Searching for feeding strategies based on sweet potato silage to improve smallholder crop-livestock production systems in Vietnam

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Abstract

Selected data from sweet potato (SP) clones tested during summer and winter was evaluated for their Root/Total biomass (R/B) ratio to identify potential dual-purpose clones. A native clone and three introduced clones with adequate R/B ratio were selected for further evaluation under two different vine cutting regimes (one and two cuts before root harvest). Clones classified as dual purpose produced 46.6% significantly more total dry matter biomass than the native clone. Two cuts produced 31.6% more total dry matter ($p<0.05$) than a single cut and the difference was accounted for by the significantly higher dry matter yield of vines developed in the warm and humid weather of the spring. The harvested vines and roots were used to make silage by combining them at different proportions. Four feeding strategies based on the use of SP silage and locally available feed resources were compared with two feeding strategies based on commercial feed. No significant differences in daily weight gain were found among the treatments including silage feeding (609±58 and 600±86g/day) but the response to the commercial feed pellets (716±70g/day) was significantly higher. However, silage utilization reduced feeding costs by 15.3 and 17.3% and increased the farm benefit by 43 and 50.8% in comparison to the use of commercial feed pellets.

Introduction

Sweet potato (*Ipomoea batatas*) is a tropical and sub-tropical plant that can be harvested twice per year in the summer and spring-winter seasons in North Vietnam. Roots are mainly used as food and the whole plant is also a good feedstuff because the roots are a source of energy and the leaves provide part of the protein requirement of livestock. As feed, SP can be used as fresh and dried matter or fermented into silage (Woolfe, 1992). In summer time in Viet Nam, sweet potato roots and vines are usually cut into small pieces and dried in the sun but this traditional farmer's way of preserving sweet potato is very demanding in labor. It is then necessary to look for more practical and economic ways of storing SP for their timely inclusion into feeding strategies. It has been shown that in the wet season in North Vietnam, SP roots and vines can be preserved as silage for later use as pig feed (Nguyen, *et al.*, 2006).

The largest component of the total production cost in most crop-livestock production systems is the feed cost and the use of local feed resources is an effective way of reducing feed expenses. In the case of pig feeding the problem is more complex than with ruminants as pigs require high protein levels in their diets, which make the feed more costly compared to ruminant diets. However, the sweet potato-pig fattening operation has a combination of advantages for improving the income of rural households by reducing the feed cost and providing other benefits. To begin with, SP produces roots for market sales and high quality feed for pigs, which convert low-value sweet potato residues into highly desired foods or marketable commodities and provide manure for maintaining and improving soil fertility (Peters, 1998).

The aim of the present research was to evaluate sweet potato varieties for dual-purpose utilization, utilize its vines and roots in different combinations to produce silage and test different feeding strategies based on silage and locally available feedstuff for crossbred fattening pigs. Also, the economic efficiency of those strategies in the context of smallholding farming conditions in North Vietnam was evaluated.

Experimental procedure

Sweet potato varieties and silage

Three introduced, improved SP varieties (Blesbok, CIP26 and KL25), selected by the ratio of roots biomass to total biomass, and a local variety were compared in two consecutive crop seasons (winter and spring) under two different cuttings regimes (one and two cuts of vines before root harvest). The test was carried out on plots of five smallholders. The two cuts treatment consisted of a harvest of vines at the middle of the crop cycle, followed by the final harvest of vines and roots at the end of the crop cycle (77 and 100 days on winter, respectively). The single cut treatment consisted simply of the total harvest of root and vines at the end of the crop cycle (100 and 112 days on winter and summer, respectively). The total measured fresh production was converted into dry matter. Protein and fiber were analyzed following standard procedures. Energy content was estimated from the literature (NRC, 2008)

Photo 1. Sequence of silage preparation; A) cutting of vines and roots; B) Mixing of additives (sugar or salt); C) compressing the silage material, and D) Plastic bag without barrel frame

Vines and roots from both seasons were used for making silage in big plastic bags (800kg), as shown in Photo 1. Table 1 shows the composition of each silo. Silage was used after 45 days.

Table 1. Composition (%) of silage prepared with vines and roots of sweet potato from the first and second cuts

Silage	Vines	Roots	Sugar	Corn meal	Salt
I*	97	--	2.5	--	0.5
II*	93.5	--	--	6	0.5
III**	49.5	50	--	--	0.5
IV**	24.5	75	--	--	0.5
V	74.5	25	--	--	0.5
VI	89.5	10	--	--	0.5

*Vines from first cut
**Vines from total harvest (first and second cuts)

Farmers use local resources to make different composite feed, which were used as basic feed supplemented by silage in each feeding strategy tested, Table 2. Different average composite feed included the following ingredients: A) corn meal (38%), rice bran (15%), cassava root meal (15%), cassava leaf meal (6%), fish meal (10%), soybean (10%) and stylo leaf meal (6%); B) rice bran (30%) and corn meal (70%); and C) Fish meal (35%), soybean (34%), cassava leaf meal (9%), Stylo meal (22%). Table 2 shows the chemical composition of each ration component.

Table 2. Chemical composition of the components of the ration for each feeding strategy

Ration component	Dry matter, %	Crude Protein* %	Fiber* %	Energy* Mcal/kg	Cost as fed VNd/kg
Silage I	14.15±1.83	15.43±0.89	18.68±0.92	--	966.47±68.72
II	17.67±2.34	15.73±2.34	15.43±0.88	--	966.47±68.72
III	18.69±2.10	9.31±1.27	10.11±0.98	--	1,133.00±69.46
IV	23.50±1.18	6.43±0.95	6.49±0.86	--	1161±68.45
V	16.53±2.71	9.59±0.59	16.05±0.81	--	519.01±71.02
VI	14.52±1.17	11.22±0.50	19.27±1.02	--	4.73±65.41
Composite feed A	86.14±0.13	14.52±0.35	5.45±0.65	2.91±0.06	6,186.00±354
B	88.71±0.01	11.19± 0.07	4.70± 0.13	3.46 ±0.01	5,000.00± 0.001
C	80.37±0.22	36.41±0.97	11.72±0.75	3.01±0.06	10,165.00±425.68
Commercial pellets	86.00±0.01	17.44±1.90	8.58±1.45	3.34±0.11	8,279.20±583.51
Concentrate (CC)	90.08±0.89	47.12±2.08	6.66±0.07	2.885±0.13	15,867±808.29

* Dry matter base
VNd 17,500 = 1US$

Animal response in pig fattening trials

Six feeding strategies consisting of different combinations of SP silage, local composite feed, commercial pellets and a concentrate were evaluated in a field trial conducted in five smallholders' farms (Table 3). The weight gain of penned crossbred pigs was registered and evaluated. The trial was divided in two stages defined by the seasonal production of sweet potato and the availability of fattening pigs in the farms. Some of the feeding strategies were applied in the first stage and others in the second stage, as shown in Table 3. Each feeding strategy included 20 pigs. Initial weight was 19.80±4.21; 19.93±4.42, 20.03±4.71; 22.00±4.85, 22.47±4.96, 22.50±4.32 kilogram for each feeding strategy, respectively. The total fattening period was ninety days. Table 3

Table 3. Feeding strategies evaluated for pig fattening in crop-livestock production systems in North Vietnam

Ingredient within Feeding strategy	Stage 1*			Stage 2*		
	S1	S2	S3	S4	S5	S6
Silage; one type in each month (50% of the ration)	I, III, III	I, II, IV	---	I, VI, VI	II, V,V	I, V,V
Composite feed: A (50% of the ration)	A	A	---	---	---	---
B (32 % of the ration)	---	---	---	B	B	B
C (18% of the ration)	---	---	---	C	C	---
Commercial concentrate (CC) (18% of the ration)	---	---	---	---	---	CC
Commercial pellets (CP) (100 of the ration)	---	---	CP	---	---	

*Stage 1 and 2 were winter and spring crop season of sweet potato

Experimental results

Sweet potato varieties

Table 4 shows the dry matter yield (t/ha) of the four varieties by season and management. The yield of vines and roots of the improved varieties was higher ($p<0.05$) than the yield of the local variety (2.92±1.67 and 2.62±1.89, respectively). The varieties KL5 and CIP26 were different to Blesblok on vines and roots yield. Overall, vine production was higher in spring than in winter: 2.99±0.33 and 1.52±0.34 for one and two cuts, respectively and 5.22±0.16 and 1.63±0.38 for two cuts. Vines production increased 41% in spring. However, the production of roots in winter was higher that in summer; 2.94±0.45 and 2.22±0.42 for one and two cuts, respectively; in summer the production was 2.05±0.36 and 1.64±0.20 for one and two cuts respectively. The roots yield increased by 28.4% in winter, in response to an adequate balance of temperature and precipitation. Water excess in spring affected root production but not the growth and yield of vines. The yields of roots and vines were 3.43±0.27 and 2.26±0.34 for two and one cut, respectively (P<0.05). Root's production was 2.49±0.41 and 1.93±0.31 for one and two cuts, respectively; a significant reduction of 22.5%, in root production occurred with two cuts. However, two cuts tended to produce more total biomass than one cut, 5.35±0.51 and 4.75±0.52 respectively, increasing the total biomass production by 11.2%. Total protein production follows the same pattern, two cuts providing more protein due to the higher vine production, which is a plus for crop-livestock systems in Northern Vietnam. Figure 1 shows the production of vines and roots under the different experimental conditions.

Table 4. Seasonal dry matter yield of four SP varieties in two cropping season under two different managements (t/ha)

Crop season	Variety	Vines t/ha	Roots, t/ha	Biomass, t/ha	Vine protein t/ha	Root protein t/ha	Protein yield t/ha
Winter, A	Blesbok	1.44±0.33	3.07±0.73	4.51±0.93	0.28±0.07	0.21±0.05	0.49±0.11
	CIP26	1.92±0.42	3.19±0.86	5.11±0.99	0.35±0.09	0.19±0.04	0.54±0.10
	KL5	1.62±0.33	3.23±0.77	4.85±0.90	0.30±0.07	0.18±0.03	0.48±0.09
	Local	1.10±0.25	2.27±0.48	3.37±0.63	0.20±0.05	0.17±0.04	0.37±0.08
B	Blesbok	1.59±0.42	2.25±0.51	3.84±0.80	0.36±0.11	0.15±0.04	0.51±0.13
	CIP26	2.07±0.50	2.57±0.64	4.64±0.84	0.44±0.11	0.15±0.03	0.60±0.12
	KL5	1.71±0.39	2.42±0.70	4.13±0.89	0.36±0.09	0.13±0.03	0.49±0.11
	Local	1.16±0.33	1.62±0.39	2.79±0.63	0.24±0.08	0.12±0.03	0.36±0.09
Spring, A	Blesbok	3.09±1.05	1.97±0.94	5.06±1.32	0.39±0.17	0.07±0.03	0.46±0.17
	CIP26	2.50±0.87	2.46±1.27	4.96±1.47	0.33±0.13	0.10±0.04	0.43±0.14
	KL5	3.22±1.38	2.17±1.09	5.39±1.75	0.41±0.20	0.06±0.03	0.47±0.21
	Local	3.14±1.46	1.61±0.97	4.75±1.57	0.44±0.20	0.06±0.04	0.50±0.19
B	Blesbok	5.31±1.49	1.49±0.78	6.80±1.83	0.71±0.20	0.05±0.03	0.76±0.21
	CIP26	5.09±1.47	1.90±1.11	6.98±2.03	0.70±0.17	0.06±0.03	0.76±0.18
	KL5	5.40±1.69	1.70±0.99	7.09±2.18	0.70±0.21	0.04±0.02	0.74±0.21
	Local	5.09±2.40	1.47±1.03	6.56±2.70	0.72±0.36	0.03±0.02	0.75±0.37

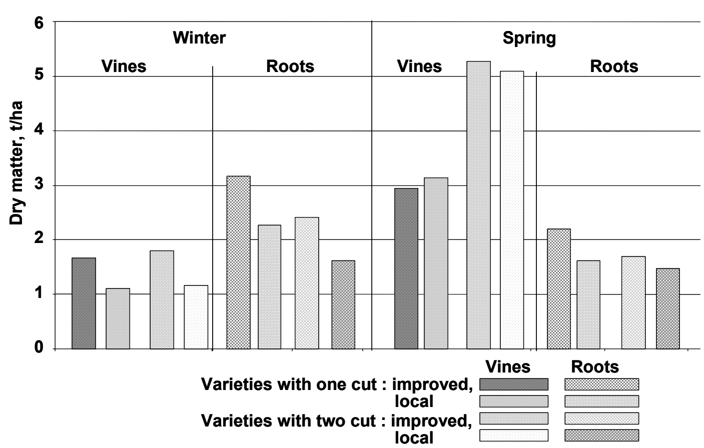

Figure 1. Sweet potato dry matter production of vines and roots of improved and local varieties under two crop managements and different cropping seasons.

Animal response in pig fattening trials

The comparison of the six feeding strategies based on different combinations of traditional feedstuff with SP silage, commercial pellets and concentrate showed (Table 5) that the strategies S3 and S6 (containing commercial pellets and concentrate) were significantly different ($P<0.05$) from the strategies containing silage and household concentrate (S1, S2, S4, S5). The average daily gain of S3 and S6 were 0.716±0.070 and 0.620±0.102, respectively whereas for the other strategies daily weight gain ranged from 0.519±0.04 to 0.609±0.05. The S3 diet included only commercial concentrate and S6 was a combination of commercial concentrate with a high level of protein (48%) and a basic mixture made in the farms (Rice bran, 30% and corn meal 70%) plus silage.

Table 5. Evaluation of feeding strategies including SP silage and commercial concentrate in Northern Vietnam

Feeding strategy	Initial weigh, kg	Final weight, kg	Weight gain difference, kg	Daily weight gain, kg/day	Feed cost * VNd/kg	Gross margin VNd
S1	19.80±4.21	74.59±8.24	54.79±5.19	0.609±0.058	17,633±1037	10,025±589
S2	19.93±4.42	73.93±10.59	54.00±7.72	0.600±0.086	17,411±1319	10,493±795
S3	20.03±4.71	84.46±8.39	64.43±6.31	0.716±0.070	21,043±1361	6,450±417
S4	22.00±4.85	68.68±8.35	46.68±4.27	0.519±0.047	19,919±1160	4,868±283
S5	22.47±4.96	71.29±10.92	48.82±6.81	0.542±0.076	20,011±1513	4,766±360
S6	22.50±4.32	78.34±11.37	55.84±9.14	0.620±0.102	21,474±1777	3,140±260

The total production feed cost of each was considered as total cost.
Pig price sale on average was 30,064±834 VNd/kg of live weight
US$ = 17,500 VNd
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Figure 2 shows the gross margins for the feeding strategies. The inclusion of SP silage tends to give a lesser final live weight, but resulted in a more uniform weight gain, which increased the gross margin by 37%. The higher cost of feeding, for strategies 3 and 6, calls for ingredients with higher protein level. The use of SP silage along with the home made concentrate (S4 and S5) resulted in similar gross margins than the strategy with no silage (S3), suggesting that SP silage is a good alternative to supplement the concentrate elaborated with local available resources.

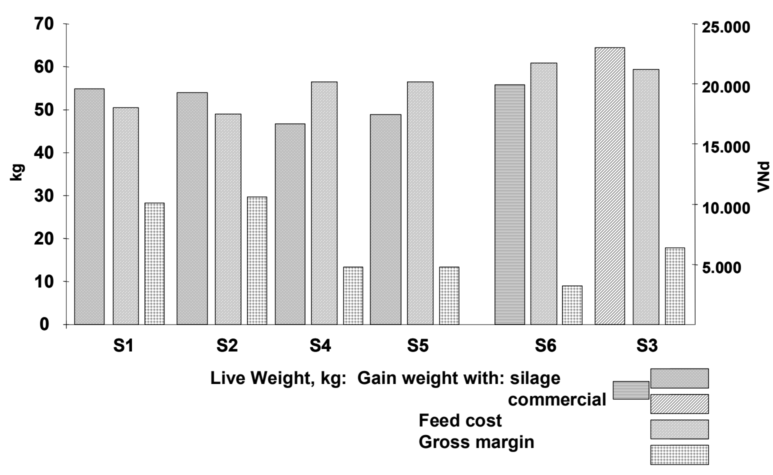

Figure 2. Comparison of feeding strategies including SP silage, commercial concentrate and home made mixture of local feed resources.

Concluding remarks

- Sweet potato can be used in crop-livestock production system as a dual-purpose crop to provide a harvest of vines at seventy days of growth.
- Cutting of vines before the end of the crop period tends to reduce root's yield but increases total biomass production.
- The use of SP silage tends to reduce production cost and increase gross margins of pig fattening production systems when it is combined with local available feed resources.

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