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OPTIMIZING BENEFITS THROUGH INTEGRATING CASSAVA RESEARCH AND DEVELOPMENT

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Abstract

An integrated cassava research approach combines research on production, processing, and utilization and marketing to alleviate constraints to, or take advantage of opportunities for, cassava development. This approach has proven to be effective in maximizing technology adoption and making positive impact on the welfare of those who depend on cassava for their livelihood. This paper describes how the Cassava Program of the Centro Internacional de Agricultura Tropical (CIAT) came to adopt this approach. It also explains why this research approach, in the case of cassava, is essential for optimizing technology adoption and impact. The paper concludes with implications for cassava research strategies.

Background

The basic premise behind the CIAT Cassava Program's philosophy for integrating research and development (R&D) activities was formulated more than a decade ago. At that time, trends for consumption of traditional cassava products in Latin America and therefore of production were decreasing, especially in those areas with few crop alternatives. It was recognized that high production and market risk at the producer level significantly depresses the demand to adopt improved production technologies that should be the vehicle whereby small-scale cassava farmers can reduce costs and generate increased income (Lynam and Janssen 1992). Faced with a depressed market and highly fluctuating cassava prices, cassava farmers did not want to assume the risk associated with adopting ‘improved’ technology. Hence, the integrated cassava project (ICP) philosophy (Pérez-Crespo 1992) was based on the premise that market and utilization research activities would develop alternative uses and products that would broaden demand and stabilize prices. The latter translates into reduced risk for the farmer, thereby creating incentive to adopt cassava production technologies.

In most production areas, cassava faces a complex of climatic, agronomic, biological, and economic constraints. Among these constraints, those related to markets and edapho-climatic conditions are the most influential in determining the crop's potential. Cassava production regions can therefore be classified and characterized according to their relative market situation and possibilities for alternative crops (Table 1):

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(1) *Regions with market limitations and reduced cropping alternatives* (e.g., North-East Brazil, East Java, North Coast—or Atlantic Coast—of Colombia).

(a) Limited, inelastic market demand for a few traditional cassava products. Price and price fluctuations are major constraints because of quality deficiencies, seasonality, and other factors.
(b) Limited crop alternatives, caused by soil constraints (fragile, infertile, upland, hilly zones) and/or by climatic constraints (low rainfall, long dry season).

(2) *Regions with market limitations that have alternative crop possibilities* (e.g., Paraguay, State of Kerala in India).

(a) Limited, inelastic market demand as in case 1.
(b) More favourable edapho-climatic conditions for which crop alternatives can be considered.

(3) *Regions with diversified markets but limited cropping alternatives* (e.g., North-East Thailand, Guangdong Province in China)

(a) Diversified, more elastic cassava demand with relatively stable prices and reduced market risk.
(b) Limited crop alternatives to cassava because of edapho-climatic constraints as in case 1.

(4) *Regions with diversified markets and alternative crop possibilities* (e.g., Paraná in southern Brazil, Sumatra in Indonesia).

(a) Diversified, more elastic cassava demand as in case 3 above.

(b) More favourable edapho-climatic conditions as in case 2 above.

The worst-case scenario is case 1, where an integrated approach is essential for successful technology adoption and impact. The other cases may need relatively less integration, depending on the level of the limitations. For example in case 4, one can introduce cassava production technologies with the success rate being **less** dependent on utilization and market research.

Why Higher Adoption and Impact?

Based on analyses of user needs, cassava research can be divided into three areas: varietal improvement, crop management and post-harvest handling, and market research. To see the benefits—described as 'level of yield gain x level of adoption in a fixed time period'—obtained from including utilization and market activities and crop management with varietal technologies, imagine a hypothetical R&D activity for case 1. The crop is grown in a semi-arid agro-ecosystem where drought, soil fertility, and planting material quality are the major constraints. The market consists of only one traditional cassava product that experiences very strong inter-seasonal price fluctuations. The different research activities and subsequent impact are illustrated in Table 2.

In this hypothetical case, if R&D is conducted only on varietal improvement, benefits are lowest. The incorporation of management components improves the benefits from 200 to 450. Integration with crop management research not only improves yield gain but also improves the sustainability of the system. If integrated with utilization and market research, however, the technology adoption rate will be significantly boosted. Additionally, the yield gain will increase because of a decreased market risk, translated in this example by +5% yield for both the varietal technology alone and the variety + management components. Total integration of varietal, management, utilization and market research can increase benefits by more than five times, compared with varietal improvement alone.

This argument is well illustrated by the case of adoption in the 'North Coast', an agricultural region in northern Colombia, abutting the Caribbean Sea. The case was quantified in a study covering six states that produced more than 50% of the country's cassava (Gottret and Henry 1994). In the early 1980s, an integrated cassava research project (ICP) was started, in which the first priority was to expand and stabilize cassava markets. This was accomplished by establishing and developing farmer cooperatives supplying dried cassava chips to the fast-growing animal feed industry. Concurrently, improved varietal and crop improvement technology components were targeted to these areas.

Table 3 shows that, after 8 years, adoption levels are significantly higher for areas with improved market access and institutional support than for those areas with only the traditional fresh market. This has been shown for different types of technology components; that is, varieties, management, and recommendations that require additional inputs. An additional factor brought by the integrated project approach was the development of cooperatives for small cassava farmers, and thus increased opportunity for members to have easier access to credit and so adopt technology components that require additional capital inputs.

Furthermore, econometric analyses estimating elasticity's of adoption show that certain factors like 'distance to market' and 'cassava cooperative membership' have a significant positive effect on adoption (Gottret and Henry 1993). For example, the probability of adopting optimal planting density and stake treatment increases by 4.5% and 15%, respectively, as the distance to the new market (cassava-drying cooperatives in this case) is reduced by 50%. The adoption of cassava production components since 1984 has resulted in considerable yield gains of 12%-25% with respect to traditional market areas. Both yield gain and adoption levels are significantly higher in areas where cassava technology components were integrated (Table 3).

Besides analysing yield gains and adoption rates, Gottret and Henry (1993) estimated the size and distribution of benefits for the ICP through econometric modelling. Benefits were also analysed by technology intervention; that is, production (varietal and crop management) versus utilization and market technologies. The results are summarized in Table 4.

Cassava producers were the group that most benefited from the ICP in the region, gaining US$15 million from 1984 to 1991. According to the analysis of cassava production technology adoption presented in the previous section, producers with better access to markets and government programmes (to a large extent a result of the project) are major adopters of new technology. Those cassava farmers who were members of cassava-drying cooperatives had easier access to fresh markets, were near drying plants, and received technical assistance and credit from government programmes. They were, therefore, the ones who received the most benefit from the ICP. To a much lesser extent, benefits were also dependent on other characteristics such as farm size, land tenure, and the farm household's education and experience.

Although cassava producers were the major beneficiaries of the technological changes in the North Coast, urban consumers of fresh cassava also benefited from the adoption of cassava drying and production technology, obtaining benefits of US$2 million. Poor urban consumers, who consume higher absolute levels of fresh cassava and show a lower price elasticity of demand, are the ones who gained most.

The group who gained the fewest benefits from the ICP in the region was the processors, who gained only US$1.1 million. Most of these small-scale processors, however, were also cassava producers and therefore benefited two ways. From 1984 to 1991, about 55,318 t of dried cassava were produced. Of this total production, an estimated 84% was produced by small farmer associations, which had a total net gain from the adoption of dried cassava technology of US$924,000 during this period. The remaining benefits of US$176,000 were received by privately run dried-cassava-processing units.

Fresh-cassava-market agents were the only group to lose as a consequence of the ICP in the North Coast. The loss of benefits to this group is mainly an effect of the inefficiency of the fresh-cassava market. Attempts to make the marketing of fresh cassava more efficient, and thus approximate perfectly competitive conditions, will decrease losses to market agents and increase gains to fresh-cassava consumers.

Although the introduction of a cassava utilization technology in the North Coast benefited dried-cassava buyers and processors the most, of much more importance is the indirect effect of creating the incentives to increase the area planted to cassava and to increase yields by adopting improved production technology. The production response to these incentives, provided by opening up a new market, reaped benefits for both cassava producers and urban consumers of fresh cassava.

The net benefits to society from the ICP are estimated to be US$22 million. If we consider that the total costs of the project were US$1.2 million, the total return to the investment was about US$18 for every dollar invested (Gottret and Henry 1993).

These results support and reinforce the argument for an integrated approach to the generation of production, processing, and marketing technology. In the absence of a widened cassava market, cassava production technology adoption would have been significantly less and the principal beneficiaries would have been fresh-cassava consumers, not the small producers to which the technology is targeted. But, in the absence of production technology, with only processing and marketing innovations, absolute total benefits would have been significantly less and the principal recipients would have been the animal-feed factories and, to a lesser extent, processors. The integration of research has been the prime factor to optimize both absolute benefits and their distribution. As such, the research objective to target benefits to small producers was fulfilled.

The foregoing qualitative and quantitative arguments show that an integrated cassava research approach (1) will generate higher yield gains and adoption levels, (2) is more sustainable from a biological, agronomic, and socio-economic sense, and (3) results in significantly larger economic benefits, compared with varietal development research only. Moreover, integrated research offers additional advantages. The output from varietal improvement-only research can, in general, be divided into per-unit cost reductions and/or yield gains. For purposes of benefit estimations, this can be considered as a supply shift. Such a shift in a market with traditional inelastic product demand (and without opportunities to export) will translate into benefits to consumers only; while producers may even lose (depending on relative elasticity's) (Alston 1990). As was shown in the case of the ICP in Colombia, utilization and market research activities broadened and stabilized the cassava market (which can be translated as a demand shift), generating two-thirds of the benefits to producers and one-third to consumers (and processors). Thus the IRP approach could be used as a benefit-distributing instrument or 'equalizer'. This is an extremely important factor if R&D is be targeted towards rural development and/or improving the welfare of the rural poor.

Implications for Cassava Research and Development Planning

The foregoing analysis of the benefits that accrue from successful integrated cassava technology development and their distribution among different beneficiaries provides a background from which several implications can be drawn for designing and executing cassava research programmes:

(1) Identification of the commodity system as the starting point from which to assess the constraints facing cassava producers and processors and to identify the opportunities offered by different consumer or client groups. Post-harvest processing and marketing are indicated. Research needs and the relative importance assigned to each of the three research areas will vary according to the production and marketing situation in different cassava-growing regions. More often than not, an integrated approach on crop management that combines germ plasm development with research production and marketing situation in different cassava-growing regions will be indicated.

(2) The market situation for cassava products greatly influences the type and rate of technology adoption. On one end of the scale, are the 'constrained' or inelastic markets and, on the other end, fully 'diversified' or elastic markets. The former requires a demand-led approach in which new market opportunities are identified and developed, either through improving existing products or by establishing a processing capacity for making new products. The subsequent development of production technology will be largely governed by the quantity, quality, and supply needs of the new market. In the case of diversified markets, emphasis is placed on sustaining or improving the cost and price competitiveness of cassava with respect to alternative sources of carbohydrates. This can be achieved through the development of germ plasm and crop management practices that reduce production costs and improve root quality.

Table 5 gives an estimate of the relative production area of cassava influenced by either 'constrained' or 'diversified' markets, by ecosystem and by continent. Currently at CIAT, data collection is under way to generate maps of each cassava-growing country, overlaying agro-ecological parameters with cassava production and market characteristics. This forms part of a priority-setting activity developed and financed by the Cassava Biotechnology Network (CBN) (Henry and Thro 1993).

Latin American cassava production is characterized by what is predominantly a constrained market situation, where technology development needs to be oriented by new market opportunities. In Africa, despite the fact that cassava markets are not diversified, demand elasticity's are greater than in Latin America because of a continuing high demand for cheap dietary carbohydrates. In the short term, research to alleviate production constraints is the most relevant intervention; whereas in the medium to longer term, market and product development will become more important with rising incomes and diversification in consumption habits. In Asia, in contrast, where market diversification is greater, production-related problems such as low and unstable yields, associated principally with edapho-climatic constraints and low DM content, are of primary research concern. Of course there are few situations that conform to the extremes mentioned here, which reinforces the case for an approach in which germ plasm, crop management, processing, and marketing research activities are integrated.

Table 6 classifies the three research areas according to the expected output of research in a particular area (e.g., yield gain or improved quality) and the direct or indirect effect of each intervention (e.g., reduced unit costs or price premium). The distribution of benefits among producers, processors, and consumers varies. Varietal improvement and crop management technologies tend to provide greater benefits to consumers and processors, while post-harvest technologies ensure that benefits are more equally distributed among the three groups of beneficiaries.

The argument for a commodity-system approach and integration of germ plasm development, crop management, processing, and market research also has very important institutional implications that need to be addressed if research is to make a significant contribution to cassava development. Seldom can an individual national institution cover the range of expertise necessary to integrate research fully in all three areas. The very nature of most agricultural R&D organizations, both public and private, often precludes the possibility of achieving a continuum from problem and opportunity identification, through technology generation and testing with farmers, to final commercial diffusion of the product(s), whether they be improved varieties, crop management practices, or novel processing techniques. Implicit, therefore, in an integrated approach to cassava R&D is the notion of institutional integration, where different entities play different roles and have different responsibilities but work together towards a common goal.

CIAT's Cassava Program: A Global Mandate

International research programmes such as CIAT's Cassava Program, in addition to contributing to scientific knowledge and technology development in specific areas, have also assumed responsibility for convening, catalysing, and supporting others in their efforts towards greater integration. This has taken place at national, regional, and global levels to facilitate the research process through an enhanced flow of information and to identify possibilities for horizontal collaboration among countries and institutions. The credibility of CIAT's Cassava Program to lead and promote integration is derived, first, from having developed and maintained a capability **and** capacity to undertake research and deliver technological products in areas where it is considered to have a comparative advantage over other research institutions. Second, it provides intellectual leadership to others in the overall cassava R&D process.

This process encompasses a spectrum of activities from research at the molecular level to the release and diffusion of technology in the field. Over the years, this has led to an investment in and the building-up of an intellectual competence, based on experience in areas other than those in which the Program is considered strictly to have a comparative research advantage. By doing so, CIAT has been able to build partnerships with institutions in both developed and developing countries that have made and continue to make significant contributions towards accelerating the generation and transfer of cassava technology. The 'global' mandate for cassava research, conferred on CIAT by the Consultative Group for International Agricultural Research, should therefore be viewed in these terms.

For new cassava technology to be successfully developed and eventually adopted, an increased understanding is needed of the complex social, technical, institutional, and often political interactions. Documentation of cases where cassava R&D planning and execution have resulted in demonstrated benefits for the intended end users of the technology generated will undoubtedly reinforce the arguments presented here. The CIAT Cassava Program is convinced that cassava R&D, wherever it is practised, should be carried out within an integrated, commodity system perspective. The Program actively advocates and encourages the incorporation of this approach among its partners, whether they be national programmes or advanced laboratories in developed countries. Hopefully, this will result in greater objectivity in setting research targets, enhance collaboration among institutions and increase the overall efficiency and effectiveness of global cassava R&D.

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Table 1. Matrix of the relationships between market demand and crop alternatives.

Market demand	Crop alternatives	
	Limited	Unlimited
Limited	1	2
Unlimited	3	4

Table 2. Estimated benefits from alternative research and development (R&D) interventions in a hypothetical case of a traditional inelastic market with few production crop alternatives (case 1 in text).

Crop alternatives (case 1)	Without utilization and market research			With utilization and market research integrated		
	Yield gain (%)	Adoption (%)	Total benefits	Yield gain (%)	Adoption (%)	Total benefits
Varietal technology only	20	10	200	20 + 5	20	500
Variety technology + additional management components	30	15	450	30 + 5	30	1050

Table 3. Cassava technology component adoption[a] and subsequent yields against different levels of market influence in the Colombian North Coastal region, 1991.

Technology component	Adopters (%)		
	Average[b]	High influence areas[c]	Low influence areas[d]
Cv. Venezolana	52.8	87.2	37.2
Cv. MP-12	2.2	6.6	0.4
Plant density	26.4	26.9	17.1
Stake selection	8.3	17.0	7.3
Stake size	0.6	1.6	0.5
Mechanization	28.5	36.4	15.6
Herbicides	27.9	47.2	15.1
1992 cassava yields (t/ha)			
Intercropping	9.2	9.7	8.7
Monoculture	10.4	13.3	10.8

a. *Adoption of components since 1984 only.*
b. *The average includes an intermediate influence level that, for simplicity, has not been included.*
c. *Strata of cassava producers in areas* ***with*** *cassava-drying activities and strong institutional presence.*
d. *Strata of cassava producers in traditional areas* ***without*** *cassava-drying activities and low institutional presence.*

SOURCE: Gottret and Henry (1994).

Table 4. *Ex post* economic benefits from the integrated cassava project in the Colombian North Coastal region, 1984-1991.

Group	Benefits from: Cassava utilization and marketing technols. (million US$)	(%)	Cassava production technologies (million US$)	(%)	Integrated crop research proect (ICP) (million US$)	(%)
Fresh-cassava consumers	233	3.4	1,806	12.1	2,039	9.3
Dried-cassava users	4,334	62.4	0	0	4,334	19.8
Cassava market agents	-78	-1.1	-584	-3.9	-662	-3.0
Dried-cassava processors	1,150	16.6	0	0	1,150	5.3
Cassava producers	1,307	18.8	13,706	91.8	15,013	68.6
Total net benefits to society	6,946	31.7	14,928	68.3	21,874	100.0

SOURCE: Gottret and Henry (1993).

Table 5. Defining cassava-growing areas by agro-ecosystem, constrained market (CM), and diversified market (DM).

Ecosystem	Latin America		Asia		Africa	
	CM (%)	DM (%)	CM (%)	DM (%)	CM (%)	DM (%)
1. Lowland humid tropics	100	0	48	52	100	0
2. Lowland subhumid tropics	90	10	30	70	100	0
3. Lowland semi-arid tropics	100	0	10	90	100	0
4. Highland tropics	90	10	-	-	100	0
5. Subtropics	75	25	37	63	100	0
Total (%)	88	12	30	70	100	0
Total ('000 ha)	2,835	425	1,176	2,744	8,922	0

Table 6. A schematic summary of cassava research and development (R&D) areas, products, and benefit distribution[a], 1993.

Cassava R&D areas	Output and products	Direct and indirect effects	Benefi-ciaries	Relative benefit distribution
1. Varietal improvement	Yield gain	Reduced unit costs of production	Producers Consumers Processors	(*)[b] *** **
2. Crop management	Yield gain	Reduced unit costs of production	Producers Consumers Processors	(*)[b] *** **
3. Processing/ marketing/ utilization	Improved root quality	• Price premium • Reduced processing costs	Producers Consumers Processors	** * ***
	New cassava products introduced	• Reduced price variability • Increased demand • Expanded processing capacity	Producers Consumers Processors	**(*)[c] ** *
	Improved processing of traditional products	• Reduced process losses • Improved product quality • Increased demand	Producers Consumers Processors	* * **

a. *Benefit distribution according to Alston (1990).*
b. *In the absence of demand improvement, the producer may lose benefits; however, if the cost reduction is higher than the price reduction, producers will gain.*
c. *By integrating production, processing, and market research, benefits to producers are maximized.*