Effects of Urea and Calcium-Boron Applied At Flower-Bud Stage on 'Md2' Pineapple Fruit

Roel R. Dayondon[1] and Vences C. Valleser[2]

[1/]PhD Student, Department of Soil Science, College of Agriculture, Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines
[2/]Faculty Member, Department of Horticulture, College of Agriculture, Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines

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Abstract: Nitrogen (N), calcium (Ca) and boron (B) are among the most important nutrients needed by plants to have better yield and fruit quality. These nutrients can be supplied in the form of urea (46% N) and liquid calcium-boron (6% Ca and 2% B) fertilizers. Hence, a study to evaluate the effects of varying rates of urea and calcium-boron (CaB) fertilizer applications at flower-bud stage on 'MD2' pineapple fruit was conducted. The experiment was laid out in 4x4 split plot in randomized complete block design (RCBD). Rates of urea (0, 25, 50 and 75 kg ha^{-1}, respectively) served as the main plot, whereas the rates of CaB (0, 20, 30 and 40 L ha^{-1}, respectively) served as the sub plot.

Applications of urea and CaB fertilizers at flower-bud stage did not significantly influenced the total soluble solids and titratable acidity of 'MD-2' pineapple fruit. On the other hand, fruit weight and translucency incidence (TI) were significantly affected by sole application of either urea or CaB. Heaviest fruits were obtained with sole application of 75 kg ha^{-1} urea, however TI was also highest at this rate. Moreover, sole application of CaB at 30 L ha^{-1} improved the fruit weight and reduced the TI. The results imply that sole application of urea and CaB affects the fruit weight as well as translucency incidence in 'MD-2' pineapple.

Keywords: foliar fertilizer, urea, calcium boron, pineapple quality, 'MD-2' pineapple, flower-bud stage

INTRODUCTION

Pineapple (*Ananas comosus* L.) is found in almost all tropical and subtropical areas of the world, and it ranks third in production of tropical fruits, behind bananas and citrus (Paull and Duarte, 2011). In the Philippines, production of pineapple in January-March 2016 reached 591.25 thousand metric tons (Philippine Statistics Authority, 2016) of which mostly were exported to other countries for fresh consumption.

Pineapple has high requirements for nitrogen (N) and relatively low requirements for calcium (Ca) and boron (B) (https://www.ipipotash.org/udocs/10_Pineapple.pdf). N and B are effective if applied through foliar spray, whereas Ca can be applied in the forms of dolomite ($CaMg[CO_3]_2$) and calcium carbonate ($CaCO_3$) prior to land preparation depending on the soil analysis results (T. Castro, personal communication, November 6, 2012). Applications of N, Ca and B in the forms of urea (46% N) and liquid calcium boron or CaB (6% Ca and 2% B) fertilizers after flower induction treatment is dependent on the D-leaf nutrient levels as practiced by Mt. Kitanglad Agricultural Development Corporation (MKADC) commercial pineapple farm in Bukidnon, Philippines (T. Castro, personal communication, November 6, 2012) to save cost and prevent nutrient toxicities.

Hence, this study was conceptualized to evaluate the effects of urea and CaB fertilizers on the fruit weight and quality of 'MD-2' pineapple. Specifically, the study aimed to (1) evaluate the effects of varying rates of urea applied at flower-bud stage on fruit weight and quality of 'MD-2' pineapple, (2) assess the effects of the varying rates of CaB applied at flower-bud stage on fruit weight and quality of 'MD-2' pineapple, (3) determine the optimum rate of urea and CaB fertilizers applied at flower-bud stage on fruit weight and quality of 'MD-2' pineapple and (4) identify the best treatment combination that will improve the fruit weight and quality of 'MD-2' pineapple.

MATERIALS AND METHODS

The experiment was conducted on April 2012 to October 2012 at Mt. Kitanglad Agricultural Development Corporation (MKADC), Valencia City, Bukidnon, Philippines. The experimental site had an elevation of 500 meters above sea level with average daily temperature ranging from 22°C to 32°C.

The study was super-imposed on May 15, 2012 (45 days after flower induction treatment or flower-bud stage) at MKADC commercial field with existing pineapple plants with uniform growth and no plant mortality incidence. The experiment was arranged in a 4 x 4 split plot in a randomized complete block design (RCBD). The main plot consisted of four rates (0, 25, 50 and 75 kg ha^{-1}, respectively) of urea fertilizer whereas the four liquid CaB fertilizer rates (0, 20, 30 and 40 L ha^{-1}, respectively) comprised the sub plot as shown on Table 1.

Table 1. Treatments and treatment combinations

RATE OF UREA, kg ha^{-1} (Main plot)	RATE OF CALCIUM BORON LIQUID FERTILIZER, L ha^{-1} (Sub plot)	TREATMENT COMBINATION	TREATMENT CODE
A_1– 0 (control)	0 (control)	A_1B_1	T_1
	20	A_1B_2	T_2
	30	A_1B_3	T_3
	40	A_1B_4	T_4
A_2 – 25	0	A_2B_1	T_5
	20	A_2B_2	T_6
	30	A_2B_3	T_7
	40	A_2B_4	T_8
A_3 – 50	0	A_3B_1	T_9
	20	A_3B_2	T_{10}
	30	A_3B_3	T_{11}
	40	A_3B_4	T_{12}
A_4 – 75	0	A_4B_1	T_{13}
	20	A_4B_2	T_{14}
	30	A_4B_3	T_{15}
	40	A_4B_4	T_{16}

Each treatment was replicated three times resulting in 48 experimental plots. Each plot had an area of 19.5 m^2 consisting of three seedbeds with 150 plant samples. 50 plants served as data row (inner seedbed) and 100 plants served as the border rows (outer seedbeds). Urea (46% N) was used as the N source and Stoller CaB (6% Ca and 2% B) liquid fertilizer as Ca and B sources.

Foliar fertilizer application was done at 6-8 am using a pre-calibrated knapsack sprayer to discharge 1,000 L ha^{-1}. Treatments were applied at 45 days and at 90 days after the flower induction treatment (flower-bud stage).

Data Gathered

Fruits were harvested at shell/peel color index 2-3. The following data were gathered:

1. Total soluble solids (TSS) (ºBrix)- five randomly selected fruits (1.5 - 1.75 kg) per experiment plot were utilized for this data. Pineapple fruit juice was collected per fruit sample and TSS was determined following the standard procedure (https://archive-resources.coleparmer.com/Manual_pdfs/Sku8115008.pdf) using a refractometer.

2. Titratable acidity (TA)- 10 mL of pineapple juice was placed inside a beaker, and 2 mL of phenolphthalein solution was added. Titration then followed by adding a basic solution (0.1 N NaOH) to the fruit juice until the color turned to light red. The equation below was then used to determine the TA.

   TA = mL NaOH added x 0.1 (NaOH concentration) x 0.064 x 100 ÷ volume of juice

3. Mean fruit weight- 50 fruit samples in the data row were weighed using a pre-calibrated digital weighing scale. Mean fruit weight was determined using the equation:

   $$\text{Average fruit weight (kg)} = \frac{\sum \text{fruit weight}}{50}$$

4. Translucency incidence (TI)- translucency occurs when the fruit cell membranes lose some integrity and allow water to move across into the spaces between the cells (Bartholomew et al., 2003). Translucent fruit has water-soaked appearance and starts to ferment giving poor flavor. In this experiment, 50 fruit samples were visually examined for translucency incidence. At first, fruits were subjected to floatation method in water. The ones that sunk were accounted as translucent fruits (more than 10% of the internal flesh exhibiting translucency). To further verify the translucency incidence, fruits that float in water were sliced into vertical halves. Fruits with more than 10% of the internal flesh exhibiting translucency were recorded. Translucency incidence (TI) in fruits was determined using the equation:

   $$\text{TI (\%)} = \frac{\sum \text{translucent fruits}}{50} \times 100$$

Data gathered were subjected to analysis of variance (ANOVA). Treatment means of significant data/parameters were compared using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Total Soluble Solids

Total soluble solids (TSS) is one of the indices used in determining pineapple maturity. To ensure acceptable flavor, a minimum TSS of 13^{O} is required (https://www.daf.qld.gov.au/__.../Ch-7-Fresh-Fruit-Varieties.pdf). The TSS of ‘MD-2’ pineapple fruits ranged from 13.95^{O} to 14.23^{O} (Table 2) and were comparable in all rates of urea applied. This result supports the report of Py et al (1987) that an increase in N may not affect TSS of pineapple. Further, application of the varying CaB rates resulted to TSS values of ‘MD-2’ pineapple fruit ranging from 13.87^{O} to 14.23^{O} and were still comparable. Moreover, no interaction effects were observed between rates of urea and CaB on the TSS content of ‘MD-2’ pineapple fruit. Results imply that applications of urea and CaB at flower-bud stage of ‘MD-2’ pineapple has no effect on the TSS content of ‘MD-2’ pineapple fruits.

Titratable Acidity

Titratable acidity (TA) is often expressed as citric acid. TA of ‘MD-2’ pineapple fruits ranged from 0.6 to 0.85 and were comparable in sole applications of urea and CaB fertilizers as well as the treatment combinations (Table 2). These results contradict the report of Py et al (1987) of which free acids in pineapple fruit was reduced as N rate increases. Further, TA values of ‘MD-2’ pineapple fruits in this experiment was detected to be slightly higher compared to the report of Valleser and Castro (2018) with only 0.48. This could be attributed by the weather condition during fruit development. In the absence of significant variation in environment temperature, irradiance can affect titratable acidity. Bartholomew et al (2003) reported that titratable acidity increased from 0.74 to 1.4% as light was decreased from ambient to 50% of ambient levels.

Fruit Weight

Results revealed that urea application at flower-bud stage had significant effects on the fruit weight of ‘MD-2’ pineapple fruit (Table 3). Application of 75 kg ha^{-1} urea produced heavier (1.52 kg) fruits, followed by the application of 50 kg ha^{-1} urea with mean fruit weight of 1.44 kg which was comparable to fruits (1.37 kg) produced with 25 kg ha^{-1} urea application. No urea application resulted to the lightest mean fruit weight (1.30 kg). Urea has 46% N which influence fruit enlargement when applied during the flower-bud stage of ‘MD-2’ pineapple (T. Castro, personal communication, November 6, 2012) but rate should be optimized to prevent high translucency incidence. Moreover, Bhugaloo (1999) reported that an increase in fruit weight can be obtained through higher dose of nitrogen application. When nitrogen is deficient, fruit and crown mass are consequently reduced. Also, Bartholomew et al. (2003) reported that increasing amount of nitrogen applied after flower induction treatment improves pineapple fruit weight.

On the other hand, fruit weight of ‘MD-2’ pineapple was significantly augmented through CaB fertilizer application. 30 L ha^{-1} of CaB application resulted to the heaviest fruit weight (1.48 kg), followed by the application of 40 L ha^{-1} of CaB with fruit weight of 1.43 kg. Lower rates of CaB (20 L ha^{-1} and 0 L ha^{-1} or the control) produced inferior fruit weights with 1.38 and 1.34 kg, respectively. The fruit weight increment could be attributed to B rather than Ca. Lin and Chen (2011) reported that ‘Tainong No. 13’ pineapple fruit weight was better even without Ca (in the form of dolomite) applied. On the other hand, application of B contributed to the improvement of ‘Comte de Paris’ pineapple fruit weight (Wei et al., 1956). Lin and Chen (2011) also stated that pineapple fruit weight was improved with the application of 30 kg ha^{-1} of borax. On the contrary however, Maeda et al (2011) reported that fruit weight of ‘Smooth Cayenne’ pineapple was not significantly affected by B, but high yield was obtained even with below adequate contents in the soil. With regards to fruit weight, these findings imply that different pineapple varieties inevitably have different responses to Ca and B applications.

Meanwhile, no significant interaction effects were observed between the varying rates of urea and calcium boron on the fruit weight of ‘MD-2’ pineapple.

Translucency Incidence

Translucency occurs when the fruit cell membranes lose some integrity and allow water to move across into the spaces between the cells (Bartholomew et al., 2003). Translucency in pineapple is associated with cultivar. For instance, ‘MD-2’ pineapple develop translucency substantially diminishing its normally very aromatic flavour than ‘Smooth Cayenne’ cultivar (Sanewski, 2008). Translucency incidence (TI) in ‘MD-2’ pineapple fruits in response to the varying rates of urea application ranged from 12.83% to 20.50% (Table 3). The application of 75 kg ha^{-1} urea resulted to highest ‘MD-2’ pineapple TI, followed by the treatment where no urea was applied (15.67 %), which was comparable with the application of 50 kg ha^{-1} urea (15.50%). Application of 25 kg ha^{-1} urea significantly reduced the ‘MD-2’ pineapple fruit TI to only 12.83%. Higher amount of N resulted also to high translucency incidence (T. Castro, personal communication, November 6, 2012) as what MKADC farm have had experienced in growing ‘MD-2’ pineapple.

On the other hand, translucency incidence of ‘MD-2’ pineapple at varying rates of CaB application ranged from 11.83% to 25.83%. No CaB application led to the highest TI, followed by the application of 20 L ha^{-1} CaB with 14%. The application of higher rates of CaB (30 L ha^{-1} and 40 L ha^{-1}) significantly reduced the TI to only 12.83% and 11.83%, respectively. Translucency in pineapple is often associated with Ca nutrition rather than B. When fruit cannot acquire sufficient Ca, cell membranes may lose integrity and lead to leakage and translucency (Silva et al., 2001). Calcium application has been associated with reduced translucency severity in pineapple (Paull and Chen, 2015), a disorder expected to be associated with dysfunctional cell membranes or cell walls. Moreover, pineapple fruit translucency index decreased by 64% as the amount of calcium applied was increased (Silva et al. 2001).

Interaction effects between urea and CaB however, showed no significant effects on TI. This simply implies that sole application of urea and CaB affects the TI of ‘MD-2’ pineapple rather than combination of the two fertilizers.

Table 2. Total soluble solids (TSS) and titratable acidity (TA) of 'MD-2' pineapple in response to varying rates of urea and CaB applications

TREATMENT		TSS	TA
kg Urea/ha	Li CaB/ha		
0	0	13.66	0.69
	20	14.65	0.83
	30	13.72	0.74
	40	14.18	0.77
25	0	14.50	0.70
	20	14.53	0.75
	30	14.73	0.73
	40	13.15	0.71
50	0	14.67	0.64
	20	13.69	0.78
	30	13.54	0.81
	40	13.92	0.85
75	0	13.80	0.77
	20	14.04	0.77
	30	14.05	0.65
	40	14.21	0.77
Urea means (A)			
0 kg Urea/ha		14.05	0.76
25 kg Urea/ha		14.23	0.73
50 kg Urea/ha		13.95	0.77
75 kg Urea/ha		14.02	0.74
CaB means (B)			
0 Li CaB/ha		14.16	0.70
20 Li CaB/ha		14.23	0.79
30 Li CaB/ha		14.01	0.73
40 Li CaB/ha		13.87	0.78
F – test			
Nitrogen		ns	ns
Calcium		ns	ns
N x Ca		ns	ns
CV (A)		5.55	14.22
CV (B)		7.14	15.14

Table 3. Mean fruit weight and percentage of translucent fruits of 'MD-2' pineapple in response to varying rates of urea and CaB applications

TREATMENT		MEAN FRUIT WEIGHT (kg)	TRANSLUCENCY INCIDENCE (%)
Kg Urea/ha	Li CaB / ha		
0	0	1.17	22.67
	20	1.31	15.33
	30	1.38	14.00
	40	1.32	10.67
25	0	1.37	25.33
	20	1.35	10.67
	30	1.49	7.33
	40	1.28	8.00
50	0	1.43	26.67
	20	1.40	12.66
	30	1.39	11.33
	40	1.55	11.33
75	0	1.37	28.67
	20	1.47	17.33
	30	1.64	18.33
	40	1.59	17.33
Nitrogen means (A)			

0 kg Urea/ha	1.30[c]	15.67[b]
25 kg Urea/ha	1.37[b]	12.83[c]
50 kg Urea/ha	1.44[b]	15.50[b]
75 kg Urea/ha	1.52[a]	20.50[a]
Calcium means (B)		
0 Li CaB/ha	1.34[c]	25.83[a]
20 Li CaB/ha	1.38[c]	14.00[b]
30 Li CaB/ha	1.48[a]	12.83[c]
40 Li CaB/ha	1.43[b]	11.83[c]
F – test		
Nitrogen	*	**
Calcium	*	**
N x Ca	Ns	ns
CV (A)	9.49	12.36
CV (B)	8.11	17.17

CONCLUSIONS

Applications of urea and CaB fertilizers at flower-bud stage did not influenced the total soluble solids and titratable acidity of 'MD-2' pineapple. On the other hand, application of urea at 75 kg ha^{-1} resulted to heaviest 'MD-2' pineapple fruit weight but translucency incidence also increased. Whereas, sole applications of 25 kg ha^{-1} urea and 30 L ha^{-1} CaB resulted to heavier fruit weights with reduced translucency incidence of 'MD-2' pineapple. It is still necessary to optimize the rates of urea and CaB applications at the flower-bud stage of 'MD-2' pineapple to minimize the likelihood of translucent fruits.

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