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

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ABSTRACT

Over the years, research conducted on the crop focused mainly on agronomic, soil fertility maintenance and soil conservation practices. Very few studies were conducted on the basic physiology of the plant.

Except for the use of fertilizers and a change in varieties, very few farmers adopted the recommended technology in cassava cultivation. Despite repeated exposure to modern technology, most farmers still follow their own traditional ways of growing the crop. Details of results obtained in the area of cassava agronomy research are presented.

INTRODUCTION

Intense competition due to globalization has energized the Philippine agriculture sector to reorient its research and development efforts in order to cope with the changing needs of world markets. With the birth of the Agriculture and Fisheries Modernization Act (AFMA), eighteen commodities were given priority by the government through the Department of Agriculture to adjust their R&D/E Programs to the current thrust. Root crops, such as cassava, are among these commodities.

The cassava industry in the Philippines is now gaining momentum with the existence of various market opportunities. Cassava is grown not only for human food, but also for starch, animal feed and industrial uses such as alcohol. Aside from the San Miguel Corporation, which currently uses cassava domestically as an ingredient in animal feeds, other firms like La Tondeña, are also working with cassava as a potential raw material for the production of alcohol. This is due to the scarcity of molasses resulting from low sugarcane production. Moreover, various food products from cassava have been developed, further increasing the demand for the crop.

Cassava Area, Yield and Production

For the past twenty years cassava production in the Philippines showed an irregular trend. For example, in the late 1970s cassava production was at its peak. There was an increase of 108% in area from 87,420 ha in 1973 to 181,770 ha in 1978, which resulted in a 356% increase in total volume of production and a 120% increase in average yield (FAOSTAT, 2001). The increase in the national average cassava yield of 6.38 t/ha during that period was attributed to the growth of large plantations, especially in Mindanao where the growing areas are free from typhoons and generally have fertile soils. Although there was a slight increase of 12% in area planted to the crop in the mid-80s, the average yield showed a considerable decrease from 11.7 t/ha in 1978 to 8.2 t/ha in 1985. A slight increase in cassava area in the early to mid 1990s, especially in Mindanao, was again due to the continued promotion of the crop. Increasing awareness on the use of cassava as food, feed and as raw material for industry, as well as the scarcity of molasses have triggered the increased demand

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for the crop. Up to the present, cassava cultivation is still concentrated in Mindanao because of the greater market opportunities, particularly the presence of chips traders, feed millers and starch processors.

CASSAVA AGRONOMY RESEARCH

Over the years the Philippine Root Crops Research and Training Center (PRCRTC) - now renamed PhilRootcrops, the national root crop center for research and development - on its own and in collaboration with the CIAT cassava program in Asia, conducted research focused on agronomy, soil fertility and soil conservation. A few studies were also conducted on the basic physiology of the plant. Results of some of these studies are as follows:

Land Preparation/Tillage

Despite the great demand for cassava-based-products, like starch, cassava continues to be grown at minimum input levels, since the primary interest of farmers with the crop is for home consumption rather than as a commercial market crop (Pardales, 1985).

Tillage or land preparation is one of the most labor-intensive operations in growing the crop (Pardales, 1985), and is one of the factors that most affects the yield of cassava, as reported by Villamayor (1983a) and (Pardales (1986) (**Table 1)**. The conventional method, consisting of harrowing-plowing-harrowing-and making furrows, gave the highest percentage germination and yield. It was also reported by several researchers that planting on ridges or mounds in areas susceptible to waterlogging is preferable to planting in flat beds or furrows, as the yield is generally higher in the former than the in the latter (Labra and Tisang, 1979; Secreto, 1981). Abenoja and Baterna (1982) stated that in newly opened areas such as in a "kaingin" (slash and burn), no tillage is necessary for at least two seasons, except that required for inserting the planting stakes into the soil. Castroverde (1983) showed that minimum tillage together with herbicide application is profitable, but suggests that some tillage operation is necessary to obtain a loose and well-aerated soil for the development of the storage roots. This was confirmed by Pardales (1986) who showed that conventional tillage (plowing and harrowing an entire area) or minimum tillage (row plowing only plus herbicide application) were better than zero tillage. In terms of plowing depth, however, Villamayor (1983a) found no advantage in preparing the soil deeper than 20 cm.

Table 1. Effect of land preparation and tillage on the yield of cassava in ViSCA, Baybay, Leyte, in 1995.

Land preparation/tillage	Root yield (t/ha)
Zero tillage	15.95b
Minimum tillage	30.83a
Conventional tillage	29.14a

Source: *Pardales, 1986.*

In a physiological study, Pardales (1985) showed that conventional tillage resulted in an increase in dry matter (DM) and nitrogen (N) accumulation; DM and N accumulation followed the order: conventional tillage > minimum tillage > zero tillage.

Selection and Preparation of Planting Materials

Good quality planting material usually results in better germination and yield of cassava. Thus, it is necessary to properly select and prepare the planting material. The presence of scale insects can reduce the sprouting percentage and yield of cassava. However, treatment of the stakes with insecticide before planting or planting horizontally minimized the yield reduction, even though sprouting percentage was not improved (Villamayor and Perez, 1986; Villamayor and Perez, 1987).

The performance of stakes produced under shade of coconut was not reduced compared with those produced in the open (Villamayor and Perez, 1986). The first planting of stakes produced under shade even gave higher yields than those produced in the open, but there were no yield differences in the subsequent stake evaluation.

One study (Ocampo, 1956) has shown that stakes cut from the base of the stem produced higher yields than those taken from the middle, which in turn produced higher yields than those taken from the top of the stem (**Table 2**).

Table 2. Effect of the part of stem used as planting material on the yield of the subsequent cassava crop (cv. Valencia) in Iloilo, in 1956.

Part of stem	Root yield (t/ha)
Top	7.91c
Middle	10.41b
Base	12.49a

Source: *Ocampo, 1956.*

There are many studies on the effect of length of cassava stakes. Some workers showed no significant difference in yield among stake lengths between 10 and 50 cm (Dacpano, 1980; Velasco, 1982). Others showed short stakes to be better than longer stakes (Pardales and Forio, 1979; Mateo, 1981; Apilar and Villamayor, 1981; Soriano, 1986; Villamayor *et al*., 1992), while still others showed the long stakes to be better than short stakes (**Table 3**). These effects were amplified by the significant interaction between stake length and cultivar. Apparently, the disagreement in results was due to the differences in the length of the stakes used in the study, the variety and the position of planting, as has been reported by Villamayor *et al*. (1992). In general, it appears that short stakes are better than long stakes when planted vertically and long stakes better than short stakes when planted horizontally.

Table 3. Effect of stake length on the yield of two cassava varieties in ViSCA, Baybay, Leyte, in 1989.

Stake length (cm)	Root yield (t/ha)	
	VC - 1	Golden Yellow
10	9.3	19.4
15	12.4	19.8
20	15.5	20.9

Source: *Villamayor et al., 1992.*

Storage of Planting Material

Parcasio (1982) showed that storage of stems for a period of up to 15 days had no significant effect on yield. Storing cassava stems for one month under a tree and protected from direct sunlight, did not affect the yield of the crop (Villamayor and Perez, 1983), but storage for one or two months significantly reduced yields even though germination was not markedly reduced. In another study (Villamayor, Perez and Destriza, unpublished) it was found that cassava stems placed vertically in the open but covered with coconut fonds could be stored for up to four months without affecting the yield of the subsequently planted crop (**Table 4**). For long-term storage of three or four months, Villamayor *et al*. (1987) reported that burying the basal part of the stem into the soil at about 2 cm depth and protecting the stems from direct sunlight did not reduce the yield compared with the use of unstored stakes. An earlier report stated that treatment of stakes to be stored with coal tar had no effect on viability and shoot development (Mendaira, 1973).

Table 4. Yield evaluation of cassava stakes (cv. Golden Yellow) stored vertically in the open for various duration and covered with coconut fonds in ViSCA, Baybay, Leyte, in 1989.

Storage duration (months)	Root yield (kg/m^2)
Zero	3.1a[1)]
One	1.6c
Two	2.4b
Three	2.7ab
Four	2.8ab

[1)] Mean seperation (LSD, 0.05)

Source: *Villamayor, Perez and Destriza. (unpublished data)*

Planting

Cassava can be planted any time of the year as long as rainfall is adequate. In areas with a distinct dry season it is best to plant at the onset of the rainy season since yields are reduced when planting is delayed towards the dry season (PRCRTC, 1986). A significant positive correlation was observed between rainfall received during the initial seven-month period and yield (Villamayor and Davines, 1987). Bernardo and Esguerra (1981) also recommended planting 3-5 months before the onset of the dry season to avoid spider mite damage. Villamayor *et al*. (1992) reported that except for the Jan planting, the three other times of plantings (Sep, Nov, Mar) had similar yield patterns at different ages of harvest. Yields increased from the 9th to the 10th month, declined at the 11th month, and increased again during the 12th month, except for the Nov planting when the yield decreased slightly. The Jan planting had the highest yield at the 11-month harvest. In general, higher yields were obtained with an increase in harvest age, particularly from the 9th to the 10th month.

Planting is usually done manually but a mechanical planter is available that can plant a hectare in seven hours; it is sometimes used in large plantations. In one pass the implement furrows the soil, drops fertilizer and planting stakes, covers the stakes and compacts the soil.

Planting position, whether vertical, slanted or horizontal, did not affect yield (Tizon, 1980; Abenoja, 1981; Credo, 1982; Soriano, 1986) of a particular variety, but the effect varied significantly among varieties (Villamayor *et al*., 1992). In vertical planting, the inverted position should be avoided since germination is low and the yield is reduced (Evangelio, 1981). However, an earlier report (Reyes and Esperidion, 1976) stated that horizontal planting is better than vertical or slanted planting. The conflicting results are probably due to the difference in soil type, climate and method of soil preparation, whether in mound, furrow, ridge, or flat. The general recommendation is to plant vertically on ridges when rainfall is heavy, especially for heavy soils, and horizontally in furrows when rainfall is scarce during planting, especially for light soils (Mendiola, 1958)

Depth of vertical planting, from 5 to 20 cm, did not affect yield (Corpuz, 1980). Baludda (1980) also did not find any significant differences in yield among 20 to 35 cm depth of planting, but there was a trend that the deeper the planting, the lower the yield. When the whole stem was buried vertically, yield was reduced compared with a planting depth of 15 cm (Villamayor, 1988). This was attributed to the development of the underground part of the stem into storage organs, as the yield reduction was minimized when the underground shoots were removed while still young (1 month old), allowing only the above-ground shoots to develop.

PCARRD (1983) recommends planting only one stake per hill, but about 45% of farmers surveyed plant two stakes per hill (Villamayor *et al*., 1987). Villamayor (1988) stated that cassava can tolerate about 30% missing hills without a significant yield reduction, regardless of variety, population density and fertilization levels used. He recommended that replanting should be done as soon as possible as the yield of the replants were drastically reduced when replanting was delayed beyond 13 days after planting.

Plant Population/Spacing

Varying the planting density from 7,000 to 28,000 plants/ha did not affect total yield (Secreto, 1981; Villamayor and Destriza, 1982a), but there was a trend that the marketable yield decreased with increasing plant density. On the other hand, Occiano (1980) and Bansil (1980) found that a spacing of 75x75 cm was better than the 75x50 cm or 75x25 cm spacing between hills compared with 60, 50 and 40 cm spacing or 50, 100 and 125 cm spacing, respectively. The conflicting results may be due to differences in variety, soil fertility and climatic conditions. For example, Villamayor and Apilar (1981) found the yield of the short-statured variety Golden Yellow not to be affected by the different populations used, but the yield of the tall-statured variety Kadabao was reduced at higher populations.

The yield in a double row system of planting, where an unplanted row alternate with two planted rows, did not differ significantly compared with a single row system (Villamayor and Destriza, 1982a). In the former, the vacant row can be planted with intercrops without interfering in the weed control operations such as off-barring and hilling-up.

In an other spacing trial conducted under mature coconut trees, Villamayor *et al.* (1992) reported that cassava planted at closer spacing or higher population (> 12,500/ha) had more roots and higher yields than those planted at wider spacing. In an open field trial, marked increases in cassava yields were also obtained when the plant density was increased to 15,625-27,780 plants/ha (Evangelio and Ladera, 1998) (**Table 5**).

Table 5. Effect of plant spacing on the yield of cassava in BES, Ubay, Bohol, in 1996.

Spacing (cm)	Plant population (no./ha)	Root yield (t/ha)
60 x 60	27,778	21.85a
80 x 80	15,625	20.97a
100 x 100	10,000	16.18b

Source: *Evangelio and Ladera, 1998.*

Weed Control and Post-plant Cultivation

It was found that the critical period for weed control in cassava is during the first two months of growth (Jumadiao, 1982; Bacusmo, 1978; Bacusmo and Talatala, 1980) (**Table 6**). Although hand weeding is the most practical method of weed control when labor is cheap (Mariscal, 1984), cultivation is also beneficial to cassava, especially during the early establishment period of the crop (Pardales, 1985). Villamayor and Reoma (1987) found off-barring two weeks after planting (WAP) followed by hand weeding within the row 3 WAP and hilling-up at 5 and 7 WAP to be the most profitable among the treatments used under ViSCA conditions.

Table 6. Effect of weeding on the yield of cassava in ViSCA, Baybay, Leyte, in 1977.

Weeding practices	Root yield (t/ha)
No weeding	8b
Weed free during 2 MAP	18a

Source: *Bacusmo and Talatala, 1980.*

Irrigation

There have been no studies conducted on the irrigation of cassava, but Villamayor and Destriza (1985) showed that watering the plants during the period of very low rainfall increased the yield of cassava significantly (Pardales *et al*., 1999) (**Table 7**). Pardales and Esquibel (1996) reported that water stress or lack of soil water during the first three months after planting remarkably reduced all growth indicators, both the above-ground (e.g., number of leaves) or below-ground (e.g., number of roots) parts of the plant. They emphasized in their succeeding study (Pardales and Esquivel, 1997) the importance of soil moisture on the development of cassava plants: a moisture content equivalent to 30% of field capacity (30% FC) of the soil significantly reduced growth and development of the plant when compared with a soil moisture contents of 80% FC or 100% FC. In a root physiology study of cassava and sweetpotato, Pardales *et al*. (1999) found that root zone temperature, which is affected by soil moisture regime, is an important factor that affects the establishment of the crop in the field. They found that 25^0C was the optimum root temperature.

Table 7. Comparative root and shoot growth (gm/plant) of cassava plants subjected to drought at various stages of crop development in ViSCA, Baybay, Leyte, in 1996.

Treatments	Shoot weight (gm/plant)	Root weight (gm/plant)
Early watered	7.53	1,020
Early drought stress, then watered	7.85	1,319
Early drought stress	2.25	887
Early watered, followed by drought stress	-	1,096
Continuously watered (no drought stress)	10.25	1,492
Continuous drought stress	-	582

Source: *Pardales et al., 1999.*

Fertilization/Liming

Many studies have been conducted on the response of cassava to N, P and K levels, either singly or in combination, or a comparison between levels of fertilizers, or between organic and inorganic fertilizers (Evangelio *et al*., 1995; Evangelio and Ladera, 1998; Villamayor *et al*., 1992; Serrame, 1982; Pineda, 1980; de Guzman, 1982; Lagrimas, 1982; Agustin, 1983; Musngi, 1985). Liquid fertilizers have also been tried (Silangan, 1982).

In Bohol, with the following soil characteristics: pH 5.5, 1.0% O.M., 6.9 ppm available P and 96 ppm exchangeable K, Villamayor *et al*. (1992) reported that no significant yield differences due to N, P or K application were observed during the first year (1989/90) of the long-term fertility trial, but that cultivar VC-1 yielded significantly more than Golden Yellow. However, Evangelio *et al*. (1995) reported significant differences in yield due to fertilizer levels in the second until the fourth (1991-1993) cropping cycles. The main responses were to K and N application (**Table 8**). Cassava yields decreased by about 50% in the second cropping cycle, but with fertilizer application yields increased again in the 3rd and 4th year.

In Leyte, a six year (1989-1995) long-term fertility trial under coconut showed a significant response to fertilizer application only after the second cropping cycle (**Table 8**). Highest yields were obtained in treatments with 60 kg of N, 90 P_2O_5, and 60 K_2O/ha, while lowest yields were obtained in treatments without P application. When maize was intercropped within cassava rows, the yield of cassava was not reduced if the fertilizer requirements of both crops were met and the population of maize was only half of that of the monocrop (Evangelio, *et al*., 1995). In Negros Occidental the long-term (1989-1992) fertility trial showed a significant yield response only to the application of N (**Table 8**). There were significant differences among the two cultivars, but no significant interaction between fertilizer rates and cultivars.

Table 8. Long term fertility trials conducted in three locations of the Philippines.

Location and duration	Response
Leyte (under coconut); 1989-1995	Occasional response to P and N only
Bohol (open field); 1989-1993	Response to K and N only
Negros (open field); 1989- 1992	Response to N only

The lack of response in some cases may be due to the high fertility of the soil used. For example, the area used by Suerte (1980) and Villaflor (1981) had a pH of 6.1, 0.28% total N, 35 ppm available P and 229 ppm exchangeable K. The yield of marketable roots alone was as high as 58 t/ha in ten months. An example of a positive response to N fertilization is the work of Abenoja (1978), as shown in **Table 9.** The soil used had a pH of 6.9, 2.0% organic matter, 19 ppm (Olsen) P and 372 ppm H_2SO_4-extractable K.

Table 9. Total root yield of cassava (cv. Golden Yellow) under different levels of fertilizer in ViSCA, Leyte, in 1977.

Fertilizer level[1)]	Total root yield (t/ha)
00 - 00 - 00	17.25 a
30 - 00 - 00	28.05 b
60 - 30 - 30	31.39 b
90 - 60 – 60	29.39 b

[1)] Initial soil analysis: 2.0% OM, 19 ppm Olsen P, 372 ppm H_2S0_4-extractable K

Source: *Abenoja, 1978.*

Continuous application of the same level of fertilization every cropping cycle could not maintain the yield of cassava in ViSCA (Quirol and Amora, 1987) as shown in **Table 10**. This was probably due to a marked reduction in the amount of K in the soil (**Table 11**). **Table 10** also shows that animal manure, especially cow manure, had some residual effect, especially during the cropping season immediately after the last application.

Table 10. Root yield (t/ha) of cassava (cv. Golden Yellow) during the first, third, fourth and sixth cropping cycle as affected by the application of different sources of chemical fertilizer or manures in ViSCA, Leyte, in 1986.

Fertilizer source[1)]	Cropping cycle			
	1	3	4	6
To - Control	31.39 b	16.58 c	11.79 d	8.78 c
T1 - inorganic (60-60-60)	38.95 a	31.71 a	23.10 ab	21.32 a
T2 - chicken manure (1.3 t/ha)	37.61 a	27.33 ab	18.17 bc	12.75 bc
T3 - pig manure (3.4 t/ha)	40.47 a	28.49 a	16.46 cd	10.33 bc
T4 - cow manure (4.4 t/ha)	39.07 a	27.51 ab	25.13 a	16.14 b
T5 - guano	34.85 ab	23.62 b	18.04 bc	12.92 bc
CV (%)	8.17	9.02	15.86	17.71

1) Inorganic fertilizer applied every cropping cycle; manure applied up to the 3rd crop only.
2) Mean separation (DMRT, 0.05).
Source: *Quirol and Amora, 1987.*

Table 11. Effect of different sources of chemical fertilizer and manures on the soil chemical characteristics at the end of the sixth crop in ViSCA, Leyte, in 1986.

Fertilizer source[1)]	Chemical analysis[2)]		
	OM (%)	Olsen P (ppm)	NH_4 Ac-K (ppm)
To - Control	2.55	4.8	42.7
T1 - inorganic (60-60-60)	3.31	13.7	96.7
T2 - chicken manure (1.3 t/ha)	3.43	6.3	50.3
T3 - pig manure (3.4 t/ha)	3.56	8.2	48.3
T4 - cow manure (4.4 t/ha)	3.65	5.4	75.3
T5 - guano	3.75	4.7	44.7

1) Inorganic fertilizer applied every cropping; manure applied up to the 3rd crop only.
2) Initial : 2.94% OM, 9 ppm Olsen P and 148 ppm NH_4Ac-K
Source: *Quirol and Amora, 1987.*

In the Philippines, most areas grown to cassava are of marginal fertility. Thus, the application of the full fertilizer recommendation based on the level recommended by the Bureau of Soils, as determined through soil analyses, was the most profitable in five out of seven trials (Villamayor and Destriza, 1986), as shown in **Table 12.**. There was little or no response in two areas (Butigan II and Igang) which were near the river and have alluvial soils.

Table 12. Total root yield and net income of cassava (cv. Golden Yellow) without fertilizer (F_0), 1/2 the fertilizer recommendation (F_1), and full fertilizer recommendation (F_2) in various locations in Baybay, Leyte, in 1985.

Location and fertilizer recommendation ($N-P_20_5-K_20$ in kg/ha)	Total root yield (kg/ha)			Net income ('000 P/ha)[3]		
	F_0	F_1	F_2	F_0	F_1	F_2
Maganhan (35-35-35)	9.00	18.32	20.05	1.50	7.17	7.82
Igang [1] (50-50-50)	20.83	21.73	26.76	9.44	9.25	10.85
Cantagnos (40-30-30)	5.67	16.08	23.21	-1.52	4.47	8.29
Butigan I (40-30-30)	10.66	14.60	16.10	2.76	4.47	5.40
Butigan II[1] (40-30-00)	21.26	21.62	20.46	10.15	9.92	8.56
Can-ipa (40-30-00)	11.58	21.56	18.90[2]	4.07	10.30	7.69
Bubon	15.44	23.29	26.25	6.55	11.59	12.84

[1] Near the river
[2] Lodged at 6 months
[3] Exchange rate: $ 1 = P 20
Source: *Villamayor and Destriza, 1986.*

Application of green manures and animal manures increased cassava yields (Lauron, 1980; Lorenzo, 1980; Ratilla, 1983; Castroverde, 1983; Molina, 1983; Mirambel, 1983; PRCRTC, 1985; Pascual *et al.*, 1987; Quirol and Amora, 1987). As an example, the data of Mirambel (1983) on the effect of animal manures is shown in **Table 13**. Evangelio *et al*. (1995) also reported that green manures (cowpea, soybean, mungbean, and peanut) incorporated into the soil at any growth stage — vegetative, flowering or harvestable — did not affect the yield of cassava (Molina, 1983). This suggests that harvesting the pods may be possible before incorporating the crop residues into the soil, which is essentially the same as crop rotation.

The time of fertilizer applications, from planting to two months after planting, did not significantly affect cassava yields (Laguna, 1977; Abenoja, 1978; Cotejo and Talatala, 1978). This is illustrated in **Table 14**. However, if application was delayed to 90 days, yields were reduced (David, 1981). The best application time of complete fertilizer was ½ basal and ½ sidedressed one month after planting (MAP). Split application (1/4 each) at planting, one, two, and three MAP was the least effective among the application times used.

For most acidic soils, liming is not necessary since cassava usually does not respond to liming (Ramos and Mosica, 1982; PRCRTC, 1983; Pardales *et al*., 1984).

Almendras (1982) showed that mycorrhizal inoculation significantly increased the shoot P concentration and uptake in pot experiments.

Talatala (1982) showed that fertilization with 60-0-0 or 60-60-120 kg N-P_2O_5-K_2O/ha did not affect the HCN contents of the roots of three varieties of cassava at 6, 8, 10 and 12 MAP.

Table 13. Root yield of cassava (cv. Golden Yellow) and net return under various soil amendments in ViSCA, Baybay, Leyte, in 1982.

Type of soil amendment[1)]	Root yield[2)] (t/ha)	Net return[3)] (Pesos/ha)
Control	5.45 c	-1,773.21
10 tons coal ash/ha	6.88 c	-2,268.08
10 tons chicken manure/ha	14.04 b	4,128.78
10 tons cattle manure/ha	9.12 d	410.47
10 tons goat manure/ha	11.36 c	1,937.14
Inorganic fertilizer (60-60-90 kg N-P_20_5-K_20/ha)	16.82 a	4,107.57

[1)] Soil analysis: 4.7 pH, 1.24% OM, 13 ppm P, 141 ppm K
[2)] Mean separation (DMRT, 0.05)
[3)] Exchange rate: $ 1 = P 20
Source: *Mirambel, 1983.*

Table 14. Effect of fractionation of fertilizer application (90 kg N, 60 P_20_5 and 60 K_20/ha) on the root yield of cassava (cv. Golden Yellow) in ViSCA, Baybay, Leyte, in 1977.

Time of fertilizer application			Root yield[1)] (t/ha)
At planting	1 MAP	2 MAP	
Check (no fertilizers)	-	-	17.25 c
1/2 N, all P and K	1/2 N	-	31.62 a
1/3 N, all P and K	1/3 N	1/3 N	29.29 ab
1/3 N, 1/2 P and K	1/3 N, 1/2 P and K	1/3 N	30.13 a
1/2 N, all P and K	-	1/2 N	26.99 ab

[1)] Mean separation (DMRT, 0.05)
Note: Initial soil analysis: 2.0% OM, 19 ppm Olsen-P, 372 ppm H_2SO_4-extractable K
Source: *Abenoja, 1978.*

Topping/Pruning

Abenoja and Cerna (1983) found that removing the upper 15 cm of shoots at 4, 6 or 8 week intervals, starting at 4, 5 or 6 MAP, did not affect root yields. On the other hand, Villamayor and Labayan (1982) found that a single pruning of 20 cm shoot length or longer at 3 MAP reduced yields significantly. Santiago (1980) reported that topping at 2-3 MAP reduced yields significantly, while Araña (1979) reported an increased yield with pruning at 2 MAP. The differences may be due to the intensity of shoot removal, the variety, the time of pruning and the length of pruning. This was confirmed by Villamayor *et al*. (1992) who reported that cassava plants pruned at 30 cm above-ground at 6, 8 or 10 months after planting produced significantly higher root yields than unpruned plants 5 months after pruning, but not at 1 or 3 months after pruning.

In a pruning and planting distance trial, Evangelio and Ladera (1998) reported marked increases in cassava yields when the plant density was increased to 15,000-25,000 plants/ha, but no significant differences were observed when the age of pruning cassava was varied from 5 to 9 months after planting.

Soil Conservation

Studies on cultural practices to control soil erosion were conducted for six years to determine their effect on soil loss and yield of cassava. During the 1988/89 trial, Villamayor *et al*. (1992) reported that minimum tillage (weed-underbrushed plot) had the lowest soil loss, and the conventional tillage (clean-weeded plot) had the highest. However, the conventional tillage/fertilized plot had the highest yield. In the 1989/90 trial, the same group of investigators observed that conventional tillage/fertilized plot had the highest yield and soil loss, while the conventional tillage/*Desmodium ovalifolium* intercropped plot had the lowest soil loss, but also the lowest yield. Similar results were obtained in 1990/91.

Evangelio *et al*. (1995) reported that during the 1991/92 erosion control trial, large soil losses were obtained in plots where vetiver or lemon grass had been recently planted as contour barriers, especially during the first year of establishment. Application of grass mulch continued to be the most effective treatment in reducing erosion, while it also resulted in the highest yield. During the 1992/93 cropping cycle, it was observed that plots with complete fertilizer (60-60-60 kg/ha) application had the highest soil loss, while plots with the application of mulch had again the lowest. Root yields were highest with the application of mulch and lowest in plots with lemon and vetiver grass barriers. Evangelio and Ladera (1998) reported similar findings for the 1993/94 trial (**Table 15**).

Harvesting

To get a maximum return the crop should be harvested at the right time. If harvested early, yields will be low and roots may still be fibrous. The right time of harvest depends on the variety. Harvesting is the most expensive operation in cassava production. A cassava grower of Bohol mentioned that harvesting costs accounted for 20% of his expenses. He pays ₱50.00/t for harvesting, which includes sacking. For fast and cheaper harvesting, the use of a carabao drawn plow is recommended. If the soil is hard, manual harvesting can be facilitated by a harvesting aid that grasps the stem as it is raised (Bandalan, 1985; Anon, 1985).

Table 15. Cassava yield and soil loss due to erosion during six cropping cycles of cassava grown under various cultural practices on 25% slope in Baybay, Leyte, Philippines from 1988 to 1994.

Treatments[1)]	Root yield (t/ha)[2)]	Soil loss (t/ha)[2)]
First cropping 1988/89 (2153 mm rainfall)		
CT with clean culture	5.3 c	190 a
Strip tillage	2.6 d	10 f
MT with herbicide	1.6 d	21 ef
MT with underbrushing	1.3 d	3 f
CT with 60-60-60 fertilizer	9.2 a	114 d
CT with sweetpotato intercrop	0.8 e	138 c
CT with *Gliricidia sepium* hedgerows	4.1 c	173 b
CT with dried grass mulch	7.5 b	31 e
CT with *Desmodium ovalifolium* intercrop	1.1 d	188 a
CT with underbrushing	9.2 a	113 d
CT with stone walls	3.5 a	65 e
Second cropping 1989/90 (1673 mm rainfall)		
CT with *Desmodium ovalifolium* intercrop	4.0 c	6.2 d
CT with 60-60-60 fertilizer	33.1 a	37.3 a
CT with *Gliricidia sepium* hedgerows	15.7 b	31.6 b
CT with dried grass mulch	28.2 a	9.7 d
CT with *Cajanus cajan* hedgerows	19.1 b	15.4 c
Third cropping 1990/91 (2526 mm rainfall)		
CT with *Desmodium ovalifolium* intercrop	5.3 e	0.7 c
CT with 60-60-60 fertilizer	16.4 b	7.9 ab
CT with *Gliricidia sepium* hedgerows	9.0 d	8.4 a
CT with dried grass mulch	19.5 a	6.1 b
CT with *Cajanus cajan* hedgerows	13.3 c	6.3 ab
Fourth cropping 1991/92 (1867 mm rainfall)		
CT with lemon grass hedgerows	18.9 b	62.8 ab
CT with 60-60-60 fertilizer	26.0 a	52.7 b
CT with vetiver hedgerows	18.9 b	70.8 a
CT with dried grass mulch	28.1 a	28.0 c
CT with *Crotalaria juncea* intercrop	17.5 b	31.0 c
Fifth cropping 1992/93 (2188 mm rainfall)		
CT with lemon grass hedgerows	12.7 d	21.7 c
CT with 60-60-60 fertilizer	25.6 b	39.8 a
CT with vetiver hedgerows	13.1 d	20.7 c
CT with dried grass mulch	32.1 a	6.6 d
CT with *Crotalaria juncea* intercrop	17.8 c	30.3 b

(Table 15 continued**)**

Treatments[1)]	Root yield (t/ha)[2)]	Soil loss (t/ha)[2)]
Sixth cropping 1993/94 (3154 mm rainfall)		
CT with lemongrass hedgerows	3.5 c	17.9 c
CT with 60-60-60 fertilizers	8.4 bc	45.0 a
CT with vetiver hedgerows	5.7 c	8.1 d
CT with dried grass mulch	14.5 a	10.7 d
CT with *Crotalaria juncea* intercrop	10.7 b	28.5 b

[1)] CT = conventional tillage (clean weeded by hand before planting) ; MT = minimum tillage
[2)] Mean separation: DMRT (0.05)
Source: *Evangelio et al., 1995.*

Cropping Systems

Intercropping legumes, like peanut, soybean, mungbean, cowpea, pigeon pea and bush sitao, oftentimes did not significantly reduce the yield of cassava (Pagaran, 1981; Tabugan, 1982; Villanueva, 1983; PRCRTC, 1983). Some researchers even reported an increase in yield of cassava (Laguna, 1982; Corpin, 1977)). However, others showed a significant reduction in yield (Evangelio and Posas, 1983; Alava, 1980). Obviously, the results vary with differences in the kind of intercrop, the spacing used, the growth duration, the time of planting the main crop and intercrop, the fertility of the soil, and the climatic conditions.

Evangelio and Posas (1983) found that maximum economic benefits were obtained when root crops and legumes in an intercropping system were planted at the same time. Alava (1980) showed that intercropping with bush sitao (*Vigna unguiculata* x *Vigna sesquipedalis*) produced better yields and income than intercropping with maize. Furthermore, maize or bush sitao planted between and within cassava rows produced the highest yield compared with those planted within cassava rows, mainly because of differences in population density. Also the yield of cassava intercropped with maize was lower than that of the monocrop.

Villamayor and Destriza (unpublished data) found that one hill of sweet corn between cassava hills did not significantly affect the yield of cassava, while two hills of sweet corn did. However, even a single hill of field corn between cassava hills reduced the yield of cassava because of the longer growth duration of field corn compared with sweet corn.

To obtain the maximum benefit from the intercrops, it is necessary to determine the best population density. Laguna (1982) found two rows of mungbean was optimum considering both the yields of cassava and mungbean. Also, Villamayor and Destriza (1981) found no advantage in having more than three rows of mungbean between cassava planted in a double row system.

In hillsides, contour strips of ipil-ipil (*Leucaena leucocephala*) planted at an interval of 3 meters and spaced 15 cm apart resulted in a reasonable yield of intercropped cassava, but the cassava monocrop produced higher yields (Escalada, 1981). On the other hand, Pascual *et al*. (1986) found that the width of the ipil-ipil buffer strip, varying from 1 to 2.5 m, did not significantly affect cassava yields, in spite of the reduction of cassava population as a result of the ipil-ipil strips. Padullo (1983) found that ipil-ipil grown in between cassava may or may not affect root yields depending on the spacing between ipil-ipil hills. Erosion was minimized, especially at 10 cm spacing between ipil-ipil hills. Pascual *et al*. (1987) found that cassava planted in between strips of N fixing trees, with their pruning applied to the soil, had a similar yield as monocropped cassava applied with 60-40-40 kg of N-P_20_5-K_20/ha.

Crop rotation is recommended, especially with legumes to minimize nutrient depletion. Escalada *et al*. (1983) found that when cassava was rotated with legumes the yield reduction was less than when cassava was grown continuously as a monocrop. A verification trial conducted by Javier and Laranang (1987) showed that cassava rotated with peanut produced a less economic benefit compared with successive croppings of cassava or cassava alternated with fallow.

In an intercropping trial conducted in Bohol (Evangelio and Ladera (1998) even after three cropping cycles cassava yields were not significantly affected by interplanting of either soybean, mungbean, cowpea, peanut or pole sitao (yard-long bean). However, row spacing significantly affected the yields of cassava and intercrops

ADOPTION

In the Philippines, there are about 2 million farming households dependent on cassava. However, over the years, these cassava farmers are still slow in adopting the technology developed by research institutions. In subsistence type agriculture, which accounts for 50% of the Filipino farming households, very few farmers adopt the new varieties; for the small-scale commercial types, which accounts for 33.33%, the farmers used both new varieties and improved cultural practices. While for commercial or plantation types (16.67%) all the production technologies, such as new varieties, improved cultural practices and fertilizers, are used.

FUTURE DIRECTIONS

With more intense competition resulting from trade liberalization, there is a need for tremendous transformation of cassava production technologies in the country, in order to make it more competitive. Thus, the integrated national rootcrops RD/E program addresses these goals in transforming cassava agriculture in the Philippines.

The national RDE program on rootcrops is focused on improving and expanding specific sectors of a rootcrop industry, namely: food, feed and starch. Development and expansion of these specific industry sectors will be attempted through the generation and promotion of appropriate technologies, provision of adequate support services, and the advocation of favorable policies for the industry. This endeavor, however, should be market-led, based on advanced and sustainable technologies, highly integrated and participatory.

CONCLUSION

Cassava agriculture in the Philippines still lags behind other Asian neighbors. But, given adequate support, it is reasonable to expect productivity and profitability of rootcrops to rapidly improve compared to other crops that have already been supported tremendously.

REFERENCES

Abenoja, C.P. 1981. Effects of different positions of planting on the growth and yield of cassava (var. Golden Yellow) during the dry season. BS thesis, DMMMSU, Bacnotan, La Union. 32 p.

Abenoja, E.A. 1978. The effects of rates and timing of NPK ferfilizers on cassava. ViSCA, BS thesis. 56 p.

Abenoja, E.A. and J.P. Baterna. 1982. Tillage practices in continuous hillside farming of root crops. The Radix 4(2) : 9-11.

Abenoja, E.A. and A.F. Cerna. 1983. The effect of age and frequency of topping cassava on quality of shoots, dry matter and tuber yield. The Radix 5(1) : 12-13.

Agustin, L.C. 1983. The use of labeled fertilizer in determining P uptake in cassava and soybean in an intercropping system. The Southern Tagalog Agri. J. 1 : 1-10.

Alava, E.V. 1980. Intercropping cassava with corn and bush sitao. PhD thesis, UPLB, College, Laguna. 213 p.

Almendras, A.S. 1982. Effect of liming, fertilization and mycorrhizal inoculation on NPK uptake and growth of cassava (*Manihot esculenta* Crantz).MSc thesis, UPLB, College, Laguna. 82 p.

Anon. 1985. Cassava harvesting: how to do it better. UPLB Phil. Agric. Mech. 3(3):9.

Apilar, E.G. and F.G. Villamayor Jr. 1981. Length of planting materials influences cassava yield. The Radix 3(1) : 11.

Arana, M.N. 1979. The effects of timing of pruning on the yield of cassava (Golden Yellow). BS thesis, CSSAC, Pili, Camarines Sur.

Bacusmo, J. 1978. Effect of time and duration of weed control in cassava. BS thesis, ViSCA, Baybay, Leyte. 71p.

Bacusmo, J.L. and R.T. Talatala. 1980. Phil. J. Crop Science 6(2): 32-33.

Baludda, R.K. 1980. The effects of depth of planting on the growth and yield of cassava (Golden Yellow variety) intercropped with giant ipil-ipil. BS thesis, DMMMSU, Bacnotan, La Union. 14 p.

Bandalan, R.B. 1985. Design, construction and evaluation of a plant puller. BS thesis, ViSCA, Baybay, Leyte. 27 p.

Bansil, A.R. 1980. The effect of different distances of planting on the growth and yield of Golden Yellow cassava. BS thesis, PAC, Magalang, Pampanga.

Bernardo, E.N. and N.M. Esguerra. 1981. Seasonal abundance of red spider mite and its predator on selected cassava accessions. Ann. Trop. Res. 3(3) : 199-205.

Castroverde, Y.L. 1983. Cassava production: influence of tillage-weed control systems, fertilizer sources and harvest age. PhD thesis, UPLB, College, Laguna. 188 p.

Corpin, R. 1977. The effect of leguminous intercrops (peanut, mungbean, bushbean and soybean) on the yield of cassava. BS thesis, ViSCA, Baybay, Leyte. 22 p.

Corpuz, E.U. 1980. The influence of different depth of planting stakes on the yield of Golden Yellow cassava. BS thesis, USM, Kabacan Cotabato. 21 p.

Cotejo, F.R. and R.L. Talatala. 1978. The effect of rate and time of fertilizer application on the yield of cassava. ViSCA Vista (1):22-23.

Credo, J.O. 1982. The effect of the length of cuttings on the growth and yield of Golden Yellow cassava grown under three methods of planting. BS thesis, UEP, Catarman, Samar. 29 p.

Dacpano, R.G. 1980. The effects of the different length of cutting on the growth and yield of cassava (cv. Golden Yellow). BS thesis. DMMSU, Bacnotan, La Union. 32 p.

David, B.C. 1981. Growth and yield of cassava as affected by frequency of applying fertilizer. BS thesis, TCA, Camiling, Tarlac. 34 p.

Escalada, R.G. 1981. Manipulation of cultural practices for ipil-ipil and its effect on intercropped cassava. Ann. Trop. Res. No. 3(2):136-143.

Escalada, R.G. , B.F. Quirol, A.B. Escasinas, F. Manatad and M. Baliad.1983. Cultural management of sweetpotato, cassava, and gabi under various multiple cropping schemes utilizing legumes as source of nitrogen. Research Terminal Report. ViSCA, Baybay, Leyte.

Evangelio, F.A. 1981. Some physiological and agronomic considerations in the production of cassava. Progress Report, ViSCA, Baybay, Leyte.

Evangelio, F.A. and J.C. Ladera. 1998. Recent progress in cassava agronomy research in the Philippines. *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. 331-339.

Evangelio L.A. and M.B. Posas. 1983. Agronomic approaches to root crop-legume intercropping systems and their economic consideration. Phil. J. Crop Sci. 8(2):3.

Evangelio, F.A., F.G. Villamayor, A.G. Dingal, J.C. Ladera, A.C. Medellin, J. Miranda and G.E. Sajise, Jr. 1995. Recent progress in cassava agronomy research in the Philippines. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Utilization Research in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6,1993. pp. 290-305.

Food and Agriculture Organization Statistics (FAOSTAT). 2001. http://www.fao.org//giews/

Guzman, D.C. de. 1982. Response of cassava to a maximum level of potassium fertilizer with constant amount of nitrogen and phosphorus. BS thesis, TCA, Camiling Tarlac. 31 p.

Javier, R.R. and C.C. Laranang. 1987. Verification trial on crop rotation of cassava with legumes as a cultural management system. Preliminary Terminal Report. ViSCA, Baybay, Leyte.

Jumadiao, O.C. 1982. The effect of different weed control duration on the yield of Golden Yellow cassava. BS thesis, UEP, Catarman, Samar. 19 p.

Labra, J.S. and N. N. Tisang. 1979. The effect of different methods of seedbed preparation and planting position on the yield and the agronomic characters of cassava (Golden Yellow variety). *In*: PRCRTC, 1979 Annual Report. Vol. II. ViSCA, Baybay, Leyte. pp. 38-41.

Lagrimas, D.C. 1982. Growth and yield response of cassava to varying levels of nitrogen and potassium. BS thesis, TCA, Camiling, Tarlac. 28 p.

Laguna, S.G. Jr. 1977. The effect of time of fertilizer application on the growth and yield of cassava. BS thesis, ViSCA, Baybay, Leyte. 22 p.

Laguna, L.M.. 1982. Evaluation of intercropping methods on cassava and mungbean in a flat land. BS thesis, ViSCA, Baybay, Leyte. 67 p.

Lauron, J.C. 1980. Effect of guano on the yield of cassava. BS thesis. BAC, Bilar, Bohol. 47 p.

Lorenzo, F.E. 1980. Effect of different kinds of animal manure added to inorganic fertilizer on the growth and yield of cassava. BS thesis, TCA, Camiling, Tarlac. 24 p.

Mariscal, A.M. 1984. Improving the productivity of cassava in the Philippines. *In*: Cassava in Asia, Its Potential and Research Development Needs. Proc. of a Regional Workshop, held in Bangkok, Thailand. June 5-8,1984. pp. 261-276.

Mateo, M.D. 1981. Growth and yield response of cassava on varying length of cuttings. BS thesis, TCA, Camiling, Tarlac. 30 p.

Mendaira, R.I. 1973. Effects of coal tar on the viability of cassava cuttings. CLSU Expt'l. Sta. Contribution Number 918.

Mendiola, N.B. 1958. Cassava culture and preparation of cassava products. The Farmers Guide Publishing Co., Malabon, Rizal, Philippines. 32 p.

Mirambel, A. de la C. 1983. Comparative effects of different soil amendments on soil chemical properties and on the growth and yield of cassava. BS thesis, ViSCA, Baybay, Leyte. 48 p.

Molina, A.P. 1983. Effects of green manure crops turned at various stages of growth on the yield of cassava . BS thesis, TCA, Camiling, Tarlac. 63 p.

Musngi, R.H. 1985. The influence of amophos and complete fertilizer on the growth and yield of Golden Yellow cassava variety. BS thesis ZNAC, Tampilisan, Zamboanga del Norte. 62 p.

Occiano, E.L. 1980. The yield performance of cassava planted at different spacing and different number of nodes per cutting. BS thesis, CSSAC, Pili, Camarines Sur.
Padullo, J.L. 1983. The effect of ipil-ipil *(Leucaena leucocephala)* planted at varying distances on the growth and yield of cassava in hilly area. BS thesis , ViSCA, Baybay, Leyte.
Pagaran, M. 1981. Yield of cassava intercropped with mungo, peanut and soybean. BS thesis, BAC, Bilar, Bohol. 43 p.
Parcasio, O.V. 1982. Yield performance of cassava as affected by the duration of incubating the seedpieces. BS thesis, TCA, Camiling, Tarlac. 31 p.
Pardales, J.R. Jr. 1985. Influence of preplanting tillage system on the dry matter and nitrogen accumulations of cassava. Phil. J. Crop Sci. 10(3): 147-152.
Pardales, J.R. Jr. 1986. Effect of croppings and preplanting tillage systems on the yield of cassava and mungbean intercrop. Phil. J. Crop Sci. 11(1): 33-36.
Pardales, J.R. Jr. and C.B. Esquivel. 1996. Effect of drought during the establishment period on the root system development of cassava. Japanese. J. Crop Sci. 65(1): 93-97.
Pardales, J.R. Jr. and C.B. Esquivel. 1997. Root development in sweetpotato stem cuttings as influenced by preplanting, planting and post-planting practices. Ann. Trop. Res. 19:56-65.
Pardales, J.R., Jr. and A.F. Forio. 1979. Length of cassava planting materials. ViSCA Vista. 2(4):19.
Pardales, J.R. Jr, F.R. Cotejo, Jr and E.M. Nuñez. 1984. Management of cassava in heavy and highly acidic soil. NSTA Technology J. 9(3d):4-8.
Pardales, J.R. Jr., D.M. Bañoc, A. Yamauchi, M. Iijima and Y. Kono. 1999. Root system development of cassava and sweetpotato during early growth stage as affected by high root zone temperature. Plant Prod. Sci. 2(3): 247-251.
Pascual, P.P., R.G. Escalada and R.L. Serohijos. 1987. Utilization of fast growing nitrogen-fixing trees for sweetpotato and cassava production. Progress Report, ViSCA, Baybay, Leyte.
Pascual, P.P., L.A. Evangelio and E.M. Cabia. 1986. Effects of widths of ipil-ipil buffer strips on the yield of rootcrops in marginal hilly areas. Preliminary Terminal Report, ViSCA, Baybay, Leyte.
PCARRD. 1983. The Philippine Recommends for Cassava. Philippine Council for Agriculture and Resources Research and Development, Los Baños, Laguna. 62 p.
Pineda, V.S. 1980. The effect of different levels of ammonium phosphate on the growth and yield of Golden Yellow cassava. BS thesis, PAC, Magalang, Pampanga. 30 p.
PRCRTC. 1983. Root Crops Annual Report. ViSCA, Baybay, Leyte.
PRCRTC. 1985. Root Crops Annual Report. ViSCA, Baybay, Leyte.
PRCRTC. 1986. Root Crops Annual Report. ViSCA, Baybay, Leyte.
Quirol, B.F. and G.L. Amora. 1987. Comparative study on the effects of four animal manures on the growth and yield of cassava and on the bulk density of the soil. Preliminary Terminal Report, ViSCA, Baybay, Leyte.
Ramos, B.B. and P.S Mosica. 1982. Productivity of cassava *Manihot utilissima* Pohl in an Ultisol. Paper presented to the 13^{th} annual scientific meeting of the CSSP, held in Cebu City, April 28-30, 1982.
Ratilla, T.C. 1983. Response of cassava to different levels of inorganic fertilizer and green manuring. BS thesis, ViSCA, Baybay, Leyte. 54 p.
Reyes, E.R. and L.T. Esperidion. 1976. The effect of different planting positions of cuttings on the growth and yield of cassava. BS thesis, AAC, Banga, Aklan. 37 p.
Santiago, C.C. 1980. Response of cassava to topping and manuring under MMSU conditions. BS thesis, MMSU, Batac, Ilocos Norte. 39 p.
Secreto, A.C. 1981. Yield response of cassava to spacing and system of planting. Phil. J. Crop Science. 6(1-2):58.
Serrame, N.D. 1982. Response of cassava (Golden Yellow) as affected by different levels of NPK fertilizer. BS thesis, PSU, San Carlos, Pangasinan. 34 p.
Silangan, M.C. 1982. Field trial on the effect of different liquid fertilizers on the yield of cassava. BS thesis, BAC, Bilar, Bohol. 43 p.

Soriano, M.B. 1986. Growth and yield performance of cassava on the length and method of planting. BS thesis, PSUCA, San Carlos, Pangasinan.

Suerte, B.L. 1980. Response of cassava (Golden Yellow) to 14 levels of NPK planted 100 cm x 100 cm. BS thesis, USM, Kabacan, Cotabato.

Tabugan, E.B. 1982. Response of cassava to legume intercropping. BS thesis, TCA, Camiling, Tarlac. 29 p.

Talatala, R.L. 1982. Cyanide contents of cassava cultivars at different fertility levels and stages of maturity. ViCARP News 3(2):10.

Tizon, J.J. 1980. A comparative study on the different methods of planting Golden Yellow cassava. BS thesis , PAC, Magalang , Pampanga. 29 p.

Velasco, O.L. 1982. The effects of different lengths of cuttings on the growth and yield of cassava. BS thesis, WLAC, San Marcelino, Zambales. 58 p.

Villaflor, P.R. 1981. Yield of cassava planted at distance of 100 cm x 75 cm as affected by 14 rates of fertilizers. BS thesis, USM, Kabacan, Cotabato. 24 p.

Villamayor, F.G. Jr. 1983a. Depth of land preparation in relation to cassava yield. The Radix 5(2):3.

Villamayor, F.G. Jr. 1983b. Root and stake production of cassava at different population and subsequent yield evaluation of stakes. Phil. J. Crop. Sci. 8(1):23-25.

Villamayor. F.G.1988. Recent progress in cassava agronomy research in the Philippines. *In*: R.H. Howeler (Ed.) Cassava Breeding and Agronomy Research in Asia. Proc. 2nd Regional Workshop, held in Rayong, Thailand. Oct 26-28, 1987. pp. 261-296.

Villamayor, F.G., Jr. and E.G. Apilar. 1981. Root and stem production of two cassava varieties at different population. Phil. J. Crop. Sci. 6(1-2):21-23.

Villamayor, F.G. Jr. and R. Davines. 1987. Optimum time of planting and harvesting cassava in areas with a distinct wet and dry season. Progress Report. ViSCA, Baybay, Leyte.

Villamayor, F.G. Jr. and T.T. Destriza. 1981. The effect of double row planting and intercropping on cassava yield. The Radix 3(1):10-11.

Villamayor, F.G. Jr. and T.T. Destriza. 1982.Yield of cassava at different plant populations and ages of harvest. The Radix 4(1):4-5.

Villamayor, F.G. Jr. and T.T. Destriza. 1985. Moisture stress and its effect on cassava yield. The Radix 7(1):5-6

Villamayor, F.G. Jr. and T.T. Destriza. 1986. Cassava production at the farm under different levels of technology. Progress Report. ViSCA, Baybay, Leyte.

Villamayor, F.G. Jr. and A.L. Labayan. 1982. Detopping and its effect on cassava production. The Radix 4(2):7-8.

Villamayor, F.G. Jr. and R.D. Perez. 1983. Effect of location, position and duration of stem storage on cassava yield. The Radix 5(1):5-7.

Villamayor, F.G. Jr. and R.D. Perez. 1986. Production and evaluation of root crop cuttings under coconut. Progress Report. ViSCA, Baybay, Leyte.

Villamayor, F.G. Jr. and R.D. Perez. 1987. Effect of horizontal planting on yield of scale insect-infected cassava cuttings. The Radix 9(1):9-10.

Villamayor, F.G. Jr.,C. Eronico and N. Euldan. 1987. Yield survey of root crops in Leyte. Progress Report for 1987. ViSCA, Baybay, Leyte.

Villamayor, F.G. Jr. and V.L. Reoma. 1987. Effect of land preparation and postplanting tillage on weed control and cassava yield. Ann. Trop. Res. 8(2): 12-19.

Villamayor, F.G. A.G. Dingal, F.A. Evangelio, J.C. Ladera, A.C. Medellin, G.E. Sajise, Jr. and G.B. Burgos. 1992. Recent progress in cassava agronomy research in the Philippines. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Utilization Research in Asia. Proc. 3rd Regional Workshop, held in Malang, Indonesia. Oct. 22-27, 1990. pp. 245-259.

Villanueva, E.S. 1983. Economics of intercropping cassava with different field legumes. BPI La Granja Expt. Stn., La Carlota City. 4 p.