CROP PRODUCTION SYSTEM AND NUTRIENT BALANCE FOR BIO ENERGY PLANT IN SUB-TROPIC REGIONS

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Abstract

In sub-tropic regions, bio energy plants include cassava and sugarcane. Cassava and sugarcane were applied to produce starch and sugar. Ethanol is generally produced by the fermentation of sugar, cellulose, or converted starch and has a long history.

Cassava and sugarcane in China is being increasingly used for ethanol fuel production. The largest cassava and sugarcane ethanol fuel production facility was completed in Guangxi with annual output of two hundred thousand tons, which would need an average of 1.5 million tons of cassava or 1.8 million tons of sugarcane. The area of cassaca and sugarcane production has reached four hundred thousand hactare and 1.86 million hactare in China, respectively.

The response to application of nitrogen, phosphorus, potassium and magnesium fertilizer, yields of cassava and sugarcane increased on average 4057.5-31321.5 kg/ha, or 5.57%-153.15%.

Cassava and sugarcane were uptake 69.4-196.5 N kg/ha, 39.3-97.2 P_2O_5 kg/ha, 65.1-198.5 K_2O kg/ha per year and 19.4-57.5 MgO kg/ha per year.

1. Introduction

It is known to all, ethanol is generally produced by the fermentation of sugar, cellulose, or converted starch and has a long history. In China, local production of ethanol from maize, millet, other starchy substrates, and cellulose is as old as the country itself. Apart from food and pharmaceutical uses, ethanol is finding itself alternative use for biofuel in most of the developed world because it does not cause air pollution or any environmental hazard and Its does not contribute to the greenhouse effect problem (CO_2 addition to the atmosphere, causing global warming).

The first type of plant will produce a strong alcohol from cassava and sugarcane. The plant would bring in fresh cassava and sugarcane, grate, cook in a jet cooker, ferment, distil, and bottle. In addition a steam boiler, generating set, effluent treatment plant and electrical system are required. The actual amount of cassava needed is dependant upon the starch content, but as a guide, cassava at 30% starch content will produce approximately 280 liters of alcohol/tonne. And the sugar content of sugarcane is about 14-16%.

Cassava and sugarcane in China is being increasingly used for ethanol fuel production. The largest cassava and sugarcane ethanol fuel production facility was completed in Guangxi with annual output of two hundred thousand tons, which would need an average of 1.5 million tons of cassava or 1.8 million tons of sugarcane. The area of cassaca and sugarcane production has reached four hundred thousand hactare and 1.86 million hactare in China, respectively.

In order to further increase cassava and sugarcane yield, it is very important to carry out influence of application fertilizer on yield and nutrient balance of Sugarcane. So, we research the crop production system and nutrient balance for bio energy plant in Guangxi.

2.0 Materials and Methods

2.1 Soil background

The soil type of field experiment were red earth, lateritic red earth and latosols.

2.2 Treatments

a. NP, b.NK, c.PK, d.NPK, e.NPKMg

2.3 Fertilizer applied rate for various crops

Cassava: N 150, P_2O_5 72, K=K_2O 150, MgO 60

Sugarcane: N 300, P_2O_5 180, K=K_2O 300, MgO 60

Nutrient contents in the fertilizers was as follows:

Calcium magnesium phosphate(CMP): P_2O_5 14%, MgO 18%; Single superphosphate(SSP): P_2O_5 14%, S 14%; kieserite ($MgSO_4$): MgO 16%, S 13%; Diammonium phosphate(DAP): P_2O_5 46%, N 18%; Urea: N 46%; KCl: K_2O 60%.

2.4 Replication

Four replications were used for cash crops. Plot area was 33.3 square meters. Plots were arranged in randomized block.

2.5 Soil analysis methods

The total K in soil was heated and melted with carbonate sodium (Na_2CO_3). The slow-release soil available K was extracted by nitric acid (1N HNO_3), then heated and boiled for 10 min. The soil available K was extracted by ammonium of acetic acid. Then, the amount was determined using a flame-spectrum meter.

For the total P soil analysis, NaOH was added to the sample and heated at 720□ for 5 minutes. To analyze the available P , the sample was extracted by 0.5M $NaHCO_3$, and the amount determined by a photometer.

Soil pH was measured in a soil to water ratio of 1:2.5 with a pH meter. Total N in soils was determined by the micro-Kjeldahl method. Exchangeable Mg and K was determined with atomic absorption spectrophotometry by extracting the soil with a 1N NH_4OAc solution in a 1:10 soil : solution ratio.

To determine S in the soil, the $Ca(H_2PO_4)_2$ extraction method was used.

2.6 N, P_2O_5 ,K_2O and MgO of cassava and sugarcane stalk and leave

Total N, P and K were determined by the $K_2Cr_2O_7+H_2SO_4$ digestion method, the $H_2SO_4+HClO_4$-molybdenum blue method, and $CaCO_3+NH_4Cl$ fusion-flame photometric method, respectively.

Total S in plants was determined by the HNO_3+HClO_4 boil method.

3. Results and discussion

3.1 Chemical properties of the tested soils

Availability and utilization by plants of essential nutrients in the soil is affected by the soil's physical and chemical characteristics, plant characteristics, and other factors affecting plant growth, such as temperature, moisture, light, etc. The agrochemical properties of the tested soils are given in Table 1.

Table 1. The chemical properties of the tested soils

Field site	pH	O.M. (%)	Avail.N (ppm)	Avail.P (ppm)	K (ppm)	Avail. S (ppm)	Avail.B (ppm)	Avail.Mg (ppm)
Nanning	5.0	2.19	47.4	11.6	43.0	18.8	0.21	62.0
Laibin	6.8	1.58	13.7	14.5	70.4	8.0	0.24	100.5

3.2 Crop production system for bio energy plant in sub-tropic regions

3.2.1 Sugarcane production system

The biomass production is 80-140 tons per hectare. Sugarcane growth is divided into four stages: seedling, tiller, stretching, and mature. Sugarcane grows quickly during tillering and stretching periods, also during these stages sugarcane biomass production is greater and more minerals are absorbed, especially potassium, than at other stages. In every development stage of sugarcane, the potassium content of a sugarcane plant is higher than other nutrient elements, except for nitrogen. Generally, sugarcane yield is 45000-60000 kg per hectare.

Guangxi is located in the southern area of sub-tropical China, and has land suitable to grow various sub-tropical crops, especially sugarcane. In the past few years, sugarcane production had been developed greatly. In 2008, the total area of sugarcane production had reached 1000,000 hectares.

3.2.2 Cassava production system

In the subtropical region of southern China, cassava is the fifth largest crop in term of production, after rice, sweet potato, sugar cane, and maize. China is also the largest export market of cassava produced in Vietnam and Thailand. Over 60% of cassava production in China is concentrated in a single province, Guangxi, averaging over seven million tons annually.In 2008, the total area of cassava production had reached 40,000 hectares.

3.3 Influence of various treatments on cassava and sugarcane growth

The application of various fertilizers increased the growth of cassava. The plant height and diameter of stem all were increased by the application of NPKMg. Single tuberous root weight and tuberous root weight per plant was also increased obviously.

Increasing potassium, magnesium fertilizer can increase plant height (Xie et al., 1991; Morris, 1990).

Table 2. The effects of fertilization on biological properties of cassava. (kg/ha)

Properties	NP	NK	PK	NPK	NPKMg
Plant height (cm)	305	319	228	326	325
Diameter of stem (cm)	3.18	3.25	2.37	3.29	3.35
Number of tuberous roots per plant	8.22	8.28	4.29	8.25	8.3
Single tuberous root weight (kg)	0.276	0.299	0.309	0.297	0.303
Tuberous root weight per plant (kg/plant)	2.27	2.47	2.56	2.45	2.51

In July and August, potassium, potassium and magnesium, and potassium, magnesium fertilizer treatments increased plant height by 13.9-16.7 cm and 26-46 cm more than the treatment of not nitrogen fertilizer, respectively (see Table 3).

Table 3. Influences of various treatments on plant height

Treatment	Plant height (cm) July 31	Plant height (cm) August 8	Plant height (cm) August 21
NP	167.5	197.4**	217.0**
NK	178.9**	203.4**	232.0**
PK	153.6	174.6	191.0
NPK	168.3	206.0**	226.5**
NPKMg	170.3	218.7**	237.0**

Note : F=96.49, LSD0.05=5.379, LSD0.01=8.653

*Significance level: *P＜LSD0.05; ** P＜LSD0.01.*

3.4 Influence of fertilization on cassava and sugarcane yield

The response to application of fertilizer, yields of cassava and sugarcane were on average 12600.0-35955.0 and 65062.0-101752.5 kg/ha, respectively (Tables 1). It is also important to note that cassava and sugarcane there were large increase to application of fertilizer (N, P, K and Mg).

Table 4. Influence of fertilization on cassava and sugarcane yield (kg/ha)

Treatments	NP	NK	PK	NPK	NPKMg
Cassava	12600.0	14340.0	19050.0	31897.5**	35955.0**
Sugarcane	65062.5	73125.0	54154.5	96384.0**	101752.5**

Note : F=72.11, LSD0.05=502.3, LSD0.01=790.3

*Significance level: *P＜LSD0.05; ** P＜LSD0.01.*

On the basis of application of phosphorus and potassium, the cassava and sugarcane yield increased 12847.5 kg/ha, or 67.44% and 42229.5 kg/ha, or 77.98%, respectively after applied nitrogen fertilizer on cassava and sugarcane.

On the basis of application of nitrogen and potassium, the cassava and sugarcane yield increased 17557.5 kg/ha, or 122.44% and 23259.0 kg/ha, or 31.81%, respectively after applied phosphorus fertilizer on cassava and sugarcane.

On the basis of application of nitrogen and phosphorus, the cassava and sugarcane yield increased 19297.5 kg/ha, or 153.15% and 31321.5 kg/ha, or 48.14%, respectively after applied potassium fertilizer on cassava and sugarcane.

On the basis of application of nitrogen, phosphorus and potassium, the cassava and sugarcane yield increased 4057.5 kg/ha, or 12.72% and 5368.5 kg/ha, or 5.57%, respectively after applied magnesium fertilizer on cassava and sugarcane.

3.5 Nutrient balance of cassava and sugarcane in various application fertilizers

3.5.1 Balance of soil nitrogen with nitrogen fertilizer application

Cassava and sugarcane were uptake 69.4-196.5 N kg/ha per year. Higher NPK fertilizer use producing higher yields has also resulted in greater crop removal of nitrogen from these soils.

Table 5. Balance of soil nitrogen with nitrogen fertilizer application (kg/ha)

	Treatment	Rate of applied N	Uptable N	Input & output balance N
Sugarcance	PK NPK	0 300.0	101.8 196.5	-101.8 +103.5
Cassava	PK NPK	0 150.0	69.4 121.1	-69.4 +28.9

3.5.2 Balance of soil phosphorus with phosphorus fertilizer application

Cassava and sugarcane were uptake 39.3-97.2 P_2O_5 kg/ha per year. Higher NPK fertilizer use producing higher yields has also resulted in greater crop removal of P_2O_5 from these soils.

Table 6. *Balance of soil phosphorus with phosphorus fertilizer application (kg/ha)*

Crop	Treatment	Rate of applied P_2O_5	Uptable P_2O_5	Input & output balance P_2O_5
Sugarcance	NK	0	52.7	-52.7
	NPK	180.0	97.2	-82.8
Cassava	NK	0	39.3	-39.3
	NPK	72.0	59.5	+12.5

3.5.3 Balance of soil potassium with potassium fertilizer application

Cassava and sugarcane were uptake 65.1-198.5 K_2O kg/ha per year. Higher NPK fertilizer use producing higher yields has also resulted in greater crop removal of K_2O from these soils.

Table 7. Balance of soil potassium with potassium fertilizer application (kg/ha)

Crop	Treatment	Rate of applied K_2O	Uptable K_2O	Input & output balance K_2O
Sugarcance	NP	0	156.3	-156.3
	NPK	300.0	198.5	101.5
Cassava	NP	0	65.1	-65.1
	NPK	150.0	116.5	+33.5

3.5.4 Balance of soil magnesium with magnesium fertilizer application

With rainfield upland crops, there are only small amounts of magnesium supplied in the rain (2.04 kg/ha per year). Additionally, the stability minerals containing magnesium in soil is poor. Combining this with the climate of high temperature and heavy rainfall Mg containing soil minerals are subject to rapid weathering, and considerable Mg is lost through leaching. At the same time higher yields and Mg-loving crops due to improved varieties and increased fertilizer use has resulted in greater removal of Mg from the soil. For instance, cassava and sugarcane were uptake19.4-57.5 MgO kg/ha per year. Higher NPK fertilizer use producing higher yields has also resulted in greater crop removal of Mg from these soils.

Table 8. Balance of soil magnesium with magnesium fertilizer application (kg/ha)

	Treatment	Rate of applied MgO	Uptable MgO	Input & output balance MgO
Sugarcance	NPK	0	42.0	-42.0
	NPKMg	60.0	57.5	+2.5
Cassava	NPK	0	19.4	-19.4
	NPKMg	60.0	39.9	+20.1

The problem of soil nitrogen, phosphorus, potassium and magnesium deficiency had not solved in Guangxi. Therefore high sustainable cassava and sugarcane yields cannot be achieved. Also, the effect and use efficiency of the other plant nutrients is less because of N,P,K and Mg deficiency. Thus, the positive effects to both yield and farmer income from balanced NPK fertilization are not brought into full play. There, Guangxi's upland sustainable agricultural development needs to pay much attention to the application of nitrogen,phosphorus, potassium and magnesium fertilizer. Otherwise, poor efficiency of presently use N, P and K fetilizers, low yields, poor crop quality and low farmer profits will result.

4. Conclusions

4.1 The response to application of nitrogen, phosphorus, potassium and magnesium fertilizer, yields of cassava and sugarcane increased on average 4057.5-31321.5 kg/ha, or 5.57%-153.15%.

4.2 Cassava and sugarcane were uptake 69.4-196.5 N kg/ha, 39.3-97.2 P_2O_5 kg/ha, 65.1-198.5 K_2O kg/ha per year and 19.4-57.5 MgO kg/ha per year.

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