UNIVERSITI PUTRA MALAYSIA

EVALUATION OF N-(N-BUTYL) THIOPHOSPHORIC TRIAMIDE-TREATED UREA WITH AND WITHOUT CHICKEN MANURE ON GROWTH, YIELD AND POSTHARVEST QUALITY OF SWEET POTATO [Ipomoea batatas (L.) Lam.]

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By

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TITLE OF THESIS EVALUATION OF N-(N-BUTYL) THIOPHOSPHORIC TRIAMIDE- TREATED UREA WITH AND WITHOUT CHICKEN MANURE ON GROWTH, YIELD AND POSTHARVEST QUALITY OF SWEET POTATO [*Ipomoea batatas* (L.) Lam.]

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Sweet potato is a versatile crop that has a high output of yield and biomass, however, it is decreased in demand through the inefficiency of nitrogen management. Farmers are unable to control N losses through water sliding, nitrification, denitrification, volatilization, mineralization and immobilization. Due to N losses, farmers are unaffordable to increase input cost caused by the demand for chemical and organic fertilizer which increases over the years, and low nutrient available in soil may affect crop production and market value. However, most of farmers use excess usage of urea in order to replace the amount of N losses which can achieve the maximum productivity with optimum dosage. Thus, the use of urease inhibitor in fertilizer can reduce nitrogen losses by inhibiting the hydrolytic activity of urea decomposition. N(n-butyl) thiophosporic triamide (NBPT) to improve nitrogen availability in the soil while reducing N loss, especially in tropical conditions. The objectives of the study were i) to investigate the effects of NCU on the plant growth, plant physiology, N content and yield of sweet potato, ii) to determine the effects of NCU and NIU on the plant growth, plant physiology, N content and yield of sweet potato, iii) to identify and differentiate the effect on postharvest quality of sweet potato (*Ipomoea batatas*) under ambient and cold storage. Experiment 1 was arranged in RCBD while in experiment 2 was arranged in CRD. Both experiment was conducted in Field 15, Faculty of Agriculture, University Putra Malaysia, Serdang, Selangor. Anggun 2 was the variety of cutting sweet potato purchased from commercial farmers in Banting. A standard cutting (25-35 cm) was treated with carboryl or malathion to avoid disease infection under the shaded area.

Experiment 1 (1A and 1B), has a total of 12 treatments subjected to two factors, with (T1-T6) and without chicken manure (CM) (T7-T12). All the

treatments used was labeled as [T1] Farmer practices (96 kg N/ha) + CM, [T2] 0 kg N/ha of NCU + CM, [T3] 57.6 kg N/ha of NCU + CM, [T4] 76.8 kg N/ha of NCU + CM, [T5] 96 kg N/ha of NCU + CM, [T6] 115.2 kg N/ha of NCU + CM, [T7] Farmer practices (96 kg N/ha), [T8] 0 kg N/ha of NCU, [T9] 57.6 kg N/ha of NCU, [T10] 76.8 kg N/ha of NCU, [T11] 96 kg N/ha of NCU, and [T12] 115.2 kg N/ha of NCU. Experiment 2 (2a & 2b) has a total of seven (7) treatments with proposed 3 new treatments (T5-T7) and labeled as [T1] Farmer practices (120 kg N/ha urea), [T2] 72 kg N/ha of NCU, [T3] 96 kg N/ha of NCU, [T4] 120 kg N/ha of NCU, [T5] 72 kg N/ha of NIU, [T6] 96 kg N/ha of NIU and [T7] 120 kg N/ha of NIU.

In conclusion, Experiment 1, NCU treated with CM show significant effect and better result in yield than NCU treated without CM by 30.99%. Plant treated with 76.8 kg N/ha urea NCU showed the highest and recommend to the farmers either with or without CM to maximize the plant growth (shoot fresh and dry weight; tuber fresh and dry weight) yield of sweet potato and nutrient uptake of sweet potato. While, in Experiment 2, NIU showed a better performance in ammonium content by 34.98% of urease hydrolysis activity better than NCU while 96 kg N/ha is the consistent rate to showed the highest significant in tuber fresh weight by 18.49% and 20.41% of NCU and NIU respectively as compared to control. In both experiments 1B and 2B, cold storage showed a significant effect in controlling postharvest quality in terms of shelf-life better than ambient storage (normal practices). As a recommendation, farmers are advised to use fertilizer with urease inhibitors to maximize crop production.

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PENILAIAN N- (N-BUTYL) THIOPHOSPHORIC TRIAMIDE (NBPT) UREA YANG DIRAWAT DENGAN DAN TANPA BAJA AYAM KE ATAS PERTUMBUHAN, HASIL DAN KUALITI LEPASTUAI UBI KELEDEK MANIS [*Ipomoea batatas* (L.) Lam.]

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Ubi keledek adalah tanaman serbaguna yang memiliki hasil dan biomassa yang tinggi, namun permintaannya menurun akibat daripada kelemahan dalam menguruskan nitrogen. Para petani tidak dapat mengawal kehilangan N melalui kehilangan air, nitrifikasi, denitrifikasi, volatilisasi, mineralisasi, dan imobilisasi. Kesan dari kehilangan N, petani menghadapi masalah untuk meningkatkan kadar penggunaan N dalam pembajaan disebabkan oleh permintaan baja kimia dan organik meningkat sejak akhir ini dan kandungan nutrien rendah dalam tanah boleh mempengaruhi hasil tanaman dan nilai pasaran. Namun, kebanyakan petani menggunakan urea secara berlebihan untuk menggantikan jumlah kerugian N bagi mencapai produktiviti yang maksimum dengan penggunaan dos yang optimum. Oleh itu, penggunaan perencat urease dalam baja dapat membantu mengurangkan kehilangan nitrogen dengan menyekat aktiviti hidrolisis penguraian urea. N (n-butil) thiophosporic triamide (NBPT) adalah bahan aktif yang boleh meningkatkan ketersediaan nitrogen di dalam tanah serta mengurangkan potensi risiko kehilangan N terutama dalam keadaan tropika. Objektif kajian ini adalah i) untuk menyelidiki kesan NCU terhadap pertumbuhan tanaman, fisiologi tumbuhan, kandungan N dan hasil ubi keledek, ii) untuk mengetahui kesan NCU dan NIU terhadap pertumbuhan tanaman, fisiologi tumbuhan, kandungan N dan hasil ubi keledek, iii) untuk mengenal pasti dan membezakan kesan terhadap kualiti pasca tuai ubi keledek (*Ipomoea batatas*) di simpan dalam suhu ambien dan sejuk. Eksperimen 1 diatur dalam susunan RCBD sementara itu eksperimen 2 diatur dalam susunan CRD. Kedua-dua eksperimen ini dijalankan di Ladang 15, Fakulti Pertanian, Universiti Putra Malaysia, Serdang, Selangor. Anggun 2 adalah jenis ubi keledek yang dibeli dari peladang di Banting. Ubi keledek yang bersaiz 25 – 35 cm dirawat dengan karbaryl atau malathion bagi mengelakkan jangkitan penyakit di kawasan tanaman.

Eksperimen 1 (1A and 1B), mempunyai 12 rawatan yang dibahagi kepada dua faktor, kehadiran (T1 – T6) dan tanpa kehadiran baja tahi ayam (CM) (T7 – T12). Ke semua rawatan digunakan dilabel sebagai [T1] Amalan petani (96 Kg N/ha) + CM, [T2] 0 kg N/ha urea dari NCU + CM, [T3] 57.6 Kg N/ha urea dari NCU + CM, [T4] 76.8 Kg N/ha urea dari NCU + CM, [T5] 96 Kg N/ha urea dari NCU + CM, [T6] 115.2 Kg N/ha urea dari NCU + CM, [T7] Amalan petani (96 Kg N/ha), [T8] 0 Kg N/ha urea dari NCU , [T9] 57.6 Kg N/ha, [T10] 76.8 Kg N/ha urea dari NCU, [T11] 96 Kg N/ha urea dari NCU, [T12] 115.2 Kg N/ha urea dari NCU. Eksperimen 2 mempunyai tujuh (7) rawatan dengan 3 rawatan baru yang dicadangkan (T5-T7): [T1] Amalan petani (120 kg N/ha urea); [T2] 72 kg N/ha urea NCU; [T3] 96 Kg N/ha urea dari NCU; [T4] 120 Kg N/ha urea NCU; [T5] 72 Kg N/ha urea NIU; [T6] 96 Kg N/ha urea NIU; dan [T7] 120 Kg N/ha urea NIU.

Kesimpulannya, Eksperimen 1, NCU yang dirawat dengan CM menunjukkan kesan signifikan dan hasil tanaman yang lebih baik daripada NCU yang dirawat tanpa kehadiran CM sebanyak 30.99%. Pokok yang menerima rawatan 76.8 kg N/ha urea NCU menunjukkan hasil yang tertinggi buat petani sama ada dengan kehadiran atau tanpa kehadiran tahi ayam bagi memaksimumkan hasil pengeluaran tanaman dan jangka hayat ubi keledek. Manakala, eksperimen 2, NIU menunjukkan prestasi yang lebih baik dalam kandungan ammonium sebanyak 34.98% aktiviti hidrolisis urease lebih baik daripada NCU, sementara itu, 96 kg N/ha menunjukkan hasil yang konsisten dan signifikasi tinggi dalam berat segar sebanyak 18.49% dan 20.41% NCU dan NIU dibandingkan dengan rawatan kawalan. Kedua-dua eksperimen lepas tuai (1B and 2B), ubi keledek yang disimpan dalam suhu sejuk menunjukkan kesan signifikasi dalam mengawal kualiti pasca tuai berbanding disimpan dalam suhu ambien (amalan biasa). Sebagai cadangan, petani disarankan untuk menggunakan baja yang telah ditambah dengan perencat urease.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
CC	Chlorophyll content
CM	Chicken manure
CRD	Completely randomized design
DAP	Day after planting
DAS	Day after storage
DBS	Day before storage
Df	Degree of freedom
LSD	Least significant difference
NBPT	N-(n-butyl) thiophosphoric triamide
NCU	NBPT coated urea
NH_4	Ammonium
NIU	NBPT incorporation urea
NO_3	Nitrates
NUD	N-urea determination
NUE	Nitrogen use efficiency
NUS	Nitrogen uptake by shoot
NUT	Nitrogen uptake by tuber
OM	Organic matter
RCBD	Randomised complete block design
RSR	Root to shoot ratio
SAS	Statistical analysis software
SDW	Shoot dry weight
SFW	Shoot fresh weight

TD	Tuber diameter
TDW	Tuber dry weight
TFW	Tuber fresh weight
TL	Tuber length
TNP	Total nitrogen in plant
TNS	Total nitrogen in soil
TNT	Total nitrogen in tuber
TY	Total yield

CHAPTER 1

INTRODUCTION

Normally, plant tissue contains high nitrogen content (1-6%) as they play an important role in the major component of plant structure and are widely used in agriculture all over the world (IFIA, 2008). The demand for urea fertilizer was increased in the agriculture sector due to an increase in nitrogen content (46% of mass). Farmers were realized urea fertilizer application with high N content will help to reduce preparation costs (Miller and Cramer, 2004). Most of the nitrogen basics in the soil were found in an organic form (plant and animal residue). However, not all N ions were available for plant uptake, as it need soil bacteria and enzymes to decompose into available forms for plants.

Of all essential nutrients, nitrogen is required by plants in the largest quantity however, with poor management of nitrogen, it will be charged on limiting nutrients in crop production and get easily lost from the soil system. Farmers frequently face ammonia volatilization, leaching, denitrification process which remain in unavailable forms for the plant (Merigout et al., 2008). Urea performance in soil depended on urease activity as this enzyme catalyst was involved in urea hydrolysis into ammonium and carbon dioxide as their products (Watson et al, 1994) and as result, it will increase the N availability for plant nutrition due to slow urea hydrolysis (Zaman et al., 2008). Despite that, due to poor management of nitrogen affected sweet potato production from 1967 to 2009 (FAO, 2017). The lowest yield of sweet potato was recorded in 2001 (15 946 t/ha), and recorded 80% lower than 1961 (FAO, 2017). Malaysia facing difficulty in sweet potato demand, due to farmer loss of interest to cultivate the sweet potato as their main source of income. In some areas in East Malaysia, they are planting the sweet potato for continued food supply.

From 2002 and onwards, sweet potato demands start to increase as well as other crops. However, the biggest farmers' challenges are the N availability and losses from the soil. Ammonium and nitrate are the major available N ions that are needed by the plant in an inorganic form more than other nutrients and minerals on earth. However, N deficiency is the most common nutritional problem affecting the agriculture sector due to abundance in unavailable form for plants. Low in N availability in N availability in soil lead to decreases in crop production due to low in nutrient uptake by the plant as they face a major mechanism for N fertilizer loss in nitrogen management.

The postharvest quality and shelf-life of sweet potato during storage have become universe problems as it contains high moisture content (60-75%) with low mechanical strength as well as highly susceptible to microbial decay, it may cause to rot during transportation. Due to high respiratory rate and heat production softens the sweet potato textures which make them susceptible to easily damage on tubers. Generally, postharvest storage together with help of slow-release fertilizer (NBPT) in urea fertilizer application can help to prolong the shelf-life of sweet potato (Watson, 2005)

N-(n-butyl) thiophosphate triamide (NBPT) is one of the examples of urease inhibitors elements and the most promising urease inhibitors product which successfully inhibit the conversion of urea to its oxidized form (Watson, 2005). The efficiency of interaction between the substrate (oxygen atoms) and active site (urease inhibitors) has influenced by environmental factors such as pH (Hendrickson & Douglass, 1993), temperature (Hendrickson & O'Connor, 1987), and soil moisture content (Sigunga et al., 2002; Clough et al., 2004).

Even though NBPT has shown a significant effect on plants, but there is a limited effect on a few species as it showed toxicity symptoms on leaf and roots development when the plants were treated with integrated urea and NBPT (Watson & Miller, 1996; Artola et al., 2011; Cruchaga et al., 2011). Based on previous studies, the urease activity can be stopped or slowed down by the NBPT application, and it happened on pea and spinach. As the NBPT is translocated from roots to the leaves (Watson & Miller, 1996; Artola et al., 2011; Cruchaga et al., 2011), the amino acid production and glutamine synthase activity are reduced as well (Artola et al., 2011; Cruchaga et al., 2011). All these information and result showed the success of the urease inhibitor which compromised the usage of N as a source for plants, however, there is still a lack of knowledge on NBPT effect on plant growth, yield, physiology and postharvest quality of sweet potato, as a selected crop in this study. Therefore, the general objectives of this study were aim:

1. To investigate the effect of NBPT coated urea (NCU) on plant growth, plant physiology, N content and yield of sweet potato (*Ipomoea batatas*).
2. To determine the effects of NCU and NBPT incorporated urea (NIU) on plant growth, plant physiology, N content and yield of sweet potato (*Ipomoea batatas*).
3. To identify and differentiate the effect of postharvest quality on sweet potato (*Ipomoea batatas*) under ambient (23±2°C) and cold storage (10±2°C

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