CASSAVA AGRONOMY RESEARCH AND ADOPTION OF IMPROVED PRACTICES IN CHINA – MAJOR ACHIEVEMENTS DURING THE PAST 20 YEARS

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ABSTRACT

During the past 20 years, cassava agronomy research in China placed major emphasis on fertility maintenance, erosion control, planting methods, time of planting and harvesting, etc. Long-term fertilization trials conducted at GSCRI, CATAS and the Upland Crops Research Institute (UCRI) in Guangzhou, Guangdong, indicate that N was the most important nutrient for increasing cassava root yields during the early cropping cycles of cassava, but that K, and in some cases P, also became increasingly important. Results of soil erosion control trials conducted in Hainan and Guangxi showed that contour ridging, intercropping with peanut or the planting of vetiver grass contour hedgerows were the most effective practices for reducing soil erosion when cassava was grown on slopes. Planting cassava stakes vertically resulted in more rapid sprouting than horizontal or inclined planting, but there was not much difference in root yield among several methods of planting. Research on time of planting and harvesting cassava conducted at CATAS indicate that when cassava was harvested at 8 months after planting, highest yields were obtained when cassava was planted during the spring (Feb-May). However, when cassava was harvested at 12 months, time of planting had no consistent effect on yield. Effect of time of fertilizer application on cassava yield conducted at CATAS showed that a basal fertilizer application at 30 days after planting resulted in highest yields; there were no significant differences between a single application at 30 days and split applications at 30 and 60 days, or at 30, 60 and 90 days.

INTRODUCTION

The earliest research on cassava cultivation in China was carried out at the Guangdong Agriculture and Sericulture Experimental Farm during 1914-1919, but systematic and intensive research on cassava cultivation was first conducted in 1958, with the objective of stimulating China's cassava production. Most of this early work was concentrated at the present Chinese Academy of Tropical Agricultural Sciences (CATAS) and was described in detail in an unpublished manuscript (in Chinese) by Prof. Wu Jian, completed in 1964. Experiments on land preparation, ridging, length of stakes, planting methods, planting density, harvesting time, NPK fertilization, systems of intercropping, etc, were conducted during 1958-1964 (Zhang Weite *et al*.,1998). Cassava agronomy research was practically suspended from 1965 to the early 1980s. During the 1980s, through cooperation with CIAT, cassava agronomy research in China entered a new stage of development; many trials were conducted in Hainan, Guangxi, Guangdong and Yunnan provinces. This paper summarizes the major results and adoption of improved practices during the past 20 years of research.

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RESEARCH RESULTS

1. Fertilization

A long-term fertility trial has been conducted at the Guangxi Subtropical Crops Research Institute (GSCRI) from 1989 to 1996 (**Figures 1** to **3**). The results indicate that there was a significant response to N throughout the period, but insignificant responses to K and P during the early cropping cycles. As of the third year, the response to K became increasingly important, and the response to P also increased. Application of N tended to increase the yield of stems; high rates of N led to excessive stem growth, while the yield of roots and the starch content tended to decrease. Different varieties showed a different response to fertilizers (**Figure 1**): SC205 was shown to be more responsive to fertilizer application than SC201; the root yield of SC205 increased markedly as the fertilizer rate increased. On the other hand, SC201 was more adapted to grow in poor soils. Similar results were obtained at CATAS in Hainan, where a long-term NPK trial has been conducted for eight years since 1992 (**Figures 4** and **5**). The results again showed the important effect of N for cassava, followed by K, while the response to P was generally not statistically significant. This is a result of the relatively high P status of the soil (Howeler, 1998). The variety SC205 was again more responsive to high applications of N, P and K than SC124 (**Figure 4**).

Table 1 shows the effect of various combinations of N, P and K on cassava yield in a trial conducted at CATAS from 1988 to 1990. Combined application of N, P and K was better than that of any single nutrient, and the application of N alone or NK were better than that of P or K alone or in combination (Zhang Weite *et al.*, 1998).

Another trial on the effect of time-of-fertilizer-application conducted at CATAS in 1988 (**Table 2**) indicate that a basal fertilizer application at 30 days after planting resulted in higher yields than later applications. When the fertilizer application was postponed the yield and the number of roots per plant decreased; however, there were no significant differences between a single application and a split application using the same total amount of fertilizer (Zhang Weite *et al.*, 1998).

2. Planting Method

Table 3 shows the results of trials on planting methods conducted at GSCRI from 1990 to 1992 and at CATAS in 1994. Vertical planting resulted in more rapid sprouting and a higher percent germination than horizontal or inclined planting (Tian Yinong *et al.*, 1995). Ridging resulted in a little lower percent germination than no ridging in GSCRI, but produced higher yields at CATAS. There was not much difference in root yield among several methods of planting, while inclined planting resulted in a slightly higher yield than horizontal or vertical planting (Tian Yinong *et al.*, 1995).

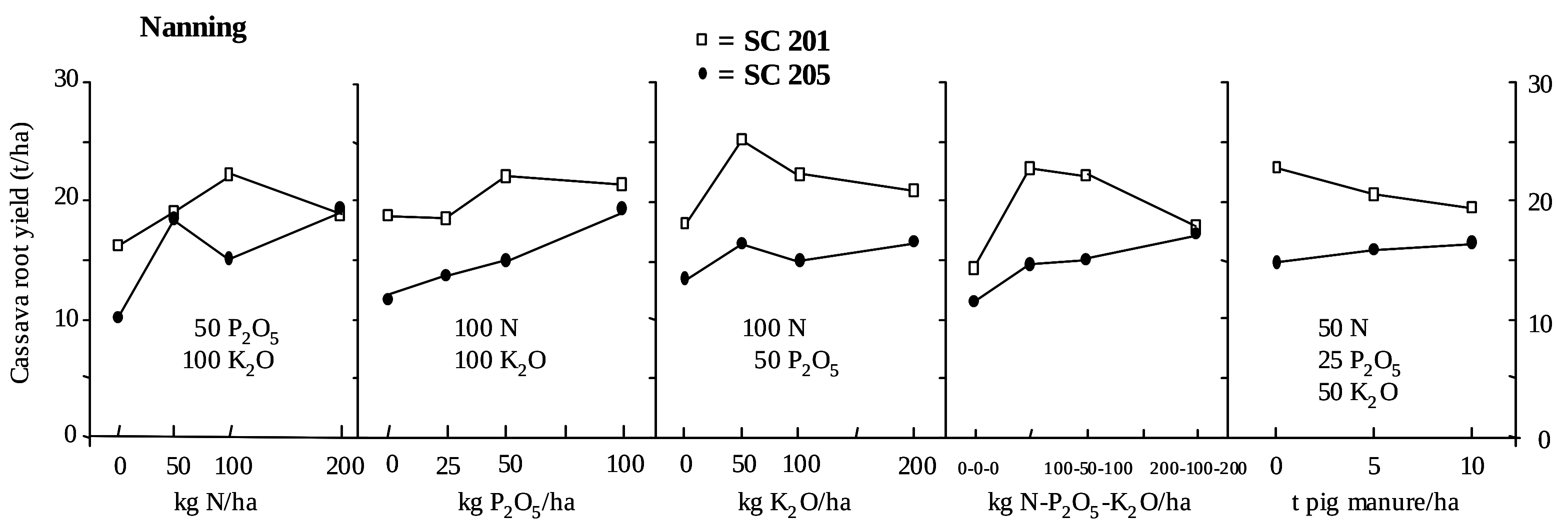

Figure 1. Effect of annual application of various levels of N, P and K as well as pig manure on the yield of two cassava cultivars grown in GSCRI in Nanning, Guangxi, China in 1996/97 (8th year).

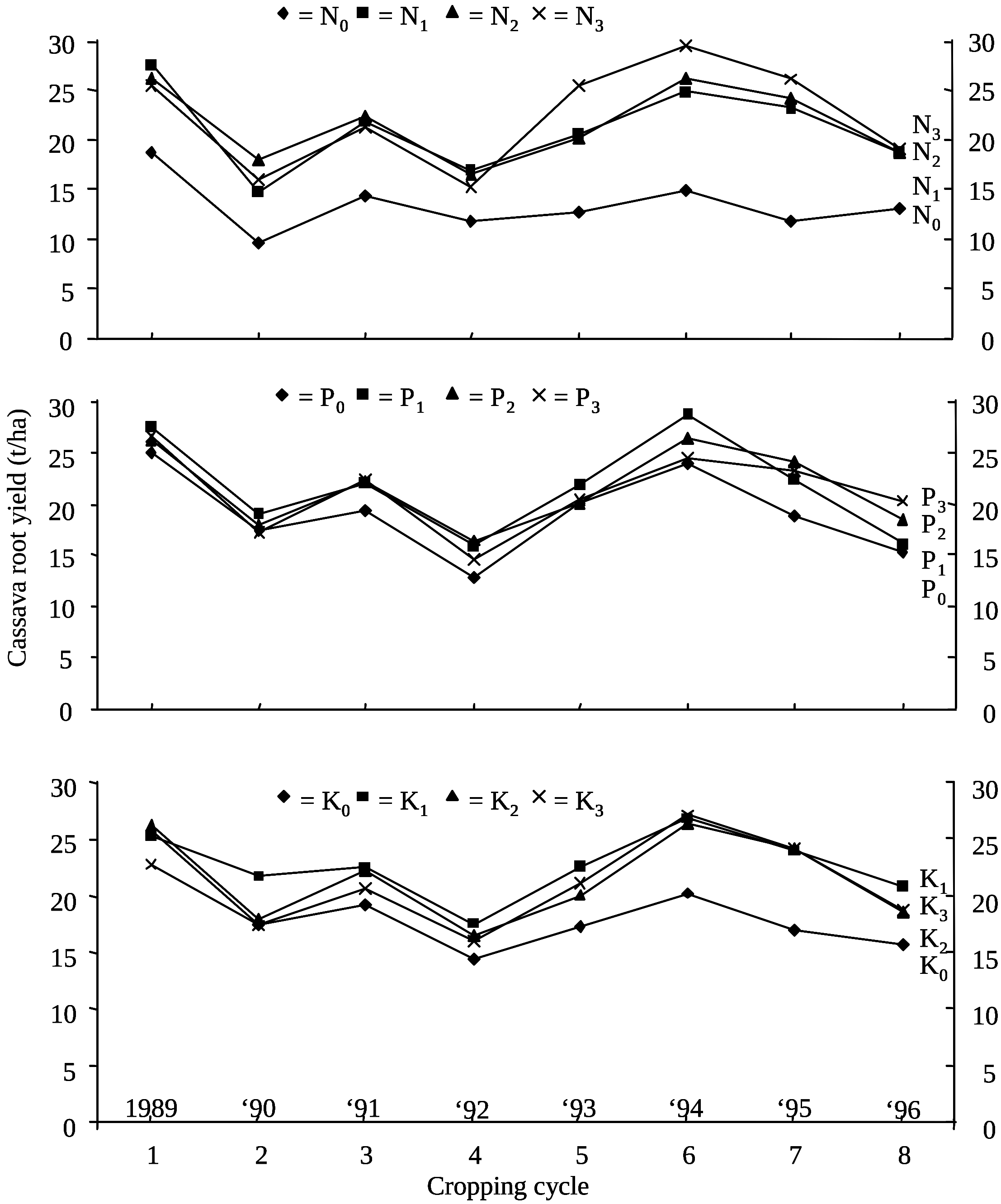

Figure 2. Effect of annual applications of four levels of N (top), P (middle) and K (bottom) on the average root yields of two cassava varieties grown during eight consecutive years at GSCRI in Nanning, Guangxi, China, from 1989 to 1996.

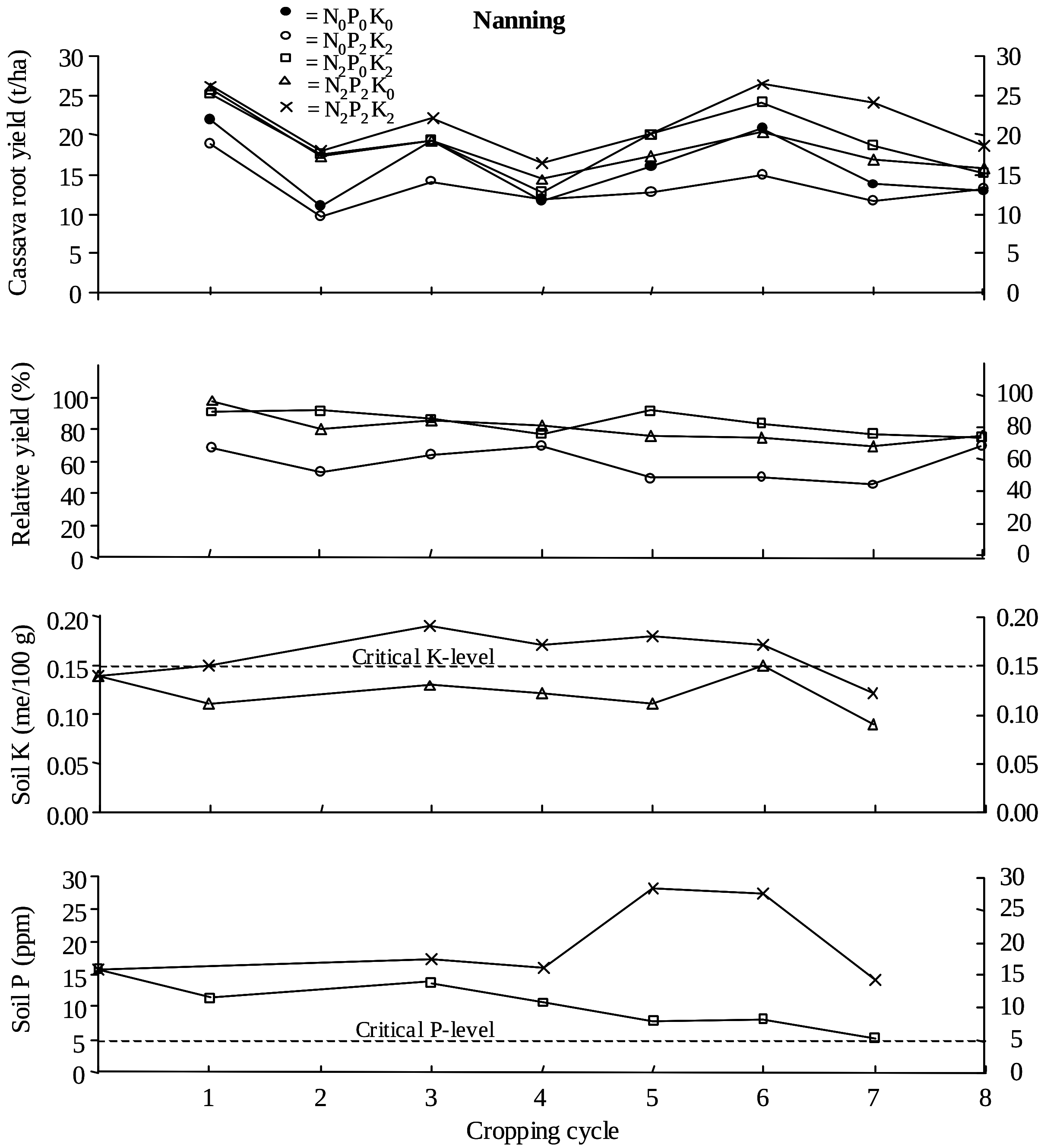

Figure 3. Effect of annual applications of N, P and K on cassava root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during eight years of continuous cropping at GSCRI in Nanning, Guangxi, China. Data are average for two varieties.

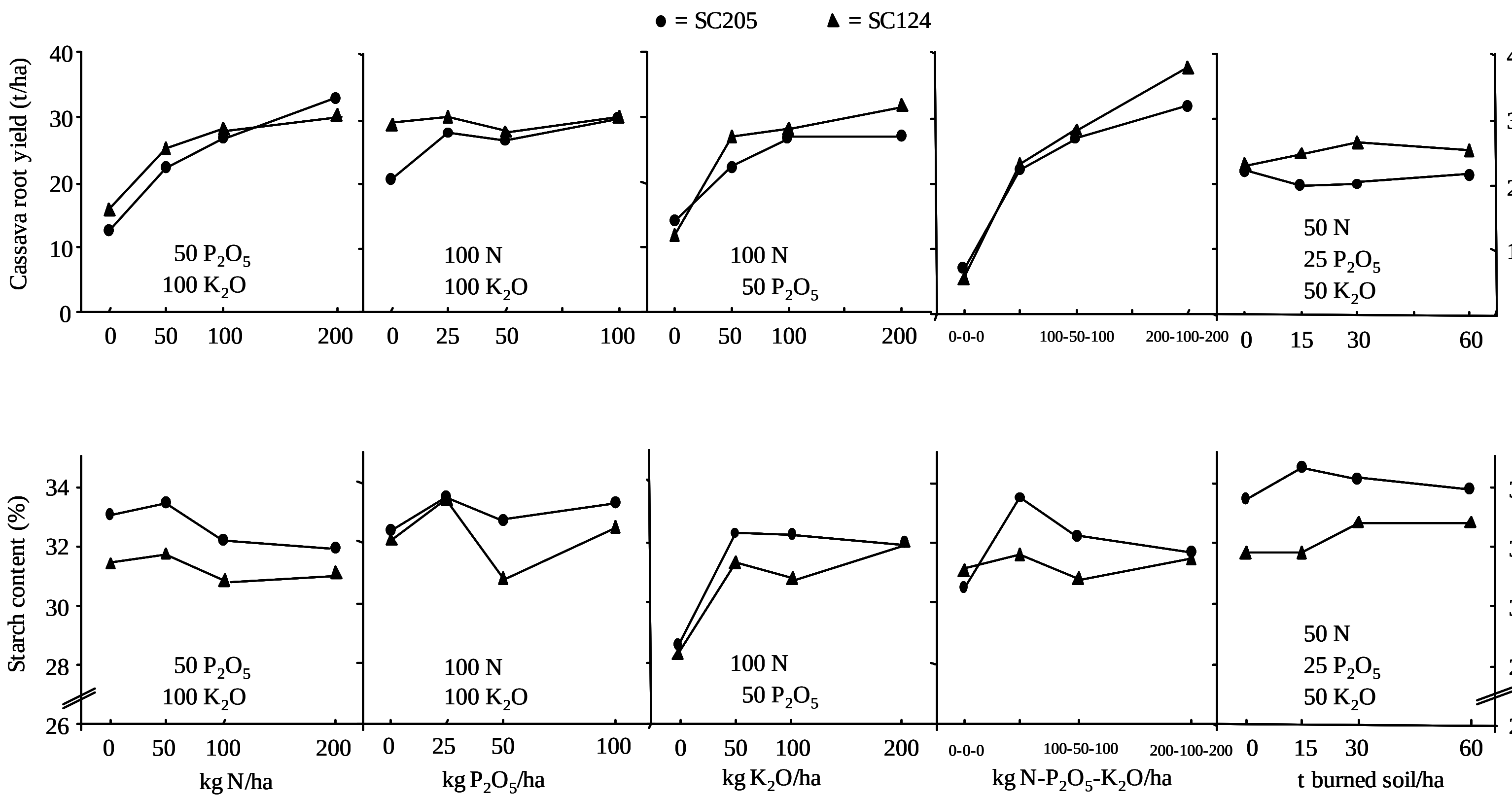

Figure 4. Effect of annual applications of various levels of N, P and K, as well as that of "burned soil" on cassava fresh root yield and starch content during the 8th consecutive cropping cycle at CATAS in Danzhou, Hainan, China, in 1999/2000.

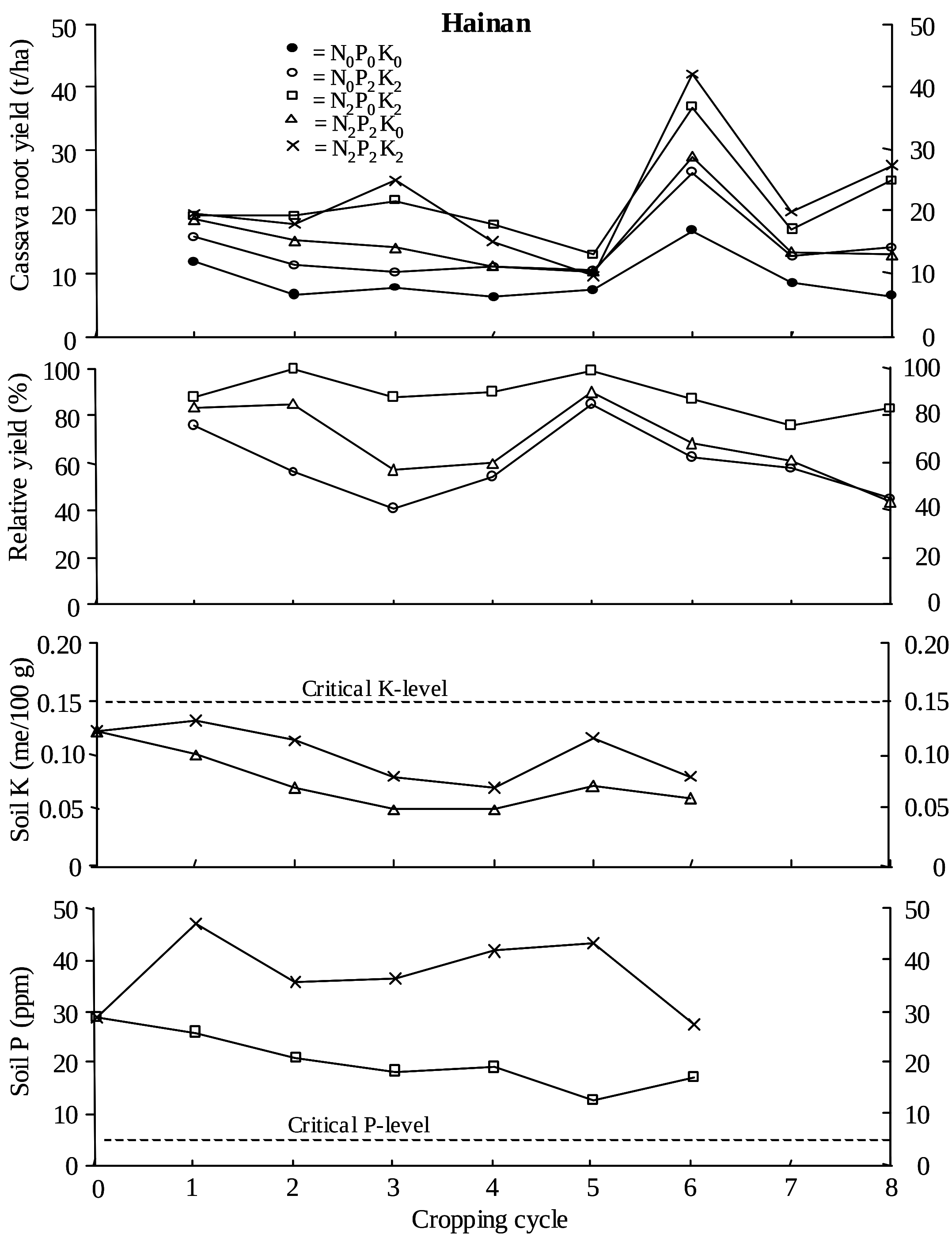

Figure 5. Effect of annual applications of N, P and K on cassava root yield, relative (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during eight years of continuous cropping at CATAS in Danzhou, Hainan China. Data are average for two varieties.

Table 1. Effect of N, P and K application, either singly or in combination, on the fresh root yield (t/ha) of cassava, SC205, planted in CATAS, Danzhou, Hainan, China from 1988 to 1990.

Treatments	1988	1989	1990	Average
Check	15.0	23.1	17.5	18.5
N	16.3	29.5	28.0	24.6
P	20.0	25.3	21.7	22.3
K	19.3	28.6	19.7	22.5
NP	16.8	27.7	22.8	22.4
NK	21.8	31.1	33.7	28.9
PK	22.7	28.5	22.7	24.6
NPK	24.8	34.7	30.2	29.9

Source: *Zhang Weite et al., 1998.*

Table 2. Effect of time of application of fertilizers on cassava root numbers and root yield at CATAS, Danzhou, Hainan, China, in 1988.

	Root numbers/plant	Root yield (t/ha)
Check without fertilizers	8.5	14.5
Fertilizers applied at:		
30 days after planting	11.8	27.2
60 days after planting	9.0	24.8
90 days after planting	8.5	24.2
120 days after planting	7.9	22.0
Fertilizers applied at:		
30 and 90 days	11.1	27.5
60 and 120 days	9.7	23.7
LSD (0.05)	2.3	4.9
(0.01)	3.1	7.5

Source: *Zhang Weite et al., 1998.*

3. Time of Planting and Harvesting

From 1990 to 1994 an experiment was conducted at CATAS in Hainan to determine the optimum time for planting and harvesting of cassava. In this trial, two cassava varieties were planted monthly and were harvested at either 8 or 12 months. The conclusion of this trial is that when cassava was harvested at 8 months the highest yields were obtained when cassava was planted from Feb to May. When cassava was harvested at 12 months, the highest yields were obtained when cassava was planted in May-June, but in two of the three years cassava yields were not greatly affected by the date of planting. The highest starch content was obtained by harvesting in Dec-March, irrespective of whether cassava was harvested at 8 or 12 months (Zhang Weite *et al*., 1998). Thus, it can be concluded that under the climatic conditions of Hainan island cassava should be planted in early spring and harvested in Dec-March, but that planting at almost any time of the year is feasible if plants are harvested after 12 months.

4. Erosion Control

Erosion control experiments have been conducted for many years in Hainan and Guangxi provinces, where the effect of soil and plant management practices on erosion have been studied intensively. With respect to soil management, the results have shown that plowing and disc harrowing increased yields compared with minimum or zero tillage, but that this also caused more soil erosion; planting cassava with zero tillage resulted in somewhat lower yields, but was quite effective in reducing erosion. Zero tillage but planting in hand-prepared planting holes (30x30 cm) resulted in good yields and good erosion control (**Table 4**). Plowing and disc harrowing followed by contour ridging not only increased yields but also reduced soil losses. Contour ridging was found to be an effective way to reduce erosion, while also increasing cassava yields (**Tables 4** to **6**).

With regard to crop management practices, fertilizer application, closer spacing, contour barriers of grasses like vetiver grass, or intercropping with early-maturing and short-stature crops, such as peanut, soybean, watermelon, and mungbean, were all found to be effective in reducing erosion. Among these various management practices, contour barriers of vetiver grass and intercropping with peanut were generally the most effective in reducing erosion, while they also increased cassava yields. The method of planting (vertical or horizontal) had no significant effect on erosion (**Tables 5** and **6**).

Table 3. Effect of stake planting position and ridging on cassava yield and germination at 1 month in GSCRI, Nanning, Guangxi, and in CATAS, Danzhou, Hainan, China. Data are the average for SC201 and SC205 in CSCRI, and for SC205 and SC124 at CATAS.

Planting Position		GSCRI (1990-1992)		CATAS (1994)
		Germination[1)] (%)	Root yield[2)] (t/ha)	Root yield (t/ha)
Horizontal				
	-ridging	61.5	11.7	20.0
	-no ridging	67.4	10.9	18.6
Inclined				
	-ridging	66.4	13.0	25.3
	-no ridging	78.1	11.5	16.9
Vertical				
	-ridging	82.8	11.1	19.4
	-no ridging	85.8	11.2	18.5

[1)]Average of 1991 and 1992 (no data taken in 1990)
[2)]Average of 1990 and 1992 (no harvest in 1991 due to drought)
Source: *Zhang Weite et al., 1998.*

Table 4. Effect of land preparation on root yield and dry soil loss due to erosion when cassava was grown on 25% slope in CATAS, Hainan, China from 1989 to 1992.

	Root yield (t/ha)					Soil loss (t/ha)				
Treatment	1989	1990	1991	1992	Average	1989	1990	1991	1992	Average
Twice plowing, twice discing, contour ridging	26.3	34.6	17.0	22.8	25.2	71.1	117.0	186.9	79.3	113.6
Twice plowing, twice discing, no ridging	26.0	29.6	18.2	22.3	24.0	141.1	193.4	261.0	134.6	182.5
One time plowing, no ridging	21.3	30.5	19.1	18.6	22.4	91.0	104.8	167.5	119.8	120.8
Zero tillage, hand prep. of planting holes 30x30 cm	25.6	27.6	20.6	21.3	23.8	45.3	97.4	203.3	90.8	109.2
Zero tillage, direct planting in small holes	22.6	29.2	16.5	19.3	21.9	59.8	88.0	201.2	115.9	116.2

Source: *Zhang Weite et al., 1998.*

Table 5. Effect of cultural practices on root yield (t/ha) when cassava was grown on about 12% slope in GSCRI, Nanning, China, during 1990-1999.

Treatment[1)]	1990	1991	1992	1993[2)]	1994[2)]	1995[2)]	1996	1997	1998	1999	Avg.
1. Plow+disc, no ridges, no fertilizer	18.5	18.0	13.6	18.3	13.8	12.8	10.0	17.3	11.9	13.0	13.9
2. Plow+disc, no ridges, with fertilizers	12.2	19.0	13.9	23.8	19.7	19.0	14.0	23.1	15.2	26.5	20.2
3. Plow+disc, contour ridges, with fertilizers	15.6	20.5	12.2	20.4	25.4	21.4	29.0	24.8	20.1	23.3	23.5
4. Plow+disc, up-down ridges, with fertilizers	-	-	-	-	-	-	16.7	-	-	-	-
5. Plow+disc, no ridges, with fert., high population	20.5	14.1	13.9	-	-	-	18.3	-	-	22.7	-
6. Plow only once, no ridges, with fertilizers	-	-	-	21.6	18.4	18.2	-	-	-	-	-
7. Plow+disc, no ridges, with fert., *Crotalaria* intercrop	-	-	-	21.6	23.0	20.0	17.7	21.9	-	-	-
8. Plow+disc, no ridges, with fert., vetiver hedgerows	-	-	-	22.5	28.1	17.9	13.5	22.4	17.9	22.5	20.7
9. Plow+disc, no ridges, with fert., branching variety	14.3	15.0	13.4	-	-	-	16.5	-	-	-	-
10. Plow+disc, no ridges, with fert., vertical planting	21.3	16.0	13.5	-	-	-	-	-	-	-	-
11. Plow+disc, no ridges, with fert., mango contour strips	-	-	-	-	-	-	-	21.2	13.8	19.3	-
12. Plow+disc, no ridges, with fert., peanut intercrop	20.8	15.0	14.3	23.4	22.7	21.6	13.0	25.2	14.7	23.8	20.6
13. Plow+disc, no ridges, with fert., munbean intercrop	-	-	-	-	-	-	14.3	22.7	14.6	23.3	-
14. Plow+disc, no ridges, with fert., soybean intercrop	-	-	-	-	-	-	15.0	27.8	-	24.8	-

[1)]Cassava was planted horizontally except in T_{10} and at a spacing of 1.0x1.0 m except in T5 (0.8x0.8m); the intercrops produced little or no yield.

[2)]Average yield of SC201 and SC205.

Table 6. Effect of cultural practices on dry soil loss (t/ha) due to erosion when cassava was grown on about 12% slope in GSCRI, Nanning, China, during 1990-1999.

Treatment[1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg. 93-99
1. Plow+disc, no ridges, no fertilizer	11.0	23.7	13.9	44.2	11.5	3.9	7.4	6.6	23.8	37.5	19.3
2. Plow+disc, no ridges, with fertilizers	7.0	27.1	9.7	23.9	4.8	1.8	2.4	2.6	13.9	12.1	8.8
3. Plow+disc, contour ridges, with fertilizers	9.5	4.6	3.0	8.3	2.1	2.3	0.8	1.9	11.3	8.6	5.5
4. Plow+disc; up-down ridges, with fertilizers	-	-	-	-	-	-	21.5	-	-	-	-
5. Plow+disc, no ridges, with fert., high population	9.5	14.1	4.3	-	-	-	2.0	-	-	14.8	-
6. Plow only once, no ridges, with fertilizers	-	-	-	22.5	7.5	2.2	-	-	-	-	-
7. Plow+disc, no ridges, with fert., *Crotalaria* intercrop	-	-	-	23.6	5.0	2.2	1.5	2.8	-	-	-
8. Plow+disc, no ridges, with fert., vetiver hedgerows	-	-	-	6.1	1.8	0.9	1.9	1.6	11.4	7.0	4.4
9. Plow+disc, no ridges, with fert., branching variety	6.8	29.8	15.3	-	-	-	1.9	-	-	-	-
10. Plow+disc, no ridges, with fert., vertical planting	8.5	20.4	11.9	-	-	-	-	-	-	-	-
11. Plow+disc, no ridges, with fert., mango contour strips	-	-	-	-	-	-	-	3.6	11.3	15.4	-
12. Plow+disc, no ridges, with fert., peanut intercrop	3.7	13.6	2.2	12.1	2.9	1.8	3.5	1.7	13.1	8.2	6.2
13. Plow+disc, no ridges, with fert., mungbean intercrop	-	-	-	-	-	-	2.6	3.4	20.4	11.8	-
14. Plow+disc, no ridges, with fert., soybean intercrop	-	-	-	-	-	-	1.0	2.8	-	9.8	-

[1)]Cassava was planted horizontally except in T_{10}, and at a spacing of 1.0x1.0 m except in T_5 (0.8x0.8 m)

5. Use of Plastic Film to Cover the Soil

The use of plastic film to cover the soil before planting crops is a new cultural method that has been recommended in China in recent years. Covering the soil with plastic film increases the temperature of the soil in early spring and maintains the moisture in the soil. Planting could be done 1-2 months earlier than without the plastic mulch, while the harvesting time could also be earlier, resulting in a higher price for the crops. The use of plastic film to cover the soil also resulted in an increased percent germination, it controlled weeds and reduced soil loss from erosion. Due to the high cost of plastic film in the past, this method was mainly used for planting high-value crops, such as watermelon, vegetables, maize etc. As the price of plastic progressively decreased, being now only about 450 yuan/ha, farmers began to use plastic film for planting cassava, either in monoculture or intercropped. A study on the use of plastic film for planting cassava intercropped with maize was conducted in Wuming county, Guangxi, in 1999. Maize was planted first with a plastic film covering the soil in early Feb; after one month cassava was interplanted between maize rows. The results shown in **Table 7** indicate that with plastic film higher yields of cassava were obtained than without plastic film, while the intercropped maize produced additional income.

6. Plant Spacing

Cassava spacing trials have been conducted in various locations in China during several years. **Table 8** shows the results of a recent spacing trial conducted in Wuming county, Guangxi, in 1999. There were no significant differences in yield when the plant spacing ranged from 1x0.5 to 1x1 m. A plant density of 12,500-20,000 plants/ha was considered most suitable for cassava in China.

Adoption of Improved Practices

Due to the low profitability of cassava and the lack of recommendations for cultural practices in the past, farmers paid little attention to the cultivation of the crop. The recent expansion of cassava processing factories in Guangxi created greater demand for raw materials, resulting in an increase in the price of cassava roots. Farmers began to request information on new technologies and started to devote more attention to adoption of improved practices. Compared with the traditional cultural practices, the adoption of improved practices in China mainly involved the use of more intensive production, better varieties, more fertilizer use, higher plant populations, better intercropping systems and the use of plastic film to cover the soil before planting. **Table 9** summarizes the main practices that were adopted in China. Some recommended practices, such as soil conservation and the optimum rate, time and method of fertilizer application, had little obvious impact on yield while requiring additional labor or money; they were therefore difficult to be accepted by farmers and were rarely used to cultivate cassava on a large scale. Practices which are simple but highly profitable will be readily adopted by farmers. Farmer participatory research will identify the needs of farmers and will help develop practical solutions to their problems. This is the future direction for cassava research.

Talble 7. Effect of using plastic film to cover the soil to plant cassava intercropped with maize on yields in Wuming county, Guangxi, China in 1999.

Treatments	Yield (t/ha) cassava	maize
Cassava intercropped with maize and using plastic film to cover the soil	54.3	5.3
Cassava monoculture without plastic film	46.5	

Source: *Science and Technology Bureau of Wuming county, Guangxi, China.*

Table 8. Effect of plant spacing on the yield of cassava, SC205, in Wuming county, Guangxi, China in 1999.

Plant spacing (m)	No. of plants/ha	Root yield (t/ha)
1x0.5	20,000	54.2
0.8x0.8	15,625	46.5
1x0.8	12,500	46.5
1x1	10,000	40.4

Source: *Science and Technology Bureau of Wuming county, Guangxi, China.*

REFERENCES

Howeler, R.H. 1998. Cassava agronomy in Asia. An overview 1993-1996. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 355-375.

Tian Yinong, Lee Jun, Zhang Weite and Fang Baiping. 1995. Recent progress in cassava agronomy research in China. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 195-216.

Zhang Weite, Lin Xiong, Li Kaimian, Huang Jie, Tian Yinong, Lee Jun and Fu Quchui. 1998. Cassava agronomy research in China. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 191-210.

Table 9. The main cultural practices for cassava that have been adopted in China.

1. Cropping system:	Monoculture mainly in mountainous areas or in soils that are too poor or too dry for other crops. Intercropping with food crops mainly in more fertile soils or in plots near the road to facilitate transport.
2. Variety:	Basically two-varieties, SC201 and SC205, but the planting areas of new varieties SC124, GR911 and GR891 are rapidly expanding.
3. Planting time:	Febr-April.
4. Land preparation:	On the flatter areas: plow once at 15-20 cm depth with oxen or tractor, followed by once disc-harrowing. On the steeper slopes: prepare planting holes with hoe or plow with oxen.
5. Planting method:	Mainly horizontal.
6. Plant spacing:	80x80 cm, 80x100 cm or 50x100 cm.
7. Fertilization:	When cassava is intercropped with other crops, farm-yard manure (FYM) and chemical fertilizers such as urea, SSP and calcium cyanamide are often applied to the intercrops, but this will also benefit cassava; when cassava is planted in monoculture, farmers also apply FYM at planting or 15-15-15 compound fertilizers after the first weeding. But in the mountainous areas, fertilizers are seldom applied to cassava.
8. Weeding:	2-3 times manually, at 30-40 days and 2-3 months later.
9. Harvesting time:	Nov-Jan.
10. Intercrop:	Mainly maize, watermelon, peanut, soybean or young fruit trees.
11. Stake storage:	In the northern regions, stems are normally stored in soil trenches or pits covered with straw and soil to protect them from frost damage; in the southern regions, stems are usually stored under the shade of trees covered with dry straw.
12. Erosion control:	Usually dig diversion channels to prevent water from entering the cassava fields.