Cassava NPK fertilizer

Huang Jie **professor**

Tropical Crops Genetic Resource Institute (TCGRI)
Chinese Academy of Tropical Agricultural Sciences (CATAS)

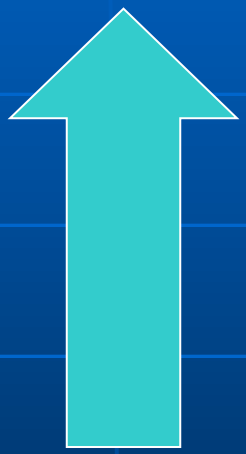
CARS-12, CIAT

Nippon foundation

Why research on agronomy?

Potential of High yield (starch) variety

Fully promote



Agronomy research

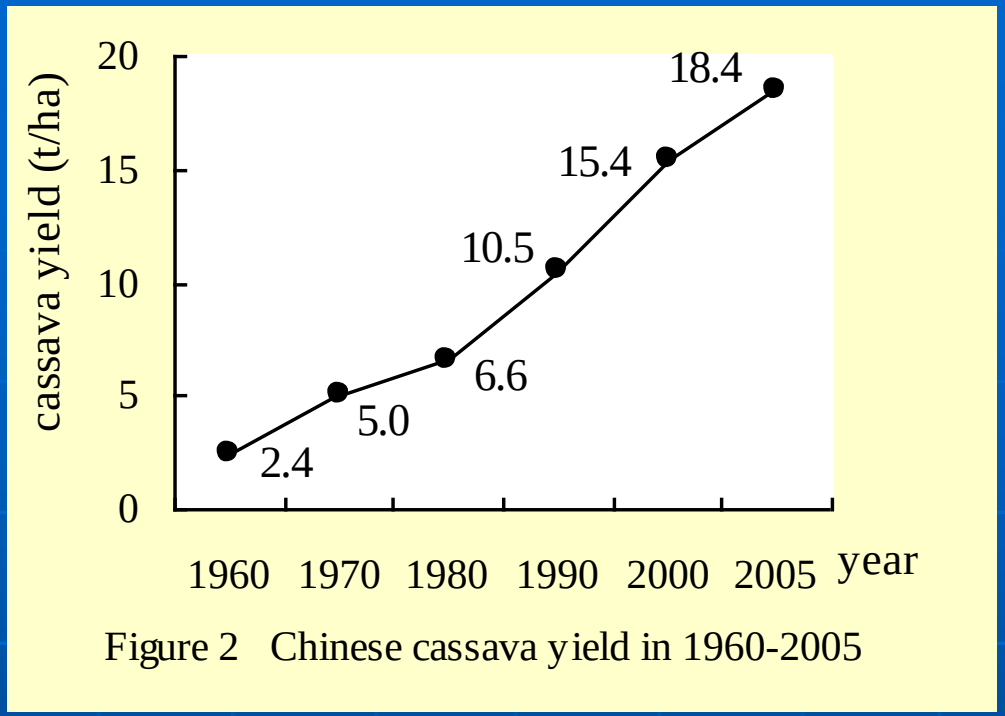


Figure 2 Chinese cassava yield in 1960-2005

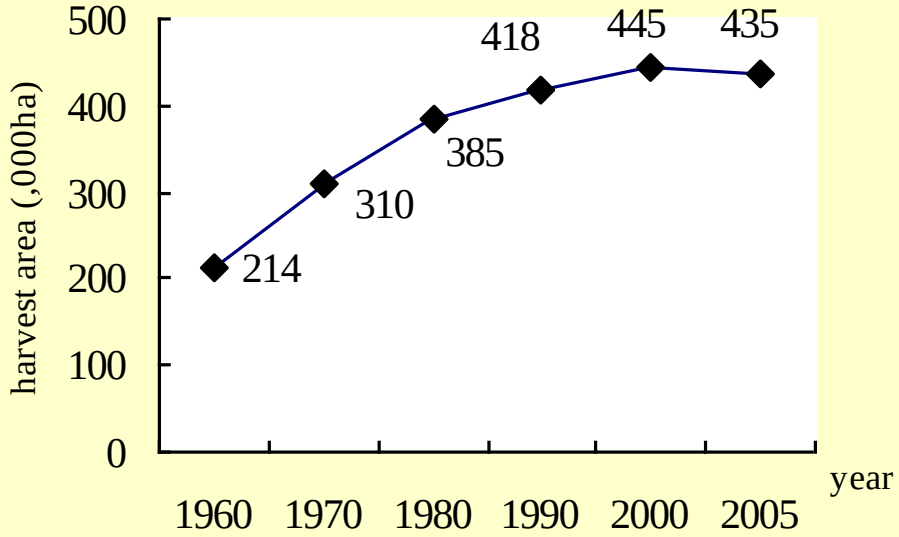


Figure 1 Chinese cassava harvest area in 1960-2005

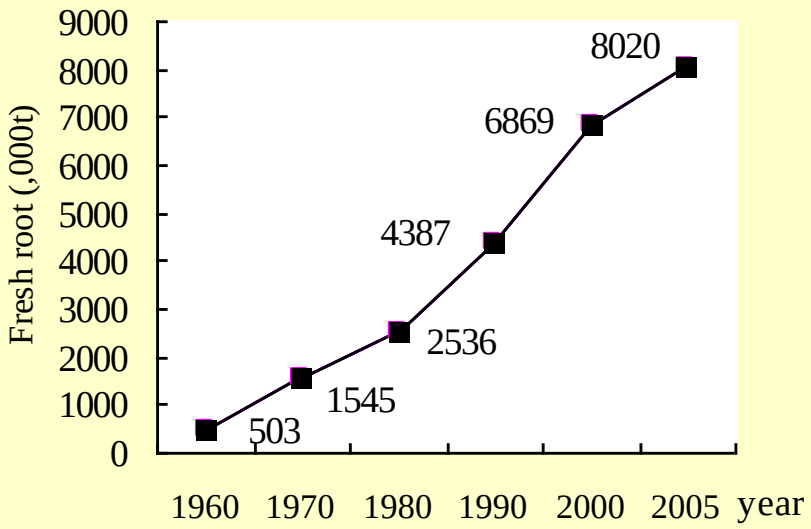


Figure 3 Chinese cassava production in 1960-2005

Fertilization

Find out problom

Fertilizer Nutrition

In 1 t dry matter	N (kg)	P (kg)	K (kg)
Fresh all plant	4.9	1.1	5.8
Fresh root	2.3	0.5	4.1
Dry root	6.0	1.0	11.0
Dry soybean	21.0	5.0	6.0
Dry maize	15.0	3.0	6.0
Dry rice	13.0	3.0	4.0

Nutritional requirements in 3-4 months young cassava leaf

Element	Very low	low	mid	high	Very high
N(%)	<4.7	4.7-5.1	5.1-5.8	>5.8	-
P(%)	<0.30	0.30-0.36	0.36-0.50	>0.50	-
K(%)	<1.0	1.0-1.3	1.3-2.0	>2.0	-
Ca(%)	<0.65	0.65-0.75	0.75-0.85	>0.85	-
Mg(%)	<0.27	0.27-0.29	0.29-0.31	>0.31	-
S(%)	<0.24	0.24-0.26	0.26-0.30	>0.30	-
B (mg/L)	<20	20-30	30-60	60-100	>100
Cu (mg/L)	<5	5-6	6-10	10-15	>15
Fe (mg/L)	<100	100-150	120-140	140-200	>200
Mn (mg/L)	<45	45-50	50-120	120-250	>250
Zn (mg/L)	<25	25-30	30-60	60-120	>120

Nutritional requirements in cassava soil

Soil prarmeter	Very low	low	medium	High	Very high
pH	<3.5	3.5-4.5	4.5-7	7-8	>8
OM (%)	<1.0	1.0-2.0	2.0-4.0	4.0-8.0	>8.0
P (mg/kg)	<2	2-5	5-20	20-50	>50
K (me/100g)	<0.10	0.10-0.15	0.15-0.25	>0.25	
Ca (me/100g)	<0.25	0.25-1.0	1.0-5.0	>5.0	
Mg (me/100g)	<0.2	0.2-0.4	0.4-1.0	>1.0	
S (mg/kg)	<20	20-40	40-70	>70	
B (mg/kg)	<0.2	0.2-0.3	0.3-1.0	1-2	>2
Cu (mg/kg)	<0.1	0.1-0.2	0.2-1.0	1-5	>5
Mn (mg/kg)	<5	5-10	10-100	100-250	>250
Fe (mg/kg)	<1	1-10	10-100	>100	
Zn (mg/kg)	<0.5	0.5-1.0	1.0-5.0	5-50	>50

Fertilization

- Regulation: no used in new land, few fertilizer in fertile land, much fertilizer in poor land,
- Basic fertilization：15-30 t farmer manuring and 200-300 kg/ha (superphosphate).
- First fertilization: 1 month after planting. 150 kg urea and 150-200 kg KCL, mix 150-300 kg compound fertilizer.
- Second fertilization: 3-4 months after planging. (normally no)

Special fertilizer

- According to soil analysis
- **12 years long term NPK trial**
- First year or new land: N:P_2O_5:K_2O = no. Second year: 1:1:1. After 4 years: 2:1:2-3.
- Increase 30-50% yield than CK (no fertilization), keep up 30 t/ha in continues planting, increase more than 200 us$ net income/ha.


2 - N0P60K60

Long-term fertility trial in CATAS -12th year - two varieties

In back: annual application of NPK

In front: without N

The fertility of the soil needs to be maintained

- Chemical fertilizers
- Organic manures
- Green manures

(depending on what is available and most economic)

Table 9. Average nutrient contents of various manures, composts, wood ash, and chemical fertilizers.

Source of manure	Moisture (%)	N	P	K	Ca	Mg	S
		(% of dry matter)					
Cattle manure	68.2	1.85	0.81	1.69	1.54	0.62	0.29
Pig manure	60.0	2.04	1.38	1.38	-	-	-
Chicken manure	43.0	2.91	1.37	1.54	4.56	0.83	-
Sheep manure	-	3.00	0.62	2.68	1.72	0.86	0.43
Human manure	-	1.20	0.06	0.21	-	-	-
City/rural compost	-	1.16	0.37	0.90	-	-	-
Rice straw compost	73.7	1.07	0.19	0.69	-	-	-
Peanut stems + leaves compost	58.6	0.81	0.10	0.38	-	-	-
Water hyacinth	-	2.00	1.00	2.30	-	-	-
Wood ash	-	-	0.87	4.17	23.2	2.10	0.40
15-15-15	0	15.00	6.55	12.50	0	0	0
Urea	0	45	0	0	0	0	0
Triple superphosphate	0	0	20	0	14	0	0
Potassium chloride	0	0	0	50	0	0	0

Source: *Howeler, 2001b.*

1.1 Long-term NPK fertilizer trial in 1992-2003, CATAS

Table 1. Design of NPK trial

4 level fertilizer and 16 treatments

Fertilizer	Application levels (kg/ha)			
	0	1	2	3
N	0	50	100	200
P (P_2O_5)	0	25	50	100
K (K_2O)	0	50	100	200
B (Burned soil)	0	1500	3000	6000

Table 2. Correlation analysis in 1992-2002.

Item	Fresh root yield	Starch content
Plant height	0.916**	-0.365
Stem diameter	0.935**	-0.358
Root/plant	0.872**	-0.316
Harvest index	-0.423*	0.656*
Fresh root yield		**-0.385**

Table 3. Yield and income in 1992-2002

TM	Fresh yield (t/ha)	SC(%)	Starch yield (t/ha)	Net income	
				US$/ha	Rank
$N_3P_3K_3$	22.4aA	30.1cdBC	6.74	490.0	5
$N_2P_1K_2$	**22.3aA**	**31.8aA**	**7.09**	**576.4**	**1**
$N_2P_3K_2$	21.3aAB	31.3abAB	6.67	500.4	3
$N_2P_2K_3$	21.2aAB	31.2abAB	6.61	496.9	4
$N_2P_2K_2$	20.7abABC	30.7bcAB	6.35	512.1	2
$N_2P_0K_2$	18.7bcBCD	31.5abA	5.89	480.0	6
$N_2P_2K_0$	14.0dE	29.4DC	4.12	335.0	13
$N_0P_2K_2$	12.3dE	31.7abA	3.90	323.8	14
$N_0P_0K_0$	7.1eF	31.7aA	2.25	221.6	15

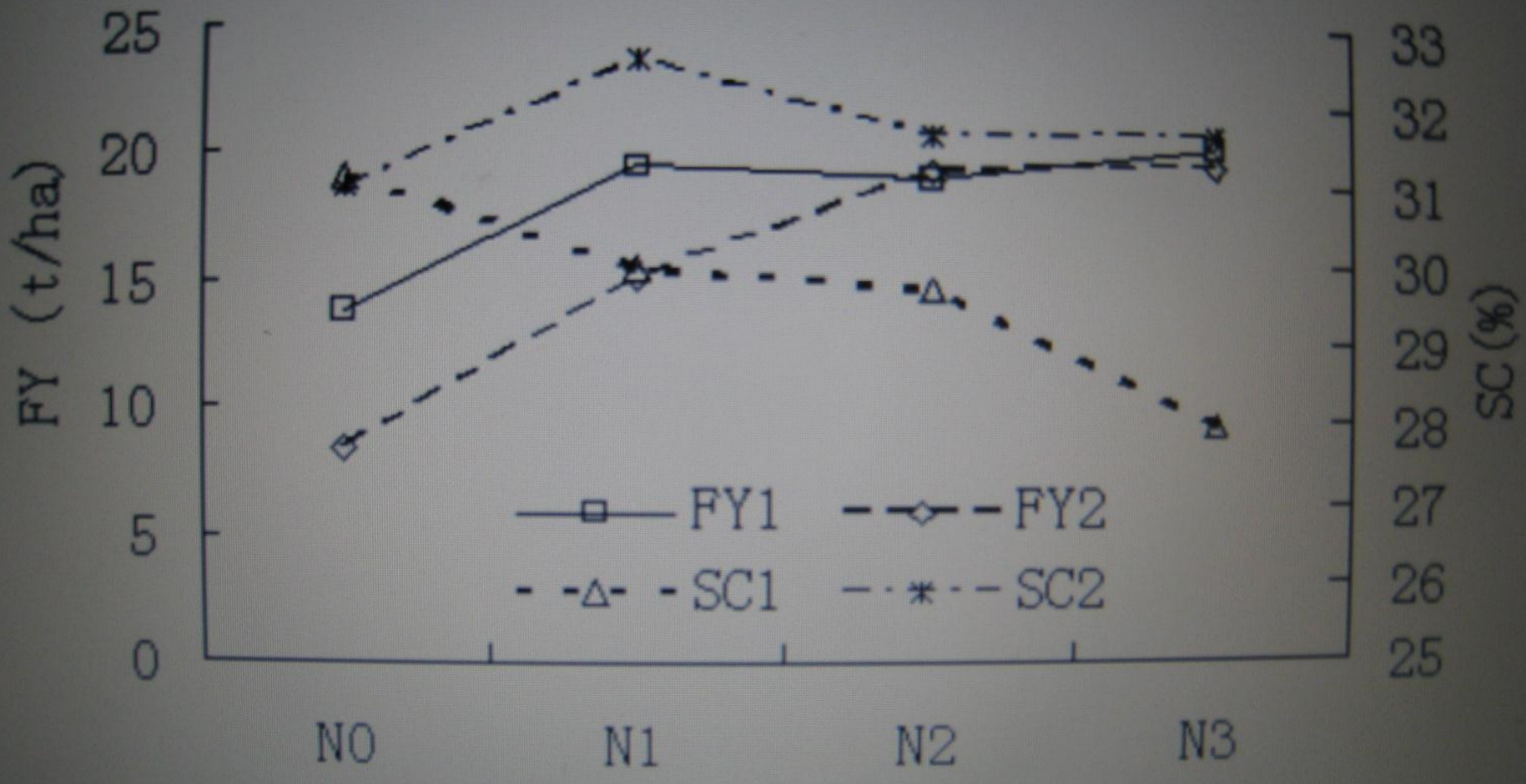
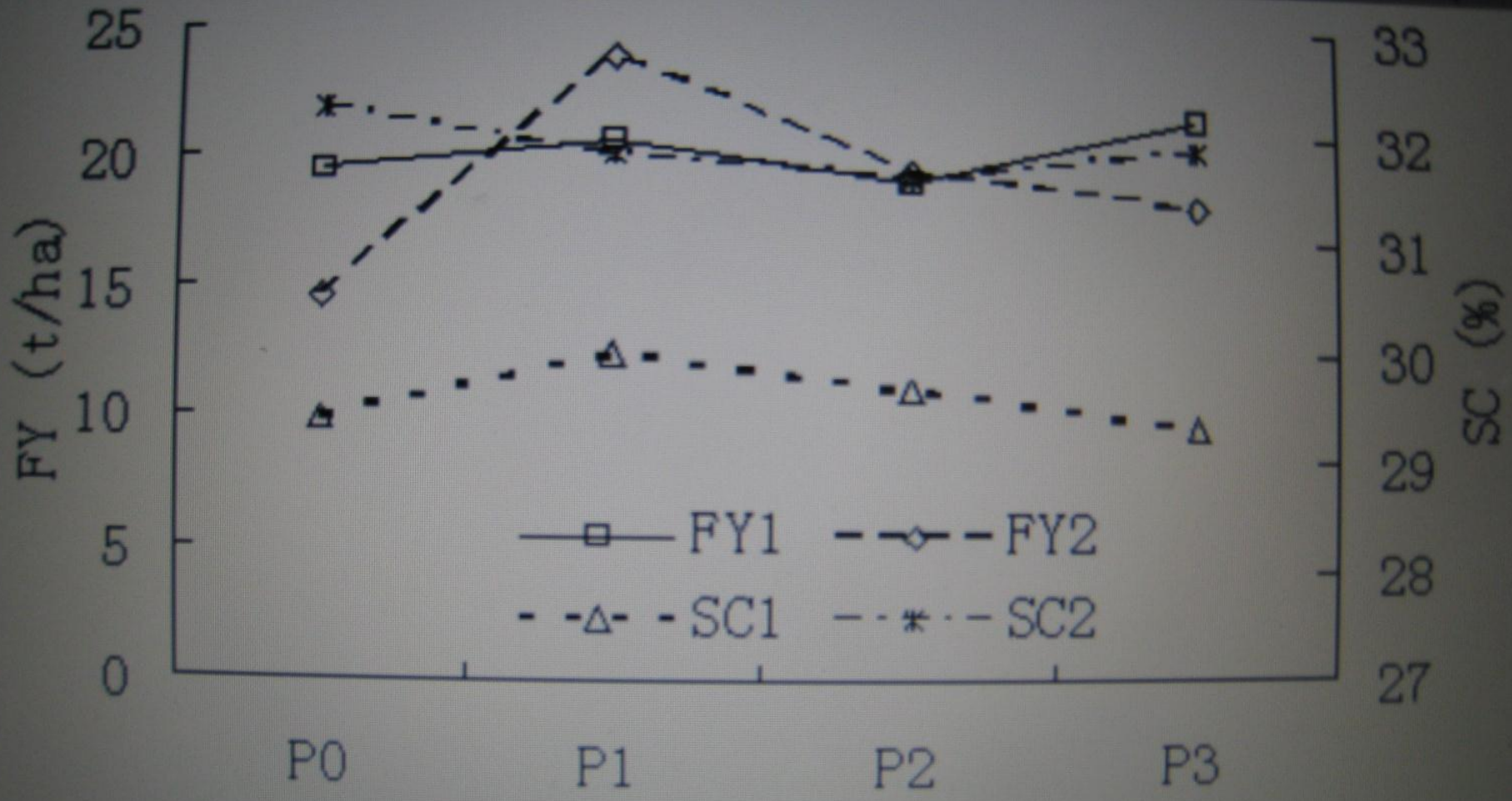
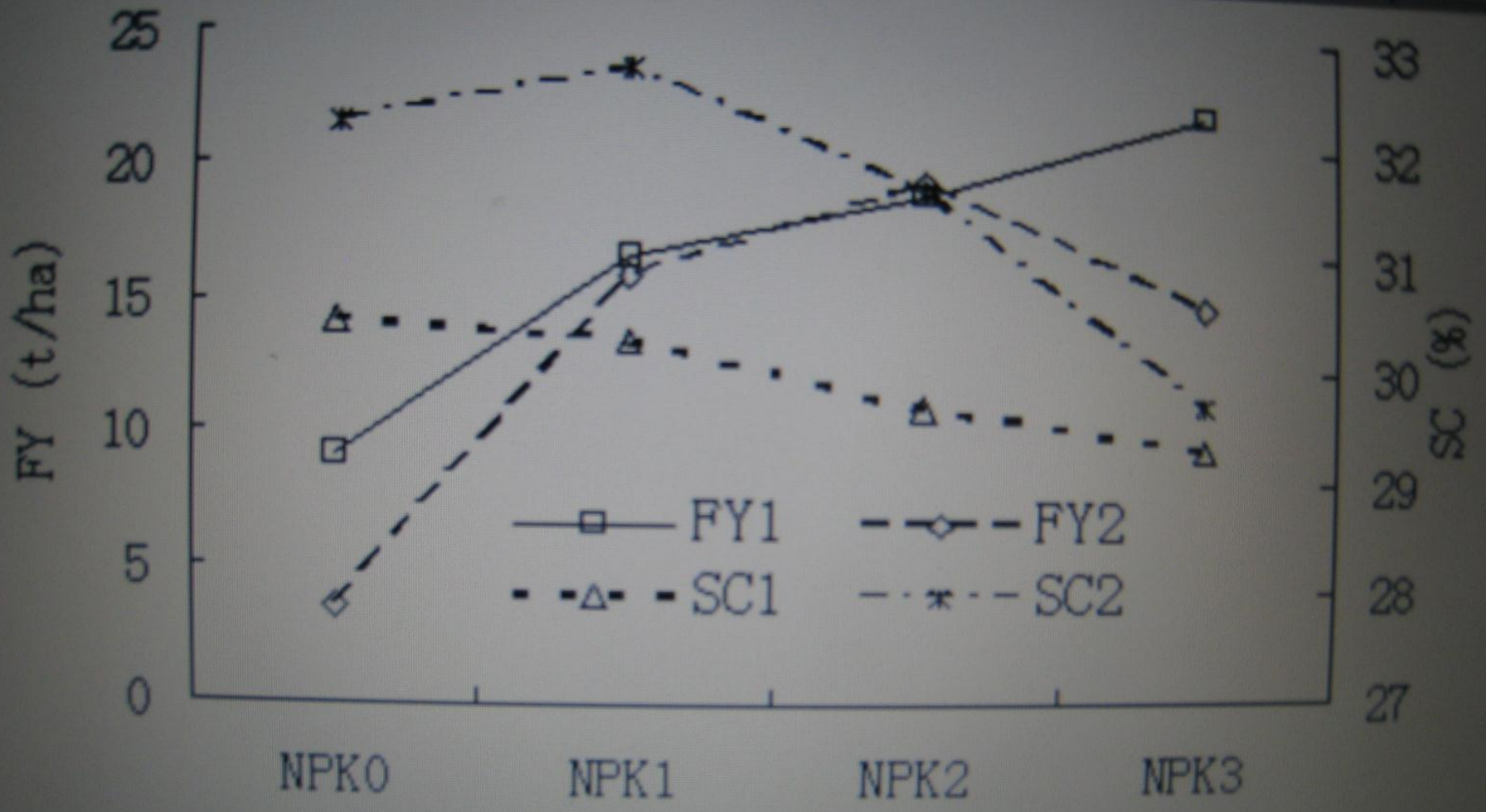


Figure 1. Different N levels



Fiugre 2. Different P levels

Fiugre 3. Different K levels



Fiugre 4. Different NPK levels

2.2 Soil analysis of NPK trial in 1993 and 2002

TM	pH	OM (%)	P (ppm)	K (me/100g)	Ca (me/100g)	Mg (me/100g)
$N_3P_3K_3$	5.3	0.88	48.0	0.13	0.74	0.14
N_2P_1K	5.3	0.91	17.7	0.10	0.51	0.07
$N_3P_2K_2$	5.4	0.88	51.8	0.08	0.64	0.07
$N_2P_3K_2$	5.3	1.10	97.5	0.09	0.67	0.08
$N_2P_2K_3$	5.3	0.88	32.6	0.14	0.60	0.07
$N_2P_2K_2$	5.4	0.88	36.5	0.10	0.70	0.15
$N_2P_2K_1$	5.3	0.75	25.6	0.08	0.43	0.06
$N_2P_0K_2$	5.2	0.80	5.8	0.12	0.38	0.07
$N_1P_2K_2$	5.3	0.83	20.3	0.13	0.59	0.08
$N_2P_2K_0$	5.4	0.91	85.2	0.08	0.66	0.15
$N_0P_2K_2$	5.4	0.83	50.7	0.16	0.58	0.10
NPK	5.3	0.75	8.8	0.09	0.44	0.08
Begin	4.6	2.3	28.7	0.12	0.65	0.11

2.4 Yield and income in 1992-2002

Treatment	FRY (t/ha)	SC (%)	SY (t/ha)	Net income	
				US$/ha	Rank
12. $N_3P_3K_3B_0$	22.4aA	30.1cdBC	6.74	490.0	5
7. $N_2P_1K_2B_0$	**22.3aA**	**31.8aA**	**7.09**	**576.4**	**1**
5. $N_3P_2K_2B_0$	21.8aAB	29.8cdC	6.50	471.3	8
8. $N_2P_3K_2B_0$	21.3aAB	31.3abAB	6.67	500.4	3
11. $N_2P_2K_3B_0$	21.2aAB	31.2abAB	6.61	496.9	4
4. $N_2P_2K_2B_0$	20.7abABC	30.7bcABC	6.35	512.1	2
10. $N_2P_2K_1B_0$	18.8bcBCD	31.2abAB	5.87	469.0	9
6. $N_2P_0K_2B_0$	18.7bcBCD	31.5abA	5.89	480.0	6
3. $N_1P_2K_2B_0$	17.9cCD	31.9aA	5.71	461.9	10
14. $N_1P_1K_1B_1$	17.7cCD	31.9aA	5.65	421.1	11
16. $N_1P_1K_1B_3$	17.6cD	31.3abAB	5.51	219.9	16
15. $N_1P_1K_1B_2$	17.6cD	32.0aA	5.63	349.9	12
13. $N_1P_1K_1B_0$	17.3cD	31.9aA	5.52	472.4	7
9. $N_2P_2\mathbf{K_0}B_0$	14.0dE	**29.4DC**	4.12	335.0	13
2. $\mathbf{N_0}P_2K_2B_0$	12.3dE	31.7abA	3.90	323.8	14
1. $N_0P_0K_0B_0$	7.1eE	31.7aA	2.25	221.6	15

1.2 NPK ratio trial

Table 6. Yield and income of NPK ratio in 2004-2005.

NPK ratio	Fresh yield （t/ha）	SC （%）	Starch yield （t/ha）	Net income	
				US$/ha	rank
5:1:5	27.3aA	25.5aA	7.0aA	340.0	1
4:1:4	24.4abcAB	24.9aA	6.1aA	259.1	5
3:1:3	25.7abAB	25.6aA	6.6aA	334.6	2
2:1:2	22.4abcABC	27.9aA	6.2aA	239.1	6
1:1:1	18.3cdBC	27.7aA	5.1abAB	111.4	10
4:1:2	24.6abcAB	25.3aA	6.2aA	297.0	4
3:1:2	24.8abcAB	26.6aA	6.6aA	315.6	3
1:1:2	21.3abcABC	28.3aA	6.0aAB	212.1	7
2:1:4	19.3bcdABC	27.8aA	5.4abAB	99.8	11
2:1:3	19.5abcABC	27.1aA	5.3abAB	118.6	9
2:1:1	20.2abcdABC	26.4aA	5.3abAB	171.0	8
0:0:0	14.1dC	26.9aA	3.8bB	0	12

Brief of long-term NPK trial

- $N:P_2O_5:K_2O=_{2:1:2}$ is the optimum formula for cassava production in China and most Asian countries.
- Recommendation of $N:P_2O_5:K_2O$ ratio in China
- 1-2:1:1-2 in initial 1-4th year
- 2-3:1:2-3 in 5-8th year
- 3-4:3-4 after 9th year.

1.8 Maintain soil fertility

7.1 Soil analysis of major cassava field in Wuming county

Item	Index	1983 (% survey samples)	2006 (% S.S)
pH	>8.5	11.3	0
	6.5-7.5	47.2	1.3
	<6.5	41.5	98.7
O.M (%)	>3.0	22.1	19.0
	2.0-3.0	31.7	**60.5**
	<2.0	46.2	14.5
Available P (mg/kg)	>10	7.3	**100**
	5-10	15.7	0
	<5	77.0	0
Available K (mg/kg)	>100	22.8	**93.4**
	50-100	32.7	6.6
	<50	44.5	0

Wei Zhiyuan et al., 2007.

- Wuming nicknamed cassava county, biggest production area, highest average fresh root yield, most cassava factories in China.
- Good agricultural habit to maintain soil fertility, highly applied chemical fertilizer and FYM, continues returned the smashing waste cassava stem and branch every year.
- Emphasize on balance fertilization, unwarranted excessive fertilization means low benefit even useless.
- Proof a mistake argument that cassava serious consumed fertility than other crop, soil fertility can sustained maintain continues cropping cassava if pay attention to return the balanced nutrition which were removed away from soil.

1.9 Summary of fertilization

- Important rank : $N > K_2O > P_2O_5$,
- Recommendation balance ratio:
- $N:P_2O_5:K_2O = 2\text{-}4:1:2\text{-}4$
- Optimum NPK/year: for moderate fertility soil about 50-100 kg/ha N and K_2O, 25-50 kg/ha P_2O_5.