Nitrogen Requirements of Sweet Corn Grown on Mea Rim soil series

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Abstract

Sweet corn (*Zea mays* L. *saccharata*) is one of the most important crops in Thailand. Nitrogen fertilizer is the major input in sweet corn production. Proper nitrogen fertilizer management practices can increase productivity and reduce production costs sustainably. This study aims to investigate the effect of nitrogen on growth, yield component, and yield of sweet corn grown on Mea Rim soil series. The experiment was laid out in the randomized complete block design (RCBD) with three replications. The nitrogen fertilizer treatment comprised control, 0, 5, 10, 20, 30 and 40 kg N/rai as urea (46-0-0). Sweet corn was harvested at 95 days. The results of the nitrogen fertilizer application showed that growth, yield, and yield components of sweet corn were significantly different. The application rate of nitrogen fertilizer in the range of 20-30 kg N/rai gave the maximum average of plant height (262.45 cm) aboveground dry weight (1,031.8 kg/rai), diameter of the husked and unhusked ear (5.39 and 4.92 cm, respectively) length of unhusked and husked ears (23.20 and 17.23 cm, respectively), and kernel number per ear (427.3 kernels). The nitrogen fertilizer rate at 30 kg N/rai gave the maximum average grain yield at 1,792 kg/rai. Besides, the yield response to nitrogen fertilizer rate of sweet corn grown on Mea Rim soil series was 1,682.1 kg/rai when applying nitrogen fertilizer rate at 29.84 kg N/rai. Based on the experiment results, using nitrogen fertilizer ranged from 25-30 kg N/rai is recommended for growing sweet corn in Mea Rim soil series with low nitrogen content.

Keywords: nitrogen; sweet corn; Mea Rim soil series

1. Introduction

Sweet corn (*Zea mays* L. *saccharata*) is a cereal grain that is important in the economy of Thailand. In 2018, the total acreage of sweet corn in Thailand had about 234,259 rai, resulting in total mass production of 502,711 tons throughout the country (OAE, 2019). Sweet corn is a crop that can be grown all year round. Most of the farmers grow to sell for fresh-market and send to processing industries. Processed sweet corn products, e.g., canning, exported to Europe, Asia, and America, generated a value of 1,704

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million baht for the country (Kunlanit and Nasompong, 2017). At present, however, it is found that the quantity, quality, and price of the yield are not consistent. One of the causes and problems comes from improper production process management. Most farmers often lack knowledge of land and fertilizer use for crop production (Attanandana and Yost, 2003; Attanandana, 2006). Boonpok *et al.* (2014) surveyed sweet corn production data of farmers and found that chemical fertilizer is used at a higher rate than the nutrient requirements of sweet corn. Besides, current fertilizer recommendations for sweet corn are general and not the most effective. Fertilizer application rates are not specific for each soil and field condition. Also, the farmers did not monitor, analyze and consider the nutrients that are already present in the soil, making the use of fertilizer according to such recommendations ineffective, resulting in higher production costs (Attanandana and Verapattananirund, 2015). Sweet corn requires relatively high nutrients, especially nitrogen, which helps to promote growth and productivity. Osotspa *et al.* (2011) reported that applying nitrogen fertilizer to sweet corn at an appropriate rate will yield the number of kernels per pod, and the number of ears per area significantly. However, adding too much fertilizer will reduce productivity because excess nitrogen will increase the stump's biomass rather than seed weight. On the other hand, using too little nitrogen fertilizer will not make the soil nutrients sufficient for sweet corn growth. Mullins *et al.* (1999) reported that not adding nitrogen fertilizer to sweet corn in Mea Rim soil series will result in a 35% reduction in yield compared to the recommended nitrogen fertilizer (16 kg N/rai). Therefore, to raise sweet corn yield and encourage farmers to use fertilizer correctly, nitrogen management is one way not to increase fertilizer efficiency and reduce the effects that may occur (Ferguson *et al.*, 2002). Malzer *et al.* (2007) reported that site- specific nitrogen management for corn and soybean production in the state of Minnesota could significantly increase farmers' profits. Nitrogen management considers concerning soil conditions, soil properties, and the environment in that area can reduce fertilizer use by up to 6-46 % (Koch et al., 2004). Therefore, the study of the nitrogen requirement for sweet corn production in a specific area should be one way to help farmers can use the factors of production to the most benefit, which will lead to cost reduction and spatial production sustainably. The objective of this research was to determine the nitrogen requirement for sweet corn grown on Mea Rim soil series, which is classified as a potential soil for sweet corn (Osotspa *et al.*, 2011).

2. Materials and Methods

2.1 Study location

The field experiment was carried out at the Faculty of Agricultural Technology, Lampang Rajabhat University (18.229 ºN 99.485 ºE), from July to December 2018. Commercial sweet corn (super sweet AGRO) was grown on Mea Rim soil series (Loamy-skeletal, mixed Oxic Paleustults) with a high sand content of 70.00

%, a soil pH of 5.8, and 0.06 % of total nitrogen. Other physical and chemical characteristics are shown in Table 1.

2.2 Experimental design

The experiment was conducted using a randomized complete block design (RCBD) with three replications. The nitrogen fertilizer treatment structure comprised control, 0 (N1), 5 (N2), 10 (N3), 20 (N4), 30 (N5), and 40 (N6) kg N/rai. The individual plot size was 3 x 1.2 m (3.6 m^2) with a plant spacing of 0.25 x 0.25 m, and the spacing between rows was 0.75 m. Nitrogen fertilizer was applied 15 and 45 days after planting, one-half of the total at each time. The fertilizers were placed uniformly by hand, 10 cm below the soil surface in the form of urea at 46 % N, triple superphosphate 46 % P_2O_5, and potassium chloride at 60 % K_2O, respectively (Table 2).

2. 3 Data collection and statistical analysis

Sweet corn was grown for 95 days after planting (maturity stage). The harvest portion of the plot was the middle row (12 samples per plot). Records taken at harvest included plant height, top dry weight, length of husked and unhusked ear, the diameter of the husked and unhusked ear, kernel number per ear and yield. Statistical analysis was performed using STATISTIX 8 software. Analyses of variance (ANOVA) and mean separation were done using the least significant difference (LSD) test. The Sigmaplot program was also used to fit a linear equation to the yield response to nitrogen fertilizer.

Table 1 Some selected soil properties before the experiment.

Properties	Methods/ References	Values
pH	Soil : Water, 1 : 2 (AOAC, 2000)	5.57
Electrical conductivity (dS/m)	Soil : Water, 1 : 10 (Jakson, 1958)	0.07
Organic matter (%)	Walkley-Black (Nelson and Sommers, 1996)	1.40
Total nitrogen (%)	Kjeldahl Method (Tel and Hegatey, 1984)	0.06
Available phosphorus (mg/kg)	Bray II method (Bray and Kurtz, 1945)	19.32
Exchangeable potassium (mg/kg)	Saturating the exchange site and displacing by 1 M NH_4OAc, at pH 7.0 and measure by ASS and flame emission spectro-photometer (AOAC, 2000)	356.41
Exchangeable calcium (mg/kg)		1,718.50
Exchangeable magnesium (mg/kg)		68.70
Soil bulk density (g/cm^3)	Core method (Blake and Hartge, 1986)	1.72
Soil texture		Sandy loam
Sand (%)	Pipette method (Gee and Bauder, 1986)	70.00
Silt (%)		18.00
Clay (%)		12.00

Table 2 Nitrogen, phosphorus, and potassium fertilizer rates in each treatment.

Treatments	Fertilizer rates (1st) (kg N-P_2O_5-K_2O/rai)	Fertilizer rates (2nd) (kg N-P_2O_5-K_2O/rai)
Control	0-0-0	0-0-0
N_1-P-K	0-10-10	0-0-0
N_2-P-K	2.5-10-10	2.5-0-0
N_3-P-K	5-10-10	5-0-0
N_4-P-K	10-10-10	10-0-0
N_5-P-K	15-10-10	15-0-0
N_6-P-K	20-10-10	20-0- 0

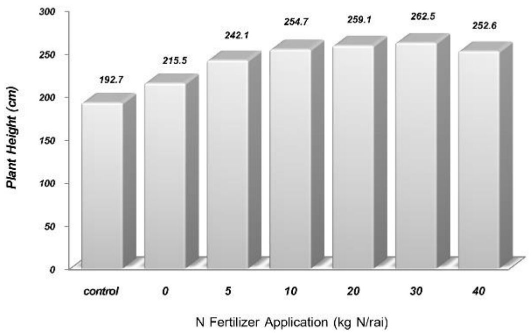

Figure 1 Effect of nitrogen fertilizer rates on plant height of sweet corn grown on Mea Rim soil series

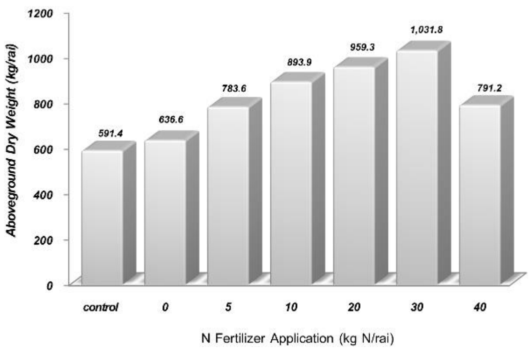

Figure 2 Effect of nitrogen fertilizer rates on the aboveground dry weight of sweet corn grown on Mea Rim soil series

3. Results and discussion

3.1 Plant height and top dry weight accumulation

The application of different rates of nitrogen fertilizer resulted in an average plant height of sweet corns at harvest date were significantly different ($p \leq 0.05$), ranged from 192.7-262.5 cm (Figure 1). The maximum plant height (262.5 cm) was obtained with the application of nitrogen fertilizer at the rate of 30 kg N/rai (N5), and the minimum plant height (192.7 cm) was recorded from the treatment control. Top dry weight accumulation was significantly different due to nitrogen fertilizer rate. The application of the nitrogen fertilizer at the rate of 30 kg N/rai (N5) gave the highest top dry weight accumulation (leaves and stems) with 1,031.8 kg/rai (Figure 2), which was not statistically different from the rate of 10 and 20 kg N/rai (N3 and N4).

The results clearly show that the plant height and top dry weight of sweet corn increase with an increasing rate of nitrogen fertilizer. Other studies have also reported similar results. Chaiwatanakul (2008) studied the optimum nitrogen fertilizer rates for sweet corn growth and yield. The results showed that the application of nitrogen fertilizer increased the plant height and top dry weight of sweet corn compared with control. Osotspa *et al.* (2011) reported that increasing the amount of nitrogen fertilizer applied to plants will increase branching and increase dry weight. Nitrogen plays an essential role in various physiological processes. It promotes leaves, stems, and other vegetative part's growth and development. Plants will be able to set themselves up early during the growth phase if there is enough nitrogen content in the soil (Lozano and Lara, 2002)

3.2 Yield components

The application of different rates of N fertilizer led to significantly different yield components at $p \leq 0.05$. Nitrogen fertilizer rate had a significant effect on the length of the husked and unhusked ear, the diameter of the husked and unhusked ear, and kernel number per ear of sweet corn (Table 3). The maximum average unhusked and husked ear of sweet corn (23.20 and 17.23 cm) was obtained from the application of 30 kg N/rai (N5). The application of nitrogen fertilizer at the rate of 30 kg N/rai (N5) gave the maximum average diameter of the unhusked ear with 5.39 cm, while the rate of 20 kg N/rai (N4) gave the maximum average diameter of the husked ear with 4.92 cm, which was not statistically different from the rate of 30 kg N/rai (N5). The maximum average kernel number per ear of sweet corn (423.7 kernels) was obtained from the application of 30 kg N/rai (N5). This led to kernel number per ear of sweet corn increase of 2.2 and 2.3 times compared to the application of 0 kg N and the control plots. Increasing the N rate from 30 kg N/rai, however, tended to reduce kernel number per ear of sweet corn.

The results clearly showed that yield component of sweet corn increases with an increasing nitrogen fertilizer rate. The results were similar to the other research. Oktem *et al.* (2010) reported that the application of nitrogen fertilizer at the rate of 120-320 kg N/ha (20-50 kg N/rai) resulted in the length and diameter of the unhusked ear of sweet corn increased when compared to not applying nitrogen fertilizer and lower than the rate of 120 kg N/ha (19.2 kg N/rai). The average maximum length (17.23 cm) and diameter (4.92 cm) of the husked ear of sweet corn obtained from the experiment when applying nitrogen fertilizer at the rate of 20-30 kg N/rai was similar to Cruz *et al.* (2015) with an average of 19.30 and 4.70 cm, respectively. Increased length and diameter of the ear due to higher nitrogen fertilizer application also increased the kernel number per ear of sweet corn (Aktinoye *et al.*, 1997; Hejazi and Soleymani, 2014).

3.3 Yield and Yield response to nitrogen fertilizer

The effect of nitrogen fertilizer on the yield of sweet corn grown on Mea Rim soil series is shown in Table 4. The application of different rates of nitrogen fertilizer resulted in average kernel weight per ear was significantly different ($p \leq 0.05$), ranged from 37.28 to 99.07 g/ear. The maximum kernel weight per ear (99.07 g) was obtained using nitrogen fertilizer at the rate of 30 kg N/rai (N5). The yield of sweet corn also was significantly different due to the nitrogen fertilizer rate. The application of nitrogen fertilizer at the rate of 30 kg N/rai (N5) gave the maximum yield of 1,792.7 kg/rai, which was not statistically different from the rate of 20 and 40 kg N/rai (N4 and N6). The results show that the yield of sweet corn increased with increasing rates of nitrogen fertilizer (from 0 to 30 kg N/rai). Other studies have also

Table 3 Effect of nitrogen fertilizer rate on yield component of sweet corn

N fertilizer rates (kg N/rai)	Length of husked ear (cm)	Length of unhusked ear (cm)	Diameter of husked ear (cm)	Diameter of unhusked ear (cm)	Number of kernels per ear (kernels)
Control	18.33	10.93	4.28	3.83	185.0
0 (N1)	20.50	12.83	4.48	4.01	188.1
5 (N2)	20.20	13.47	4.72	4.27	239.7
10 (N3)	22.07	14.27	4.92	4.41	293.2
20 (N4)	23.10	16.07	5.30	4.92	415.2
30 (N5)	23.20	17.23	5.39	4.90	427.3
40 (N6)	20.87	15.87	5.37	4.91	305.8
F-test	*	*	*	*	*
$LSD_{0.05}$	2.76	2.46	0.65	0.56	93.79
C.V. (%)	7.31	9.64	7.39	7.04	17.96

* = significant at 0.05; ns = non-significant

Table 4 Effect of nitrogen fertilizer on kernel weight per ear and yield of sweet corn

N fertilizer rates (kg N/rai)	kernel weight per ear (g)	Yields (kg/rai)
Control	37.28	504.9
0 (N1)	40.68	698.3
5 (N2)	55.42	776.5
10 (N3)	63.58	1,103.0
20 (N4)	89.07	1,597.9
30 (N5)	99.07	1,792.7
40 (N6)	74.37	1,490.5
p-Value	*	*
$LSD_{0.05}$	25.36	367.96
C.V. (%)	20.80	18.18

* = significant at 0.05; ns = non-significant

reported similar to the results. Mullins *et al.* (1999); Orosz *et al.* (2009); Cruz *et al.* (2015); Seekhwan *et al.* (2017) studied concerning the effect of nitrogen fertilizer on the yield of corn. All the studies found that the application of nitrogen fertilizers at higher rates also increases the yield. Providing adequate nitrogen to the crops can optimize yield and increase grain weight (Satjipanon *et al.,* 1984). Sinclair and Witt (1975) reported that kernels are considered the essential source of nitrogen for sweet corn, which is twice as concentrated in stems and leaves. Osotspa *et al.* (2011) reported the relationship between kernel nitrogen content and production. When the kernels' nitrogen concentration increased from 28 to 40 grams N/kg, the relative yield will increase from 40 to 90 percent. It indicates that nitrogen not only influences the growth of the stems and leaves but also affects productivity. Therefore, adequate nitrogen fertilizer application can make the corns absorb nitrogen better than not using fertilizer, which will significantly increase corn growth and yield if combined with proper management of phosphorus and potassium (Johnson and William, 1997).

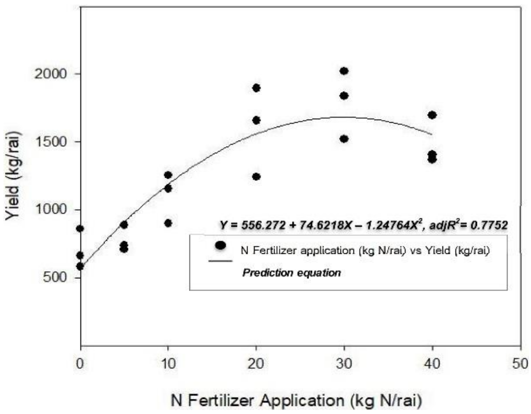

Figure 3 Responses to nitrogen fertilizer of sweet corn grown on Mea Rim soil series.

Figure 3 shows the response to the nitrogen fertilizer of sweet corn grown under Mea Rim soil series type. The yield increased rapidly when the nitrogen fertilizer rates increased from 0 to 10 and 20 kg N/rai, and the yield began to stabilize to the rate of 30-40 kg N/rai. A regression analysis was performed to quantify the yield response to nitrogen fertilizer and to determine the response was quadratic. The quadratic coefficient was significant. The relationship between sweet corn yield and nitrogen rates was quadratic with a regression equation $Y = 556.272 + 74.6218X - 1.24764X^2$ when Y is sweet corn yield (kg/rai), and X is nitrogen fertilizer rate (kg N/rai). The regression equation can be interpreted that sweet corn responds to the nitrogen fertilizer application at the rate of 29.84 kg N /rai, which gave the yield at 1,682.1 kg/rai. Lucas (1986) reported that most of the corn varieties responded to nitrogen fertilizer at the rate of 120-150 kg N/ha (19.2-24.0 kg N/rai), which is slightly lower than the equation. However, the yield is close to the national average range of 1,581-2,161 kg/rai when sufficient nitrogen and other nutrients are managed (OAE, 2019).

4. Conclusion

The results of the nitrogen fertilizer application showed that growth, yield, and yield components of sweet corn were significantly different, as expected. The application rate of nitrogen fertilizer in the range of 20-30 kg N/rai gave the maximum average plant height top dry weight, the diameter of the husked and unhusked ear, length of husked and unhusked ear, and kernel number per ear. As for the production, it was found that the application of nitrogen fertilizer at the rate of 30 kg N/rai gave the highest grain yield at 1,792 kg/rai. However, it was not statistically different with the application of nitrogen fertilizer at the rate of 20 kg N/rai which gave grain yield at 1,597.9 kg/rai. The quadratic plateau model best-described yield response to nitrogen fertilizer, with 29.84 kg N/rai producing the maximum grain yield at 1,682.1 kg/rai.

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