Effectiveness of Urea-Coated Fertilizer on Young Immature Oil Palm Growth

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***Abstract*—Urea-coated fertilizers were invented to reduce ammonia volatilization and act as slow-release fertilizers in the oil palm field. This study was designed to examine the effectiveness of three types of urea-coated fertilizers namely Urease Inhibitor-coated urea 25% N (UICU), resin-coated urea 43% N (RCU), Sulphur-coated urea 32% N (SCU), uncoated urea 46% N (UU) and uncoated AS, (SOA) 21%N on oil palm early growth. The trial commenced from planting of the new oil palms until 36 months after planting (MAP). The fertilizer rates were applied with equivalent nutrient content of conventional compound fertilizer, NPKMg (9/9/12/4+0.5%B-AS based) as Control (Co) treatment. From the analysis, RCU showed significantly bigger girth size over UU and UAS by 13%, respectively starting at 18 MAP and 24 MAP while SCU recorded significant performance over UU by 8% at 36 MAP. The result also showed that SCU produced significantly longer fronds over Co, UU and UAS by 9%, 13% and 10%, respectively at 30 MAP. The similar performance was shown by SCU which produced bigger petiole cross section (PCS) and higher leaf dry weight over UU and Co at 30 to 36 MAP respectively. Foliar analysis found that higher leaf-N was recorded at the SCU plot and exceeded the UU by 18% and over the critical level by 7% at 24 MAP. From the results, it indicated that SCU had consistent performance over UU on girth size, frond length, PCS, leaf dry matter and leaf-N content. Even though there was no significant difference between the other types of urea coated fertilizers, SCU was able to produce more vigorous vegetative growth. Therefore, SCU fertilizer can be used as an alternative source of urea to improve immature oil palm growth especially in dry regions where high volatilization rate occurs.**

***Index Terms*—urea-coated fertilizer, ammonia volatilization, oil palm replanting**

I. Introduction

Urea has the highest nitrogen content (46% N) of all solid nitrogenous fertilizers that are common for oil palm such as Sulphate of Ammonia, SOA (21% N), ammonium nitrate, AN (26% N) and ammonium chloride, NH4Cl (25% N). The N losses from urea by volatilization caused by the immediate increase in pH and NH_4 concentration during the enzyme urease activity around the fertilizer micro site [1]. Substantial literatures [2]-[4] stated that N volatilization from urea-based compound fertilizer was low (2%) compared with urea-based straight fertilizer due to the inhibitive effect of KCl and MgO. The use of AN in inorganic fertilizer is particularly damaging, as plants have a preference for ammonium ions over nitrate ions during absorption, while excess nitrate ions which are not absorbed will dissolve into groundwater and cause soil acidification. Ammonia volatilization from urea on Typic Hapludox soil was about 41% over 10 days [5]. Likewise, losses of 27% N of urea by volatilization was reported at the third day of incubation for Typic Kandiudult soil [6]. Urea in the form of controlled release fertilizers (CRFs) have been used for many years starting with sulphur coated urea which provided a longer lasting nitrogen supply combined with lower application cost [7]. CRF can be an alternative form of urea fertilizer to reduce losses by its ability to limit water solubility and to delay the release of N to the soil [8]. The early sulphur coated materials did not always give a uniform response due to the structure cracking or uneven thickness causing the fertilizer granules to break down at different times. Other than sulphur, resin coats have better control of the fertilizer release. Polymer coats also look promising for widespread use in agriculture because they can be designed to release nutrients in a more controlled manner by manipulating properties of polymer coating. It is hypothesized that the volatilization rate and nutrient leaching of urea fertilizer can be minimized and improved fertilizer efficiency can be achieved as compared to conventional urea fertilizer.

II. Materials and Methods

This study was carried out at Phase B, FASSB Jengka 24 Station located in Pahang, Malaysia from new planting until 36 months after planting (MAP). The annual and monthly rainfall is about 2,579 mm and 227 mm respectively. Oil palms of DXP Yangambi (ML 161 crosses) origin were planted at a density of 148 palms per hectare on flat to gently undulating terrain dominated by *Typic Kandiudult* soil types. The fertilizer rates applied were equivalent nutrient content with conventional compound fertilizer, NPKMg (9/9/12/4+0.5%B-AS based) as Control (Co) treatment (TABLE I). Each treatment consisted of 32 palms with plot size of 4 rows x 8 palms with three replications and the centre plot (2 rows x 6 palms) was selected as recording palms. The parameters measured were vegetative growth including girth size and frond measurement every six months, chlorophyll content

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by using SPAD Chlorophyll Meter every three months and foliar sampling every six months. Equation (1), (2) and (3) were used to calculate the petiole cross section (PCS), leaf dry weight (LDW) and leaf area index (LAI), respectively. Frond number-9 was used as a standard foliar sampling protocol [9]. The data obtained were tested for their significance using the one-way analysis of variance (ANOVA) and the mean values were ranked using Tukey test by using SAS package version 9.3 for windows.

$$\textit{Frond width(cm) x frond depth (cm)} = \textit{PCS}, P\,(cm^2) \quad (1)$$

$$0.1023P + 0.2062 = \textit{LDW}, W\,(kg); \text{ where } P \text{ is the petiole cross-section} \quad (2)$$

$$\textit{Leaflet length (m) x Leaflet width (m) x number of leaflet} = \textit{LAI}\ (m^2) \quad (3)$$

TABLE I. APPLICATION OF EQUIVALENT NUTRIENT CONTENT OF EACH TREATMENT FROM 1 MAP UNTIL 36 MAP.

Palm Age	Nutrient application (kg palm^{-1}year^{-1})					
	UCPD /Control (Co)*	UICU	RCU	SCU	UU	UAS
1-12 MAP	**N:** 0.36; $\mathbf{P_2O_5}$**:** 0.69; $\mathbf{K_2O}$**:** 0.48; **MgO:** 0.16; **B:** 0.02					
13-24 MAP	**N:** 0.59; $\mathbf{P_2O_5}$**:** 0.58; $\mathbf{K_2O}$**:** 1.68; **MgO:** 0.26; **B:** 0.03					
25-36 MAP	**N:** 0.67; $\mathbf{P_2O_5}$**:** 0.57; $\mathbf{K_2O}$**:** 1.90; **MgO:** 0.40; **B:** 0.05					

**Conventional fertilizer, NPKMg (9/9/12/4+0.5%B-AS based)*

III. RESULTS AND DISCUSSIONS

Table II summarized the performance of different types of urea coated fertilizers on vegetative growth. The early observation showed that initial response of urea-coated fertilizers was seen as early as 18 MAP particularly on girth size which RCU gave significantly bigger girth size than UU and UAS by 13%, respectively. This trend was similarly recorded at 24 MAP, when UU recorded significantly smaller girth size as compared with RCU (p-value<0.01). At 36 MAP, SCU showed good response on girth growth which was significantly bigger than UU by 8% (p-value<0.01). The frond length parameter only had significant effect at 30 MAP by SCU when it produced longer fronds than Co, UU and UAS by 9%, 13% and 10%, respectively. In term of PCS, SCU produced bigger frond size significantly over UU (24%) at 30 MAP and over Co (21%) at 36 MAP. The similar trend was shown in LDW as the value will increase proportionally with the increasing value of PCS [9]. The nutritional result from foliar sampling revealed that UCPD only showed significant difference over UICU by 13% at 18 MAP. Meanwhile SCU produced higher leaf-N content over UU (18%) at 24 MAP (Table III). All treatments did not show any significant effect on chlorophyll content and LAI at all. From the results, it indicated that coated urea (SCU) had improved immature palm growth and nutritional aspect as compared with uncoated urea (UU) due to the ability of SCU to remain the available nitrogen in the fertilizer to be transported for palm growth [10].

TABLE II. EFFECT OF UREA COATED FERTILIZERS ON YOUNG IMMATURE OIL PALM VEGETATIVE GROWTH.

Trt.	Girth size (cm)					
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP
UCPD	12.26	25.42	36.85ab	49.01ab	51.61	61.48ab
UICU	12.45	25.93	36.50ab	49.42ab	53.47	61.44ab
RCU	12.44	26.09	40.08a	51.89a	55.99	61.51ab
SCU	12.17	26.00	38.08ab	51.11ab	56.87	61.73a
UU	12.19	23.82	35.00b	47.85b	49.79	57.00b
UAS	12.30	24.91	35.15b	49.04ab	54.29	59.26ab
ANOVA	ns	ns	*	**	ns	**
CV (%)	4.74	11.04	4.03	2.50	5.84	2.73
Trt.	**Frond length (m)**					
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP
UCPD	1.26	1.55	2.07	2.33	2.77bc	3.04
UICU	1.30	1.59	2.10	2.34	2.85abc	3.15
RCU	1.26	1.61	2.27	2.45	2.94ab	3.21
SCU	1.28	1.64	2.19	2.50	3.03a	3.37
UU	1.26	1.55	2.09	2.48	2.65c	3.00
UAS	1.26	1.54	2.02	2.16	2.72bc	3.14
ANOVA	ns	ns	ns	ns	**	ns
CV (%)	2.29	4.39	4.88	7.85	3.20	4.90
Trt.	**Petiole Cross Section, PCS (cm^2)**					
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP
UCPD	3.82	5.26	9.03	8.74ab	9.54ab	11.03b
UICU	3.99	5.91	8.78	8.69ab	9.81ab	12.34ab
RCU	3.76	5.72	9.13	9.61ab	10.63ab	13.10ab

SCU	3.74	5.91	8.92	10.00a	11.44a	14.04a
UU	3.78	5.79	7.93	7.75b	8.75b	11.51ab
UAS	4.10	5.59	8.29	8.67ab	9.99ab	12.65ab
ANOVA	ns	ns	ns	ns	*	*
CV (%)	12.35	6.91	6.64	8.35	8.23	8.32
Trt.	Leaf Dry Weight, LDW (kg)					
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP
UCPD	0.60	0.74	1.13	1.10ab	1.18ab	1.33b
UICU	0.61	0.81	1.10	1.10ab	1.21ab	1.47ab
RCU	0.59	0.79	1.14	1.19ab	1.29ab	1.55ab
SCU	0.59	0.81	1.12	1.23a	1.38a	1.64a
UU	0.59	0.80	1.02	1.00b	1.10b	1.38ab
UAS	0.63	0.78	1.05	1.09ab	1.23ab	1.50ab
ANOVA	ns	ns	ns	ns	*	*
CV (%)	8.37	5.12	5.33	6.69	6.88	7.12
Trt.	Leaf Area Index, LAI (m2)					
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP
UCPD	0.26	0.58	1.02	1.18	1.31	1.50
UICU	0.30	0.64	0.97	1.22	1.33	1.59
RCU	0.26	0.64	1.04	1.32	1.36	1.76
SCU	0.29	0.61	0.99	1.29	1.45	1.82
UU	0.25	0.57	0.86	1.11	1.27	1.49
UAS	0.30	0.65	0.93	1.17	1.39	1.71
ANOVA	ns	ns	ns	ns	ns	ns
CV (%)	10.53	12.56	10.83	8.35	11.25	10.12
Trt.	Chlorophyll (SPAD)					
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP
UCPD	16.79	52.75	59.86	73.97	72.55	72.00
UICU	16.72	37.31	55.60	72.43	71.69	68.39
RCU	18.30	55.22	61.70	73.85	70.48	73.24
SCU	18.94	57.84	63.67	74.14	69.90	72.68
UU	20.44	58.63	58.70	74.13	68.72	72.36
UAS	16.09	42.38	56.48	71.40	70.56	70.09
ANOVA	ns	ns	ns	ns	ns	ns
CV (%)	42.82	43.71	9.59	2.44	4.34	4.04

*Note: mean values with different letters within the column are significantly different at: * - significant at p<0.05; ** - significant at p<0.01; ns-not significant at p<0.05, as determined by Tukey's test.*

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TABLE III. EFFECT OF UREA COATED FERTILIZERS ON LEAF-N CONCENTRATION.

Trt.	N (%)				
	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP
UCPD	2.94	2.73	2.70a	2.42ab	2.74
UICU	2.86	2.74	2.35b	2.37ab	2.75
RCU	2.88	2.51	2.46ab	2.55ab	2.64
SCU	2.94	2.47	2.59ab	2.73a	2.68
UU	2.78	2.57	2.42ab	2.24b	2.71
UAS	3.01	2.41	2.42ab	2.57ab	2.79
ANOVA	ns	ns	*	*	ns
CV (%)	6.13	6.41	5.09	6.57	4.35

Note: mean values with different letters within the column are significantly different at:
** - significant at p<0.05; ns-not significant at p=0.05, as determined by Tukey's test.*

IV. CONCLUSION

This study found that as compared with uncoated urea, the coated urea (SCU) had improved early palm growth. Even though there was no significant difference between the other types of urea coated fertilizers, SCU was able to produce more vigorous vegetative growth. It clearly showed that utilization of sulphur as a coating agent showed better results for immature oil palm growth. Therefore, urea-coated fertilizer particularly SCU can be used as an alternative urea fertilizer especially for dry regions where the volatilization rate occurs a higher rate. The effectiveness of different coating agent on FFB yields of oil palm deserves more attention in any future study of oil palm nutrition research.

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