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Value Addition in Crops and Livestock Production through Processing Linkages: The Case of 4FGF Project in Vietnam

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Abstract: *New high-yielding canna and cassava varieties were adapted to growing conditions at research site (Bac Kan province, Vietnam) and made site-specific recommendations for management practices (i.e., fertilizer and planting densities) to maximize yields of such new varieties, which were grown by farmers and supplied as raw materials to a local processor in the commune. Localized processing provides secure markets, adds value for cassava and canna growers, and can improve sustainability of production systems if by-products are used to feed livestock. Farmers were trained in livestock feeding practices using low-cost feeds based on cassava and canna processing residues and locally available feeds to improve profitability of household-scale livestock production. Eco-efficiencies gained from improved two-way producer/processor linkages and better crop/livestock integration made production systems more competitive, as households increased income with less cash outlay for fertilizers and livestock feed.*

Keywords: *Processing; crop-livestock linkages; crop production; livestock feeding*

1. BACKGROUND

Cassava is a pro-poor crop. It tolerates drought and low fertility soils, so it can be grown on marginal lands which are often farmed by the poorest households. Because of its indefinite maturity period, cassava is a flexible crop that can be harvested in response to household needs and market opportunities.

In the uplands of tropical Asia, cassava has long been an important substitute staple crop (for rice) in times of food insecurity and, as a cheap feed resource for intensifying livestock production, it helps to increase incomes of smallholder farmers. With simple treatments (drying, cooking, ensilage) to remove toxic compounds, cassava roots provide a rich source of calories and cassava leaves provide quality protein for both humans and livestock. Because of improved trade and transport linkages and strong demands for cassava as a feedstock for a wide range of domestic and regional agro-industries, cassava is also becoming an important cash crop for poor smallholders, even in remote upland areas.

Canna is another starch-producing cash crop grown by farmers in the northern mountainous region of Vietnam. Canna starch is used to produce canna noodles, a very popular food in Vietnam. Demand for canna wet starch is high and canna producers can get high income from selling fresh roots to local processors.

The *Programme for Linking Livelihoods of Poor Smallholder Farmers to Emerging Environmentally Progressive Agro-Industrial Markets* (IFAD Grant 1031-CIAT), also known as the "Food, Feed, Fuel, and Fibre for a Greener Future (4FGF) Project" worked with smallholder cassava and canna farmers in Cambodia, Laos, and Viet Nam to improve linkages with processing industries and to promote sustainable production by improving integration between crop and livestock production systems. The programme was implemented by the International Center for Tropical Agriculture (CIAT) and the International Potato Center (CIP), in partnership with national research institutions, IFAD development projects and their implementing partners in the agricultural extension services, and private sector partners in the cassava and canna processing and livestock feed industries. The programme piloted innovations by on-farm demonstration trials, trainings, and farmer field days directly with four IFAD-funded investment projects and promoted knowledge sharing with a wider group of partners through multi-level stakeholder platforms, known as “learning alliances”.

In Viet Nam, the 4FGF project worked together with researchers from the Vietnam Academy of Agricultural Sciences (VAAS), the National Institute for Animal Sciences (NIAS), and Thai Nguyen University of Agriculture and Forestry (TUAF), to test research products within the context of farmers’ livelihoods and to identify appropriate technologies for scaling out to larger groups of beneficiaries through partnerships with IFAD-funded investment projects. This paper looks at some of the key component innovations tested within the context of integrated crop production, processing, and livestock feeding systems and explores some of the synergies and livelihoods benefits realized from systems integration.

2. Research Content And Methodology

2.1. Research Content

There were three streams of research: (1) On-farm trials to improve productivity and sustainability of cassava and canna (varieties, planting density, fertilization, erosion control, practices); (2) On-farm livestock feeding trials, including the utilization of cassava and canna processing residues and locally available feeds to improve profitability of household-scale livestock (buffalos, pig) production, and biogas utilization; (3) Investigation of linkages and interactions between a local small-scale starch processor and cassava and canna and livestock producers.

2.2. Research Methods

A participatory technology development (PTD) process began with household visioning of livelihoods strategies and focus group discussions that resulted in formation of farmer interest groups and initiated participatory planning of on-farm trials. Researchers worked with lead farmers to implement demonstration trials. Results were shared among a larger group of farmers and extensionists during harvest field days. Farmer field schools were organised to train farmers in feed preparation and utilization and management of on-farm livestock feeding trials. Social science research methods (e.g., direct observation, semi-structured interviews, and focus group discussions) were used to collect data on processor operations and investigate linkages between cassava and canna and livestock producers and the local processor.

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Table1: *Cassava variety trial result in year of 2011 at Bac Kan*

No	Cassava variety	Root number	Root weight (kg/plant)	Fresh root yield(tons/ha)	Starch content (%)	Starch Yield (t/ha)
1	KM 98-7	7.93	2.61	26.1	25.2	6.6
2	HM 911	8.36	1.84	18.4	25.8	4.7
3	DT 2	13.8	2.34	23.4	28.5	6.7
4	KM 94 (Control)	7.9	2.25	22.5	27.6	6.2

5	HM 125	10.0	2.39	23.9	25.4	6.1
6	DT 1	9.4	2.87	28.7	29.6	8.5
7	KM 21-12	12.0	3.08	30.8	27.7	8.5
8	Rayong 9	9.6	3.45	34.5	30.4	10.5
CV%				18.6		
LSD (.05)				2.4		

Researchers from the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI) worked with households and extensionists to implement cassava intercropping and erosion control demonstration trials. None of the intercrops decreased cassava root yields and they provided supplemental income to farmers. Black bean (a local cowpea variety) was the most profitable intercrop, providing a supplemental economic benefit of 47% compared to cassava mono-cropping. Legume intercrops (black bean and peanut) were also effective in reducing weeds and soil loss, while providing supplemental harvest of food/feed crops for food security and/or income generation and soil fertility enhancement through nitrogen fixation. Farmers are benefiting from sustainable management practices and higher yields through increased sales of roots and intercrops and increased availability of livestock feed.

Three high-yielding, high starch content canna varieties were identified and adopted by farmers in Bac Kan (Table 2). All but one of the eight introduced varieties tested had higher fresh root yields than the local variety, but the local variety had the highest starch content. The two highest yielding varieties (DR 1 and VCIP) yielded 2.8 times more fresh roots than the local variety. Even though the starch contents were less than the local variety, the much higher root yields from DR 1 and VCIP resulted in starch yields that were 2.5 times greater than the local variety. Under farmer management conditions, DR 1 yielded at least twice as high as the local variety. DR 1 was multiplied in on-farm trials for distribution to more farmers at the harvest field day. High canna yield requires highly fertile soils or application of fertilizers. Fertilizer trials with DR 1 showed that the highest root yield was achieved at a rate of 300 kg N + 200 kg P_2O_5 + 300 kg K_2O + 5 tons of farmyard manure per hectare. A cost-benefit analysis needs to be applied to determine fertilizer rates that should be recommended to farmers. Results from density trials revealed that DR 1 yields were highest from a plant population of 40,000 plants per hectare (4 plants/m^2).

Table2: *Canna variety trial results in the year of 2011 at Bac Kan*

Canna variety	Fresh root yield (tons/ha)	Starch content (%)	Dry matter content (%)	Wet starch yield (tons/ha)	Dry starch yield (tons/ha)
DR3	63.5	22.1	14.2	14.0	9.0
21	69.2	22.1	14.5	15.3	10.0
DR70	24.6	23.0	14.8	5.7	3.6
49	66.7	23.1	15.2	15.4	10.1
DR1	72.5	23.4	15.4	17.0	11.2
DR49	55.8	20.8	14.9	11.6	8.3
VCIP	71.3	23.0	15.3	16.4	10.9
VC	65.0	22.7	14.5	14.8	9.4
Local variety (Control)	25.2	25.6	17.1	6.5	4.3
CV%	12.5				
LSD 05	3.5				

3.3. Livestock Feeding

Researchers from the National Institute for Animal Sciences (NIAS) organized farmer field schools to train farmers in livestock feeding practices that utilize cassava and canna processing residues and locally available feeds to improve profitability of household-scale livestock production. NIAS researchers worked with farmers to implement pig, cattle, and buffalo feeding trials to demonstrate increased growth rates and organized a programme for hands-on training to construct biogas digesters together with farmers collaborating with feeding demonstrations.

In one of the feeding trials, growth of pigs was compared from feed treatments that consisted of 50% commercial feed and 50% of four different silage formulations: (i) 99.5% cassava root slices +0.5%

salt, (ii) 99.5% cassava starch residue + 0.5% salt, (iii) 93.5% cassava starch residue +6% rice bran + 0.5% salt, and (iv) 89.5% cassava starch residue + 10% fresh cassava leaves + 0.5% salt. All treatments resulted in high live weight gains and lower costs compared to feeding only commercial feed. Silages made from starch residue resulted in higher weight gains than silage made from cassava root slices, but feed costs from starch residues were higher than from the fresh cassava roots. Since consumption of starch residues allows a second (recycled) use for the cassava roots, if a farmer sells cassava roots to a factory and then buys back the starch residues, the income from sales of the fresh cassava roots should be deducted from the cost of residue-based feeds. Starch residues could be fed fresh or ensiled. Ensilage facilitates preservation and storage for use as a feed resource during seasonal scarcity.

Three farmers who had completed the livestock feeding field school implemented another pig feeding demonstration trial in Kim Lu commune, Bac Kan province (Northern Viet Nam) between March and June 2012 (trial duration = 90 days). Each household raised a total of 12 piglets. NIAS researchers worked with farmers to test growth rates and profitability. Four feeding ration treatments were compared: (i) 25% silage, 75% compound feed; (ii) 50% silage, 50% compound feed; (iii) 75% silage, 25% compound feed; and, (iv) 100% commercial feed pellets. Silage consisted of cassava starch residue (purchased from the processing cooperative) mixed with 0.5% salt. Compound feed consisted of rice bran, maize meal, cassava leaf meal, and commercial feed concentrate (30% of the compound feed formulation was fed to younger pigs, decreasing to 28% and 25% in months 2 and 3, respectively). All feed materials were sourced on-farm except salt, cassava starch residue, and commercial feed concentrate (pellets). At the end of the trial, there were no statistically significant differences in live weights or live weight gains between the different feeding treatments, though pigs fed a ration of only commercial pellets gained 4-8% less weight than those fed with the mixed rations (Table 3). Roughage consisted of various formulations of silage made from cassava starch residue (CSR) and sweet potato vines or non-commercial sweet potato roots, peanut vines, and maize stover and husks.

Table3: *Feed costs, sale price, and profits from feeding pigs with various ration formulations*

Feed Treatment	Feed Cost (VND/kg LWG)	Feed Cost (VND/pig)	Avg Sale Price (VND/pig)	Profit/loss (VND/pig)	Profit/loss (~USD/pig)
25% CSR, 75% compound feed	40,800	2,462,000	2,293,000	-169,000	- 8.45
50% CSR, 50% compound feed	29,600	1,862,000	2,393,000	531,000	26.55
75% CSR, 25% compound feed	18,100	1,106,000	2,320,000	1,214,000	60.70
100% commercial concentrate pellets	49,400	2,869,000	2,179,000	-691,000	- 34.55

Based on demonstration trial results, farmers in the commune began using cassava starch residues to feed pigs. Development outcomes resulting from pig feeding demonstration trials could be summarised as: higher weight gains, up to 15-30 kg/month (previously 8-10 kg/month); Shorter fattening time, 3 months/cycle (previously 6-8 months/cycle): more production cycles per year, and faster rotation of cash capital. Several farmers increased the number of pigs fattened, up to 30-40 pigs/cycle (previously 4-5 pigs/cycle). Improved feeding practices eliminated cooking for feed preparation, so farmers saved labour and fuel costs, compared to traditional practices. In addition, manure from intensified livestock production provided fertilizer to increase crop yields and household energy from production of biogas.

3.4. Linkages between a Local Starch Processor and Root Crop (Cassava, Canna) and Livestock Producers

The 4FGF Project worked with a small-scale wet starch processing cooperative located in Kim Lu commune, Na Ri district, Bac Kan province and farmers in the commune that were supported by the IFAD-funded “Pro-Poor Partnerships for Agro-forestry Development Programme” (3PAD) in Bac Kan province to demonstrate eco-efficiencies of crop/livestock integration. The processor sells wet cassava and canna starch to wholesale buyers at a starch marketing cluster in Hanoi where it is resold to starch refiners, dryers, and processors of various food and industrial products.

The factory has capacity to process about 10 tons of fresh cassava or canna roots per day or about 1,000 tons of roots per processing season. It produces about 300 tons of fibre residue by-products, which is enough to feed approximately 2,300 pigs per year (raised on a ration of 50% fibre residues for 3 months, from initial weight of 25-30 kg to a market weight of 80-100 kg/head). Trial results showed that feeding 100% commercial feed pellets resulted in sales of pigs at a loss, but feeding 50% cassava starch residues, compound feed from locally grown feed resources, and less than 25% commercial feed pellets makes pig fattening profitable.

Before the 4FGF project began working in the commune, farmers did not appreciate cassava starch residues as a feed resource and the processor disposed of starch residue waste by dumping it into the river. After trainings and demonstrations on the use of starch processing residues to feed livestock, all of processing residues are sold to 80 households in the commune (Table 4) for feeding livestock and the factory benefits from selling the fibre residues -- estimated at 15-20% of total income.

Table4: *Some preliminary impacts of 4FGF project on the small-scale starch processor*

Criteria	Before intervention (2009)	After intervention (2011)
Number of households in the commune using fibre wastes for animal feeding	0	80
Number of growers selling fresh roots to processor	few	208
Number of farmer groups under contract with the processor	0	5
Average sales of cassava fresh roots to the processor (kg/household)	1,718	1,854
Percentage of new high-yielding, high starch content cassava and canna varieties bought by processor (%)	20	80

The processing cooperative bought cassava from approximately 208 households in Kim Lu commune in 2011. In previous years fewer households in the commune grew cassava and many of those who did grow cassava sold it as dried chips to one of three collectors operating in the commune, rather than as fresh roots to the processor. In 2010 the processing cooperative had to buy most of its feedstock from Lang Son and Cao Bang provinces (50-80 km away) and they had to pay higher prices to cover transport costs. In 2011, about 50% of the processor's cassava roots came from Kim Lu commune and another 50% came from three nearby communes that are 10-40 km away. Cassava from the more distant communes is delivered by collectors using small trucks. Most cassava grown in Kim Lu is delivered by farmers using motorcycles. Fibre residues are often collected from the factory and transported back to the household on the same trip. About 30% of cassava farmers in Kim Lu commune buy starch fibre residues from the processor to feed livestock (Table 4). Cassava farmers may be more inclined to sell fresh roots to the processing enterprise (rather than selling dried chips to collectors) if they are buying back residues to feed to livestock.

Farmers receive information on cassava and canna prices by contacting the cooperative (and cassava chip buyers) by mobile phone. The cooperative does not base prices on starch content or varieties. As locally available supplies of higher starch content varieties have increased, in the future the processor may cease buying traditional (low starch) varieties.

Adoption of improved varieties benefits both producers and processors. Farmers benefit from higher root yields (and also higher starch content if buyers pay a higher price based on starch content). Factories benefit from higher starch yields (tons of starch produced per hectare, i.e. root yield multiplied by starch content). The proportion of improved varieties (with higher starch content) bought by the processor increased from approximately 50% to 80% from the 2010 to the 2011 season.

The local starch processing cooperative confirmed in their own separately managed trials that starch yields from KM 21-12 and Rayong 9 were 20% and 62% higher than the prevailing high-yielding variety (KM 94), so they decided to support multiplication of 84 ha of these two new varieties and dissemination of planting materials to 113 households supplying roots to the processing enterprise. The processor provided the planting materials "for free" at planting, but recovered the cost by subtracting it from the price paid for roots at harvest. The processor is benefiting from a plentiful local supply of cassava roots for his factory. Farmers benefit from selling from 19% to 47% more roots (from KM 21-12 and Rayong 9, respectively) than they currently grow on the same land area. They may also be able to sell some planting materials (stems) of their improved varieties to other farmers after harvesting the roots.

Another 150 hectares of KM 94, KM 21-12, and Rayong 9 will be scaled out to 3PAD communes in the three target districts (Na Ri, Pac Nam, and Ba Be) by the investment project. The Bac Kan Department of Agriculture and Rural Development is multiplying out canna variety DR 1 for distribution of planting materials to canna-growing communes throughout the province. This will help to improve supplies of roots to local starch processors and increase the amount of starch residues for livestock feeding.

4. CONCLUSIONS

The 4FGF Project worked with farmer groups at Kim Lu commune in Bac Kan province in the northern mountainous region of Vietnam to pilot technical innovations in root crop production and livestock feeding.

Higher-yielding cassava and canna varieties and improved crop management practices increased productivity and sustainability of root crop production. Root crop growers benefited from increased sales of roots. A small-scale starch extraction enterprise benefited from increased local supply of roots with higher starch contents and from decreased transport costs.

Localized starch processing provides farmers with a stable market for root crops. Starch processing also provides household-scale livestock producers with a by-product (fibre residues) that is an important component in low-cost feed formulations. Use of residue-based feeds increases profitability of household-scale livestock production, improves profitability of small-scale processors through sales of a previously wasted feed resource, and eliminates a pollution problem.

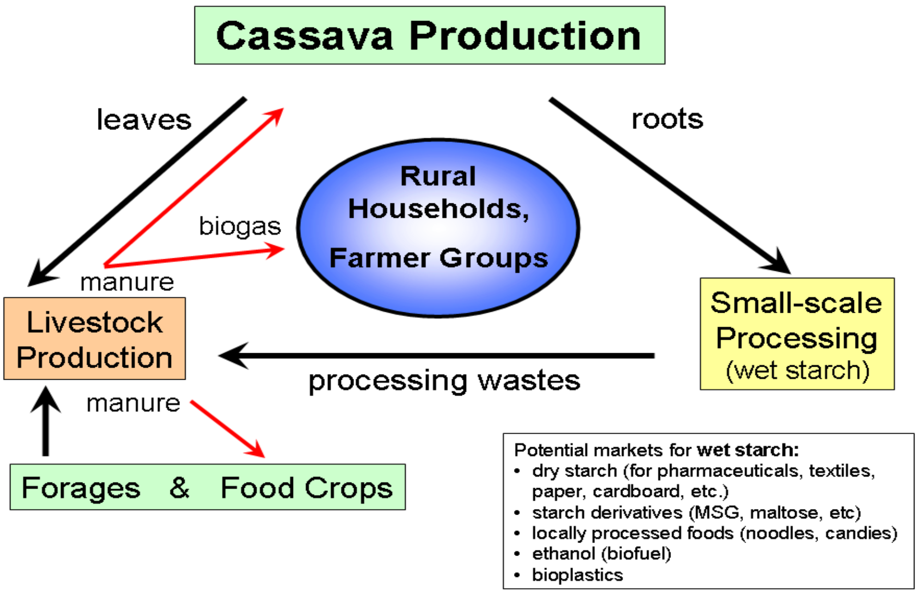

Figure1: *Integrated crop and livestock production linked to starch processing*

Eco-efficiencies gained from improved two-way producer/processor linkages and better crop/livestock integration (illustrated in Figure 1) make production systems more competitive and profitable, as households can increase income with less cash outlay for fertilizers and livestock feed.

The mutually interdependent relationship between producers and processors was strengthened because of cassava and canna yield increases, which resulted from improved varieties and better crop management practices. The processing cooperative realised the profit potential of these production increases and invested in multiplication and dissemination of improved cassava and canna varieties. Increased access to these new varieties and production technologies is expected to increase incomes of many root crop and livestock producing households and stimulate establishment of more processing enterprises.

Recommendations on cassava and canna varieties, fertilizers, and planting densities and feed processing, storage and utilization recommendations were documented in an extension manual, which was developed in collaboration with the 3PAD Project and the Provincial Extension Centre in Bac Kan.

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