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Improving Crop-livestock Production Systems in Rainfed Areas of Northeast Thailand

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Abstract: Crop-Animal Systems Research Network of Thailand (CASREN-Thailand) has been surveyed for general information on livestock-crops farming systems to find out the main problems encountered by smallholder farmers and to implement appropriate technologies to farmers in order to improve farm productivity. Using a farmer participatory approach, recommended technologies such as on-farm feed production and feeding strategies have been offered to farmers. Improving on-farm grass yield by using high production grass varieties such as Purple Guinea grass could increase both quantity and quality of roughage for animals. Cassava/legumes intercropping could provide protein sources for both animal and human (food-feed system), however, the role of legumes in improving soil fertility should be also considered. In addition, supplementation with cassava hay produced on-farm could improve animal productivity particularly milk quality such as milk fat. Moreover, production and utilization of home-made concentrate using local feed resources was key to decrease the cost of production. The overall activities under CASREN-Thailand are fulfilled by improving crop-livestock production systems in rainfed areas.

Key words: Crop-livestock system, local feed resources, food-feed, participatory approach, on-farm, dairy farming

Introduction

Livestock raising is linked up with rural smallholder farmers in many developing countries. Poverty is a rural dilemma and continues to be a persistent multidimensional problem. It is associated with poor farmers, small farm holdings, the landless resource endowments, the socioeconomic environment and externalities (Devendra and Chantalakhana, 2002). The Crop-Animal System Research Network (CASREN) Thailand was established to generate appropriate technology options to offer to farmers using participatory approaches to spread the application of appropriate technologies by farmers to enhance the productivity and economic viability of smallholder crop-livestock systems in rainfed areas. Crop-livestock production systems in Thailand have been commonly distributed and practiced by smallholder farmers throughout the country. Dairy farming for smallholders has been promoted and encouraged as a means to produce milk, increase income and improve the standard of living (Chantalakhana, 1994). Many factors especially feed and feeding could attribute to the efficiency and success of dairy production as well as other associated dimensions (Wanapat, 1999). It is therefore the objectives of this study to identify a benchmark site (BMS) at Mahasarakham in N.E. Thailand along with all essential characteristics and attributed factors which could be used to improve the existing dairy-crop production systems and associated systems. In addition, scale-up of the generated technologies has been expanded to other sites in other provinces namely Khon Kaen, Udon Thani, and Sakon Nakorn of the northeast of Thailand.

Materials and Methods

Identification of benchmark sites and expansion sites: CASREN-Thailand Phase I (1999-2002) was conducted at Muang District, Mahasarakham Province which is situated in the middle of the Northeast region of Thailand. The area is in the Asian monsoon zone which is characterized by a classification of climate with a rainy season from May to October and a dry season from November to April. Annual rainfall is about 1,147 mm, of which about 90 percent falls in the rainy season, and the remainder in the dry season. Major crops are rice, cassava and sugarcane etc, and major livestock are cattle, buffalo, swine and poultry, etc. Dairy production is new in this area and rapidly expanding due to its potential high incomes. However, low productivity of dairy production has been observed, and most of production factors are based on off-farm factors. Thus production systems could produce improved productivity and

sustainability in dairying are needed.

Later, CASREN-Thailand Phase II (2002-2004) was continued to expand the activities into the other sites. With closely collaboration with Dairy Farming Promotion Organization-Northeast Region (DPO-NE), CASREN activities have been expanded and distributed to 6 sites in three provinces in the NE of Thailand, Srithat, Kudjub and Thungphon, in Udon Thani Province, Charoensin, in Sakonnakhon Province and Nampong and Kranuan, in Khon Kaen Province. The general agro-ecological characteristics in these sites were similar regarding soil (sandy-loam type), low rainfall (800-1200 mm/year), long dry season (up to 6 months), crop production pattern (rice in lowland and cassava/sugarcane in upland) etc.

Consolidation of local networks: The CASREN-Thailand has strongly collaborated with many organizations/institutes both in Phase I and II. In Phase I at Mahasarakham site, CASREN-Thailand has collaborated with researchers from both Department of Animal Science and Agronomy, Faculty of Agriculture, Khon Kaen University for planning and conducting researches, while Mahasarakham Provincial Livestock Office, Department of Livestock Development (DLD) who worked closely as extension and advisory staff with participatory dairy farmers in that area, and Khon Kaen Animal Nutrition Research and Development Center, DLD also collaborated with CASREN activities in terms of researches, technicians and supporting materials. Furthermore, in Phase II, except those institutes, the Tropical Feed Resources Research and Development Center (TROFREC), Khon Kaen University has collaborated and supported a lot in terms of research, facilities and also researchers and students who help and are involved in CASREN activities, while DPO-NE worked very closely with dairy farmers. DPO-NE has mandates and responsibilities in supporting, promoting and providing related services particularly training in various fields, veterinary services including AI, milk collection from farmers etc. In addition, CASREN-Thailand has consolidated the existing personnel and infra-structure under KKU, DLD, DPO and TROFREC as well as other educational institutions to make mutual efforts for the emerging expansion activities in the sites.

Assessment of farmers' needs and preferences: CASREN-Thailand staff surveyed for general information and discussed with farmers to find out what were the problems, constraints and farmers' needs, and it was found that the main problems encountered by smallholder farmers were the high costs of production particularly the cost of concentrate use and shortage of good quality-protein roughage for year-round feeding. Later, discussions among DLD and DPO staff who work closely with farmers and CASREN staff were conducted to find out appropriate technology options to offer to farmers in order to solve their problems. Finally, overall group meeting among researchers, extension staff and farmers was conducted, and on-farm feed and feeding technologies for reducing cost of production were discussed for use to increase efficiency and sustainability in crop-dairy production systems.

General household survey and results: In Phase I at Mahasarakham, there were 38 dairy farmers in the site and all farms were selected to determine the existing farming systems as compared with 40 randomly selected non-dairy farmers in the same area by using questionnaire and interviews. Before the actual fieldwork began, the Rapid Rural Appraisal (RRA) methodology was prepared and implemented. Information concerning household information was collected, tabulated and encoded following the procedures given by ILRI.

Results of the survey on general information between September 1999 to January 2000 were found that general household characteristics of farmers who run dairy farms and non-dairy farms exhibited similar characteristics between the two groups. Most farmers in the dairy group owned 3 parcels of land which were located an average of 1.4 km from their house, and the area of each parcel was 1 ha, while the area of each parcel was slightly lower in the non-dairy group. Approximately 60 % of the land in the dairy group was used for annual crops and grassland while most of the land (89 %) in the non-dairy group was used for annual crops (67 %) and perennial crops (22 %) with some used for forest/trees or orchards. Formal training in livestock husbands was seen in the dairy group while very little could be seen in crops and in the non-dairy group. Regarding labor use for livestock production, it was demonstrated that household males and females shared all activities on their farms, this means that household males and females in the dairy group worked closely together. In the non-dairy group, labor was concentrated on the crop enterprise and partly on animal section particularly pig and poultry. Household males dominated the work in all activities while household females participated in some activities.

Dairy farmers owned about 9.7 head of dairy cattle per farm (mean 5.0 cows, 2.7 heifers and 2.0 calves). In addition, there were about 40 % of dairy farmers who also raised chickens, duck and beef cattle whilst only two farmers owned buffalo. In comparison, in the non-dairy group, farmers owned beef cattle, chickens, ducks and buffaloes in similar numbers to the dairy group. However, the new species of animals which they preferred to start to raise (except dairy cattle) were beef cattle and buffalo because of favorable market conditions. Farmers took good care/management of dairy and beef cattle; vaccination, drenching and deworming were regularly practiced while no vaccination

was given to poultry because diseases were generally perceived to not be a problem.

For feeding practices, free grazing, cut and carry/stall fed were the main feeding practices for dairy cattle while tethering and free grazing were the main feeding practices for beef cattle and buffalo. The main basal feed from farmers' own crop land for ruminants in the rainy season was ruzi grass (*Brachiaria ruziziensis*) while native grasses were also used. In the dry season, rice straw and native grasses from contour hedgerows were the main basal feed sources while ruzi grass also used but was not sufficient due to its limited re-growth in the dry season. In addition, the seasonal sporadic and unreliable availability of feeds were of great concern to farmers. Although farmers believed that the quality of the basal feed was good, dairy farmers had to supplement with a high level of concentrate, either commercial or farm-mixed. In addition, farmers also used other feeds and by-products such as cassava chip, rice bran, copra meal, dried cassava leaves/hay, dried leucaena leaves and others (not specified). Feeding practices to non-ruminants in the dairy and non-dairy groups were similar in both the dry and rainy seasons, scavenging derived from kitchen refusals from household supply was the main poultry feed, and grains were also used as poultry feed while some farmers used commercial feeds obtained from market/store.

In addition, based on the analyzed data from the questionnaires and from observations during farmers' interview, the major constraints identified were as follows:

1) Nutritional inadequacy: both consistency of quantity and quality is the main constraint to dairy production.
2) Since farmers largely depend on commercial feeds and the cost is very high, it is seen as imperative for farmers to establish on-farm feed sources and be trained in how to prepare farm-made concentrate especially those based on cassava.
3) There have not been sufficient training and development strategies by the government to improve farmers' skills and management in order to support livestock development.
4) Socio-economic management is not sound among extension workers, technical personnel and farmers to effectively collaborate on livestock programs with a view to increase production efficiency.

Identification of technology options and technology implementations: Based-on the results of on-station research data and discussion among farmers, extension officers and researchers, the following interventions were proposed for further development to increase efficiency in dairy production enterprises:

Improving on-farm grass yields by using high-production grass variety: An on-farm trial was conducted to investigate the grass varieties with greatest potential to use in smallholder dairy farms in order to improve production of on-farm roughage source. In Phase I, four varieties of grasses, ruzi (*Brachiaria ruziziensis*), napier (*Pennisetum purpureum*), purple guinea (*Panicum maximum*) and atratum (*Paspalum atratum*) were planted in four dairy farms in order to compare yield and nutritive values, while in Phase II, the grass variety with the most potential productivity was recommended to the farmers to plant on-farm at least 0.16 ha using the cut and carry system. Yield was measured and compared to the existing variety (Ruzi).

Cassava-cowpea intercropping as on-farm protein sources production: Cassava (*Manihot esculenta*, Crantz) is an annual crop grown widely in the tropics as a good source of readily fermentable carbohydrate in its tubers which has been widely used in livestock production systems. In addition, cassava leaf, as a crop-residue from cassava tuber production has been successfully used as a supplement for ruminants. It is considered as a good source of escape-protein for ruminants due to its property of containing condensed tannins (CT). In addition, the research by (Wanapat *et al.*, 1997) has found that harvesting of cassava at an early growth stage to make hay (cassava hay, CH) could improve nutritive values, digestibility and biomass yield. Moreover, intercropping cassava with leguminous crops such as cowpea or others (Polthanee *et al.*, 2001) could improve soil fertility and provide food and feed for human and livestock, respectively. Therefore, production of on-farm cassava/legume intercropping and utilization of cassava hay as a good-quality protein source were recommended to dairy farmers, particularly smallholders one for improving their farming productivity. In Phase I, cassava materials and cowpea seeds were distributed and planted in farm areas of participatory farmers (0.16-0.32 ha each). Cowpeas were strip sown in cassava plots (2 rows of cowpea in every 4 rows of cassava) to produce food/feed and improve soil fertility. Yield of cassava foliage and cowpea pod and residue were measured. In Phase II, farmers were suggested to plant at least 0.32 ha of cassava on-farm for making hay. Several local-available varieties of cassava were used, while some cassava materials were supported by the project to areas where these materials were not available. Moreover, legumes namely cowpea and stylosanthes were recommended to strip sow in cassava plots for both improving soil fertility and providing food-feed sources for human and cattle, respectively.

Cassava hay supplementation in lactating dairy cows: In the second stage of CASREN-Thailand, cassava hay

Table 1: Concentrate formulae offered to farmers as technology intervention options

Feed ingredients (%)	Conc.1[a]	Conc.2[a]
Cassava chip	60.0	60.0
Fine rice bran	4.0	2.0
Broken rice	4.0	2.7
Palm kernel meal	2.0	-
Capok seed meal	4.7	-
Chopped cassava hay	20.0	30.0
Molasses	1.0	1.0
Urea	2.8	2.8
Sulfur	0.5	0.5
Salt	0.5	0.5
Minerals mixed	0.5	0.5
Total	100	100
Chemical composition (%)		
DM	88.9	89.0
CP	18.1	18.2
TDN	74.4	74.3
Home-made concentrate cost (US $/kg)	0.08	0.07
Commercial concentrate cost (US $/kg)	0.15-0.17	

[a]Conc. 1 = Concentrate 1; Conc. 2 = Concentrate 2

Table 2: Yield and chemical compositions of selected grasses

Items	Selected grasses			
	Ruzi	Napier	Guinea	Atratum
Phase I				
Dry matter yield (ton DM /ha)				
1st cutting	2.13	1.91	2.95	1.36
2nd cutting	1.69	2.15	2.96	1.79
Total	3.82	4.06	5.91	3.14
Chemical compositions (%)				
DM	22.7	19.6	21.4	20.4
Ash	8.3	10.5	10.4	10.0
CP	10.8	10.8	11.3	9.7
NDF	77.4	83.3	83.3	80.8
ADF	34.6	42.1	41.2	44.8
Phase II				
Dry matter yield (ton DM/ha)				
Mono-1st cutting	2.12	2.85	-	-

produced on-farm was supplemented to two milking cows on each farm at 2 kg/ha/d. At the same time, individual-daily milk yield was recorded by farmers and monthly milk samples were taken and analyzed for chemical composition and all results were compared with 2 non-supplemented milking cows (control).

Improving home-made concentrate production and utilization: The technology of home-made concentrate production and utilization was started at the beginning of the second phase. CASREN-Thailand surveyed and advised farmers on feeding systems and management during the monthly-regular visits. Therefore, CASREN-TH has conducted a training workshop for farmers, entitled "Development of Home-made Concentrate by Using Local Feed Resources in Smallholder-dairy farmers". During the discussion session of this workshop, farmers were offered 2 recommended concentrate formulae (Table 1) based on local feed resources using particularly cassava chip, rice bran, CH and urea as technology options for improving feed efficiency. In a similar manner to the previous activity, of CH supplementation farmers were selected to receive one of two formulas to make their own home-made concentrate, which was supplemented to another 2 separate lactating cows (except cows in control and CH supplemented groups). Home-made concentrate supplementation lasted for 2 months. Milk yield and milk compositions were compared with other group within each farm.

Table 3: Yield of on-farm intercropping crops

On-farm crops	Yield of on-farm crops (ton DM / ha)	
	Phase I	Phase II
Cassava hay (harvesting for 4 times)	4.35±0.88	6.83±3.11
Rainy season	2.05±0.0.37	3.80±1.82
Dry season	2.30±0.51	3.61±1.30
Stylosanthes	-	3.51±0.97
Cowpea		
Leaf + stem	1.51±0.44	0.89±0.12
Pods (fresh weigh)	5.96±0.05	6.95±1.58

Table 4: Milk yield and milk compositions of dairy cows supplemented with CH at 2 kg/hd/d

Items	Control	CH supplementation	P-value
Milk yield (kg/h/d)	12.4	13.8	0.281
Milk compositions (%)			
Fat	2.98[a]	3.56[b]	0.043
Protein	2.95	2.98	0.122
Lactose	4.83	4.73	0.451
TS	11.47	11.41	0.159
SNF	8.48	8.41	0.635

[ab]Means in the same row with different superscripts differ (P<0.05), CH = cassava hay

Results and Discussion

Improving on-farm grass yields by using high-production grass variety: The results of the on-farm trial at Mahasarakham site (Phase I) in ordered to evaluate the production of four selected grasses in smallholder farms revealed that guinea grass produced the highest dry matter yield while nutritive values such as ash, crude protein, NDF and ADF of the four grasses species were similar (Table 2). Therefore, guinea grass was regarded as the most suitable and recommended to the farmers in order to improve the yield of production of roughage source for their animals particularly on farms where the land area for pastures was restricted. This would enable the farmers to produce good roughage for year-round feeding.

In addition at the expansion sites (Phase II), the results of previous work at Mahasarakham (Phase I) were

Table 5: Milk yield and milk compositions of dairy cows supplemented with CH at 2 kg/h/d

Items	June-August 2004				
	C	CH	Conc.1	Conc.2	SEM
Milk yield (kg/h/d)	10.8	11.1	10.2	10.5	1.25
Milk compositions (%)					
Fat	3.53	3.89	3.73	3.52	1.96
Protein	3.05	2.96	3.07	3.06	2.21
Lactose	5.08	5.01	5.17	4.97	1.96
TS	12.38	12.83	12.67	12.34	1.02
SNF	8.83	8.67	8.94	8.72	1.63

C = Control group, CH = Cassava hay supplemented group, Conc.1 = Concentrate 1, Conc.2 = Concentrate 2

Table 6: Economical comparison of using cassava hay and home-made concentrate in dairy production of smallholder-farmers

Items	C	CH	Conc.1	Conc.2	SEM
3.5 % FCM (kg/hd/d)	10.8	11.8	10.2	10.5	0.92
Milk sold (US $)	3.01	3.32	2.96	2.97	0.97
Concentrate intake (kg/hd/d)	7.0	7.0	7.0	7.0	-
Concentrate cost (US $/hd/d)	0.96	0.96	0.59	0.52	0.78
Cassava hay intake (kg/hd/d)	-	2.0	-	-	-
Cassava hay cost (US $/hd/d)	-	0.1	-	-	-
Total feed cost* (US $/hd/d)	0.96	1.06	0.59	0.52	0.71
Income over feed (US $/hd/d)	2.06	2.24	2.37	2.41	0.52
US $/hd/month	61.8	67.2	71.1	72.3	4.78

*Not including cost of roughage. C = Control group, CH = Cassava hay supplemented group, Conc.1 = Concentrate 1, Conc.2 = Concentrate 2 FCM = Fat corrected milk, Milk price = 0.28 US $/kg, Cassava hay cost = 0.05 US $/kg. Concentrate cost (control) = 0.13 US $/kg, Conc.1 cost = 0.08 US $/kg, Conc.2 cost = 0.07 US $/kg.

recommended to dairy farmers in order to improve on-farm roughage source. Purple guinea grass was selected for use as it could produce the highest yield compared with commonly used existing variety (Ruzi). Cassava-cowpea intercropping as on-farm protein.

sources production: Yield of cassava foliage and legumes as intercropping crops are shown in Table 3. In Phase I, farmers could produce an average 4.35 ton DM/ha of cassava foliage to produce hay (cassava hay) by harvesting, 4 times throughout the year. Cowpea as an intercropped-legume produced 5.96 ton/ha of green cowpea pod and 1.51 ton DM/ha of residues. In Phase II, it was found that productivities of intercropping crops were improved as compared with the previous period. Biomass of 6.83 ton DM/ha of cassava foliage, and 0.89 ton DM/ha of cowpea residues was produced. In addition, a legume, Stylosanthes, was also intercropped in the cassava plot, and it produced 3.51 ton DM/ha.

Technology of cassava/legumes intercropping could improve farm productivity particularly for production of on-farm feed sources. Cassava foliage harvested at an early growth stage and every 2 months subsequently provided a protein source for animals all-year-round particularly in the dry season period which both quantity and quality of roughages were insufficient. However, farmers encountered problems with making (drying) hay in the rainy season, therefore the alternative strategies such as constructing solar-drying houses using simple materials, plastic sheet and bamboo was recommended to farmers. Green cowpea pods were used for household consumption, gifts for neighbors and sold for more incomes, while cowpea residues and Stylosanthes fodder were also used as animal feeds (food-feed).

Cassava hay supplementation in lactating dairy cows: Cassava hay produced on each farm was supplemented to 2 milking cows and the results are shown in Table 4. It was found that milk yield of milking cows supplemented with 2 kg/h/d of cassava hay (CH) (13.8 kg/h/d) tended to be higher than control group (12.4 kg/h/d) Although, the results were not significantly different but the income from milk sales was numerically higher. Milk fat in CH supplemented group (3.56 %) was significantly higher than in the control group (2.98 %) ($P<0.05$) while other compositions were similar. This finding was similar to those found earlier by (Wanapat *et al.*, 2000; Wanapat, 2003; Wanapat and Khampa, 2006).

Improving home-made concentrate production and utilization: The results of supplementation of recommended home-made concentrates on milk yield and milk composition are shown in Table 5. Milk yield and milk composition were similar among the groups. It is therefore concluded that farmers can use available local feed ingredients such as cassava chip, rice bran and cassava hay to make their own concentrate to be fed to dairy cows. Home-made concentrate was easily mixed and handled and low in cost (0.07-0.1 US $/kg) as

compared to commercial concentrate (0.15 US $/kg). This establishment and development was well accepted by participating farmers.

Results on economic return of CH supplementation and utilization of the recommended cassava based home-made concentrates to milking cows are presented in Table 6. Simple economic analysis showed that income over feed of CH supplementation at 2 kg/h/d group was higher than the control group, while using Conc.1 and Conc.2 resulted in the highest income among the groups. This result indicate that while commercial feeds were highly price, the home-made concentrates were a good alternative provided that farmers were trained and local feed resources were available for use.

Implications: Technologies disseminated by Crop-Animal Systems Research Network (CASREN-Thailand) have the potential to enhance the productivity of crop-livestock production systems in rainfed areas particularly for smallholder farmers. Using a high production grass variety such as Purple Guinea grass that could improve biomass and quality of on-farm roughage sources. Cassava/legumes intercropping system (food-feed) has provided both feed and food for animal and human, and also could improve soil fertility. On-farm feed sources such as cassava hay could be used as a high quality protein supplement for animals which could improve both yield and quality of milk. Moreover, the technology of production and utilization of home-made concentrates using local feed resources such as cassava chip and hay could decrease feed cost of production and lead to the development of sustainable crop-dairy production systems.

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References

Chantalakhana, C., 1994. Report on Status and Development of Dairy Production and Milk Products in Thailand: Research Approach and Development in the Future. Thailand Res. Fund , Bangkok, 88p.

Devendra, C. and C. Chantalakhana, 2002. Animals poor people and food insecurity: opportunities for improved livelihoods through efficient natural resource management. Outlook on Agri., 3: 161-175.

Polthanee, A., S. Wanapat, M. Wanapat and C. Wachirapokorn, 2001. Cassava-legumes inter-cropping: A potential food-feed system for dairy farmers. Proceeding of International Workshop on Use of Cassava as Anim. Feed, held in Khon Kaen, Thailand, July 23-24, 2001.

Wanapat, M., 1999. Feeding Ruminants in the Tropics Based on Local Feed Resources. Khon Kaen Publishing Company Ltd. Khon Kaen, Thailand. 236p.

Wanapat, M., 2003. Manipulation of cassava cultivation and utilization to improve protein to energy biomass for livestock feeding in the tropics. Asian-Aust. J. Anim. Sci., 16: 463-472.

Wanapat, M. and S. Khampa, 2006. Effect of cassava hay in high-quality feed block as antheminthics in steers grazing on Ruzi grass. Asian-Aust. J. Anim. Sci., 19: 611-762.

Wanapat, M., O. Pimpa, A. Petlum and C. Wachirapakorn, 2000. Participation scheme of smallholder dairy farmers in the NE, Thailand on improving feeding systems. Asian-Aust. J. Anim. Sci., 13: 830-836.

Wanapat, M., O. Pimpa, A. Petlum and U. Boontao, 1997. Cassava hay: A new strategic feeding for ruminants during the dry season. In: Proc. International Workshop on "Local Feed Resources-Based Animal Production" organized by Ministry of Agriculture, Forestry and Fisheries. Cambodia and FAO/Japan Regional Project, University of Agriculture, Ho Chi Minh City, Vietnam.