Improved forage varieties for smallholder cattle farmers in South Central Coastal Vietnam

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Abstract

On-farm forage assessment was conducted on sandy soils in three provinces (Binh Dinh, Phu Yen and Ninh Thuan) of south central coastal Vietnam (SCC VN) from May 2010 to December 2011. The experiment had two purposes. The first was to evaluate the yield and nutritive value of five forage species, *Panicum maximum*, TD58; *Brachiaria* hybrid, Mulato II; *Pennisetum purpureum*, VA06; *Paspalum atratum*, Terenos; and *Stylosanthes guianensis*, CIAT 184, in sandy soils. The second purpose was to assess farmer preference of these species. The greatest yields were obtained from TD58, Paspalum, and VA06. Crude protein concentration was greatest for Stylo, and of the grasses, Mulato II had the greatest concentration. For other measures of nutritive value there were interactions between season, province, and species; however the results were similar to previous studies. For areas prone to waterlogging the best performing grass was Paspalum due to its high vigour and low mortality. Most farmers preferred two or three of the forage species. Mulato II, TD58, and VA06 were the most popular, with more than 80% of farmers favouring them. This research was the first time that most of these species had been introduced in the sandy areas of the south central coast. Although there were significant differences in production and quality, between varieties and between provinces, all of the species proved suitable for cultivation and valuable additions to other feed and supplements available to beef cattle. We recommend that farmers plant a mixture of forage varieties, including grasses and legumes, to diversify cattle diets and to build resilience to cope with variable environmental conditions that prevail in SCC VN.

Key words: *Biomass yield, nutritive value, cultivated grass, farmer preferences, waterlogging*

Introduction

Beef production has traditionally been an important component of smallholder farming systems in Vietnam and production has increased steadily in recent years, from

approximately 100,000 t live weight in 2001 to 290,000 t live weight in 2011 (General Statistical Office, 2012). Many smallholder farmers use a combination of supervised grazing and cut and carry methods to feed their cattle. Cut and carry fodder is collected from communal land, waste areas on roadsides and crop margins, and from crop residues. There is a significant opportunity for smallholder crop-livestock farmers in South Central Coastal Vietnam (SCC VN) to improve their overall household income by changing the balance of their farming systems in favour of beef cattle. However, the availability of labour and competition for traditional feed resources, particularly communal grazing land, are major impediments to farmers realising this opportunity and progressing from cattle keepers to cattle producers.

Cattle production in SCC VN is further constrained by low fertility sandy soils, and harsh climatic conditions. The dry season is long and hot, and flooding regularly occurs in the wet season. The limited quantity and quality of feeds, and poor husbandry practices lead to low cattle productivity and efficiency. Improving feeding options by making better use of locally available feed resources and introducing specialist forages suited to the region and farming system is a key strategy for improving beef cattle production in SCC VN (Parsons et al 2013).

In recent years numerous high yielding forage species have been imported and evaluated for adaptation, biomass yield and quality in certain areas of Vietnam (Phan et al 1999; Khanh 1999) although there is little evidence of widespread adoption beyond the original locations. Involving smallholder farmers in applied research projects, through participatory research methods such as the best-bet approach (Lisson et al 2010), increases the likelihood of adoption of research findings in the community. The forage development study reported here was conducted to (i) assess the on-farm seasonal production and nutritive value of a range of promising forage species in three locations in SCC VN, and to (2) facilitate farmer assessment and preferences of the forage species.

Materials and methods

Climatic conditions in the three provinces

The experiments were conducted in three provinces in SCC VN, Binh Dinh, Phu Yen and Ninh Thuan. The average annual rainfall and average daily maximum and minimum temperature in the provinces over a period of 10 years are shown in Figure 1. Temperature ranges are similar (annual mean of 26 to 27 ^{o}C) but the mean annual rainfall is higher in Binh

Dinh and Phu Yen (1710 mm, 1540 mm respectively) than Ninh Thuan (1160 mm). Rainfall occurs predominantly from September to December.

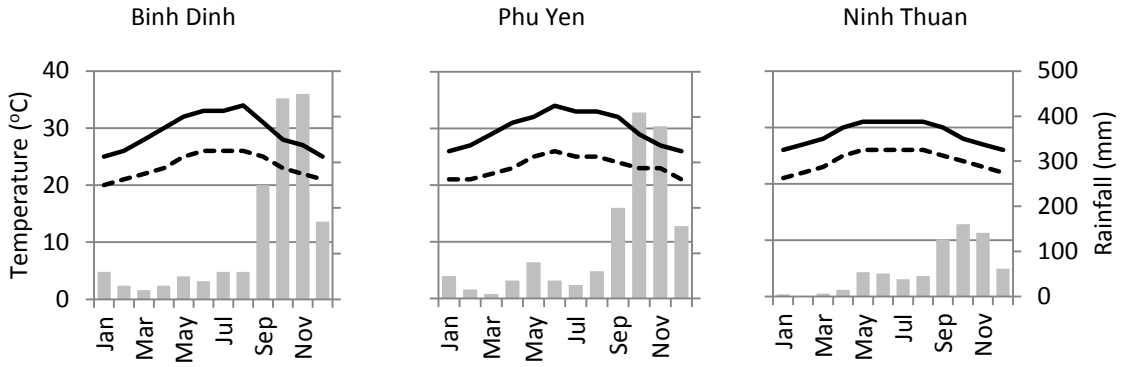

Figure 1: Average annual rainfall and average maximum (solid line) and minimum (dotted line) temperatures in Binh Dinh, Phu Yen and Ninh Thuan for the period 2003 to 2012. (Source: www.weatherbase.com).

Forages

Five improved perennial forage species (4 grasses and 1 legume) were introduced to farmers: *Pennisetum purpureum* VA 06, *Panicum maximum* TD58, *Brachiaria* hybrid cv Mulato II, *Paspalum atratum* cv Terenos, and *Stylosanthes guianensis* CIAT 184.

Soil characteristics

Soil samples were collected at 5 different locations from each plot to a depth of 15 cm, and bulked. A representative sub sample was taken for analysis at the Laboratory of Soil Resource and Environment Faculty, Hue University of Agriculture and Forestry. The data presented (Table 1) are the average of four farm sites from each province. Soils in Binh Dinh and Phu Yen had a lower pH (pH_{KCl} 4.46, 4.81) than in Ninh Thuan (pH_{KCl} 5.72) (Table 1). Organic carbon levels were low (0.84, 1.16%) in Binh Dinh and Ninh Thuan provinces but higher in Phu Yen province. The total Nitrogen (N), Phosphorus (P), and Potassium (P) concentrations were low in all three provinces.

Table 1. Average soil characteristics of forage experiments at the three provincial sites (mean ± standard deviation).

Areas	**pH_{KCl}**	**Organic Carbon (%)**	**N (%)**	**P_2O_5 (%)**	**K_2O (%)**
Binh Dinh	4.46 ± 0.22	1.16 ± 0.29	0.026 ± 0.003	0.029 ± 0.014	0.098 ± 0.055
Phu Yen	4.81 ± 0.73	1.78 ± 0.37	0.035 ± 0.004	0.048 ± 0.010	0.075 ± 0.024
Ninh Thuan	5.72 ± 0.12	0.84 ± 0.22	0.028 ± 0.005	0.027 ± 0.004	0.103 ± 0.021

On-farm forage experiments

Between May 2010 and December 2011 in Binh Dinh, Phu Yen and Ninh Thuan, the five forage species were evaluated on-farm for yield and chemical composition. Four farms in each province were selected as experimental sites (blocks) and planted with the forage species (treatments).

Each treatment plot was 5 m long by 1 m wide, with 0.5 m between plots. King grass (*Pennisetum purpureum*) was grown as a buffer row to separate the plots. Each site was managed in as similar a manner as reasonably possible, in terms of cutting management, irrigation, and fertilization, to assess yields under typical on-farm growing conditions. NPK fertiliser (16:8:8 at 600 kg/ha/yr) and urea (200 kg/ha/yr) were applied alternately after each cutting.

Forage measurements

Forages were first harvested for biomass production 60 days after establishment, and subsequently at approximately 44-day intervals (Table 2), for a total of 8 harvests over the length of the experiment. The four grasses were harvested at a stubble height of 15 cm and the stylo at 20 cm. Measurements were also taken for canopy height, tallest tiller and leaf fraction. Forage samples for chemical analysis were collected twice, once in March 2011 during the dry season and once in September 2011 during the rainy season. Samples were dried at 60 °C, and ground to pass a 1-mm screen. Samples were analysed for NDF using the procedure described by Van Soest et al (1991), using the ANKOM fibre analyser (ANKOM Technology, Maceon, NY). Samples were also analysed for crude protein (CP; AOAC 2000; method 990.03), and ash (AOAC 2000; method 942.05).

Table 2: Average, maximum, and minimum harvest intervals in three provinces in South Central Coastal Vietnam.

Province	Mean ± SD (days)	Maximum (days)	Minimum (days)
Binh Dinh	44 ± 5.5	53	35
Phu Yen	44 ± 6.9	60	37
Ninh Thuan	43 ± 9.0	60	31

Evaluation of waterlogging resistance of the forage species

When the plants were newly established at the end of 2010, there was an extended wet period in all three provinces (e.g. Phu Yen November rainfall was 1224 mm). After one month of

heavy rain, with waterlogging and inundation observed at all sites, we recorded plant vigour using the rating scale below:

1. All plants are dead.
2. Major plant damage, but not all dead.
3. Moderate damage, including some plant death, chlorosis, necrosis.
4. Minimal damage, some chlorosis or necrosis.
5. Virtually no damage. All plants are alive and healthy.

In addition, survival was measured as the percentage of plants in each plot that had green tillers or leaves. Data were not recorded for stylo because individual plants were difficult to identify.

Farmer forage assessment

Adjacent to the plots managed by the researchers, additional plots were established for farmers to manage and test the new species. In addition, small plots of each species were established on other farms to enable farmers to assess the new forage varieties under typical farming conditions in each province. In total fifteen farmers in each province were provided with seed or tillers of the new forage varieties to establish small nursery areas, then encouraged to expand the area of those that they preferred.

Farms were visited regularly to work through technical issues, provide training in planting, fertilising, cutting management and feeding, and record data. Farmer preferences for forage variety were evaluated in workshops and through a simple questionnaire where farmers were able to “like” as many forage species as they wanted.

Statistical analysis

Data were analysed using PROC MIXED (SAS Institute 2003). Province and species were fixed variables and farm a random variable (nested within province). For some analyses, season or the cutting event were added as repeated measurements, using the ‘repeated’ statement. Tukey’s statistic was used to test differences ($P<0.05$) among means.

Results and Discussion

On farm forage experiments

Yield and plant growth characteristics

The harvesting intervals varied between seasons and ranged from 31-60 days (Table 2). In the rainy season (which is also the cooler season) the interval was longer than in the dry spring-summer seasons. The harvest intervals in this experiment were similar to the prior work of Tuan and Binh, 2004; Ba, et al, 2010; Mui, et al 2011.

There was a significant effect of species on annual yield (Table 3), but no effect of province. TD58, Paspalum, and VA06 were similar in yield (Table 3), as were Paspalum, VA06 and Mulato II. Stylo was lower yielding than the other species. The average yield for TD58 was 41.5 t/ha/yr. Although the field sites featured sandy soils and difficult climatic conditions, the forage yields were similar to forage experiments in more fertile parts of Vietnam (Ha et al 1995; Khanh 1999 in DakLak; Mui et al 2011 in Red River Delta, Central Coast, and Southern East; Quang et al 2011 in two areas of Lai Chau province; and Anh and Mui 2009).

Table 3: Average annual dry matter (DM) yield and leaf fraction (%) of five introduced forage species in three provinces of South Central Coastal Vietnam.

Species	Yield (t DM/ha/yr)		Leaf (%)	
TD58	41.5	a	70.7	b
Paspalum	36.0	ab	80.5	a
VA06	35.1	ab	63.7	b
Mulato II	29.1	b	81.3	a
Stylo	14.8	c	-	-
SEM	2.8		2.7	
Prob.	<0.0001		<0.001	

In each column, means followed by the same letter are not significantly different ($P < 0.05$) according to Tukey's test.

The percentage of grass leaf varied from 63.7 to 81.3 % (averaged across all cuts) and was greater for Mulato II and Paspalum than TD58 and VA06 (Table 3). These results are consistent with those reported for similar studies in other provinces in Vietnam (Ba et al 2010; Tuan and Binh 2004).

Table 4: Significance (Probability>F) of treatment effects on yield and growth measurements in three provinces in South Central Coastal Vietnam over a period of a year.

Effect	Yield	Canopy	Tallest plant
Province	0.2176	0.7302	0.5286
Species	<0.0001	<0.0001	<0.0001
Harvest	<0.0001	<0.0001	<0.0001
Species * Province	<0.0001	0.0322	0.0059
Province * Harvest	<0.0001	<0.0001	<0.0001
Species * Harvest	<0.0001	<0.0001	<0.0001

In addition to annual yield, there were also interactive effects of the treatments on yield over time (Table 4). The nature of the interaction between harvest event and province is unclear

and the data are not presented. The interaction between species and cutting event (Figure 2) shows that there were differences in how the species yield over time. Initially VA06 had the greatest yield, but declined over the duration of the experiment. Mulato II and Paspalum showed an initial increase in yield, but then yields declined over the final harvests. The yield pattern for TD58 was similar, but with a generally increasing trend in yield until the final harvest.

The interaction between species and province (Figure 3) shows that there were differences in how the species yielded across the provinces. In Phu Yen and Binh Dinh, TD58 was the greatest yielding, and the other three grasses yielded similarly. In Ninh Thuan, VA06 and Paspalum were the greatest yielding. This is initially surprising as Paspalum was not expected to perform well under the drier Ninh Thuan conditions; however the plots were located in low-lying areas that could be irrigated, and the results reflect this.

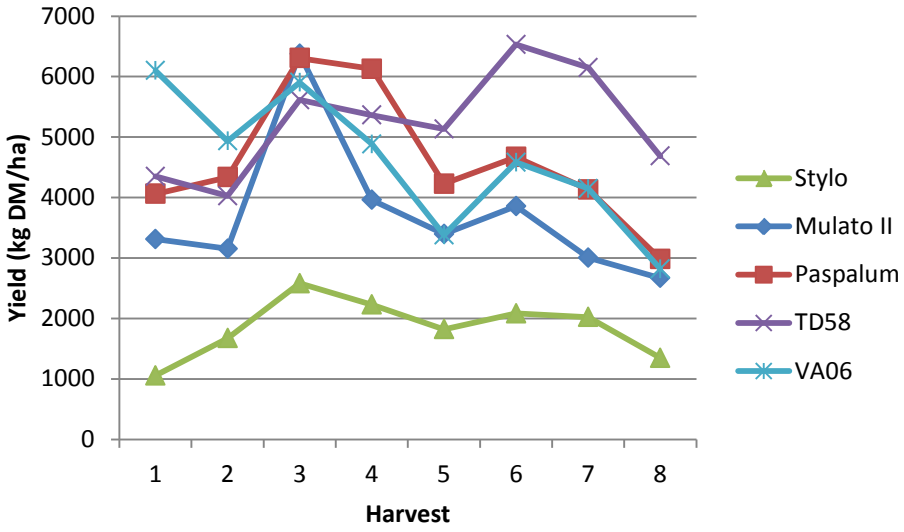

Figure 2: Average dry matter (DM) yield for eight harvests of five introduced forage species, in three provinces in South Central Coastal Vietnam. SEM = 652

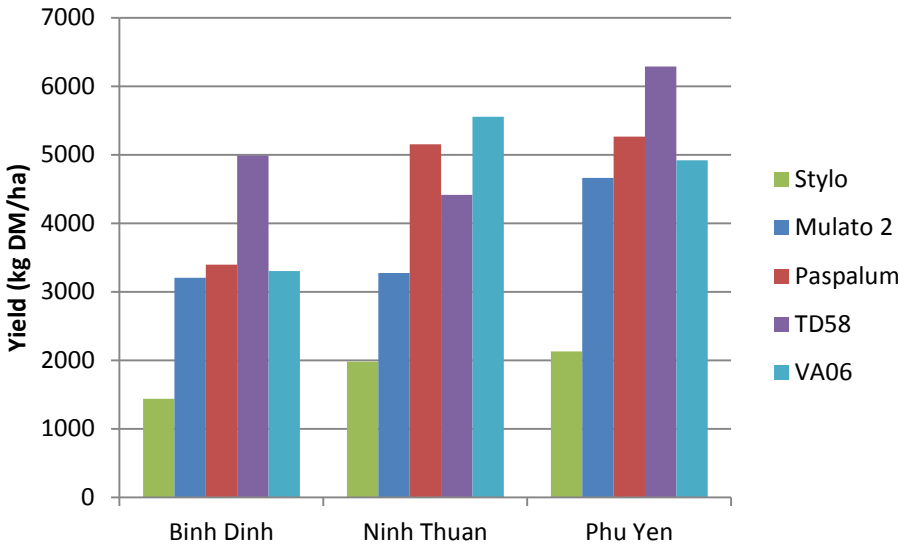

Figure 3: Average dry matter (DM) yield of five introduced forage species, in three provinces in South Central Coastal Vietnam. SEM = 561

There were interactive effects of the treatments on plant height (both canopy height and tallest tiller) (Table 4). The results for canopy height and tallest tiller were similar and are discussed together. The nature of the interaction between harvest event and province is unclear and the data are not presented. The interaction between species and province is also not presented as there are no clear differences between the provinces – all provinces showed that VA06 was the tallest, TD58 the next tallest, and the other species were similar in height. The interaction between species and harvest event (Figure 4) shows that there were differences in plant height over time. VA06 was initially much taller than the other species, but the gap narrowed over the course of the sampling period, mirroring the decrease in yields of VA06 (Figure 2). The height of the other species was more constant throughout the experiment. The canopy height of species in this experiment was similar to that reported in other experiments (Tuan and Binh 2004; Ba et al 2010).

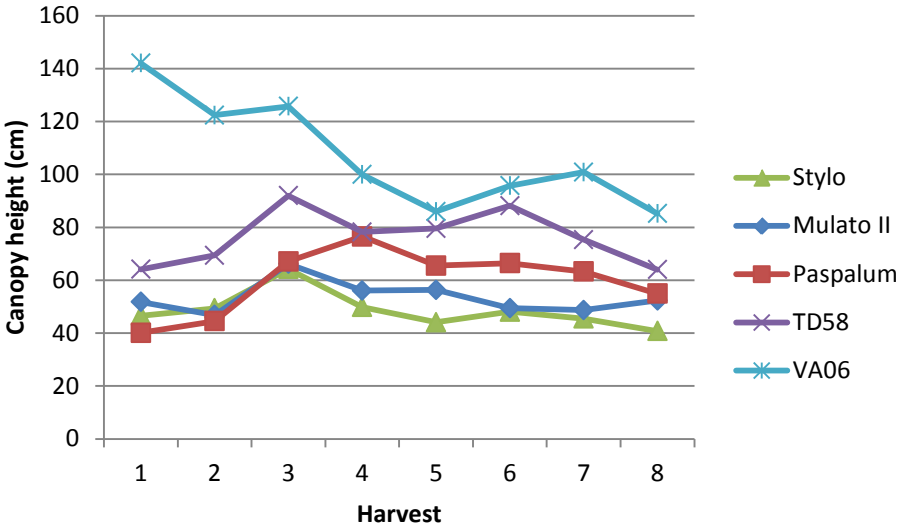

Figure 4: Average canopy height for eight harvests of five introduced forage species, in three provinces in South Central Coastal Vietnam. SEM = 7.6

Nutritive value

There were significant main effect differences in the CP concentration of species (Table 5). As expected of a legume, Stylo had a greater CP concentration than all of the grasses (Table 6). Of the grasses, Mulato II had the greatest CP concentration, TD58 and VA06 had the next highest CP, and Paspalum the lowest. The CP concentrations are similar to other studies conducted in Vietnam (Ba et al 2010; Khanh 1999; Thoa and Dinh 2001; Ba et al 2005; Cuong et al 2009)

Table 5: Significance (Probability>F) of treatment effects on forage nutritive value in three provinces in South Central Coastal Vietnam.

Effect	CP	NDF	ADF	Ash
Province	<0.0001	0.2233	0.7175	0.0110
Species	<0.0001	<0.0001	<0.0001	0.0029
Season	<0.0001	0.0065	0.3928	0.4532
Species * Province	0.2848	0.0075	0.1193	0.0390
Province * Season	0.0004	0.0004	0.2246	0.0032
Species * Season	0.3570	0.6510	0.4781	0.3471

Table 6: Average crude protein concentration of five introduced forage species in three provinces of South Central Coastal Vietnam.

Species	CP (%)
Stylo	16.7 a

Mulato II	12.2	b
TD58	10.8	c
VA06	10.2	c
Paspalum	9.0	d
SEM	0.27	
Prob.	<0.0001	

In each column, means followed by the same letter are not significantly different (P < 0.05) according to Tukey's test.

There was also an interactive effect of province and season on CP concentration (Table 7). The CP concentration for Ninh Thuan was lowest, and did not change between the wet and dry seasons. In comparison, the CP concentrations for Phu Yen and Binh Dinh were greater than Ninh Thuan, and were greater in April than in September. The change between seasons may reflect changing plant maturity, or less availability of nitrogen, possibly due to leaching. The lower CP concentrations for Ninh Thuan may reflect the lower level of organic matter (Table 1) and consequent reduced availability of N through mineralisation; or it could reflect the more sandy texture of Ninh Thuan soils (data not shown) and consequent lower exchange capacity for N retention.

Table 7: Average crude protein (CP) and neutral detergent fibre (NDF) for two seasons, for three provinces in South Central Coastal Vietnam. Data points are averages of five introduced forage species.

	CP (%)		**NDF (%)**	
	April	**September**	**April**	**September**
Binh Dinh	14.7	11.7	67.3	64.8
Ninh Thuan	10.4	9.6	66.3	61.5
Phu Yen	13.4	11.0	63.4	65.2
SEM	0.31		1.1	
Prob.	0.0004		0.0004	

There were interactive effects of the treatments on NDF (Table 5). The interaction between species and province is not presented as there are no clear differences between the provinces – all provinces had similar NDF concentrations for the grasses, and lower NDF concentrations for Stylo. There was an interactive effect of province and season on NDF concentration (Table 7). The differences in NDF between seasons may reflect lower yield and plant height; however the magnitudes of the differences are small.

The ADF represents the least digestible portion of forage and includes lignin and cellulose, but not hemicelluloses. There was a significant effect of species on ADF (Table 5), but no effect of province or season. The differences in ADF are not clear cut (Table 8); however some trends are evident. Stylo was lowest in NDF, but one of the highest in ADF. This may

reflect the high proportion of lignin in the NDF component, a characteristic of many legumes. Mulato II had a low ADF concentration, consistent with its high leaf fraction (Table 3) and soft, palatable texture.

Table 8: Average acid detergent fibre (ADF) concentration of five introduced forage species in three provinces of South Central Coastal Vietnam.

Species	ADF (%)	
Stylo	41.9	a
TD58	41.4	ab
Paspalum	38.5	abc
VA06	37.7	bc
Mulato II	35.6	c
SEM	1.1	
Prob.	<0.0001	

In each column, means followed by the same letter are not significantly different ($P < 0.05$) according to Tukey's test.

There were significant effects of treatments on ash concentrations; however the magnitudes of differences were small. In general, the chemical analyses for all species were similar to results from other regions in Vietnam (Khanh 1999; Thoa and Dinh 2001; Cuong et al 2009; Ba et al 2005; Ba et al 2010).

Waterlogging resistance

Paspalum had the greatest resistance to waterlogging (Table 9), with an average score of 4.8 out of 5, and continued to persist and grow under waterlogged and inundated conditions. Mulato II, TD 58, and VA06 had less resistance to waterlogging, and Stylo had poor waterlogging tolerance. Of the grasses, the majority of plants were able to recover from waterlogging; however VA06 had a lower survival percentage.

Table 9: Water logging resistance of five introduced forage species in three provinces of South Central Coastal Vietnam.

Species	Vigour rating (1-5)	Survival (% of plants)
Mulato II	3.1	98.6
Paspalum	4.8	99.8
TD58	3.7	96.9
VA06	3.5	83.4
Stylo	2.9	Not recorded

Farmer forage assessment

In general, farmers preferred two or three species, and of the grasses Mulato II, TD58, and VA06 were very popular, with 92, 85 and 82% of farmers favouring Mulato II, TD58, and VA06 respectively. Paspalum (46%) and Stylo (36%) were less commonly preferred. The main factors that influenced farmer choice were yield, palatability to cattle, and ease of establishment (by stem or tiller rather than seed). Generally, farmers with cow-calf systems preferred Mulato II and TD58 because they appeared more palatable and had higher leaf fractions. However, farmers operating fattening systems often preferred VAO6 because it provided bulk to complement concentrate feeding.

After three years of on-farm assessment of forages, 95% of the farmers were using the improved forages and 90% had expanded beyond their original planted area.

Conclusions

This research was the first time that most of these species had been introduced to SCC VN. The DM yield of the five forage species was relatively high, and similar to previous studies in other regions of Vietnam. Although there were significant differences in both yield and quality, all five forage species are suitable for cultivation, and may fit different growing conditions and farmer preferences. The high yield and farmer preference suggest that Mulato II, TD58, and VA06 are excellent forage options for SCC VN. Although less popular with farmers, for areas prone to waterlogging during the wet season Paspalum has great potential to persist and produce reasonable quality forage. We recommend that farmers plant a mixture of forage varieties, including grasses and legumes, to diversify the diet of their cattle and to build resilience to the variable environmental conditions in South Central Coastal Vietnam.

Development of the beef cattle industry in Vietnam has been constrained by limitations in forage supply and quality. Improved knowledge regarding growing, managing and feeding new and existing fresh forages, utilization of crop residues and use of feed supplements will encourage greater intensification of beef cattle production. A video of newly introduced forage species (www.youtube.com/watch?v=R1NNlGAb72M) was developed by the project team and aired on Vietnamese national television (Channel VTV2) in December 2012. Communicating such findings through TV offers the opportunity to reach a wider audience of farmers. In addition, the experimental sites have been used to share the results with other farmers and extension workers (Photo 1).

Photo 1: Extension works assess one of the experimental sites and discuss the results with the farmer, Mr Xin (red shirt).

Balanced intensification of cattle farming has the potential to improve the livelihoods of smallholder farmers. The research presented here provides the basis for further investigation into forage management (stubble height, fertiliser management, irrigation) and cattle performance using these varieties.

Acknowledgments

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