak menunjukkan kesan yang bererti terhadap indeks tanaman, indeks gred atau peratus daun tanpa gred bagi tanaman tembakau awet panas di Rantau Abang.

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Abstract

The response by tobacco to formaldehyde treated granular urea (viz. 2.0–2.8 mm Ø and 6.0–8.0 mm Ø) and NH_4NO_3 were compared under traditional management for two seasons (Rusila soil series) and regularly sprinkler irrigated (Rhu Tapai soil series) conditions using ^{15}N isotope labelling technique.

Treatments receiving granular urea consistently had higher N yield and lower percentage ^{15}N atom excess – indicating a higher efficiency, than treatment receiving NH_4NO_3 although these were not significant (p =0.05) at any one location. None of the commercial N fertilizer sources tested had any significant effect on dry matter yield.

In terms of efficiency expressed in equivalent standard ^{15}N fertilizer units, granular urea consistently supplied higher amounts of plant available N than did NH_4NO_3. The effects were however significant (p =0.05) only at Bachok in 1986 where LGU and SGU supplied approximately 1.3 times more plant available N than did NH_4NO_3.

Uptake of commercial N fertilizer sources as measured in the plant tops was highest with LGU and lowest with NH_4NO_3 under both management conditions although these differences were not significant (p =0.05).

None of the commercial N fertilizer sources had any significant effect on the crop index, grade index or the percentage non-descript of the flue-cured tobacco at Rantau Abang.

Introduction

In Peninsular Malaysia, approximately 75% of the tobacco crop is grown on marine sand deposits. These marine sand deposits, commonly referred to as the 'Bris Complex' have a very low nutrient status and low water holding capacity (Aminuddin et al. 1982, 1985) and high soil temperatures (Wahab 1984). Typical soils of the Bris complex contain less than 10% clay.

At present, ammonium nitrate is the preferred nitrogen source for tobacco cultivation on these impoverished soils. Earlier attempts to use urea as a nitrogen source have not been successful. Since urea is the cheapest nitrogen source and is locally manufactured its use will not only reduce production cost, but will also result in foreign exchange saving. These Malaysian-made granular urea contain a small additive of formaldehyde (averaging 0.55% by weight) making it harder, more compact and resistant to crushing.

The objective of the study was to compare the efficiency of ammonium nitrate and two formaldehyde treated granular urea [viz. 2.0–2.8 mm Ø (SGU) and 6.0–8.0 mm Ø (LGU)] for tobacco.

Materials and methods

Field experiments were conducted on two important tobacco soils viz. Rusila series (at Bachok) and Rhu Tapai series (at Rantau Abang). The crops at Bachok were managed under traditional management (i.e. applying additional water when deemed necessary by the farmer) while at Rhu Tapai it was regularly sprinkler irrigated.

The technique assumes that if a plant is confronted with two or more sources of a given nutrient, it will absorb from each source in direct proportion to the respective quantities available (Fried and Dean 1952). The supply of N from soil and commercial fertilizer expressed in equivalent standard ^{15}N labelled fertilizer

Table 1. Treatment details

Bachok	8 May – 3 July 1985
1) 40 kg N/ha ^{15}N-urea at 10% atm. excess (control)	
2) 10 kg N/ha ^{15}N-urea at 10% atm. excess plus 50 kg N/ha SGU	
3) 10 kg N/ha ^{15}N-urea at 10% atm. excess plus 50 kg N/ha LGU	
4) 10 kg N/ha ^{15}N-urea at 10% atm. excess plus 50 kg N/ha NH_4NO_3	
Variety : Coker 254	
Bachok	22 Jan – 5 March 1986
1) 40 kg N/ha ^{15}N-NH_4NO_3 at 10% atm. excess (control)	
2) 10 kg N/ha ^{15}N-NH_4NO_3 at 10% atm. excess plus 50 kg N/ha SGU	
3) 10 kg N/ha ^{15}N-NH_4NO_3 at 10% atm. excess plus 50 kg N/ha LGU	
4) 10 kg N/ha ^{15}N-NH_4NO_3 at 10% atm. excess plus 50 kg N/ha NH_4NO_3	
Variety : Coker 254	
Rantau Abang	25 March – 28 July 1986
1) 60 kg N/ha ^{15}N-urea at 2% atm. excess (control)	
2) 10 kg N/ha ^{15}N-urea at 10% atm. excess plus 50 kg N/ha SGU	
3) 10 kg N/ha ^{15}N-urea at 10% atm. excess plus 50 kg N/ha LGU	
4) 10 kg N/ha ^{15}N-urea at 10% atm. excess plus 50 kg N/ha NH_4NO_3	
Variety : Mc Nair 14	

SGU = Small granular urea (2.0–2.8 mm Ø)
LGU = Large granular urea (6.0–8.0 mm Ø)

units may be obtained as follows:

$$\frac{\%\text{Ndff, } ^{15}\text{N isotope}}{\text{Amount of } ^{15}\text{N labelled fertilizer applied}} = \frac{100-\%\text{Ndff, } ^{15}\text{N isotope}}{\text{N supply from soil and commercial fertilizer}}$$

while the supply of soil N also expressed in equivalent standard ^{15}N fertilizer unit may be obtained as follows:

$$\frac{\%\text{Ndff, } ^{15}\text{N isotope}}{\text{Amount of } ^{15}\text{N labelled fertilizer applied}} = \frac{100-\%\text{Ndff, } ^{15}\text{N isotope}}{\text{N supply from soil}}$$

Because the supply of soil N is independent of the rate of N fertilizer applied (Aleksic et al., 1968) the supply of N from the commercial fertilizer expressed in equivalent standard ^{15}N labelled fertilizer unit can therefore be estimated by difference.

The trial at Bachok was carried out for two seasons while at Rhu Tapai it was carried out for one season only. Some physical and chemical characteristics of the soils are given in *Appendix A*.

Plots (4 m x 4 m) arranged in a randomized complete block design and replicated four times were planted with four rows of 75 days old tobacco seedlings spaced 0.5 m along the row and 1.0 m between rows. Fertilizers were applied 3 days after transplanting at 10-cm depth along the row in a narrow band of 10 cm on either side of the plant. Treatment details are given in *Table 1*. All the plots also received the following basal fertilizer: triple superphosphate (≡50 kg P_2O_5), sulphate of potash (≡132 kg K_2O), kieserite (≡50 kg M_gO) and 3.4 kg borate 65. Five plants in each of the two centre rows received labelled ^{15}N solution in a 30 cm band along the row.

Six plants, three per treated row were harvested at ground level at early maturity. Samples were then weighed and the dry matter (DM) determined on sub-samples that were finely chopped and dried over night at 70 °C in a force-draught oven. Total plant nitrogen was determined by the Kjeldahl method and the $^{15}N/^{14}N$ ratio by Mass Spectrometry. The effects of commercial N sources on the yield (crop index) and quality (grade index and percentage non-descript) at Rantau Abang were determined from the remaining four treated plants per plot which was harvested at commercial standard of maturity and flue-cured.

Table 2. Effects of nitrogen sources on dry matter (DM) yield, N yield (gram per 6 plants) and percentage ^{15}N-atom excess in the plant tops

Treatment	Bachok						Rantau Abang		
	1985			1986			1986		
	N yield (g)	DM yield (g)	% ^{15}N atom exc.	N yield (g)	DM yield (g)	% ^{15}N atom exc.	N yield (g)	DM yield (g)	% ^{15}N atom exc.
Control	11.9a	877a	2.412a	9.1a	641a	5.108a	14.3a	842a	1.042a
NH_4NO_3	19.6b	1 271b	0.472b	12.1b	767b	0.860b	14.7a	927a	0.583b
SGU	19.7b	1 294b	0.445b	12.8b	831b	0.763b	16.3a	961a	0.534b
LGU	20.5b	1 348b	0.422b	12.8b	820b	0.733b	15.5a	890a	0.528b
C.V.	11.5	11.8	28.8	6.2	7.6	5.1	11.6	10.2	9.6

Values followed by the same letter in a column are not significantly different at the 5% level based on Duncan's multiple range test

Table 3. Effects of nitrogen sources on efficiency

Treatment	Bachok				Rantau Abang	
	1985		1986		1986	
	Available N Std. ^{15}N-fert. unit (kg N/ha)	% N uptake	Available N Std. ^{15}N-fert. unit (kg N/ha)	% N uptake	Available N Std. ^{15}N-fert. unit (kg N/ha)	% N uptake
Control	137a	19.3a	46a	31.0a	66a	33.3a
NH_4NO_3	73b	38.8b	65b	38.1b	103b	48.8b
SGU	86ab	41.8b	81c	44.3c	115b	57.3b
LGU	99ab	47.5b	87c	45.0c	118b	54.9b
C.V.	35.8	23.20	13.3	8.36	16.5	12.96

Values in a column followed by the same letter are not significantly different at the 5% level based on Duncan's multiple range test

Results and discussion

Effects on dry matter yield, total N uptake and percentage ^{15}N atom excess

A summary of the effects of the three commercial N fertilizer sources tested (viz. SGU, LGU and NH_4NO_3) on the dry matter (DM) yield, total N uptake and percentage ^{15}N atom excess in the plant tops grown under traditional management (Bachok) and regular sprinkler irrigation (Rantau Abang) are shown in *Table 2*.

At Bachok, application of N fertilizer (viz., SGU, LGU and NH_4NO_3) significantly increased the total N uptake and DM yield over the control in both 1985 and 1986. At Rantau Abang, where the soil N status was appreciably higher (*Appendix A*), none of the treatments showed any significant effect either on total N uptake or DM yield.

No significant differences were observed between the three nitrogen fertilizers tested at both Bachok and Rantau Abang on either DM yield or N uptake. However, both the granular ureas tended to show higher N uptake than NH_4NO_3 at both sites and higher DM yield at Bachok.

Although differences amongst the three commercial N fertilizers tested were not statistically significant, the percentage ^{15}N atom excess in the plant tops were consistently lowest in treatments receiving LGU and highest in the NH_4NO_3 treatment – indicating that LGU supplied more plant available N than did NH_4NO_3.

Effects on efficiency

The relative efficiencies of the three commercial N fertilizer sources contributing to the supply of N to the plant expressed in equivalent standard ^{15}N labelled fertilizer units and percentage N fertilizer uptake are given in *Table 3*.

In all cases, granular urea consistently supplied higher amount of plant available N than did NH_4NO_3. The effect was however significant (p = 0.05) only at Bachok in 1986 where LGU and SGU supplied an equivalent of 87 and 81 kg N/ha respectively as compared to 65 kg N/ha by NH_4NO_3. By expressing the efficiency of the commercial granular urea fertilizer relative to NH_4NO_3, LGU and SGU supplied approximately 1.3 times more plant available N than did NH_4NO_3. Differences between LGU and SGU were small (Bachok) or negligible (Rantau Abang) and were not significant at p = 0.05.

Based on the fractional utilization ratio concept, the efficiency expressed as percentage uptake of the commercial N fertilizer applied may be estimated as follows:

$$\frac{\text{Uptake } ^{15}\text{N fertilizer in plant}}{\text{Amount } ^{15}\text{N fertilizer applied}} = \frac{\text{Uptake commercial N fertilizer in plant}}{\text{Supply of commercial N fertilizer (}^{15}\text{N labelled fertilizer unit)}}$$

$$\text{and, \% N uptake} = \frac{\text{Uptake of commercial N fertilizer in plant}}{\text{Amount of commercial N fertilizer applied}} \times 100$$

In general, the effects of the commercial N sources on percentage N uptake efficiency by the tobacco crop followed similar trend to those expressed as equivalent standard ^{15}N labelled fertilizer unit although the former represents a yield dependent parameter (*Table 3*). In all cases, percentage N uptake were higher with both the granular urea than with NH_4NO_3. The effects were again however significant (p = 0.05) only at Bachok in 1986. Nitrogen utilization was highest for LGU at 45% and lowest for NH_4NO_3 at 38%.

Table 4. Effect of nitrogen sources on the yield and quality of tobacco grown on a Rhu Tapai soil series

	Net grade index	Crop index	% Non-descript
NH_4NO_3	18.4a	285a	25a
SGU	18.7a	318a	24a
LGU	21.0a	275a	28a

Means with the same letter are not significantly different at the 5% level based on Duncan's multiple range test

Effects on crop index and grade index

None of the N fertilizer sources tested had any significant (p = 0.05) effect on either the crop index, grade index or the % non-descript (*Table 4*) of the flue-cured tobacco at Rantau Abang although the use of urea as a N fertilizer source had been known to have variable effects on yields of tobacco (Tisdale 1952; William and Miner 1982) grown under field conditions.

In contrast, flue-cured tobacco receiving part or all of its N as NH_4-N have been reported to have lower yields (Evans and Weeks 1948; Gilmore 1953) and absorbed less cations than plants receiving NO_3-N (Evans and Weeks 1948) under sand or solution culture.

Since soils differ greatly in the rate of nitrification of NH_4-N formed on urea hydrolysis (Eno and Blue 1957; Gasser 1964; Low and Piper 1970; Soulides and Clark 1958), the rate at which the NH_4-N is nitrified would influence the N nutrition and consequently the response of the tobacco crop to urea fertilizer.

Conclusion

This study shows that formaldehyde-treated granular urea can be equivalent to or better than the commonly used NH_4NO_3 as a N fertilizer source for tobacco cultivation on bris soils in

Peninsular Malaysia. Since the rate of nitrification of the NH_4-N formed from hydrolysed urea will determine the comparative efficiency of urea and NH_4NO_3 and little is known of it in our tobacco soils, further studies are needed before urea could be recommended to tobacco growers on a commercial basis.

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