Effect of NBPT Coated Urea (NCU) and NBPT Incorporated Urea (NIU) application on growth and yield of sweet potato (*Ipomoea batatas*)under Malaysia Conditions

Muhammad Zulhilmi Mohd Nasirudin
Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

SakiminSitiZaharah
1. *Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM,Serdang Selangor, Malaysia*
2. *Institute of Tropical Agriculture & Food Security (ITAFoS), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*

Noraini Md. Jaafar
Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang Selangor, Malaysia

MohdKhanifYusop
Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang Selangor, Malaysia

Abstract - Urease inhibitor has developed to improve urea efficiency by reducing N losses through blocking and slowing down the urease activity in urea hydrolysis. Thus to increase N availability for plant nutrition, NBPT can be added either by coating or incorporating to granulated urea. However, the field trials investigating the effects of NBPT coated or incorporated urea on sweet potato are limited. Thus, this research is to determine the effects of NBPT coated urea (NCU) and NBPT incorporated urea (NIU) on plant growth and yield of sweet potato. An experiment was conducted in Field 15, Faculty of Agriculture, Universiti Putra Malaysia by using Randomly Complete Block Design (RCBD) with four replications. Treatments were subjected to 2 fertilization factors: NBPT coated urea (NCU) and NBPT incorporated urea (NIU), and varying rate of urea. All treatments were applied NPK fertilizer at 1000 kg N/ha of $12N_2$: $12P_2O_5$: $17K_2O$. The treatments were subjected into seven treatments; T1 : Farmer practices (120 kg N/ha urea); T2 : 72 kg N/ha urea of NCU; T3: 96 Kg N/ha urea of NCU; T4 : 120 Kg N/ha urea of NCU; T5 : 72 Kg N/ha urea of NIU; T6 : 96 Kg N/ha urea of NIU; and T7 : 120 Kg N/ha urea of NIU. The study can be concluded that 72 kg N/ha NIU (T5), 96 kg N/ha NIU (T6) and 96 kg N/ha NCU (T3) was the recommendation ratio of fertilizer to the farmer to maximize the tuber production while both have an advantage in controlling N losses to the environment.

Keywords - sweet potato, urea fertilizer, urea losses, N availability, NBPT coated urea (NCU), NBPT incorporated urea (NIU).

I. INTRODUCTION

N-(n-butyl) thiophosphoric triamide (NBPT) is a chemical compound which contains urease inhibitors and acts as an effective way to inhibit urease activity and slow the urea hydrolysis as well as minimize ammonia losses to the environment [1]. In Malaysia, the composition of urease inhibitors in urea has increased due to effective in reducing volatilization losses which are delaying enzymatic action in soil [2]. NBPT has been increasingly applied to urea either in urea N fertilizer manufacturing productions as well as via simple procedure through the coating process or complicate procedure through the incorporate process.

NBPT can be added in form or coat or incorporate to granulate urea. NBPT technology can be produced in two ways; coated urea fertilizer was first introduced to spray the solution onto urea granules and become the most feasible method for farmers as it was easy to apply on urea [3]. Second, incorporated urea fertilizer was normally prepared by fertilizer manufactured. The melted urea was adding urease inhibitory through the bed granulation process [4]. Although the method of preparation was physically and chemically different, the basic mechanism of action on urease enzyme carries an equivalent purpose of application as both methods were used similar urease inhibitors (NBPT). There are numerous related studies on coating NBPT into urea (NCU) but not

incorporation onto urea (NIU). NBPT coated urea (NCU) have been confirmed in reducing NH_3 losses as well as increasing the nitrogen uptake and yield various places such as in Brazil [5], in Tennessee, USA [6], and Pakistan [7]. Meanwhile, NIU showed low traceability and availability in finding due to lack in study and research. However, [8] found in their study that NIU gives a positive response to the yield, [9] found, there was a slightly different in effectiveness between NCU and NIU in reducing NH_3 loss. Due to the limited information on evaluation or performance of the NBPT technology in this tropical country, thus, this study was conducted to determine the effects of NCU and NIU on the growth, N uptake, and yield in soils.

II. METHODOLOGY

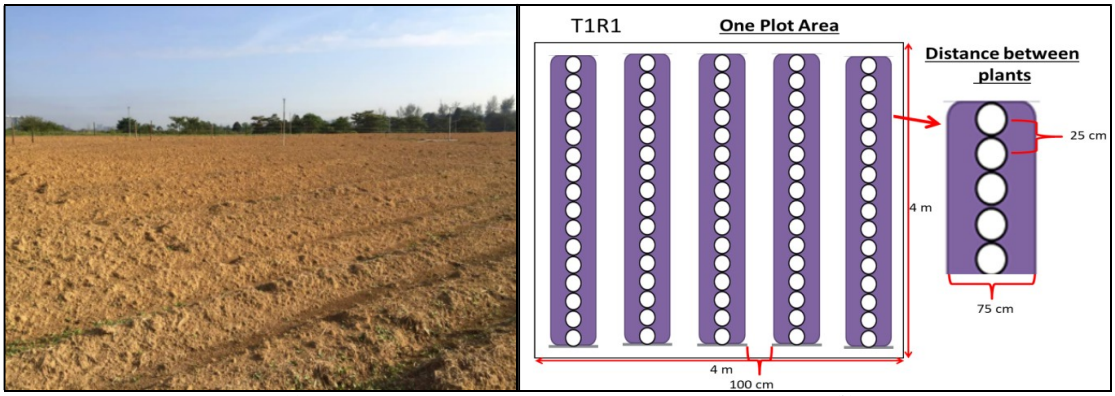
2.1 Site study

A field experiment was conducted at Field 15, Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Malaysia.

2.2 Land preparation

Land preparation started a month before planting, with the cleaning work on the experimental site was carried out to remove weeds and the plot area was fenced (Figure 1a). The land was plowed and left for 2 weeks followed by the lime application at 5 kg GML per plot (5 ton/ha) The plot was left for 3 days before the second plowing. The size of a plot was 4 m x 4 m, consisting of 5 beds in each plot. The size of each planting bed was 0.75 m x 4 m, and the number of cuttings planted within one bed was 16 cuttings with a planting distance of 25 cm each (Figure 2). The plots were applied with a pre-emergence herbicide (glufosinate magnesium) at 1.8 L ha-1 and sprayed all over the sweet potato area just before planting.

The soil physical and chemical properties at the plot of the experiment were analyzed. The soil sample was collected from 20 cm depth above the ground. Soils initial characterization before and after liming us, pH was 4.49 (before) and 5.52 (after liming) (Table 1).



(a) (b)

Figure 1. (a) Land preparation (b) Ploughed land ready to cover with silver shine

2.3 Planting materials

Sweet potato (*Ipomoea batatas* var Anggun 1) cuttings were purchased from commercial farmers. The cuttings were in standard size between 25 to 30 cm length and aged between 2 to 2 ½ months (young or soft cuttings) (Figure 2), containing 6-7 nodes from the terminal shoots with the lower leaves has been removed for good root growth. The cuttings were left overnight or immediately treated by soaking them in a fungicide solution (carbaryl 0.1%) before planting. The cuttings were planted (one cutting per hole) in the soil about 10 cm depth.

Table 1. Soil physical and chemical properties at the experimental site (0 – 20 cm depth)

Parameter	Value
pH before liming	**4.49**
pH after liming	**5.52**
Soil texture class	**Clay**
Total (%)	
Sand	**40.79**
Silt	**14.29**
Clay	**44.92**
Mineral N (µg g^{-1})	
NH_4^+-N	**10.32**

NO_3^-N	**7.43**
Total C (%)	**-**
Total N (%)	**0.12**
Available P (mg kg^{-1})	**1.50**
Exchangeable (mg kg^{-1})	
K	**33.45**
Ca	**66.80**
Mg	**9.73**
CEC (cmol kg^{-1})	**-**

2.4 Experimental Design

The experiment was conducted using Randomly Complete Block Design (RCBD). The study consists of 28 plots subjected to seventreatments including different rates and types of NPK fertilizer with or without application of CM with 4 replications and replicated four times. Figure 2, shaded in white and grey color is referring to the treatment with and without CM, respectively, it was randomized within each block.

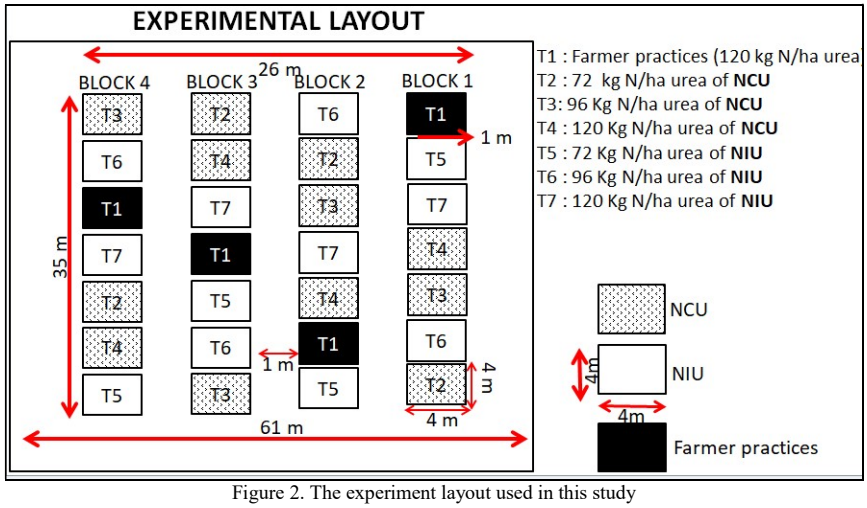


Figure 2. The experiment layout used in this study

2.5 Fertilization and treatments

The type of fertilizers used for this experiment was urea (46%N) for farmer practices NBPT coated urea (NCU) and NBPT incorporated urea (NIU) were from Agrotain as an N source for alltreatment. The NBPT coated urea (NCU) was prepared in the Chemical Process Engineering Laboratory 2 at Faculty Engineering, UPM by spraying the NBPT at a standard volume (3 ml) on a 1kg batch of urea and blended for 5 minutes at a constant speed (55 rpm) and angle (45^o) in SOLTEQ rotary drum as recommended by Koch industries. Inc. This fertilizer was dried and kept in store at room temperature. While NIU was prepared by fertilizer manufactured.

Sweet potato cuttings were grown in soils subjected to 2 factors type of NBPT urea fertilizer (NCU & NIU) and varying rate of urea 7 treatments: [T1]120 kg N/ha (100% FP), [T2]72 kg N/ha (60% NCU), [T3]96 kg N/ha (80% NCU), [T4]120 kg N/ha) (100% NCU), [T5]72 kg N/ha (60% NIU), [T6]96 Kg N/ha NIU (80% NIU), and [T7] 120 Kg N/ha NIU(100% NIU) and was replicated for 4 times.

The fertilizer rate was 800 kg/ha by using the ratio $12N_2$:$12P_2O_2$:$17K_2O$ followed the recommendations by the Malaysian Agriculture Research and Development Institute (MARDI). The type of fertilizer used as a single fertilizer in the form of urea, Triple Super Phosphate (TSP), and Muriate of Potash (MOP) respectively to provide Nitrogen (N), Phosphorous (P), and Potassium (K) – commonly referred to as NPK. NPK fertilizer as a side dressing was given just after 7 days of planting. Each plot had the same proportion of P and K but the different rate of N according to each treatment.

The fertilizer was applied every 3 weeks interval. Treatments 1 was applied with farmer practice, T2 to T4 were applied with NBPT coated urea (NCU), and T5 to T7 were applied with NBPT incorporated urea (NIU) which received respective kg N/ha rate urea similar as NCU treatments.

2.6 *Agronomic data collection*

There were 4 sampling times (S1, S2, S3, S4) which were sampled at 26, 52, 78, and 104days after planting (DAP), respectively. S4 was the final harvest to collect the yield of sweetpotato. Data on plant growth measurements (fresh and dry weight of shoot and tuber),ammonium (NH_4), nitrate (NO_3), N determination, yield, total N in soil leaves, and tuberof sweet potato collection were collected during the study.All plant sampled were harvested, cleaned, and segregate into the top and bottom part of sweet potato. The fresh weight of the top and bottom parts were weighed immediately by using an analytical balance, while a dry weight of the top and bottom parts must be kept in the oven-dry at 70ºC for 2 days before weight and both parameters were expressed in ton/ha. Ammonium (NH_4), nitrate (NO_3), N determination use the Kjeldahl method to determine the quantitative value of N in the sample through 3 important techniques which are distillation, digestion, and titration. 40 mL of acid-alkali reagent (potassium chloride and phenylmercuric acetate) were added to 20 g of the soil sample in a container and shook for one hour. Filtered the sample and left overnight. In preparing a test for NH_4 and NO_3,10 ml of boric acid was poured into two titration flask. 10 ml of sample were respectively added into two titration flask contain 2 g magnesium oxide and devarda's alloy. The presence of NH_4 and NO_3 was proven when purple boric acid turns to green color. The titration reading in ml of NH_4 and NO_3 was expressed in ug/g. In preparing a test for urea determination, 4 standards and samples were prepared by adding 10 ml sample and 30 ml of color reagent into 50 ml of volumetric flask. All prepared samples and standards were placed in a water bath at 80°C for 27 minutes and ready to read absorbance at 527 nm by using a spectrophotometer. Total N in soil was determined by Bray and Kurtz method, while leave and tuber were determined by the ashing method.Reagent A and reagent B were used in Bray Kurtz method mixed into the test tube and cover with parafilm to avoid evaporation during shaking for 45 seconds. While 0.5 g dried samples were measured and place in a crucible for burning in a furnace (550^{o}C – 660 ^{o}C) for 7-8 hours. 2 ml of HCl was added and placed under a hot plate. 10 ml of 20% of HNO_3 was added before put into a water bath (80 ^{o}C) for 45 minutes. Samples are ready to send for analysis.The yield of sweet potato was determined by using a quadrant size of 3 m x 3 m. The sample of fresh weight of tuber was divided by 1,000 (convert to ton/ha) and multiply with ratio between total crop area (1 ha = 10,000 m^2) and size of the quadrant (3 m x 3 m) and expressed in ton/ha.

3.1 Statistical data analysis

All data collected were analyzed by using two-way variance (ANOVA) by Statistical Analysis System (SAS 9.4) for randomized completely block design (RCBD) with factorial and replicated four times to determine the significant differences between treatments means. Difference between means separated using the least significant difference (LSD) at $P<0.05$ level.

III. RESULTS AND DISCUSSION

3.1 Shoot fresh weight (SFW)

Observation on NCU and NIU fertilizers were significantly increased the SFW as compared to control treatment. Among all treatments, SFW of sweet potato that was applied with NIU fertilizer showed a better result than NCU fertilizer at S2 and S4. In Figure 3, showed the highest SFW at S1 was T6 which increased by 67.7% followed by T5 (50%) and T7 (44.7%) respectively as compared to control (T1). The lowest SFW was recorded at T4 (31.3%) and T2 (33.3%) respectively as compared to control treatment. While at S2, the highest SFW was recorded at T6 which increased by 55.7% followed by T3 (31.7%), T5 (31.6%), and T7 (30.9%) respectively as compared to control (T1). The lowest SFW at S2 was reported at T2 (11.5%) and T4 (8.6%) respectively as compared to control treatment. Next, at S3, the highest SFW was showed at T6 which increased by 65.6% followed by T5 (58.9%) as compared to control (T1) while the lowest SFW was showed at T4 which increased by 19.6% as compared to control treatment. Lastly, the highest SFW at S4 was recorded at T6 which increased by 78.2% followed by T5 (66.7%) as compared to control (T1) and the lowest SFW at S4 was showed at T4 which increased by 21.1% as compared to control treatment. According to the study by [10] all the growth parameters involved in plant height, the number of leaves, and the tuber number showed a significant effect within all treatments. The study proved, the coated fertilizer showed the best results in all parameters especially the plant treated with 100% recommended doses of fertilizer (RDF) N coated with Neem cake 5% compared to other treatments and zero fertilizer application.

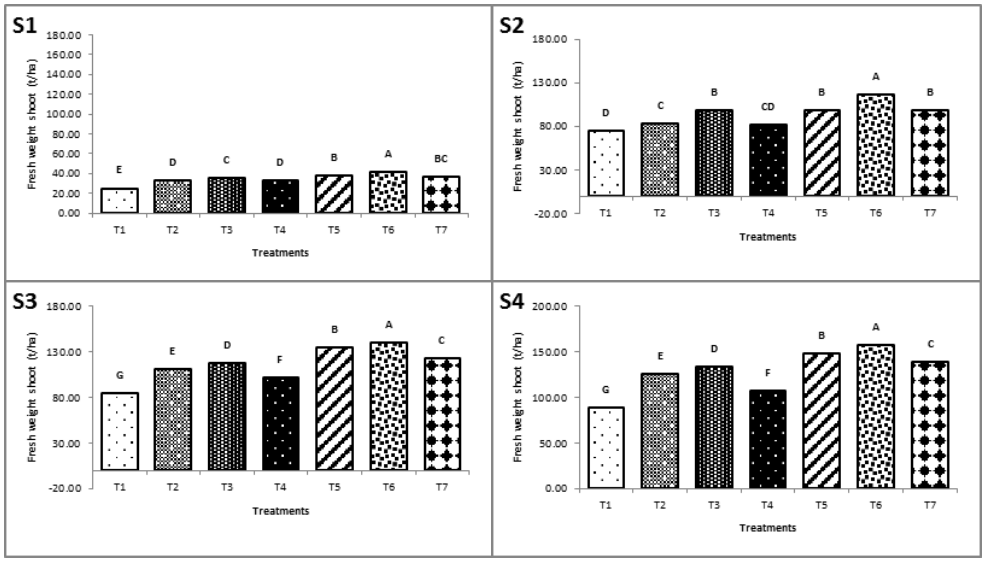


Figure 3. The effect of different N rates between NCU and NIU on fresh weight of shoot of sweet potato at (S1) 26 DAP, (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant difference (LSD).(Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

3.2 Shoot dry weight (SDW)

Figure 4showed the effect of different N rates between NCU and NIU on shoot dry weight (SDW) and tuber dry weight (TDW) compared with control treatments (Farmer practices). In Figure 4, shoot dry weight (SDW) showed the highest SDW at S1 was T6 which increased by 57.5%, followed with T7 (45.4%), T3 (44.3%), and T5 (44.3%) respectively as compared to control (T1). The lowest SDW at S1 was recorded at T4 (25.7%) as compared to control treatment. While at S2, the highest SDW was recorded at T6 which increased by 54.9% followed by T5 (33.9%), T7 (32.4%), and T3 (28.9%) respectively as compared to control (T1). The lowest SDW at S2 was showed at T2 (9.7%) and T4 (9.4%) respectively as compared to control treatment. Next, the highest SDW at S3 was reported at T6 and T5 which increased by 70.8% and 65.1% followed with T7 (45.0%) and T3 (40.6%) respectively as compared to control. the lowest SDW at S3 was recorded at T4 which increased by 19.9% as compared to control treatment. Lastly, at S4, the highest SDW was reported at T6 which increased by 77.1%, followed with T5 (58.2%) and T7 (57.9%) respectively as compared to control (T1). The lowest SDW was showed at T4 which increased by 18.9% as compared to control treatment. Similar findings by [11], his study found that all the dry matter increased as the rate of N increased, however, any increased from the optimum rate would degrade the dry matter accumulation in corn. Among all the treatments, V_6 (polymer-coated urea) showed the highest value of dry matter and grain yield as well as total N and N uptake as compared to non-coated urea.

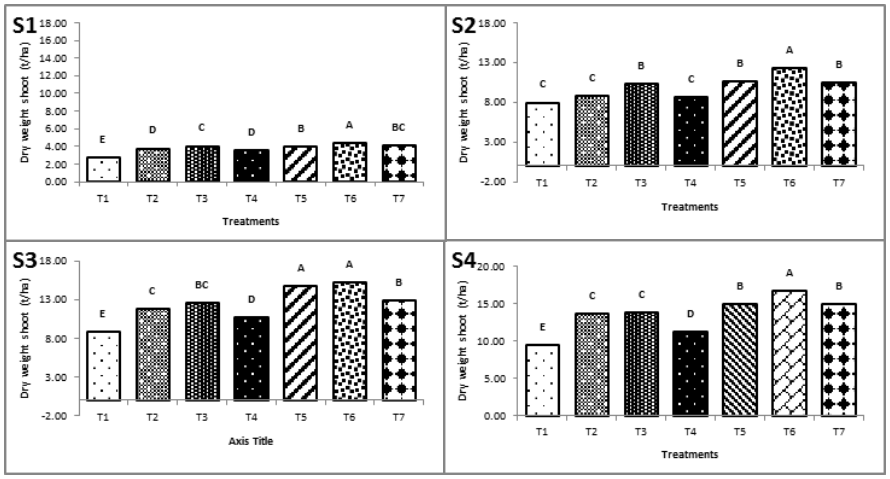


Figure 4. The effect of different N rates between NCU and NIU on the dry weight of shoot of sweet potato at (S1) 26 DAP, (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant

difference (LSD). (Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

3.3 Tuber fresh weight (TFW)

The effect of different N rates between NCU and NIU fertilizer as compared to control treatment (T1) on TFW was demonstrated in Figure 7and showed a better result on NIU fertilizer than NCU fertilizer at S2 and S3. In Figure 5, the highest TFW at S2 was recorded between T6 and T5 which increased by 151.4% and 145.7% respectively followed by T7 (130.6%) as compared to control (T1). The lowest TFW was recorded at T4 which increased by 68.2% as compared to control treatment. While at S3, the highest TFW show at T6 which increased by 230.7% followed with T5 (188.3%) and T7 (164.8%) as compared to control (T1). The lowest TFW at S3 was showed at T4 which increased by 46.5% as compared to control treatment. Next, the highest TFW at S4 was reported between T6 and T5 which increased by 26.4% and 19.3% followed by T7 (18.5%) as compared to control (T1). while the lowest TFW was reported between T1 (control) and T4 (0.56%) as compared to control treatment.[12] was experimented to see the effect of slow release fertilizer on a few parameters such as planting growth; root and shoot growth and stem and root dry weight. These parameters showed a significant increase with slow release fertilizer at $P > 0.05$ compare with the control treatment (untreated fertilizer).

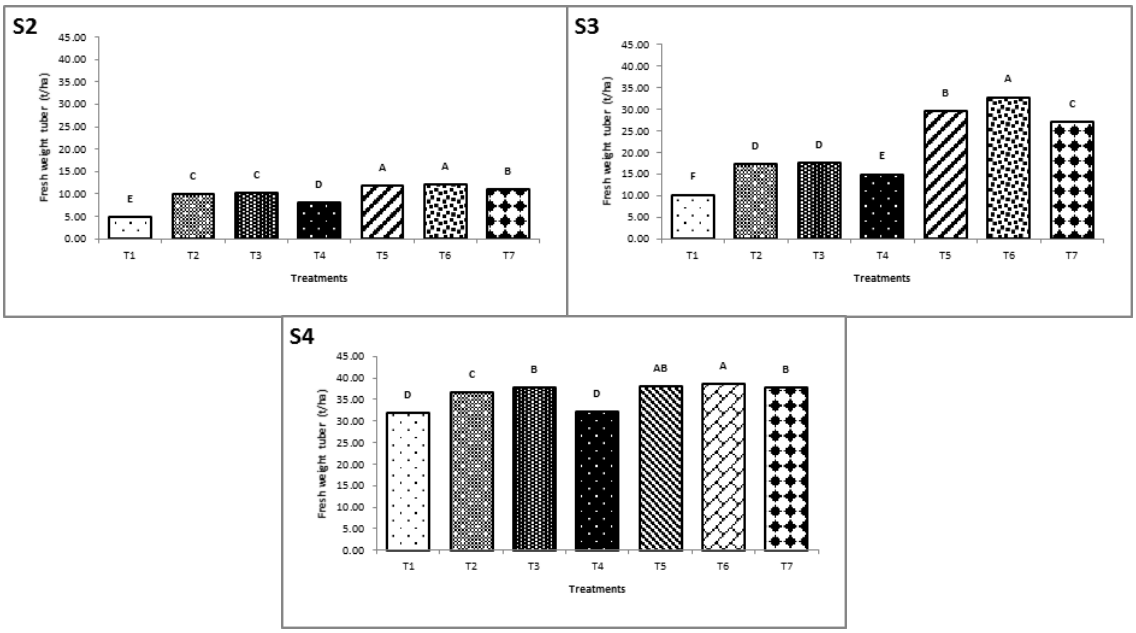


Figure 5. The effect of different N rates between NCU and NIU on fresh weight of tuber (t/ha) of sweet potato at (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant difference (LSD). (Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

3.4 Tuber dry weight (TDW)

Figure 6 showed the effect of different N rates between NCU and NIU on tuber dry weight (TDW) compared with control treatments (farmer practices). From the graph, the application of different types of fertilizer and different N rate fertilizer has increased the mean values TDW of sweet potato. In figure 8, the highest TDW was recorded between T6 and T5 which increased by 156.8% and 152.6% respectively followed by T7 (143.2) as compared to control (T1). The lowest TDW was recorded at T4 which increased by 69.5% as compared to control treatment. At S3, the highest TDW was showed between T6 and T5 which increased by 214.4% and 194.2% respectively as compared to control (T1). The lowest TDW was showed between T4 and T3 which increased by 65.9% and 46.6% respectively as compared to the control treatment. Next, at S4, the highest TDW as reported between T3, T5, T6, and T7 which increased by 16.3%, 17.9%, 20.3%, and 17.7% respectively as compared to control (T1). While the lowest TDW was reported between T1 (control) and T4 (1.37%) as compared to control treatment. Inline study with [13] showed there was no significant difference in leaf dry weight, stem dry weight, or leaf and stem dry weight for potato with any of the treatments, however, tuber dry weight showed significant and varied at harvesting time between treatment 10 (133.9 g/plant), treatment 6 (110.4 g/plant) and treatment 14 (108 g/plant) compared to no coated material treatments (82.3 g/plant).

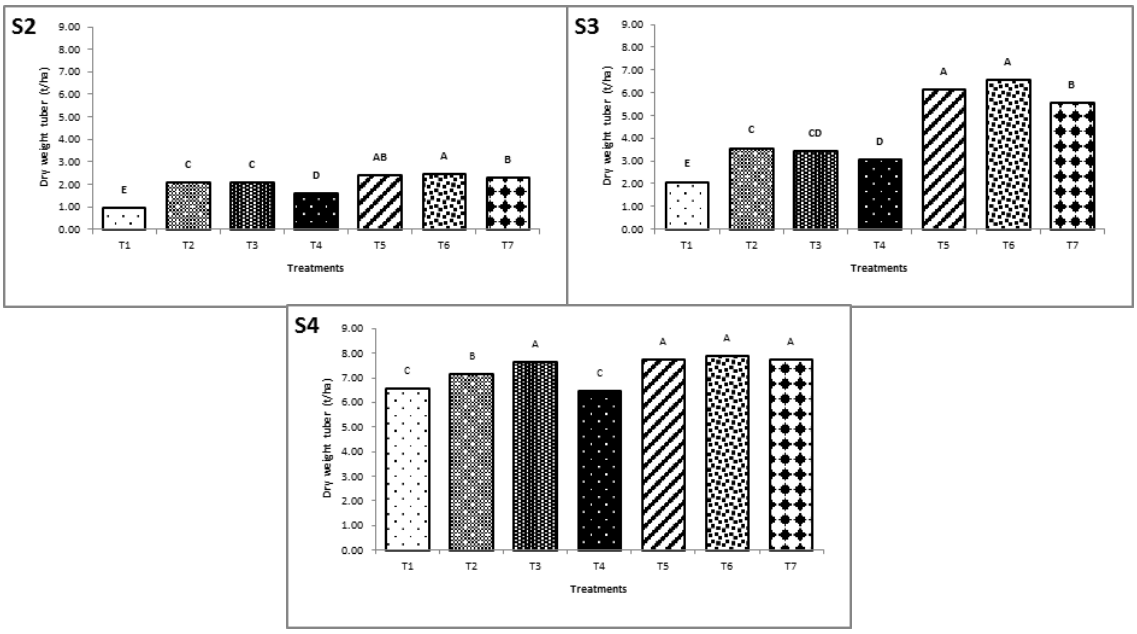


Figure 6. The effect of different N rates between NCU and NIU on dry weight of tuber (t/ha) of sweet potato at (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant difference (LSD). (Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.

3.5 Ammonium (NH_4)

High ammonium content in the soil promotes plant growth and improves tuber production, resulting in a greater yield. The variance analysis of studied in Figure 7 showed there were significant differences between different N rates of NCU and NIU fertilizer on the sweet potato as compared to farmer practices (control). Figure 7 showed the highest NH4 at S1 was recorded at T6 which increased by 26.3% while the lowest NH4 was recorded between T1 (control) and T4 which increased by 2.9% as compared to control treatment. At S2, the highest NH4 was reported at T6 which increased by 51.0% followed with T5 which increased by 38.9% as compared to control (T1). The lowest NH4 was reported at T4 which increased by 6.8% as compared to control treatment. Next, the highest NH4 at S3 was showed between T5 and T6 which increased by 29.6% and 31.7% respectively as compared to control (T1), followed by T3 (16.8%) and T7 (18.7%), while the lowest NH4 was showed between T1 (control), T2 and T4 when increased by 0.29% and 0.54% respectively as compared to control treatment. Lastly, at S4, the highest NH4 was recorded at T6 which increased by 100.4% followed with T5, T6, T3, and T2 which increased by 54.6%. 40.6%, 34.9% and 30.6% respectively as compare control (T1). The lowest NH4 was recorded between T1 (control) and T4 (6.6%). The comparison of mean values has proved that NIU fertilizer showed a better performance compared to NCU fertilizer.

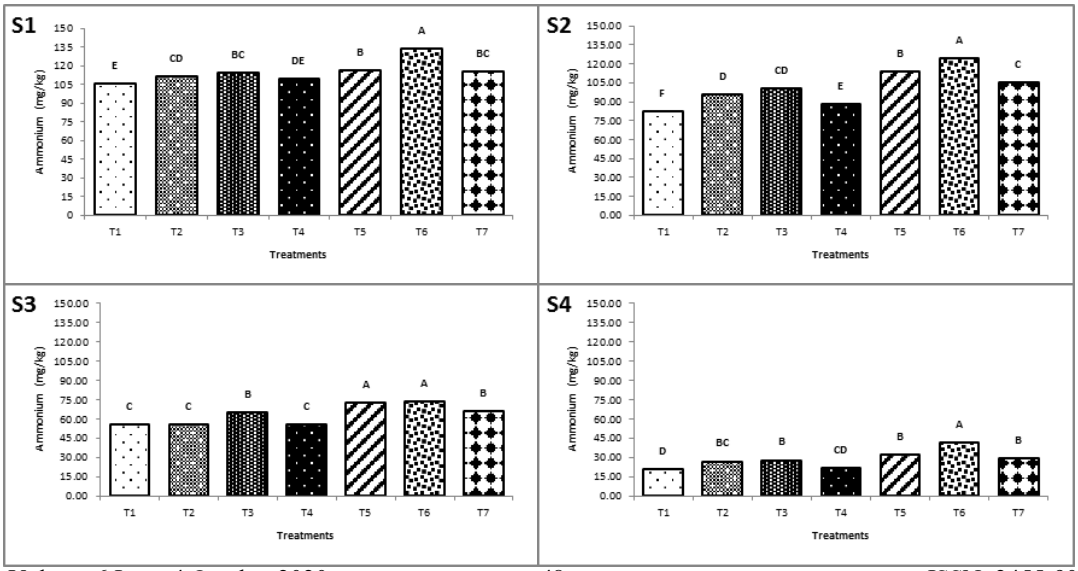


Figure 7. The effect of different N rates between NCU and NIU on Ammonium content of sweet potato at (S1) 26 DAP, (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant difference (LSD).(Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.

3.6 Nitrate (NO_3)

Figure 8 showed the highest NO_3 at S1 was recorded between T5 and T6 which increased by 47% and 54.6%. While the lowest NO_3 was recorded at T1 (control) however, there is no significant difference between T2 (7.8%) and T4 (5.7%) as compared to the control treatment. At S2, the highest NO_3 was reported at T6 which increased by 58.1% as compared to control (T1), followed with T5 (37.1%) and T7 (31.2%). The lowest NO_3 was reported between T1 (control), T2 (3.7%), and T4 (2.5%) respectively as compared to control treatment. Next, the highest NO_3 at S3 was showed at T6 which increased by 39.3% as compared to control (T1), followed with T5, T7, and T3 which increased by 23.7%, 24.0%, and 15.4% respectively. The lowest NO_3 was showed at T1 (control). Lastly, during S4, the highest NO_3 was recorded between T5 and T6 which increased by 56.7% and 61.0% respectively as compared to control (T1), followed with T3 (28.4%) and T7 (36.2%) respectively. while the lowest NO_3 was recorded between T1 (control), T2 (7.4%), and T4 (6.1%) as compared to control treatment.

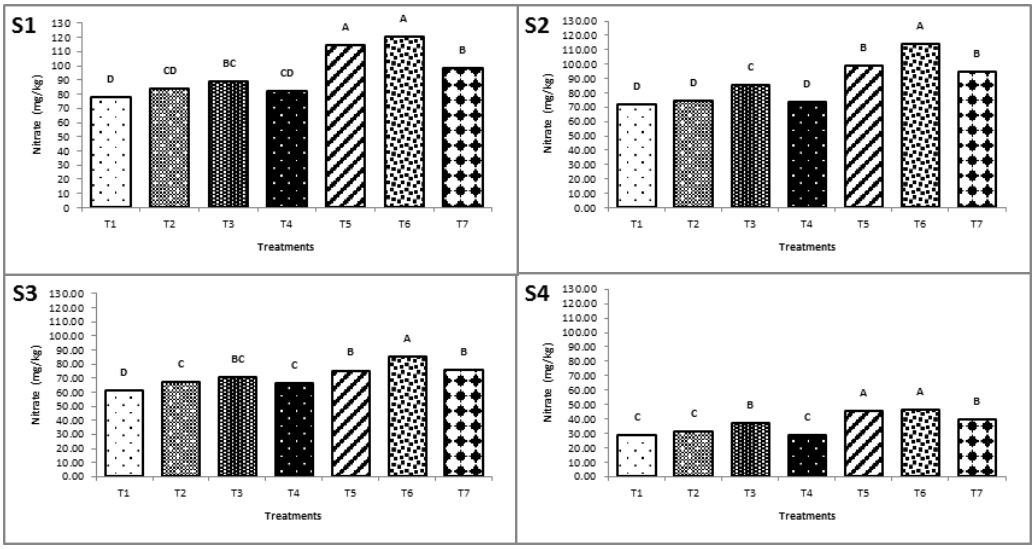


Figure 8. The effect of different N rates between NCU and NIU on Nitrate content of sweet potato at (S1) 26 DAP, (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant difference (LSD). (Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

3.7 Urea N determination

Mean values results represented in Figure 9 showed there were significant differences (P>0.05) between NCU fertilizer, NIU fertilizer, and farmer practices treatments. From the figure it showed the highest NUD at S1 was reported at T6 which increased by 286.5%, followed with T5 (206.4) and T7 (139.7%) respectively as compared to control (T1). While the lowest NUD was reported between T4 and T2 which increased by 39.7% and 55.3% as compared to control treatment. The highest NUD recorded at S2 was presented by T6 which increased by 376.2% followed with T5 (238.1%) and T7 (195.2%) respectively as compared to control (T1). While the lowest NUD was presented by T4 which increased by 61.9% as compared to control treatment. At S3, the highest NUD was showed by T6 which increased by 189.1% followed with T5, T6, and T3 which respectively increased by 166.3%, 161.9%, and 161.9% as compare control (T1). While the lowest NUD was presented by T4 (72.8%) as compared to control treatment. Lastly, the highest NUD was recorded by T6 which increased by 1071.6%, followed with T5 and T7 which respectively increased by 957.1% and 914.3% as compared to control (T1). While the lowest NUD was recorded at T4 which increased by 307.1% as compared to control treatment.

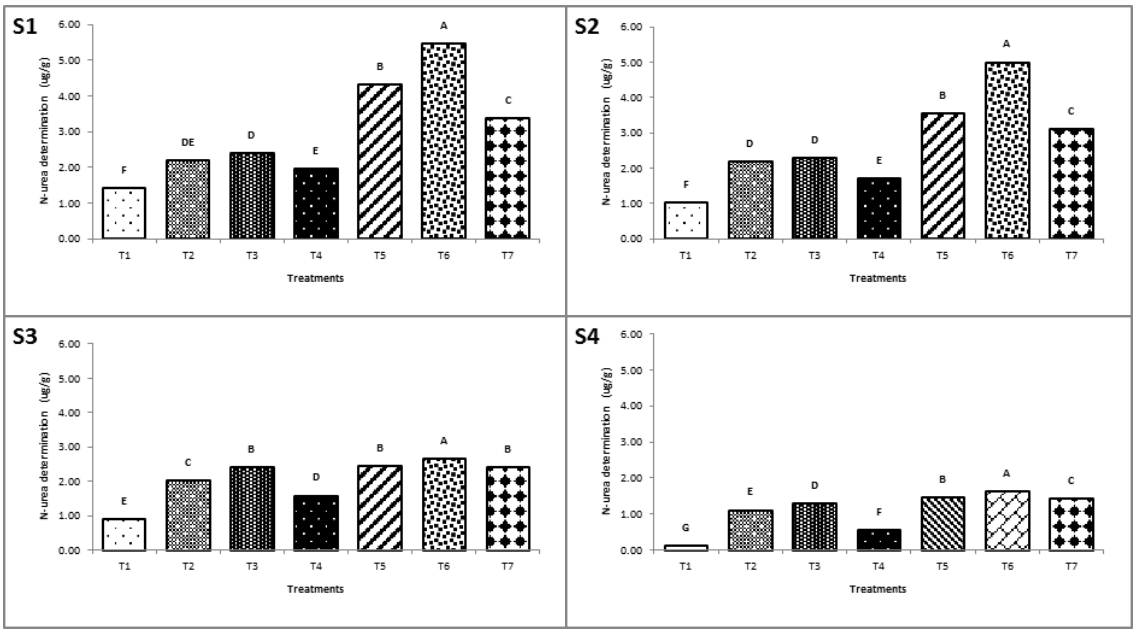


Figure 9. The effect of different N rates between NCU and NIU on N-urea determination of sweet potato at (S1) 26 DAP, (S2) 52 DAP, (S3) 78 DAP, and (S4) 104 DAP. Mean values with the same letter are not significant differences at P<0.05 by the least significant difference (LSD).(Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

3.8 Total N in soil, leaves, and tuber of sweet potato

Figure 10 presented of NIU fertilizer against NCU fertilizer which acts better performance in total N in soil (TNS), total N in the plant (TNP), and total N in tuber (TNT) as compared to control (T1). The highest TNP was recorded between T5, T6, and T7 which increased by 25.0%, 27.4%, and 21.8% respectively as compared to control (T1). However, T7 showed no significant difference with T3 which increased by 13.7% as compared to control (T1). The lowest TNP was recorded between T1 (control) with T2 and T4 which increased by 4.0% and 2.4% as compared to control treatment. The highest TNT was reported between T5 and T6 which increased by 47.3% and 53.3% respectively as compared to control (T1). Followed with T7 which increased by 36.5%. While the lowest TNP was recorded between T2 and T4 which increased by 19.2% and 18.6% as compared to control treatment. However, T2 showed no significant difference with T3 (26.3% as compared to control treatment.The highest TNS was showed between T3 and T6 which increased by 27.8% and 33.3% respectively as compared to control (T1), followed by T7 (5.6%). However, T7 showed no significant difference between T4 and T5. The lowest TNS was recorded at T1 (control) but recorded no significant difference between T2 and T4. Following the study by [14] which stated tuber crops that were treated with coating material proved a better result in total N, nitrogen uptake, phosphorus uptake, and potassium uptake while the lowest result showed at control treatment and untreated crops with the coating material.

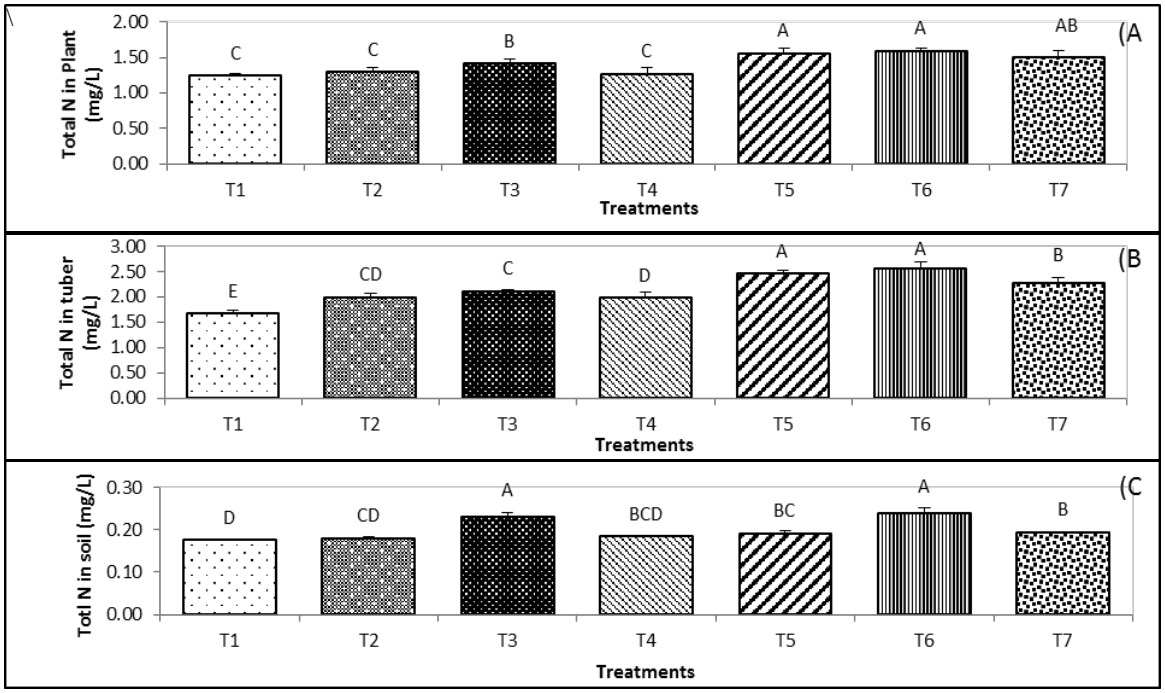


Figure 10. The effect of different N rates between NCU and NIU on yield (t/ha) of sweet potato at 104 DAP. Mean values with the same letter are not significantly different at P<0.05 by the least significant difference (LSD). (Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

3.9 The yield of sweet potato.

The variance analysis results of the study showed there were significant differences between all these treatments. Figure 11 was presented the yield of sweet potato that was recorded at 104 days after planting (DAP). The highest yield of sweet potato was showed at T6 which increased by 33.1% as compared to control (T1). However, T6 showed no significant difference between T3 and T5 which increased by 26.6% and 27.2% respectively as compared to the control treatment. While the lowest yield of sweet potato was recorded at T1 (control), but showed no significant difference with T4 which increased by 8.2% as compared to control treatment. The average mean values of sweet potato treated with NCU fertilizer (T2, T3, and T4) and NIU fertilizer (T5, T6, and T7) showed there was significant difference which increased by 16.1% and 26.6% respectively as compared to control treatment [15] and [16] has stated, sweet potato treated with coating material can improve the yield of sweet potato and reach a marketable size up to 12 – 19%. This is because the coating material can avoid or minimize the N losses through denitrification, nitrification, and leaching. In many cases showed there was significant effect on other crops too, it similar to trials with maize and sugarcane by [17], which proved the treated fertilizer initiated substantially more plant leaf N and more corn grain as well as highly recoverable sugar (ethylene receptors structure) % cane and fibre % cane values than equivalent uncoated fertilizer.

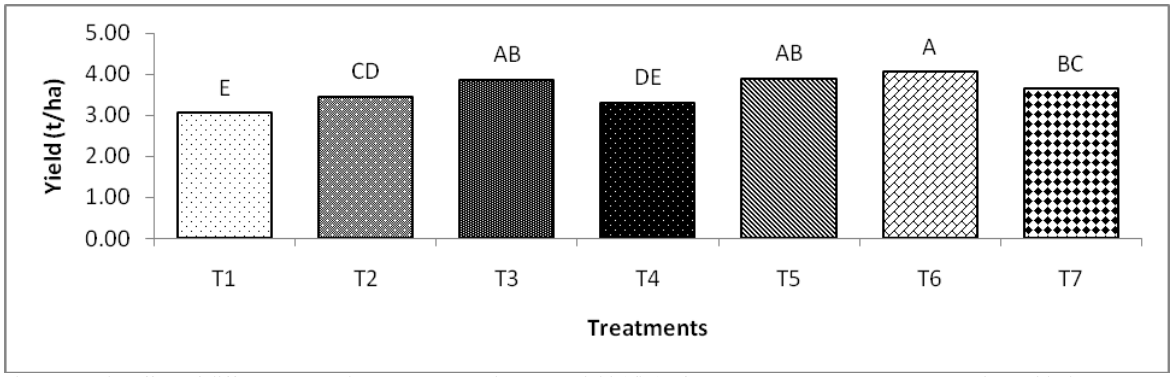


Figure 11. The effect of different N rates between NCU and NIU on yield (t/ha) of sweet potato at 104 DAP. Mean values with the same

letter are not significantly different at P<0.05 by the least significant difference (LSD). (Note: T1 = Farmer practices (120 kg N/ha urea); T2 = 72 kg N/ha NCU; T3 = 96 kg N/ha NCU; T4 = 120 kg N/ha NCU; T5 = 72 kg N/ha NIU; T6 = 96 kg N/ha NIU; and T7 = 120 kg N/ha NIU.)

IV. CONCLUSION

In conclusion, both NBPT coated urea (NCU) and NBPT incorporated urea (NIU) fertilizer showed a significant effect on the sweet potato as compared to farmer practices (urea alone). However, NIU fertilizer showed better performance as compare to NCU fertilizer on shoot fresh weight at S3 and S4, tuber fresh weight at S2 and S3, shoot dry weight at S4, tuber dry weight at S2 and S3, nitrate at S2, N-urea determination at S1, S2 and S4, total N in tuber at S4. However, the total yield of sweet potato was recorded no significant difference between NCU fertilizer and NIU fertilizer. Coating material that contains urease inhibitor either in coating or incorporating method was proved to improve N available for the plant. Thus, 72 kg N/ha NIU (T5), 96 kg N/ha NIU (T6), and 96 kg N/ha NCU (T3) was the recommendation ratio of fertilizer to the farmer to maximize the tuber production while both have the advantage in controlling N losses to the environment.

REFERENCES

[1] Christianson C.B., and Vlek P.L.G. Alleviating soil fertility constraints to food production in West Africa: Efficiency of N fertilizer applied to food crops. In: Alleviating soil fertility constraints to increase crop production in West Africa. Mokwunye U (Ed.), Kluwer Academic Publichers, Dordrecht. Netherlands pp. 45-59, 1991.

[2] Désiré, T.V., Gilles, N., and Claude, S. Evaluation of different sweet potato varieties for growth, quality and yield traits under chemical fertilizer and organic amendments in sandy ferralitic. Soils African J. Agric. Res, 12(48), 3379-88, 2017.

[3] Dinesh, R., Srinivasan, V., Ganeshamuthry, A.N., and Hamza, S. Effect of organic fertilizers on biological parameters influencing soil quality and productivity (Book Chapter), 2012.

[4] Fageria, N.K., Santos,A.B. and Cutrim, V.A. 2011. Productivity and nitrogen use efficiency of lowland rice genotypes. Proceedings of the 2nd Brazilian Rice Productivity Congress April 26-28, 2006, Brasilia, DF., Brazil, 2011.

[5] Girma, K., Teal, R.K., Freeman, K.W., Boman, R.K. and Raun, W.R. Cotton Lint Yield and Quality As Affected by Applications of N, P, and K Fertilizers. The Journal of Cotton Science 11:12–19, 2007.

[6] Hendrickson, L.L., and Douglass, E.A. Metabolism of the urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT) in soils. Soil Biol. Biochem. 25, 1613–1618, 1993.

[7] Hue, S.M., Chandran, S., Boyce, A.N. Variations of leaf and storage roots morphology in *Ipomoea batatas* L.(Sweet potato) cultivars. In Asia Pacific Symposium on Postharvest Research, Education and Extension 943, pp. 73-79, 2010.

[8] Islam, M.K., Akhteruzzaman, M., Ullah, M.S. Effect of poultry manure and inorganic fertilizer on the productivity of cotton. Journal of Agroforestry and Environment, 7(1), 31-36, 2013.

[9] Junejo, N., Khanif, M. Hanfi, M.M., Wan, MDZ.W.Y, and Dharejo, K.A. Maize response to biodegradable polymer and urease inhibitor coated urea. Int. J. Agric. Biol., 12: 773–776, 2010.

[10] Laurenece, R.C.N., Armour, J.D., Shophered, RK, Leader, L.R. and Dwyer, MJ.Nitrogen fertilizer requirements of irrigated potatoes on the Athertable land north queen land. Australian Journal of Experimental Agricultural. 25:924-958, 1985.

[11] Magagula, N.E.M., Ossom, E.M., Rhykerd, R.L., & Rhykerd, C.L. Effect of CM on soil properties under sweet potato (*Ipomoea batatas* (L.) Lam) culture in Swaziland. American-Eurasian Journal of Agronomy, 3(2), 36-43, 2010.

[12] Masarirambi, M.T., Dlamini, P., Wahome, P.K., and Oseni, T.O. Effects of CM on growth, yield and quality of lettuce (*Lactuca sativa* L.)'Taina'under a lath house in a semi-arid sub-tropical environment. American-Eurasian J. Agric. & Environ. Sci, 12(3), 399-406, 2012.

[13] Niassy, S., and Diarra, K. Effect of organic inputs in urban agriculture and their optimization for poverty alleviation in Senegal, West Africa. Organic Fertilizers: Types, Production and Environmental Impact, 1-22, 2012.

[14] O'Sullivan, J.N., C. J. Asher, and F.P.C. Blamey. Nutritional Disorders of Sweetpotato. ACIAR Working Paper No. 45. Dept. of Agr. University of Queensland, Brisbane. 75pp, 1995.

[15] Patidar, R., Gaur, D., Singh, S.P., Sharma, K., Sharma, S.K., Dhakad, H., and Dixit, J.P. Evaluation of different fertilizer coating material to increase Nitrogen use efficiency in potato (*Solanum tuberosum* L.). IJCS, 5(6), 147-151, 2017.

[16] Schwab, G. J., and Murdock, L. W. Department of Plant and Soil Science. Nitrogen transformation inhibitors and controlled release urea. Cooperative extension service, University of Kentucky, College of Agriculture, Lexington Kentucky. Accessed on November 23, 2014.

[17] Tewolde, H. and Fernandez, C.J.Vegetative and reproductive dry weight inhibition in nitrogen and phosphorus deficient Pima cotton. J. Plant Nutr. 20:219-232, 1997.