CASSAVA AGRONOMY RESEARCH AND ITS CONTRIBUTION TO A SECURE FOOD SYSTEM IN INDONESIA

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ABSTRACT

Cassava production in Asia is projected to grow at an annual rate of 1.95% from now to 2020, while cassava production in Indonesia during the past ten years increased at a rate of 0.8%. Since 67% of cassava production in Indonesia is used for human food, the growth in cassava production should be higher than that of the population. Rice is the main staple food, but its production growth over the past ten years has stagnated. Increasing cassava production for food diversification would be a way to help achieve food security in the country. Most cassava production areas in Java island are located on soils classified as Inceptisols, while cassava soils outside of Java are generally Ultisols. Average cassava yields of about 12.2 t/ha of fresh roots are much below the potential yield obtained in experiments, which ranges from 20 to 40 t/ha. Therefore, there is still a potential to improve production technologies so as to increase yields and food security, as well as farmers' income. Most areas where cassava is grown in Indonesia have relatively infertile soils. Agronomy research that focuses on maintaining or improving both soil fertility and cassava productivity will be discussed.

INTRODUCTION

By 2020 over two billion people in Asia, Africa, and Latin America will use roots and tubers for food or feed, or as a source of income (CGIAR, 2000). In Indonesia the main staple foods are rice, maize, cassava and sweetpotato. Demand for rice and cassava as food are about 48 million tonnes dry grain and 11 million tonnes fresh roots, respectively; that for maize and sweetpotato are less than those for rice and cassava (CBS, 2000).

In Indonesia rice production during the last ten years has stagnated. Maize production satisfies only 60% of demand, while cassava demand for food during the last five years has increased about 20% (CBS, 2000). This indicates that cassava will be more important as a food security crop. As cassava production has increased during the last ten years at about 0.8% per year, that growth rate will need to be increased to 1.95% per year according to CGIAR projections.

By 2020 cassava will be integrated into emerging markets through the efficient and environmentally sound production of a diversified range of high-quality competitive products for food, feed and industry. In Southeast Asia, in particular in Indonesia, demand for cassava will increase for use as food or processed food, animal feed and for specialized starch products (dTp Studies, 1998). The availability of cassava in the global food system, the competitiveness of these products and the resulting benefits to low-income households will be assured by the continued reduction of production costs through the development of suitable high-yielding and high-dry matter content varieties (to maximize the conversion rates from raw material to processed products), low external input, the adoption of technologies to maintain fertility and control erosion.

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CASSAVA IN THE FOOD SECURITY SYSTEM

The food security system consist of food availability, distribution and diet pattern sub-systems. Factors affecting the food availability system are production, processing, stocking and storing. Factors affecting the distribution system are infrastructure and the marketing system, while factors affecting diet or food consumption are culture or tradition, income, food availability, nutritient content and food hygiene.

1. Food Availability System

Production system

The nutritional requirement of each household (4.14 persons) varies from 3,113 to 6,143 Kcal/day and 167-242 gram/day of protein (CBS, 2000). Production of rice, maize and cassava, being the main sources of calories, should meet this demand.

Rice production in Indonesia has been stagnant and the continued importation of rice indicates that rice production is below demand. As rice productivity is leveling off and the area under rice has decreased, food diversification is one way to improve food security. About 40% of demand for maize is supplied by imported maize. It means that food diversification using cassava is one way to achieve food security. The problem of cassava is that it is low in protein; as such, legumes should be part of the diet when rice is substituted by cassava (**Table 1).**

Table 1. Scenario to partially substitute rice by cassava and legumes to maintain a balanced diet in the household.

Substituted rice (%)	Cassava	Legumes[1)]
	(kg/year/household)	
20	372	13
40	744	26
60	1,116	39
80	1,488	52
100	1,813	65

[1)]to increase the protein content of the substituted food in the diet.

Cropping patterns to be established to meet the energy and protein requirements are:

- Irrigated lowland: Rice – rice – legumes + maize
  Cassava planted on plot borders, in back-yards or as an upland crop
- Rainfed lowland: Rice – cassava + legumes + maize
- Upland: Cassava + maize + rice – legumes
  Cassava + maize + legumes
  Cassava + maize – legumes

Processing system

Cassava can substitute for rice both in the form of snack food and staple food. The raw material for snack food can be both fresh roots or processed roots, such as flour or starch, while the raw material for staple food is generally flour. Substituting rice through food diversification is commonly done as follows:

- 20% substitution of rice: as snack or breakfast food
- 40%, 60% and 80% substitution of rice: mixing of rice and cassava flour in the proportions of 60:40, 40:60 and 20:80; or by consuming during the year rice for 8, 6 or 4 months, followed by consuming cassava for 4, 6 or 8 months, respectively. The period of rice consumption generally starts after the rice harvest at the end of the rainy season.
- Cassava being consumed as staple food is common for communities in marginal upland areas that traditionally consume cassava as a staple food.

Processing cassava roots into flour allows it to be stored and to prevent pests such as dried cassava borer. The use of a mobile flour processor is very practical, especially in those villages that process large amounts of dried cassava into flour.

Storing system

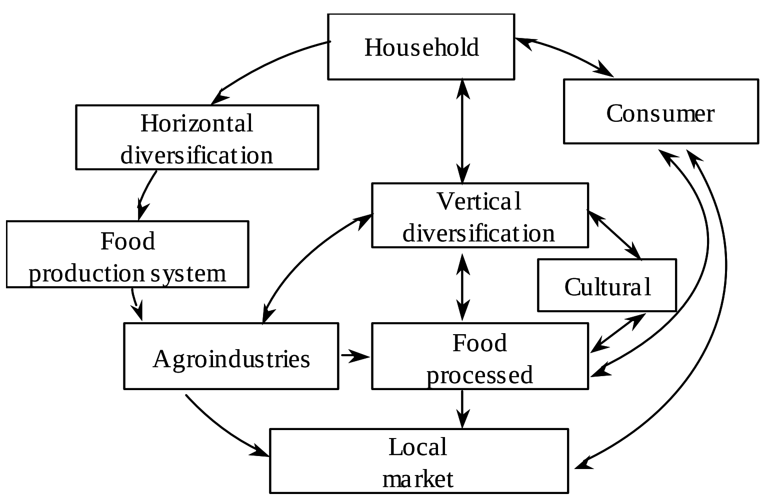
Cassava can be stored as follows:

- Farmers with small land holdings generally store cassava in the form of dried cassava pieces (called *gaplek*), or as flour stored in plastic bags.
- Farmers with larger land holdings generally harvest cassava at monthly intervals in amounts that are needed for the monthly consumption of the household.

2. Distribution System

In any particular region the production of rice as a main staple food and that of cassava as either a staple food or for rice substitution do not always correspond to the demand. Rice is mostly available in both supermarkets and the local market, so it is easy for the consumer to buy rice. Fresh cassava, on the other hand, is both bulky and perishable, making transportation expensive. As such, cassava should be produced locally to reduce transportation costs and it should be harvested periodically to minimize losses due to spoilage.

The cassava distribution system in Indonesia can be schematically presented as follows:



3. Diet

Factors affecting people's diet are food availability, nutritient content, tradition and food hygiene.

- Food crop production is affected by the environment, especially the climate and soil; therefore, people's diet generally depend on the food crops that can be grown in their region.
- The micro-nutritient content of rice is rather low, while that of cassava is higher. As such, the diversification of the diet by eating cassava is a good way to increase micro-nutrient consumption.
- The consumption of cassava as a staple food is traditionally done in a variety of ways such as by substitution of cassava for rice during certain periods of the year or by consuming rice mixed with cassava in various proportions.
- The cost of production to supply the daily per capita requirement of calories in the form of rice, maize or cassava are Rp 172, 84 and 59, respectively. This means that using cassava as a staple food can save the household's expenditure for calories. To support the ample availability of cassava and maintain its low production cost of calories, suitable production technologies should be developed for each agro-ecosystem. More agronomy research to identify these suitable technologies is urgently needed.

CASSAVA AGRONOMY RESEARCH

The expected output of agronomy research are technologies that will increase crop production, and reduce the cost of production of fresh roots and that of the various processed products. Suitable component technologies in sustainable cassava farming systems include suitable varieties, cropping patterns and fertilization.

1. Suitable varieties

On calcareous soils in the southern part of Yogyakarta province, cassava yields are very low. **Table 2** shows that the local varieties Kirik, Bodin and Inak as well as the introduced variety KM 98-1 had slightly higher yields than others. However, Ispandi (2001) obtained very high yields on another type of soil in Patuk, Yogyakarta (**Table 3**). Breeding lines OMM90-3-76 and OMM90-7-74 produced yields of 56.8 and 60.5 t/ha, respectively, when managed optimally by the application of 6 t cattle manure plus 90 kg N, 35 P_2O_5 and 60 K_2O/ha. The yield of Adira 1 was 14.0 t/ha under farmer management and 32.1 t/ha in the experiment, indicating that application of both organic and inorganic fertilizer increased yields significantly. Since most cassava production areas are located in soils with low contents of both organic matter and nutrients, the application of both organic and inorganic fertilizers to increase the yield of suitable varieties is advised.

2. Cropping systems

Most farmers in Indonesia plant cassava in the early rainy season. Factors that influence the time of planting are: 1) water availability is dependent on rainfall; 2) small land holdings; and 3) cassava is generally intercropped with other food crops, to increase land use efficiency (Wargiono, 1997). The root yield decreased when cassava was planted one to three months after that of the intercrop, because the young cassava plants could not compete with interplanted crops that had already grown tall (Wargiono, 1997). The higher root yields of cassava intercropped with maize or after maize may be due to residual effect of fertilizers, since the amount of fertilizers applied to maize is much higher than that applied to peanut. Applying fertilizer to both the main crop and the interplanted crops in intercropping systems is one way to minimize the competition effect between the main and interplanted crops.

Table 2. Root yields of cassava varieties grown in a highly calcareous soil in Playen, Yogyakarta, in 2000/01 and 2001/02.

Varieties	Root yield (t/ha)		
	2000/01	2001/02	Average
Peking	0.32	-	-
Kirik	5.97	2.91	4.44
Sekong	0.51	-	-
Garbu	3.15	-	-
Bodin	6.41	3.79	5.10
Ireng	5.60	1.29	3.44
Enak	3.96	4.50	4.23
Sonoyo	4.96	3.18	4.07
Cilacap 1	4.48	2.14	3.31
Valenca	3.10	-	-
KM 98-5	4.48	2.05	3.26
KM 99-4	3.93	1.02	2.48
KM 937-26	3.73	1.10	2.42
KM 98-1	6.17	3.52	3.84
Adira 1	1.06	-	-
Adira 4	0.41	1.49	0.95

Table 3. Varietal performance in an Alfisol when optimally managed in Patuk, Yogyakarta, 1997.

Varieties	Root yield (t/ha)
KTKN	51.3 b
OMM90-6-72	40.9 c
OMM90-2-66	41.3 c
OMM90-3-76	56.8 ab
OMM90-7-74	60.5 a
Faroka	20.7 e
Adira 1	32.1 d

Source: *Ispandi and Lawu 2002.*

3. Fertilization

Most cassava production areas have marginal soils. Soil analysis of cassava production areas of Gunung Kidul, Yogyakarta indicate that most of the soils are low in organic matter and macro- and micro-nutrients (Ispandi, 2002). This means that high yields can only be obtained by applying both organic and inorganic fertilizers.

3.1 Micro-nutrient fertilization on calcareous soil

Symptoms of serious deficiencies of Zn and Fe in cassava have been observed in some farmers' fields in Playen, Yogyakarta. An experiment on Zn and Fe fertilization in this soil indicate that foliar spraying at one, two and three months with 1% $ZnSO_4$ or a stake dip for 15 min in 2% $FeSO_4$ before planting increased root yields as well as the Fe and Zn contents of upper leaves as compared to that of the control (**Tables 4** and **5**). Since stake dipping is easier than foliar spraying this practice might be adopted by farmers. Growing varieties that are tolerant of micro-nutrient deficiencies to obtain high yield is much simpler and cheaper than applying micronutrient fertilizers; thus, the application of $FeSO_4$ and/or $ZnSO_4$ is recommended only when suitable varieties are not available.

Table 4. Effect of stake treatment or foliar sprays with Zn and Fe on the yield of Adira 1 in Playen, Yogyakarta, in 1999/00 and 2000/01.

	Root yield (t/ha)		
	1999/00	2000/01	Average
1. Without micro-nutrients	6.25	4.07	5.16
2. Stake dip in 2% $ZnSO_4$	8.29	2.37	5.33
3. Stake dip in 4% $ZnSO_4$	7.36	3.52	5.44
4. Foliar spray with 1% $ZnSO_4$	6.62	5.37	6.00
5. Foliar spray with 2% $ZnSO_4$	6.43	5.06	5.74
6. Foliar spray with 1% $FeSO_4$	5.13	5.75	5.44
7. Stake dip in 2% $FeSO_4$	9.53	3.58	6.56
8. Stake dip in 4% $FeSO_4$	5.44	5.00	5.22

Table 5. Effect of stake treatment or foliar sprays of Zn and Fe on the nutrient concentration of youngest fully-expanded leaf (YFEL) blades of Adira 1 at 3 months after planting in Playen, Yogyakarta, in 2000/01.

	N	P	K	Ca	Mg	B	Fe	Mn	Cu	Zn
Treatments			%					ppm		
1. Without micro-nutrient	3.54	0.30	1.13	0.80	0.29	13.2	59.9	99.3	6.50	27.3
2. Stake dip in 2% ZnSO4	3.77	0.33	1.15	0.65	0.24	12.9	63.8	82.3	6.58	28.2
3. Stake dip in 4% ZnSO4	3.52	0.28	1.22	0.66	0.23	15.2	63.4	85.3	7.28	31.2
4. Foliar spray with 1% ZnSO4	3.39	0.30	1.16	0.68	0.29	15.3	64.9	68.3	6.75	29.3
5. Foliar spray with 2% ZnSO4	3.47	0.31	1.20	0.70	0.27	17.0	67.9	127.3	6.61	40.4
6. Foliar spray with 1% FeSO4	3.49	0.31	1.16	0.68	0.27	16.4	76.1	95.6	7.04	34.5
7. Stake dip in 2% FeSO4	3.40	0.29	1.11	0.79	0.28	14.7	91.2	76.8	6.45	27.0
8. Stake dip in 4% FeSO4	3.98	0.38	1.37	0.72	0.29	15.3	76.3	97.6	6.78	38.9

3.2 Macro-nutrient fertilization on an Alfisol

The chemical characteristics of the soil where the trial was conducted indicate a low content of N, P, K, Zn, Cu, OM, and a medium content of Mg and S. **Table 6** shows that applying macro-nutrients for cassava intercropped with peanut increased yields and gross income significantly. The highest root yield and gross income were obtained when cassava was fertilized with 90 kg N applied as urea (200 kg/ha) and ammonium sulfate

(430 kg/ha) and 54 kg P_2O_5 + 60 kg K_2O/ha. The S content of this soil is rather low and the application of S in the form of ammonium sulfate increased the cassava root yield and gross income by 19% and 18%, respectively, as compared to that without application of S. When S was applied to peanut only, the cassava root yield decreased 14% as compared to S applied to cassava. It means that S should be applied to both cassava and the interplanted crop to obtain the highest gross income for cassava intercropping systems on low-S soils.

Table 6. Effect of NPK fertilization of cassava monoculture or intercropped with peanut or maize, on the yield value and soil nutrients in Patuk, Yogyakarta in 1998.

Treatments			Yield value (Rp' 000/ha)			Characteristics of soil nutrients		
Cropping system	Crop fertilized	Fertilizers applied	Cassava	Interplanted crops	Total	K	Ca	SO_4
Cm	C	-	4,660	-	4,660	-	-	-
Cm	C	N+P+K	7,090	-	7,090	-	-	-
C+P	C	N+P+K	8,100	985	9,085	M	H	M
C+P	C	N	7,141	577	7,991	H	H	M
C+P	C	N+P	8,114	938	9,052	L	H	M
C+P	C	N+ZA+P+K	9,616	1,087	10,701	L	H	M
C+P	P	N	5,634	1,085	6,719	H	M	H
C+P	P	N+P	7,440	1,417	8,857	L	H	H
C+P	P	N+P+K	7,384	1,277	8,671	L	H	M
C+P	P	ZA+P	8,294	1,330	9,624	H	H	M
C+P	P	ZA+P+K	7,826	1,480	9,308	L	H	M
C+M	M	N+P+K	8,104	1,050	9,154	M	H	H
C+M	M	N+P+K	4,634	1,260	5,894	M	H	M
	C	N+P+K				H	H	M

*compared to soil nutrients before planting
Cm : Cassava monoculture
C : Cassava
P : Peanut
M : Maize
ZA : ammonium sulfate
Source: *Ispandi and Lawu, 2002.*

3.3 Long-term NPK fertilization of intercropped cassava on an Utilisol

Since rice is the main staple food, farmers will always try to grow rice on their land. Cassava farmers in Lampung province generally have small land holdings, they have limited capital and family labor, and their subsistence farming system is dependent on rainfall (Wargiono *et al*., 1997). Therefore, most farmers grow various food crops in intercropping systems during the rainy season, as their main objective is to obtain enough household food for the year. The objective of a long-term NPK trial was to determine the most suitable annual application of N, P and K to maintain high yields of both cassava and intercrops over time. The data in **Table 7** indicate that after ten years of continuous cropping the highest production of calories and net income were obtained by applying annually 90 kg N + 25 P_2O_5 + 90 K_2O/ha or 90 kg N + 50 P_2O_5 +180 K_2O/ha.

In Lampung province each household requires an annual supply of about 479 kg of rice and 393 kg of cassava to meet their calorie requirements. The average upland land holding is about 0.5 ha. Thus, the data in **Table 7** indicate that with adequate NPK fertilization their calorie requirements can be met even if they have somewhat less than 0.5 ha. By growing soybeans after the harvest of rice, the consumption of protein is also increased. This cropping pattern can thus be recommended for maintaining food security.

Table 7. Effect of annual applications of various levels of N, P and K on the yield of cassava and intercropped rice, the total calories, and crude protein produced, as well as the net income obtained in Tamanbogo, Lampung, in 2001/02 (10th year).

Fertilizer treatments N-P_2O_5-K_2O (kg/ha			Cassava monoculture				Cassava intercropped				
			Roots yield (t/ha)	Calories (Kcal/ha)	Protein (kg/ha)	Net income ('000 Rp/ha)[1)]	Root yield (t/ha)	Rice yield (t/ha)	Calories (Kcal/ha)	Protein (kg/ha)	Net income ('000 Rp/ha)[1)]
0	0	0	6.23	9,030	68.53	1,246	6.22	0.05	9,133	72.87	1,299
0	50	90	11.62	16,849	127.82	1,744	10.17	1.61	18,402	255.16	3,225
45	50	90	12.53	18,169	139.93	1,806	8.40	1.97	16,652	267.73	3,147
90	50	90	17.66	25,675	194.26	2,712	11.23	2.24	21,369	322.89	3,890
180	50	90	15.20	22,040	167.20	1,980	10.26	1.49	18,259	245.47	2,631
90	0	90	15.07	21,852	165.77	2,444	8.49	1.04	14,672	184.17	2,272
90	25	90	19.01	27,565	209.11	3,107	11.21	2.07	20,954	307.44	3,824
90	100	90	13.36	19,372	146.96	1,602	9.19	1.87	17,571	267.52	2,825
90	50	0	6.38	9,251	70.18	786	4.24	0.83	8,032	120.51	1,271
90	50	45	17.45	25,303	191.95	2,835	8.49	1.89	16,601	266.11	3,122
90	50	180	19.03	27,594	209.33	2,656	10.93	2.63	21,819	354.30	3,929
180	100	180	16.26	23,577	178.86	1,612	9.46	1.90	18,030	273.22	2,342

[1)]Net income = gross income-fertilizer cost

REFERENCES

Asher, C.J., D.G. Edwards and R.H. Howeler. 1980. Nutritional Disorders of Cassava. Dept. of Agriculture, Univ. of Queensland , St. Lucia, Queensland, Australia. 48 p.

CGIAR, 2000. Root and Tuber Crops in the Global Food System. A Vision Statement to the Year 2020. CIP, Lima, Peru.

dTp Studies 1998. Global cassava market study: Business opportunities for the use of cassava. Mimeo, Guelph, Canada: dTp studies Inc.

Fujita, K. and K.G.O. Budu. 1994. Significance of legumes in intercropping systems. Roots and Nitrogen in Cropping Systems of the Semi-arid Tropic. JIRCAS International Agric. Series pp 9–40.

Howeler, R.H. 1981. Mineral Nutrition and Fertilization of Cassava. CIAT, Cali, Colombia. 52 p.

Ispandi A. and J.S. Lawu, 2002. Tanggap beberapa klon ubikayu terhadap pemupukan P, K dan Za pada tanah Alfisol. Penelitian Pertanian Tanaman Pangan, Puslitbangtan. 21/2, 36-42.

National Socio-Economic Survey. 1999. Consumption of Calories and Protein in Indonesia. Badan Pusat Statistik, Jakarta, Indonesia.

Scott, G.J., R. Best, M. Rosegrant and M. Bokanga. 2000. Roots and Tubers in the Global Food System: A. Vision Statement to the Year 2020. CIP-CIAT-IPRI-IITA and IPGRI. Lima, Peru.

Statistik Indonesia. 2000. Food Crops Production and Population Projection, Badan Pusat Statistik (CBS), Jakarta.

Wargiono J., Tuherkih E., Zulhaida, Heryani N and S. Effendi, 1997. Waktu tanam ubikayu dalam pola monokultur dan tumpangsari (Effect of time of cassava planting on yield in monoculture and in an intercropping system). Penelitian Pertanian Tanaman Pangan 15/2: 55-61.

Wargiono J., Koeshartojo, Suyamto H. and B. Guritno, 1998. Recent progress in cassava agronomy research in Indonesia. *In:* R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Farmer Participatory Research in Asia. Proc 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 307-330.

Wargiono, J., Y. Widodo and W.H. Utomo. 2001. Cassava agronomy research and adoption of improved practices in Indonesia. *In*: R.H. Howeler and S.L. Tan (Eds). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 259-269.