ผลของการเพิ่มปริมาณแอมโมเนียม โพแทสเซียม แมกนีเซียม และสังกะสี ต่อการดูดใช้ธาตุอาหารและคุณภาพผลของส้มโอ

Effects of ammonium, potassium, magnesium and zinc manipulation on nutrient uptake and fruit quality of pummelo

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บทคัดย่อ: ดินปลูกส้มโอในพื้นที่อำเภอขนอม จังหวัดนครศรีธรรมราช เป็นดินกรดจัด ฟอสฟอรัส โพแทสเซียม แคลเซียม แมกนีเซียม และสังกะสีต่ำกว่าค่ามาตรฐานที่ได้จากการศึกษาครั้งก่อน ส้มโอแสดงอาการขาดธาตุอาหารเหล่านี้ ทำให้เกษตรกรต้องใช้ปุ๋ยและวัสดุปรับปรุงดินปริมาณมากเพื่อแก้ไขปัญหาเหล่านี้ การทดลองนี้มีวัตถุประสงค์เพื่อศึกษาผลกระทบต่อการดูดใช้ธาตุอาหารและคุณภาพผลผลิต เนื่องจากการใช้ปุ๋ยแอมโมเนียม โพแทสเซียม แมกนีเซียม และสังกะสี เพิ่มมากขึ้นจากอัตราที่เกษตรกรใช้ตามปกติ การทดลองแบ่งออกเป็น 5 ตำรับ คือ ใช้ปุ๋ยทุกชนิดที่ศึกษา ไม่ใช้ปุ๋ยแอมโมเนียม ไม่ใช้ปุ๋ยโพแทสเซียม ไม่ใช้ปุ๋ยแมกนีเซียม ตามวิธีที่เกษตรกรปฏิบัติ (ไม่ใช้ปุ๋ยสังกะสี) ผลการทดลองพบว่า ส้มโอมีแนวโน้มตอบสนองต่อปุ๋ยแอมโมเนียมในกรณีที่ความเข้มข้นในใบต่ำกว่า 27 g/kg ความเข้มข้นของโพแทสเซียมและแมกนีเซียมในใบอยู่ในระดับมาตรฐาน (15 - 20 และ 3 - 5 g/kg ตามลำดับ) ทุกตำรับทดลอง จึงไม่พบการตอบสนอง ความเข้มข้นของแคลเซียมในใบก่อนทดลองต่ำกว่าค่ามาตรฐาน (30 - 40 g/kg) ความเข้มข้นเพิ่มขึ้นทุกตำรับหลังทดลอง โดยการเพิ่มสอดคล้องกับ pH และความเข้มข้นในดิน ตำรับที่ไม่ใส่โพแทสเซียม มีแนวโน้มทำให้น้ำหนักผลลดลง ปริมาณน้ำคั้นลดลง และดัชนีรสชาติต่ำลง การทดลองนี้แสดงให้เห็นว่า ส้มโอในพื้นที่แห่งนี้ยังคงต้องการโพแทสเซียม แม้ความเข้มข้นในดินและในใบอยู่ในระดับมาตรฐาน และพืชไม่ตอบสนองในใบแล้วก็ตาม

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ABSTRACT: Pummelo growing soil in Khanom District, Nakhon Si Thammarat Province is strongly acid. Phosphorus, potassium, calcium, magnesium and zinc are lower than sufficient amounts according to a standard recommendation of our previous study. Pummelo shows deficiency symptoms of these nutrients, and farmers have to apply a large amount of fertilizers to correct these problems. This study was carried out in order to examine effects of ammonium (NH_4), potassium (K), magnesium (Mg) and zinc (Zn) fertilization over farmer practice on nutrient uptake and fruit quality. The experiment comprised of 5 treatments; apply all, not apply NH_4, not apply K, not apply Mg and farmer practice (not apply Zn). Pummelo tended to respond to NH_4 manipulation only leaf-N was lower than 27 g/kg. Concentrations of K and Mg in leaves were in optimum ranges (15 - 20 and 3 - 5 g/kg, respectively), therefore no any leaf response was found. Concentrations of leaf-Ca were lower than an optimum range (30 - 40 g/kg) in every treatment; therefore pummelo tended to uptake more Ca. Fruit weight, juice volume and test index (total soluble solid/titratable acidity) tended to decline on the not apply K treatment. This study showed that K is still required for pummelo growing on this soil, although its concentrations in soil and leaves were in the optimum range and no K response in leaves.

Keywords: pummelo, plant nutrition, nutrient uptake, fruit quality

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Introduction

Pummelo (*Citrus maxima* Merr.) is a indigenous citrus to Southeast Asia. It was introduced to China more than 2000 years ago, and was brought to Europe and America in the late 17th Century (Morton, 1987). Pummelo is the biggest fruit producing citrus species. A 10 - 20 year-old pummelo planted from air-layering stock, with proper growing practice is able to bear 200 - 250 fruits/year or 200 - 300 kg/year. Large amounts of nutrients are removed from soil; consequently, concentrations and balance of the nutrients are change. Quality of the fruit declines and nutrient disorder occurs in a short period. Quality of pummelo fruit is susceptible to soil properties; therefore, fruits from the same variety can be changed from place to place. Acceptable pummelo by consumers in one place may not accept in other places. Sometimes name of a variety has to change according to name of the growing place to overcome the problem. Generally, fruit quality of pummelo growing on salt marsh area is more superior to the same variety growing on upland area (Morton, 1987; Maneepong, 2013). Standard recommendations for pummelo growing soil and nutrient concentrations in pummelo leaves were established in our previous study (Maneepong, 2008; Maneepong, 2013). However, nutrient response base on the recommendations is not clearly understood. This study was carried out in order to examine effects of ammonium (NH_4), potassium (K), magnesium (Mg) and zinc (Zn) fertilization over farmer practice on nutrient uptake and fruit quality. Every treatment was applied manure once a year and compound fertilizers 3 times a year according to the farmer practice.

Materials and Methods

A representative pummelo plantation in Khanom District, Nakhon Si Thammarat Province (latitude 9° 19′ 43.2″ N, longitude 99° 78′ 91.3″ E) was selected for this study. Most of the pummelo trees were planted in 1997, but some of them were re-planted in later year. Only Khao Thongdee variety is grown in this plantation. The pummelo was grown in blocks of land. Each block was separated by a furrow of 1 m width, and 0.5 m depth. Twelve trees were arranged in double row in each block. Spacing between trees is 8 m, and between rows is 9 m. Five trees which had similar canopy volume from each block were selected for placing into each treatment (**Table 1**). Ammonium sulfate, potassium chloride, magnesium sulfate and zinc sulfate were applied for the treatment 1 (T1). Ammonium sulfate was omitted for the treatment 2 (T2). Potassium chloride was omitted for the treatment 3 (T3). Magnesium sulfate was omitted for the treatment 4 (T4). No any amendment material was applied for the treatment 5 (T5).

Before treatment application, soil samples were taken from 4 positions directly beneath of outer canopy of each tree between 0-15 cm depth by a sampling tube. The samples were mixed, air-dried, ground and gravel and debris were removed by sieving through a 2 mm screen. Soil pH and electrical conductivity (EC) were measured using 1:2.5 and 1:5 soil:water ratios, respectively. Electrical conductivity at the saturation point (ECe) was estimated by multiplying the EC by 6 (Shaw, 1999). Available P was extracted by 0.03 M NH_4F in 0.10 M HCl (Bray II solution), and its concentration was analyzed using the molybdenum blue method. Exchangeable K, Ca and Mg were extracted with 1 M NH_4OAc at pH 7.0. Concentration of K was analyzed by a flame photometer. Concentrations of Ca and Mg were analyzed by an atomic absorption spectrophotometer (AAS). Available S was extracted by 0.01 M $K(H_2PO_4)_2$ solution, and its concentration was analyzed using turbidimetric method. Fe, Mn, Cu and Zn were extracted with diethylenetriaminepentaacetic acid (DTPA) solution, and their concentrations were analyzed by an AAS (Jones, 2001; Jones, 2003).

Table 1 Fertilizer rates and number of application times in a year for each treatment. First application was performed on June 2013.

Treatments	$(NH_4)_2SO_4$ (21-0-0)	KCl (0-0-60)	$MgSO_4{\cdot}7H_2O$	$ZnSO_4{\cdot}7H_2O$
T1 (All)	4 kg (1x4)	2 kg (1x2)	4 kg (1x4)	250 g
T2 (-N)	0	2 kg (1x2)	4 kg (1x4)	250 g
T3 (-K)	4 kg (1x4)	0	4 kg (1x4)	250 g
T4 (-Mg)	4 kg (1x4)	2 kg (1x2)	0	250 g
T5 (farmer practice)	0	0	0	0

Pummelo leaves were sampled 1 month before treatment application and 2 months after application. The leaves were sampled from 3rd or 4th position of 3- 4 month old, newly flush, and non-fruiting twig on the outer canopy. The samples were dried at 65 °C, ground, pass trough 1 mm sieve, and kept in tight plastic boxes. N was analyzed by the Kjeldahl method. The samples were digested with 2:1 HNO_3 : $HClO_4$ for K, Ca, Mg and Zn analysis. Concentration of K was analyzed by a flame photometer. Concentrations of Ca, Mg and Zn were analyzed by an AAS. (Soil and Plant Analysis Council, 1998)

A medium size of fully ripen pummelo fruit was sampled from each replication (one fruit from each tree). Fruit weight and endocarp (pulp) weight were determined, and edible portion was calculated from their ratio. Thickness of flavedo and albedo (peel), juice volume ratio, total soluble solid (TSS), and titratable acidity (TA) were determined. The TSS was determined using a hand refractometer. The TA was determined by titration of 50 mL juice with 0.1 M NaOH and calculated by assuming that all acids in the juice are equivalent to citric acid.

Results and Discussion

Chemical properties of the study soil were showed in **Table 2**. Soil pH tended to decrease from T1 to T5, whereas the ECe were not significant difference between the treatments. The soil samples were taken from fertilizer bands around pummelo. Therefore, concentrations of available P were affected by fertilizer and high variation. The values were much higher than recommendation range (15-25 mg/kg; Maneepong, 2013), although the available P of original soil is low.

Concentrations of exchangeable K of T1, T2 and T4 fell at margin of recommendation range (100-150 mg/kg; Maneepong, 2013), whereas those of T3 and T5 were in the range. Concentrations of exchangeable Ca tended to decrease from T1 to T5, and corresponded to their pH. Ca of the T1 fell at lower margin of the recommendation range (1000-2000 mg/kg; Maneepong, 2013), and the other were not sufficient. Concentrations of exchangeable Mg of every treatment were in optimum range (120-240 mg/kg; Maneepong, 2013). Concentrations of DTPA extractable Fe, Mn and Cu were higher than the optimum ranges, therefore pummelo should not suffer from these elements. Concentrations of DTPA extractable Zn of T3 and T5 were at lower margin of the recommendation range (1.1-3.0 mg/kg; Maneepong, 2013), but the others were higher than the range and varied greatly. The results indicate accumulation of Zn in soils of some treatments due to previous application.

Table 2 Chemical properties of top-soils under pummelo canopy (mean ±SD). The samples were taken before treatment application.

Chemical properties	Treatments				
	T1	T2	T3	T4	T5
pH in water (1:2.5)	6.0±0.2	5.8±0.2	5.8±0.2	5.6±0.4	5.3±0.3
ECe (mS/cm)	0.46±0.19	0.37±0.07	0.45±0.09	0.44±0.10	0.35±0.14
Available P (mg/kg)	97±59	94±64	147±63	158±66	98±37
Exch. K (mg/kg)	97±16	107±30	158±34	116±22	137±46
Exch. Ca (mg/kg)	1045±333	667±159	673±90	757±423	499±148
Exch. Mg (mg/kg)	225±34	131±44	168±65	144±36	168±36
Available S (mg/kg)	18±25	8.6±0.6	9.5±0.5	6.5±1.1	6.9±1.4
Extr. Fe (mg/kg)	36±7	45±10	51±18	50±9	46±14
Extr. Mn (mg/kg)	40±16	26±5	21±7	25±15	16±4
Extr. Cu (mg/kg)	5.4±1.9	3.8±1.4	4.5±1.4	4.0±1.1	3.6±2.0
Extr. Zn (mg/kg)	6.4±9.8	4.7±5.8	1.4±0.5	4.8±2.2	1.1±0.4

Concentrations of nutrient elements in pummelo leaves were shown in Table 3 and Table 4. Concentrations of N, K and Mg did not have any significant difference between treatments and sampling times. The values of these elements were in optimum ranges, therefore pummelo do not require more than those levels. Concentrations of P were not significant differences between the treatments, but tended to decrease after treatment application. The results may be deduced that P was moved out from leaves to fruits, because the samples were taken during fruiting period. Concentrations of Ca were significant difference between the treatments. The highest values were found on T1 and the lowest values were found on T5, both before and after treatment application. The Ca in leaves corresponded to the values in soil and soil pHs. Increasing of Ca was found although Ca was not applied by authors, but the farmer did it. The Ca concentrations before treatment application were lower than optimum range (30-40 g/kg; Maneepong, 2013) for every treatment. Pummelo showed more requirements, and increased the concentrations into the optimum range. Concentrations of Fe and Mn were in optimum ranges or slightly over (40-80 mg-Fe/kg and 5-15 mg-Mn/kg; Maneepong, 2013). Both of these elements were not significant difference between treatments and sampling times. Concentrations of Cu were not significant difference between treatments, but they showed a large increment on the second sampling. This finding may due to the farmer applied Cu containing fungicides. Concentrations of Zn did not have any significant difference between treatments and sampling times, although Zn concentrations in soils for T3 and T5 were low (**Table 2**).

Table 3 Nutrient composition of pummelo leaves (mean ±SD). The samples were taken before treatment application (June 2013).

Treatment	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
T1	26.2±1.8	1.6±0.1	22.1±1.3	25.4±2.3	4.6±0.7	58±14	17±5	7.7±0.3	33±9
T2	27.1±1.2	1.5±0.0	20.7±0.8	22.7±4.0	4.1±0.7	49±4	17±4	6.7±0.6	34±7
T3	25.8±1.3	1.5±0.1	21.6±1.9	22.5±2.5	4.6±0.8	43±3	25±5	6.9±0.6	53±9
T4	27.5±1.3	1.6±0.1	23.0±1.5	21.4±2.2	4.7±0.3	47±6	26±2	6.9±0.5	53±4
T5	26.8±1.6	1.6±0.1	22.6±1.7	18.2±1.2	4.6±0.3	42±2	21±4	7.1±0.1	49±10

Table 4 Nutrient composition of pummelo leaves (mean ±SD). The samples were taken after treatment application (September 2013).

Treatment	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
T1	27.8±1.1	1.3±0.1	19.1±1.8	42.0±5.8	4.7±0.5	146±25	19±2	18±2	35±6
T2	27.3±1.9	1.2±0.1	18.2±0.9	34.5±3.3	4.3±0.6	105±10	16±3	14±2	33±9
T3	27.7±2.1	1.2±0.1	20.0±2.6	30.7±3.8	4.8±0.9	95±8	20±2	12±2	35±3
T4	27.8±0.7	1.3±0.1	22.2±1.4	32.6±4.2	4.7±0.3	82±5	19±2	14±1	38±7
T5	27.3±1.1	1.3±0.0	22.9±1.9	26.0±3.2	4.9±0.4	74±5	16±2	13±1	33±4

Peel thickness of fruits taken from all treatments fell between 1.4 to 2.1 cm, and their mean was 1.7 cm. The peel was fairly thick comparison to generally accepted at 1.5 cm. They were no significant difference treatments; however, no addition of N and K (T2 and T3) tended to be thicker than the others (**Figure 1**). Edible portion of the -K treatment (T3) was lowest (**Figure 1**). Although, K concentration in surface soil of the T3 was above the sufficient level (**Table 2**), and the concentrations in leaves did not show response to K (**Table 3 and 4**). The results can be deduced that K is still required for this plantation.

Juice volumes of pummelo fruits taken from T3 tended to be lower than the other (**Figure 2**). Test indexes (TSS/TA) also had the same trend of those juice volumes. Soil K of the T3 was the highest value, and leaf K did not differ from the other. However, KCl was not applied to the pummelo of the T3, therefore the trees may not receive sufficient amount of K. Pummelo trees of T5 also did not receive additional K, but Ca in soil was lower than that of the T3 and may contribute to K uptake.

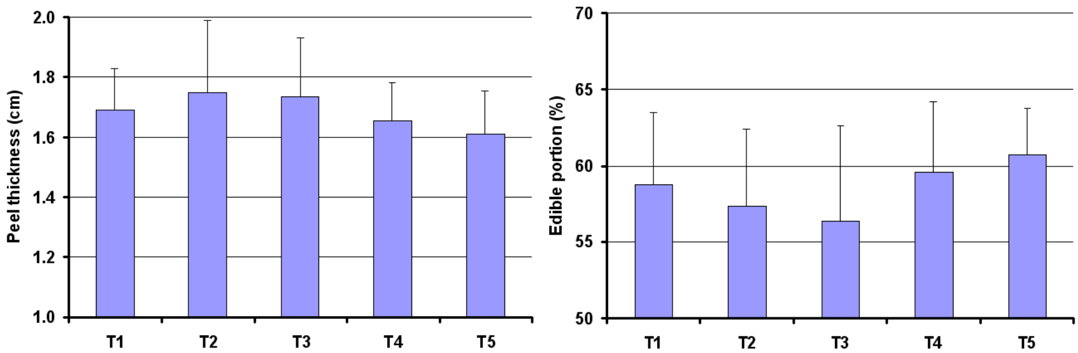

Figure 1 Peel thickness and edible portions of pummelo fruits. The samples were taken on November 2013. There are no significant differences between treatments.

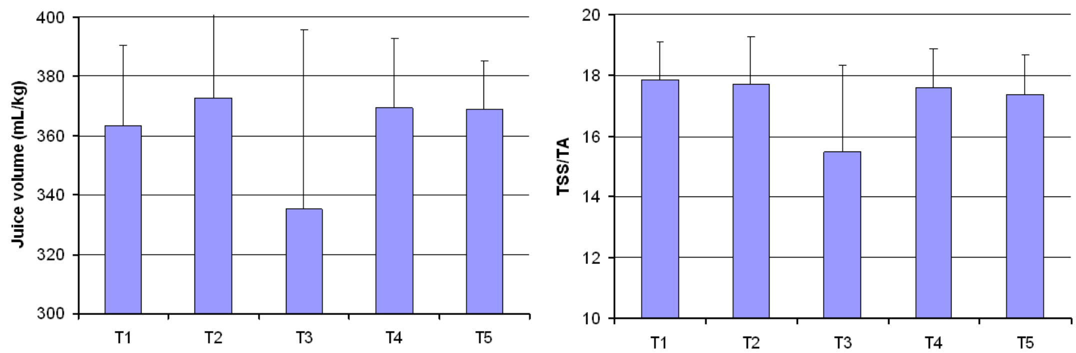

Figure 2 Juice volume and test index (TSS/TA) of pummelo fruits. The samples were taken on November 2013. There are no significant differences between treatments.

Conclusion

The concentrations of N, K, Mg and Zn in leaves fell in the optimum ranges, and did not respond to additional fertilizer application. K uptake may not fulfill pummelo requirement, if no additional application. K tended to contribute to juice volume and test index of pummelo.

Acknowledgments

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