



INITIATIVE ON
Nature-Positive
Solutions

PRELIMINARY REPORT

Evaluation of improved forage varieties in Mai Son district, Son La province, Vietnam

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Photo credit: Hieu, Do Trong (NOMAFSI)

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1. Introduction¹

According to the 2021 statistics released by the provincial government, Son La province has a total of 118,102 buffalos and 373,276 cattle (345,018 beef and 28,258 dairy cattle). The shift in agricultural policies towards crop restructuring has resulted in a rapid increase in the area dedicated to perennial crops, coupled with a corresponding decrease in the cultivation of annual crops. Concurrently, the widespread adoption of mechanization in agricultural production has led to a diminishing reliance on cattle traction. Moreover, the grazing area has experienced a significant reduction. These factors have collectively contributed to a sharp decline in the buffalo herd. In contrast, the cattle numbers are on the rise mainly due to the financial support, provision of breeds, and adoption of advanced breeding techniques facilitated by the local government. However, without timely interventions to address the shortage of feed sources, and the sustainable development of the province's livestock sector is at risk. Prompt solutions are essential to ensure its long-term viability and prosperity.

In 2021, the planted forage area for cattle and buffalo in Son La province increased by 15.74% to 10,242 hectares, with an output of 337,270 tons, a 14.7% rise from 2020. However, the province's animal feed remains monotonous, primarily relying on Napier grass, with minor contributions from corn biomass, wheat crops, and other agricultural by-products. Notably, legumes are absent from the feed basket, limiting the nutritional quality of livestock feed. Diversifying feed sources could significantly improve the overall health and productivity of the province's cattle and buffalo.

The Son La Livestock Development Scheme (2022-2025, with an orientation to 2030) prioritizes enhancing livestock production in region III communes which are classified as extremely difficult communes with the poverty rate of over 20%, and challenging villages, primarily ethnic minority in mountainous areas. These regions contend with high poverty rates, limited land access, transportation challenges, and constrained investment capacities among farming households. Emphasizing a shift from scattered, small-scale farming to intensive and commercial-scale operations underscores the crucial selection of livestock breeds with robust growth, high yield, and resilience to drought and cold conditions. This strategic focus aims to address specific challenges and promote sustainable livestock development in Son La province.

Findings from a survey conducted by Atieno et al. (2021)² and (Tran et al., 2023a) on animal feed resource use in Mai Son district, using the Gendered Feed Assessment Tool (G-FEAST), revealed livestock as one of the two key income sources for local farming households. The survey identified a significant challenge: insufficient livestock feed, particularly in the dry season. This scarcity poses a major hurdle for the local livestock industry. The study emphasizes the importance of

¹ The information and statistics in this section are taken from the Scheme on livestock farming development in Son La province for the period 2022-2025 and orientation to 2030

² [G-FEAST Vietnam 2020 Final Report \(CGIAR\)](#)

introducing new, high-yielding forage crops that can withstand local farming conditions, especially in the dry season in the northern mountainous region is identified as a fundamental solution to mitigate this issue.

Addressing the aforementioned concerns, the CGIAR initiatives on Sustainable Animal Productivity for Improved Livelihoods, Nutrition and Gender Inclusion (SAPLING) and Nature-Positive Solutions (Nature+) has initiated evaluations on eight potential forage varieties in Mai Son district, Son La province. This diverse set encompasses both grasses and legume species. The findings from this study are poised to diversify the array of livestock forage varieties in Son La province. This diversification is crucial for resolving issues pertaining to livestock feed sources and aligns with the provincial programs and overarching goals of the project.

2. Literature review

2.2. *Global and regional context*

Forage crops play a crucial economic role globally (Capstaff and Miller, 2018). According to FAO, grasslands cover about 26% of the world's land area and 70% of agricultural land (Conant, 2010). Forage crops are classified into the Poaceae and Fabaceae families, showing varying distribution based on weather and climate conditions. In the tropics, common grass species include Napier grass (*Cenchrus purpureus* [syn. *Pennisetum purpureum*]), *Urochloa* [syn. *Brachiaria*] species, and Guinea grass (*Megathyrsus maximus* [syn. *Panicum maximum*]) (Njuki et al., 2013). In temperate climates, dominant grass species comprise bentgrass (*Agrotis spp.*), fescue (*Festuca spp.*), ryegrass (*Lolium spp.*), and orchard grass (*Dactylis spp.*) (Ghesquière et al., 2010).

Livestock holds significant importance, not only in food and cuisine but also in cultural and social aspects (Thornton, 2010). Particularly for developing countries, livestock plays a crucial role for smallholders, with large animals like buffaloes, cattle, and goats serving as common savings to cover family expenses, including children's education costs (Herrero et al., 2013). Given these considerations, forage crops will continue to play a pivotal role for decades to come. However, research on forage crops has not received sufficient focus, despite their enormous improvement potential. Enhancing the productivity and quality of forage crops can significantly improve livestock productivity and efficiency, mitigate sustainability challenges and negative impacts associated with the livestock industry (Capstaff and Miller, 2018).

In Southeast Asia, fodder crops are primarily utilized in three main systems: (1) intercropping fodder crops in plantation systems such as rubber, oil palm, and coconut... (2) cultivating fodder crops in large grazing systems, often in areas characterized by extended dry seasons or fallow lands invaded by weeds, and (3) incorporating fodder crops into small-scale livestock farming systems (Stür et al., 2002).

Since the 1960s, numerous research projects in the region have focused on identifying forage species resilient to prevalent weather conditions, including droughts, floods, and acidic soils (Rao et al., 2015). The Southeast Asian Forage Seed project, conducted from 1992 to 1994 in Indonesia, Malaysia, Thailand, and the Philippines, successfully identified six species comprising ten varieties of high-quality, suitable forage crops, particularly effective on acidic soils with low pH. These included: CIAT 621 (*Andropogon gayanus*), *Brachiaria brizantha* "Marandu"; *Brachiaria decumbens* "Basilisk"; *Brachiaria humidicola* "Tully," "CIAT 6369," "CIAT 16886," and "CIAT 6133"; *Centrosema pubescens* "Barinas"; and *Stylosanthes guianensis* "CIAT 184" (Stür et al., 2002).

These varieties were further assessed, alongside 500 other potential forage species, as part of The Forage for Smallholders Project implemented in various countries, including Laos, southern China,

and Vietnam (Stür et al., 2002). Research outcomes led to the identification of 10 grass species and 9 legume species well-suited for the local conditions of small farmers in Southeast Asia (Stür et al., 2002). These included Guinea grass (*Megathyrsus maximus*), Napier grass (*Cenchrus purpureus*), Ruzi (*Urochloa ruziziensis*), and stylo (*Stylosanthes guianensis*). Among these grass species, except for Ruzi, which is suitable for grazing, the remaining species are suitable for cut-and-carry feeding system (Stür et al., 2002), a prevalent feeding system for growing livestock in the mountainous region of Northern Highlands of Vietnam.

2.2. National context

2.2.1. Policy on developing fodder crops in Vietnam

According to Decision No. 124/QĐ-TTg, dated February 2, 2012, the Prime Minister approved the Master Plan for agricultural production development until 2020 and vision to 2030. The allocated land area for animal feed crops is 300,000 hectares, marking a 260,000-hectare increase from 2010. This expansion is concentrated in key production regions linked with large livestock farming, including the Northern Midlands and Mountains, the North Central Coast, the South Central Coast, Southeast, and the Central Highlands (TheGovernment, 2012).

In the scheme to prioritize the implementation of the livestock development strategy for the period 2021-2030, vision 2045 in Decision No. 1520/QĐ-TTg of the Prime Minister dated October 6, 2020 also mentioned the goal to accelerate the conversion of parts of agricultural land to growing forages and fodder crops (TheGovernment, 2020). However, up to now, the whole country only has 70,000 hectares of land for growing forage crops (including areas for growing grass and biomass maize to raise dairy and beef cattle) (Phuc, 2020).

In northern mountainous localities, particularly provinces with substantial livestock numbers based on 2020 statistics (GSO, 2023) such as Son La (358,000 cows; 118,100 buffaloes), Dien Bien (82,000 cows; 134,000 buffaloes), Ha Giang (122,700 cows; 147,600 buffaloes), and Cao Bang (107,200 cows and 106,100 buffaloes), there are plans to expand the cultivation area for high-quality livestock feed crops. Forage crops that will be selected need to have high yield, superior quality, and adaptability to local farming conditions (Giang, 2023) (Bằng, 2021).

2.2.2. Past research on forage crops in Vietnam

Over the past two decades, the National Institute of Animal Science (NIAS) has introduced and tested several forage varieties under diverse ecological and environmental conditions, identifying several promising varieties (Mui, 2003). In lowland areas, commonly utilized varieties include *Cenchrus purpureus*, *Urochloa ruziziensis*, *Megathyrsus maximus* K280, and *Megathyrsus maximus* Likoni. Legume varieties encompass *Stylosanthes* Cook, *Stylosanthes* verano, *Stylosanthes* seca, *Glycine* Cooper, *Centrosema pubescens*, and *Stylosanthes guianensis* CIAT 184 (Mui, 2003).

Notably, *Stylosanthes guianensis* Cook exhibits high yield and good quality, with biomass yield of up to 87.2 tons/ha/year from four cuts in the rainy season (Chau, 1999).

In a study evaluating the growth, yield, and quality of forages, including *Urochloa ruzizensis* (Ruzi), *Megathyrsus maximus* (varieties: Guinea TD58, Common), *Sorghum bicolor* (varieties: Honey, Jumbo, BMR), and *Cenchrus purpureus* (varieties: Pakchong, King Grass, VA06, and elephant grass), conducted in Hanoi (Nhung et al., 2020), elephant grass demonstrated the highest green matter yield (171.2-210.4 tons/ha/year), remaining stable across cuttings. *Cenchrus purpureus* and Ruzi groups exhibited significantly lower biomass yields.

In a study conducted across several provinces in the South Central Coast, including Binh Dinh, Phu Yen, and Ninh Thuan (Ba et al., 2013), the research team assessed the yield and crude protein content of five different forage plant varieties (*Megathyrsus maximus* cv. TD58, *Urochloa hybrid* cv. Mulato II, *Cenchrus purpureus* cv. VA06, *Paspalum atratum* cv. Terenos, and *Stylosanthes guianensis* cv. CIAT 184). The results indicated that the productivity of these varieties varied according to the site conditions such as fertility, drainage and availability of irrigation. However, the highest recorded yield was observed with TD58 at the experimental site in Binh Dinh (40.0 tons of dry matter/ha/year). While stylo exhibited significantly lower yield compared to the grasses, it has the highest crude protein content.

In the highland areas characterized by poor soil conditions, grass varieties such as *Megathyrsus maximus* Hamil, *Megathyrsus maximus* Likoni (the same species as Guinea grass), *Cenchrus purpureus* King grass (the same species as elephant grass), and *Urochloa mutica* demonstrate the ability to produce dry matter productivity ranging from 10-23 tons/ha/year (Ha et al., 1995). The results from the mountainous district of Thach Thanh, Thanh Hoa province, evaluating five grass varieties including VA06, Guinea TD-58, Superdan, Mulato II, and *Paspalum atratum*, indicated that all these grass varieties grew and developed well. Specifically, VA06 exhibited the highest growth, yielding 342.12 tons/ha/year, followed by the Mulato II with a yield of 225.07 tons/ha/year (Tuong, 2019).

On sloping land with gradients ranging from 8-10° and 20-25° in the Northeast region, dominant varieties include *Urochloa decumbens*, *Setaria splendida*, *Megathyrsus maximus* TD58, *Panicum maximum* Guinea, and *Paspalum atratum*. These varieties exhibited six cuttings per season, with dry matter productivity ranging from 11.6-16.1 tons/ha on slopes of 8-10° and from 8.89-14.1 tons/ha on slopes of 20-25° (Quang, 2001).

Evaluation of 12 forage varieties in the districts of Than Uyen and Sin Ho in Lai Chau province revealed 3 varieties that demonstrated high yield, good quality, and robust growth during winter consisting of: Mulato II, Guinea Mombasa, and Stylo Ubon (Quang et al., 2010). In Than Uyen, the corresponding green matter yields for these three grass varieties were 115.23, 112.45, and 58.75 tons/ha, respectively. The ratios between winter crop yield and yearly yield were 35.42%, 25.17%,

and 27.35%, respectively. In Sin Ho district, the biomass yields for the mentioned grass varieties were 132.16, 137.93, and 65.17 tons/ha, respectively, with ratios of winter crop yield to yearly yield at 37.23%, 26.52%, and 29.56%, respectively.

3. Methodology

3.1. Study site

The experimental areas are located in four communes of Mai Son district, detailed information is summarized in Table 1.

Table 1. General information on experimental sites

No.	Commune	Village	Name of household head	Planting date	Longitude	Latitude
1	Muong Bon	Doan Ket	Hoang Van Nhien	May 19, 2023	21.25274°	104.0575°
2	Chieng Chung	Khoa	Ha Van Kim	May 20, 2023	21.21501°	103.9061°
3	Chieng Luong	Mon 1	Cam Van Thao	May 18, 2023	21.09511°	104.1099°
4	Hat Lot	Na Sang	Vi Van Cong	May 19, 2023	21.167687°	104.09958°

3.2. Experimental design

The experiment tested 8 different forage varieties (6 grasses and 2 legumes):

- 1) Mun River Guinea - *Megathyrus maximus* cv. Mun River (MR)
- 2) Mombasa Guinea - *Megathyrus maximus* cv. Mombasa (MG)
- 3) Mulato II - *Urochloa hybrid* cv. Mulato II (MII)
- 4) Taiwanese Green Elephant Grass - (*Cenchrus purpureus*)- (GE)
- 5) VA06 - *Cenchrus purpureus* cv. VA06 (Napier grass)
- 6) Biomass maize variety NK7328s - *Zea mays* (NK7328/ NK7328s)
- 7) *Stylosanthes guianensis* var. *guianensis* cv. Ubon stylo (US)
- 8) Rice bean - *Vigna umbellata* – RB

Experimental design: A Randomized Complete Block Design (RCBD) was used, the forage varieties were arranged in 3 replicates as shown below:

Table 2. Trial arrangement

Block 1	MII	MR	RB	US	NK7328	GE	Napier	MG
Block 2	RB	MII	Napier	NK7328	MR	MG	GE	US
Block 3	NK7328	MR	MII	Napier	RB	MG	US	GE

3.3. Data collection

Timelines for planting and data collection are summarized in the table below.

Table 3. Planting and data collection dates

Location	Planting date	Date of data collection		
		1st	2nd	3rd
Muong Bon	May 19, 2023	July 19, 2023	September 4, 2023	October 22, 2023
Chieng Chung	May 20, 2023	July 29, 2023	September 4, 2023	October 22, 2023
Chieng Luong	May 18, 2023	July 20, 2023	September 5, 2023	October 23, 2023
Hat Lot	May 19, 2023	July 21, 2023	September 5, 2023	October 23, 2023

3.3.1. Soil sampling and analysis

At planting and harvesting (flowering stage for legumes) of the forages at each site, soil samples from the field were collected at depths of 0-20 cm and 20-40 cm and pooled into a composite sample of about 0.5 kg. Collected samples were sent to NOMAFSI soil lab for analysis. Elements measured included soil pH, EC, total N, available P and K, organic carbon, CEC, texture and bulk density.

3.3.2. Agronomic data collection

Rainfall and weather data: Rainfall, temperature (mean maximum and minimum), and relative humidity monthly data was collected from the nearest meteorological station for the entire experimental period (Annex 1).

Field establishment rate and refilling: planting dates, germination rate and survival rate for each forage were monitored and recorded. After 4 – 5 weeks after planting (WAP) the percentage establishment was recorded (Annex 2).

Number of tillers: Number of tillers per plant were counted from 4 plants within a 1 x 1 m frame after every 4 weeks during the establishment phase and after every 8 weeks (at harvest) during the production phase (Annex 2).

Plant height: 5 random points were marked and measured throughout the experiment, and the first measurement taken 30 days after planting. A ruler was used to measure the height from the ground to the top of 2/3 of the longest and tallest group of leaves (Annex 2).

Pests and diseases: Pests and diseases incidences were assessed and recorded every month throughout the experimental period (Annex 2).

Fresh and dry matter yield: The first biomass yield was taken 60 days after planting from a 2 x 2 m² harvest area per plot, fresh biomass was weighed then a sub-sample (1 kg) collected and dried at 105°C for 48 hours for dry weight measurements. Subsequent harvests were done after every 45 days (Annexes 2 & 3). Maize biomass was measured at the waxy ripening stage.

Note: During the second yield monitoring session, only 1 m² of each plot was cut and measured for yield data. The remaining portion of each plot was preserved for use in the Training of Trainers (ToT) and Training of Farmers (ToF) sessions conducted on August 22-24, 2023 (<https://cgspace.cgiar.org/handle/10568/134692>).

4. Results

4.1. Soil properties at the experimental sites.

Soil analysis of samples taken from the experimental sites before trial establishment indicated no significant difference in the soil layer from 20 to 40 cm. In the soil layer from 0-20 cm, the differences in chemical properties among experimental sites are more noticeable. However, in overall, the soil at all sites is classified as slightly acidic, with pH ranging from 4.84 to 5.15. Chieng Luong has a higher total organic matter content compared to other sites. For total nitrogen, the soil at these points is categorized as having an average total nitrogen content (0.08 - 0.15%, based on the Kjeldahl method (Ho et al., 2006)). All these sites also exhibit high available phosphorus content, as per the Oniani method, with the topsoil's available P content exceeding 15 mg P₂O₅/100g (Ho et al., 2006). In terms of available K content, the soil at these sites can be considered médium level (within the 10-20 mg K₂O/100 g soil range)(Tien, 2019). With a cation exchange capacity ranging from 1.48 to 1.81, these soil groups can all be classified as having low cation exchange capacity.

Table 4. Soil chemical properties at experimental sites

Location	Soil layer from 0 - 20 cm					
	pH _(H2O)	OC	Total N	Available P	Available K	CEC
		(%)	(%)	(mg/100g)	(mg/100g)	(meq/100g)
Chieng Luong	5.15	3.01	0.10	38.80	10.83	1.50
Muong Bon	4.84	2.16	0.14	20.00	7.07	1.48
Chieng Chung	5.00	1.76	0.10	35.00	15.24	1.60
Hat Lot	5.16	1.72	0.13	19.30	11.27	1.81
Layer 20 - 40 cm						
Chieng Luong	5.33	2.23	0.14	20.53	7.73	1.36
Muong Bon	5.06	1.74	0.14	15.03	3.54	1.58

Location	Soil layer from 0 - 20 cm					
	pH _(H2O)	OC	Total N	Available P	Available K	CEC
		(%)	(%)	(mg/100g)	(mg/100g)	(meq/100g)
Chieng Chung	5.26	1.75	0.14	19,17	8.40	1.68
Hat Lot	5.45	1.59	0.15	7.80	8.84	1.58

Note: pH (TCVN 5979:2021), OC (TCVN 7376:2004), Total N (Kjeldahl method - TCVN 6498:1999), Available P (Oniani method - TCVN 5256- 2009), Available K (TCVN 8662:2011), CEC (TCVN 8568: 2010).

The results of soil analysis revealed that, with the exception of the Chieng Chung site classified as silty loam with a relatively high proportion of fine sand, the remaining experimental sites are all categorized as clay loam according to the USDA's classification method. Despite having a high clay content, these sites are not affected by waterlogging mainly due to sloping lands. However, the high clay content may lead to soil compaction and reduced air circulation, potentially impacting plant growth adversely.

Table 5. Physical characteristics of soil at the experimental sites

Location	Soil layer 0 - 20 cm			
	Coarse sand	Fine sand	Limon	Clay
	(2.0-0.2mm)	(0.2-0.02mm)	(0.02-0.002 mm)	(<0.002 mm)
Chieng Luong	2.63	27.10	34.53	35.73
Muong Bon	2.31	35.12	21.57	41.00
Chieng Chung	8.68	40.12	26.40	24.80
Hat Lot	5.48	30.52	27.07	36.93
Location	Soil layer 20 - 40 cm			
Chieng Luong	4.00	35,33	35,20	25.47

Muong Bon	3.77	20.76	44.93	30.53
Chieng Chung	5.35	46.91	28.00	19.73
Hat Lot	3.43	30.17	35.87	30.53

The analysis of the physicochemical properties of the soil during and after implementing the experiment will be conducted in the near future to assess the impact of the forage crops on soil quality.

4.2. Growth and development of forage crops

The selected forages were planted at the experimental sites from May 18 to 20, 2023. After 2 months of growth, during the collection of the first biomass yield data on July 19 and 20, 2023, the forage varieties exhibited robust growth and relatively uniform development at the experimental sites.

Table 6. Growth rates of selected forages

Forage varieties	Height t (cm)	Growth speed (cm/day)	N° of tillers	Green weight of 1 m² (kg)	Green weight yield (tons/ha)
Mun River Guinea	106.4	1.8	2,2	2.6	25.6
Mombasa Guinea	126.8	2,1	2,4	2.6	25.8
Mulato II	68.0	1.1	2,3	1.7	16.6
Taiwanese GE grass	135.9	2,3	3.1	3.5	35.1
Maize NK7328*	152.1	2.5	-	-	-
Stylo*	45.0	0.8	-	-	-

Rice bean*	103.8	1.7	-	-	-
VA06	163.5	2.7	2,3	3.3	32.6

* *Note: During the first yield harvest, data on the yield of rice beans and stylo beans were not collected due to their limited growth. The maize biomass yield was only collected once in September when the maize began to ripen..*

The biomass growth rate rankings are as follows: The group with the fastest-growing biomass includes VA06 (32.6 tons/ha), Taiwanese green elephant grass (35.1 tons/ha), and NK7328 maize. The group with an average growth rate comprises Mun River guinea, Mombasa Guinea, and rice bean. Mulato II and stylo exhibit slower growth compared to the other varieties, with stylo being the least productive.

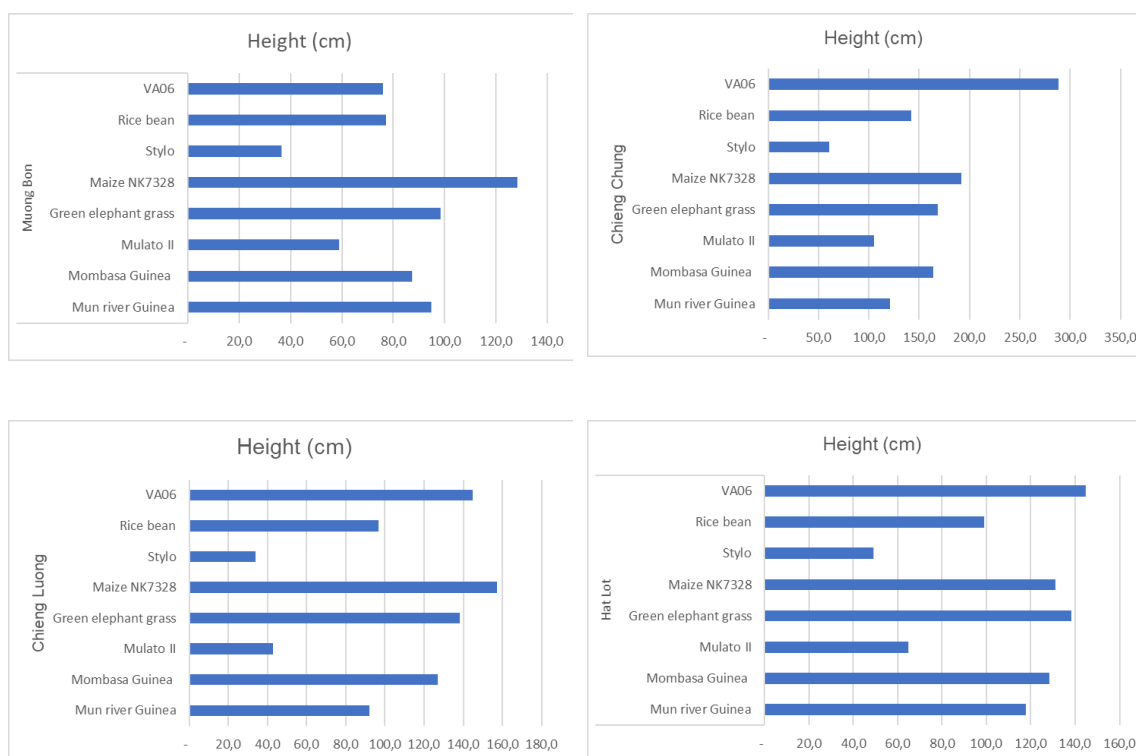


Figure 1. Growth of forages in the experimental sites, 2 months after planting

After three months of growth and development, the grasses achieved maximum biomass, with the highest being the Taiwanese green elephant grass reaching 88.3 tons/ha, followed by Mombasa Guinea (69.0 tons/ha), VA06 (68.1 tons/ha), and Mun River Guinea (66.3 tons/ha). Mulato II, maize NK7328, and the two legume crops (stylo and rice bean) had lower biomass yields.

Table 7. Growth and yield of forages, 3 months after planting

Forage varieties	Height (cm)	Fresh weight of 1 m ² (kg)	Fresh weight yield (tons/ha)
Mun River Guinea	207.3	6.6	66.3
Mombasa Guinea	230.7	6.9	69.0
Mulato II	142.3	4.5	45.0
Taiwanese GE grass	313.5	8.8	88.3
Maize NK7328	199.4	4.4	43.8
Stylo	103.5	2.5	24.8
Rice bean	171.6	3.0	30.4
VA06	260.8	6.8	68.1

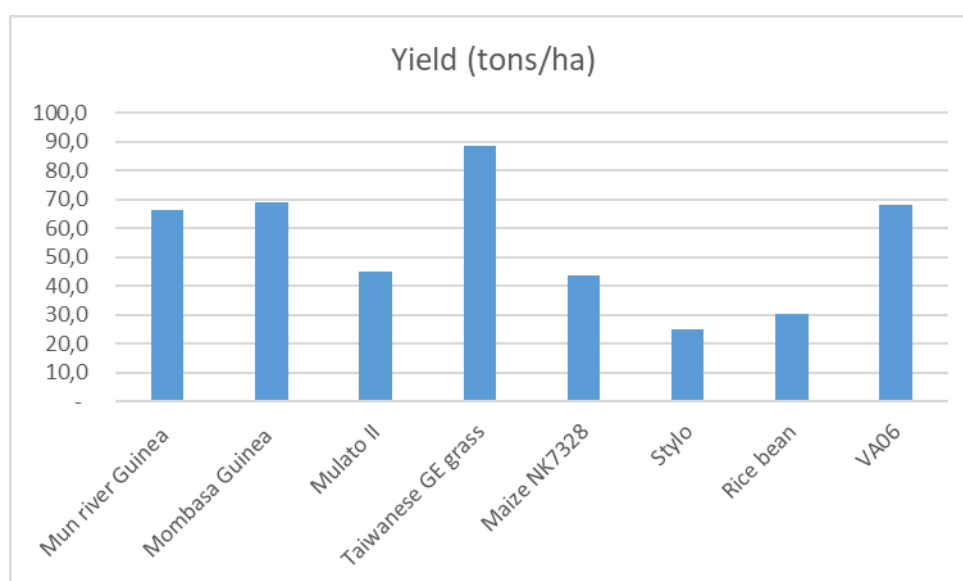


Figure 2. Average yield of the forage varieties, 3 months after planting

The evaluation results of the regeneration ability in the rainy season for the selected forages are summarized in Table 8. Overall, the regeneration ability of the grass varieties is relatively good, with significant differences observed in varieties with large biomass such as Taiwanese green elephant grass and VA06. Specifically, after 45 days from the first cutting, green elephant grass achieved a yield of 13.9 tons/ha, and VA06 grass reached 19.8 tons/ha.

Table 8. Regeneration ability of selected forages, 45 days after the first cut

Forage varieties	Height (cm)	Regeneration speed (cm)	N° of tillers	Green weight of 1 m ² (kg)	Green weight yield (tons/ha)
Mun River Guinea	81.8	1.8	18.7	1.7	16.9
Mombasa Guinea	87.5	1.9	21.2	0.9	9.1
Mulato II	48.9	1.1	13.2	0.6	6.4
Taiwanese GE grass	112.8	2.5	11.3	2.0	19.8
Maize NK7328*	67.1	1.5	-	-	-
Stylo*	144.9	-	8.2	3.2	31.8
Rice bean*	167.8	-	3.8	2,3	22.7
VA06	99.7	2,2	13.0	1.4	13.9

* Note: Maize was replanted after the first harvest, while stylo and rice bean were retained, and their regeneration ability was not evaluated.

The results of assessing the ability to regenerate in the dry season for all forages in the experiment will be compiled and analyzed in the next harvesting period.

4.3. Pest and disease incidences

Monitoring and data collection process for the experiment revealed that the forages were not significantly affected by pests and diseases. In some plots where maize NK7328 was planted, the research team noted the presence of fall armyworms, but there was no clear impact on the plants.

4.4. Evaluation of officials and farmers on the growth and development of the forage crops

Within the framework of SAPLING, Training of Trainers (ToT) and Training of Farmers (ToF) classes were organized to enhance the capabilities of agricultural extension officers and farmers at the experimental sites (Tran et al., 2023b). Throughout the training courses, the participants visited the demo farms and learned about the forage crops. Each participant received an evaluation sheet to rate the growth and development ability of each variety on a scale of 1 to 5. The results indicated that all participants exhibited interest in the new forage varieties and expressed a desire to test them in the near future.

Table 9. Results of scoring and evaluating the grass varieties by local officials and farmers

Participant	Score							
	Mun River Guinea a	Mombasa Guinea a	Mulatto II	Taiwanese GE grass	Maize NK7328	Stylo	Rice bean	VA06
Chieng Chung	3.63	3.79	3.81	3.88	4.08	3.52	3.56	4.06
Chieng Luong	3.29	3.28	2.61	4.51	3.81	3.31	4.04	4.11
Muong Bon	4.43	4.2	3.52	4.13	4,3	4.22	4	4.17
Hat Lot	3.79	3.68	3.56	3.75	3.72	4.07	3.91	3.68
TOT participants	3.78	3.67	3.15	3.04	2.57	2.67	3.04	2.67
Evaluation by the demo plots owners	4.42	4.25	3.58	4.17	3.83	3.67	4	4.08

Average	3.89	3.81	3.37	3.91	3.72	3.58	3.76	3.8
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* Note : scale from 1-5, 1: poor, 2: average, 3: Good, 4: Very good, 5: Perfect

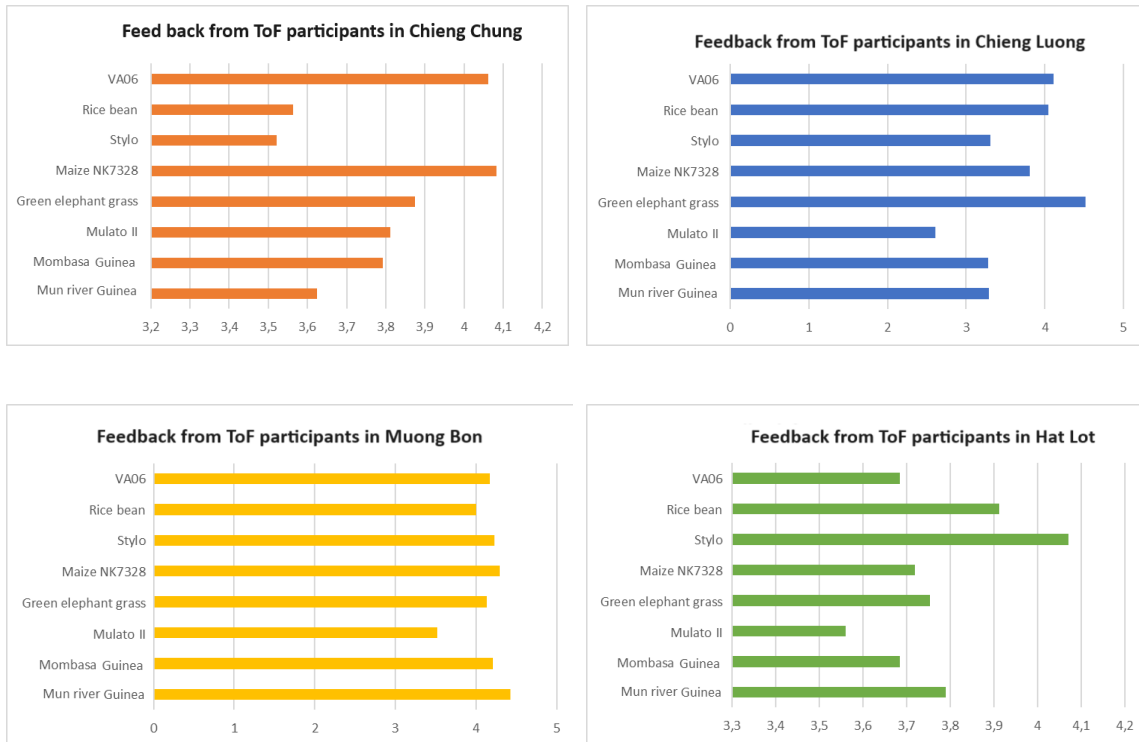


Figure 3. Evaluation by ToT and ToF participants at experimental sites

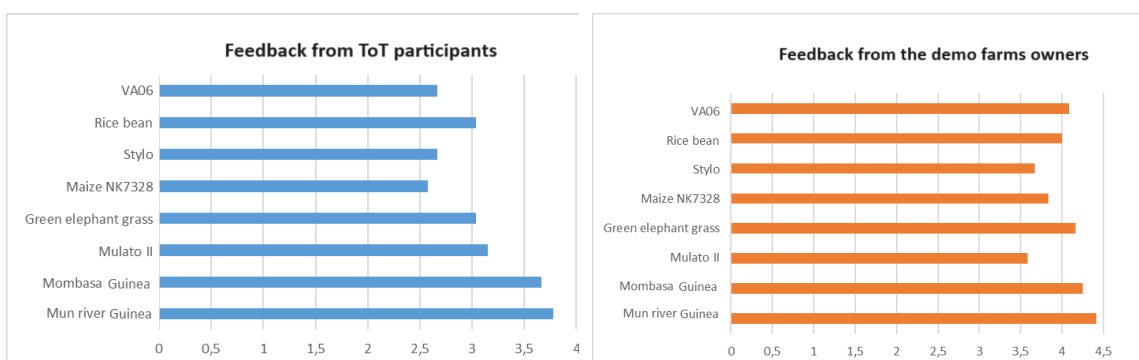


Figure 4. Evaluation of ToT participants and households participating in the study

Overall, the majority of the forage crops received positive feedback from households participating in the demos and from the trainees. Among them, Taiwanese green elephant grass, VA06 grass, and two guinea grass varieties - Mun River and Mombasa - were the most highly rated varieties for their growth, development, and productivity.

Mulato II, stylo, and rice bean received lower ratings. For stylo, mainly due to its lower yield compared to the remaining varieties. Meanwhile, Mulato II and rice beans, despite yielding well, were not highly scored by the attending trainees. Participants mentioned that Mulato II is quite hairy, which could cause difficulties during cutting. According to the participants' experience, cattle often do not prefer to eat hairy grasses. The assessment results partly reflect people's limited knowledge about the positive effects of using legumes in diversifying and supplementing nutrition in livestock feed.

Table 10. Summary of evaluation results of local partners and farmers on the selected forage crops

N°	Forage varieties	Most preferred variety	Planting material		Recommended multiplication method
			Seed	Cuttings	
1	Mun River Guinea	✓	✓	✓	Both by seeds and cuttings
2	Mombasa Guinea	✓	✓	✓	Both by seeds and cuttings
3	Mulato II		✓	✓	Both by seeds and cuttings
4	Taiwanese GE grass	✓		✓	Cuttings
5	VA06	✓		✓	Cuttings
6	Corn NK7328		✓		Seed
7	Stylo		✓	✓	Seed
8	Rice bean		✓		Seed

1. 5. Conclusion

Most of the forage varieties evaluated exhibited robust growth and development, well-suited to local conditions. Notably, grasses demonstrated fast growth and regeneration rates, along with high biomass yields, particularly the Taiwanese green elephant grass, VA06, Mun River Guinea, and Mombasa Guinea. These varieties received positive feedback from both local partners and farmers.

For the legumes, rice bean displayed strong growth and high biomass yield. However, being an annual crop, they can only be harvested once and need replanting after each crop. Although stylo has slower growth, it is a perennial variety that can be utilized for several years.

These are preliminary conclusions drawn from monitoring during the first crop cycle and only after the rainy season. Ongoing evaluation data collection, especially during the dry season, will provide a more comprehensive assessment of the growth and development capabilities and suitability of these forages, their utilization as feed and livestock productivity in Son La province.

In addition to the experiments, training and capacity-building activities have been organized. Training sessions and field visits have helped local partners and farmers to enhance their knowledge of growing and managing forage crops, as well as mastering the techniques of silage making. This contributes to overcoming challenges of feed shortage in the region. Local partners and farmers participating in the training highly benefit from generated knowledge and skills.

The impacts of these forages on soil health and nutritional quality of the forage crops will be evaluated in the coming months.

2. References

- BA, N. X., LANE, P. A., PARSONS, D., VAN, N. H., KHANH, H. L. P., CORFIELD, J. P. & TUAN, D. T. 2013. Forages improve livelihoods of smallholder farmers with beef cattle in South Central Coastal Vietnam. *Tropical Grasslands-Forrajés Tropicales*, 1, 225-229.
- BẰNG, U. T. C. 2021. Kế hoạch Phát triển chăn nuôi giai đoạn 2021-2025, định hướng phát triển giai đoạn 2026-2030 trên địa bàn tỉnh Cao Bằng
- CAPSTAFF, N. M. & MILLER, A. J. 2018. Improving the yield and nutritional quality of forage crops. *Frontiers in Plant Science*, 9, 535.
- CHAU, L. H. 1999. Response of *Stylosanthes guianensis* cv Cook on nitrogen fertilizer in peri-urban area of Ho Chi Minh city. *Proceeding of Seminar on feed resources and animal nutrition*. Hanoi Viet Nam: Ministry of Agricultural and Rural Development.
- CONANT, R. T. 2010. *Challenges and opportunities for carbon sequestration in grassland systems*, FAO Rome, Italy.
- GHESQUIÈRE, M., HUMPHREYS, M. & ZWIERZYKOWSKI, Z. F. 2010. Fodder crops and amenity grasses. *Boller, B., Posselt, UK, Veronesi, F., Eds*, 288-311.
- GIANG, U. T. H. 2023. Kế hoạch Phát triển chăn nuôi theo hướng hàng hóa với quy mô trang trại, nâng cao chất lượng, giá trị sản phẩm, phấn đấu giữ vững tỷ trọng chăn nuôi năm 2023 là 32% trong cơ cấu giá trị ngành nông nghiệp.
- HA, N. N., BINH, L. H. & MUI, N. T. 1995. Phan Thị Phần và Đoàn Thị Khang (1995). *Đánh giá khả năng sản xuất của một số giống cỏ trồng tại các vùng sinh thái khác nhau của Việt Nam. Tuyển tập các công trình khoa học chọn lọc*, NXB. Nông nghiệp.
- HERRERO, M., GRACE, D., NJUKI, J., JOHNSON, N., ENAHORO, D., SILVESTRI, S. & RUFINO, M. C. 2013. The roles of livestock in developing countries. *animal*, 7, 3-18.
- HO, P. N., VIET, N. Q., MINH, N. N. & ANH, N. N. 2006. Methods for assessment of soil environmental quality - applying for establishment maps of soil environmental status in Hoa Binh province. *Cadastral Magazine*, 5, 16-23.
- MUI, N. T. 2003. Country pasture/forage resource profiles. *Vietnam. FAO, Rome, Italy*.
- NGOC, T. T. B., GIANG, N. T. T., THAO, H. X., HANG, D. T. T., PHUONG, N. T. M., TRIANA, N., PETERS, M., DUNCAN, A. & ATIENO, M. 2023a. Assessment of feed resources availability and use for cattle and pigs in Mai Son District, Son La Province, Vietnam.
- NGOC, T. T. B., PHUONG, T. V., GIANG, N. T. T., TIEN, N. Q., HIEU, D. T., SINH, N. T., HANG, D. T. T., ATIENO, M. & DUNCAN, A. 2023b. Training of trainers (TOTs) and farmers (TOFs) on cattle and pig feed technologies in Main Son district, Son La province.
- NHUNG, P. T. H., HANG, D. T. T., NGOC, T. T. M., LOC, N. V., HANH, T. T. & LONG, N. V. 2020. Evaluation of the Growth, Yield and Quality of Some Forage Species at the Different Cutting Times in Gia Lam, Hanoi. *Vietnam Journal of Agricultural Sciences*, 18, No.8: 580-58.

- NJUKI, J., WAITHANJI, E., LYIMO-MACHA, J., KARIUKI, J. & MBURU, S. 2013. *Women, livestock ownership and markets: Bridging the gender gap in eastern and southern Africa*, Routledge.
- PHUC, M. 2020. Khuyến khích chăn nuôi bò, nhưng khó chuyển đổi sang trồng cỏ. Báo Nông nghiệp Việt Nam.
- QUANG, N. V. 2001. Studies on biomass yield and effects of manure supplied of grass varieties under shade of fruit trees on the hilly area of Thainguayen. *Proceeding of Seminar on feed resources and animal nutrition*. Hanoi Viet Nam: National Institute of Animal Husbandry.
- QUANG, N. V., PHONG, B. V., HONG, B. T., MINH, N. D. & PHUONG, N. D. 2010. Nghiên cứu tuyển chọn giống cây thức ăn gia súc phù hợp, phục vụ chăn nuôi trâu bò tại huyện Than Uyên và Sìn Hồ tỉnh Lai Châu.
- RAO, I. M., PETERS, M., CASTRO, A., SCHULTZE-KRAFT, R., WHITE, D., FISHER, M., MILES, J. W., LASCANO AGUILAR, C. E., BLÜMMEL, M. & BUNGENSTAB, D. 2015. LivestockPlus: The sustainable intensification of forage-based agricultural systems to improve livelihoods and ecosystem services in the tropics. *CIAT Publication*.
- STÜR, W., HORNE, P., GABUNADA JR, F., PHENGSAVANH, P. & KERRIDGE, P. C. 2002. Forage options for smallholder crop–animal systems in Southeast Asia: working with farmers to find solutions. *Agricultural systems*, 71, 75-98.
- THEGOVERNMENT 2012. Quy hoạch tổng thể phát triển sản xuất ngành nông nghiệp đến năm 2020 và tầm nhìn 2030. *In: MARD (ed.)*.
- THEGOVERNMENT 2020. Chiến lược phát triển chăn nuôi giai đoạn 2021-2030, tầm nhìn 2045. *In: MARD (ed.)*.
- THORNTON, P. K. 2010. Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365, 2853-2867.
- TIEN, T. M. 2019. Bản đồ nông hóa vùng sản xuất nông nghiệp tỉnh Hải Dương. Viện Thổ nhưỡng Nông hóa (Soil and Fertilizer Research Institute).
- TUONG, T. Q. Q., NGUYEN VAN; THUAN, NGUYEN DUC 2019. Đánh giá khả năng sinh trưởng và hiệu quả của một số giống cỏ cho chăn nuôi bò sinh sản tại Thạch Thành - Thanh Hóa. *Tạp chí Khoa học Công nghệ Việt Nam*, 5(102)/2019.

3. Appendix 1: Technical guideline for intensive cultivation of VA06 grass in the Northern mountainous region

Based on the technical process recognized and issued by the Department of Crop Production - Ministry of Agriculture and Rural Development, it can be applied to green elephant grass varieties.

1. *Establishment*

Variety selection

- Plant from cuttings, choose mature plants that are 4-6 months old, healthy, pest-free, cut off old roots and tops. After peeling off all the sheath leaves in the axillary buds, use a sharp knife to cut them into cuttings (do not break or crush the cuttings). The length of the cuttings is 30 - 35 cm, each cutting has at least-3 nodes.
- It is also possible to separate shoots from grass clumps to make new varieties. Be careful not to damage the grass roots when separating. After separating the buds, cut the young stem at the top, only keeping the stem 10-15cm away from the base. If the roots are too long, use scissors to trim them.

Planting season:

- Can be planted from February onwards and during the rainy season, the most suitable planting time is from March - May. In highland areas with long cold and dry winters, plant from March onwards (when there is steady rain, and the soil is moist enough). Be careful not to plant grass in winter.
- VA06 grass can be grown on most types of soil, preferably soil with an arable layer of over 30cm, fertile, well-structured, and well-drained.
- Land preparation: Plow thoroughly, loosen the soil, level the surface, and remove weeds. Then make incisions 15-20 cm deep, 20 cm wide, with a row spacing of 60 cm. For sloping land, dig incisions along contour lines or create holes for planting.

Planting and fertilization

Planting density:

- Row spacing is 60cm; Number of cuttings: 50,000 – 55,000 cuttings/ha, equivalent to 3.0-3.5 tons of cuttings/ha.
- Planting: 0.5-2m between rows, 0.3-1 m within rows

How to plant:

- Plant in a incision, place the cuttings in the incision (already fertilized) inclined at 45° or vertically one after another under the groove, fill with fine soil 5cm layer, if planted in the rainy season, leave the tips of the cuttings exposed to avoid rot.
- It can be planted in holes on sloping land with density and techniques such as planting in incision, paying attention to the holes being staggered along the contour lines.

Fertilization: Amount of fertilizer for 1 hectare (fertilizer for the new planting year and fertilizer for 26grass regeneration in the following years)

- Decomposed manure: 15-20 tons (or apply 2.0-2.5 tons of microbial organic fertilizer)
- Nitrogen Fertilizer: 250 kg N (equivalent to 543 kg urea)
- Phosphate fertilizer: 80 kg P₂O₅ (equivalent to 500 kg super phosphate)
- Potassium fertilizer: 100 kg K₂O (equivalent to 170 kg potassium chloride)

Fertilization application

- Apply the entire amount of manure, micro-organic fertilizer, and phosphate fertilizer (for regenerated grass gardens from the 2nd year onwards, apply the entire amount of manure, micro-organic fertilizer, and phosphate fertilizer once at the beginning of the year).).
- Nitrogen and potassium are used as top dressing when plants are still young (25-30 days after planting) and as top dressing for regenerated grass (applied 10-12 days after cuttings). The amount of nitrogen and potassium fertilizers is divided equally among the cuttings.
- Yields decline rapidly if fertility is not maintained.

2. *Management*

- After planting, if the weather is sunny or dry, it's essential to water and maintain soil moisture. Check and replant dead trees 15 days after planting.
- Do weeding and mulch the roots after each harvest.
- In conditions where it is feasible, water the garden during the dry season and prolonged drought periods, aiming for watering once a week. Drain excess water promptly during the rainy season to prevent flooding.
- With proper care, a grass garden can be exploited for 5-6 years.
- VA06 grass exhibits excellent resistance to pests. However, occasional harmful pests such as gray caterpillars, aphids, stem borers, leaf spot disease, and anthracnose may be present in the garden. In the event of pest damage, prevention methods involving cultivation and biology should be employed, including regular field cleaning, weed tillage, ensuring good garden ventilation, and applying balanced fertilizers. It's advisable to avoid the use of chemical pesticides whenever possible.

3. *Harvest*

- The first harvest should be conducted 70-75 days after planting when the grass reaches a height of 120-140cm.
- Subsequent harvests should occur when the grass reaches a height of 120-140cm, with intervals of 40 days per cluster during the rainy season and 60-80 days per cluster in the dry season. Aim for 5-7 harvests per year.
- Cut the grass 5cm above the ground, avoiding excessive height to prevent the emergence of roots. Cut all leaves, leaving no seedlings to ensure even regeneration. After each harvest, combine fertilizer application and till the roots.
- In high mountain areas: Employ the method of cutting 5cm above the ground, with a higher cutting height of 15-20cm at the end of the year. During the first crop of the year in spring and autumn, lower the cutting height back to 5cm.
- Note: Avoid harvesting grass during rainy conditions and when the temperature is below 10°C.

4. Appendix 2: Technical guideline for planting, managing and harvesting forage grasses

The technique can be applied for growing forage grass varieties such as Mombasa Guinea, Mun River Guinea, Mulato II

1. *Establishment*

For the Northwest region, it's recommended to plant grass during the rainy season, preferably from April to July when there is abundant rainfall to ensure the highest survival rate. Grass can be cultivated from seeds (8-10 kg seeds/ha) or rooted slips or stolon cuttings. Planting should be done in furrows with a row spacing of 1.25 – 1.5 m and on contour every 0.5-0.6 m.

2. *Fertilizer application*

2.1. Amount of fertilizer

For 1 hectare of newly planted grass and annual fertilizer for regenerated grass, the recommended amounts are as follows:

- Decomposed manure: 15-20 tons (alternatively, apply 2.0-2.5 tons of microbial organic fertilizer)
- Nitrogen fertilizer: 200 kg N
- Phosphorus fertilizer: 80 kg P₂O₅
- Potassium fertilizer: 80 kg K₂O.
- Soils with pH<5 require addition of lime to raise pH to 5.5-6.

2.2. Fertilizer application

- Apply the entire amount of manure, micro-organic fertilizer, and phosphate at the beginning of the year for both newly planted grass and regenerated grass gardens (for regenerated grass gardens from the 2nd year onwards).
- Nitrogen and potassium are used as top dressing when plants are still young (25-30 days after planting) and as top dressing for regenerated grass (applied 10-12 days after cuttings). The amount of nitrogen and potassium fertilizer should be divided equally among the cuttings.

3. Harvesting

- Harvest time: Initiate the first harvest 60 days after planting, with subsequent harvests every 30 days per crop during the rainy season and every 50-60 days per batch during the dry season.
- Plan the final harvest at the end of the year (winter harvest) between November 15-30. Avoid cutting in December-January due to the dry and cold weather, which hampers grass bud regeneration. Cutting during this time, especially in prolonged cold and dry conditions, may lead to grass death.
- Harvesting method: Cut 5cm above the ground. In highland areas with extended dry and cold winters, employ a cutting height of 5cm above the ground, with the last crop of the year cut at 10cm high. When the first spring and autumn crops of the year come, lower the cutting height back to 5 cm.

5. Appendix 3: Technical guideline for planting, managing, and harvesting stylo.

1. *Establishment*

- Soil Preparation: Ensure the soil is free of weeds and create rows about 5 cm deep, 20 cm wide, with row spacing of 40-50 cm.
- Seed Preparation: 1 hectare requires 10 kg of seeds. Can break dormancy by: (a) mechanical scarification; (b) immersion in water at 80 °C for 10–15 minutes, and cooling for 40 minutes; (c) treating with concentrated sulphuric acid for 10 minutes, wash and dry; (d) pass seed over hot surface at 120 °C for 15 seconds
- Stylo grass can also be propagated from cuttings. Cut the cuttings to 30 cm in length, allow them to root, and then plant. Note that the survival rate may not be as high as sowing seeds.
- Planting procedure: Seed can be broadcast after light cultivation or drilled at 2–5 kg/ha, sowing no deeper than 1–1.5 cm. Seed can also be broadcast onto ash following fire, providing the area is continuously stocked after seeding to reduce grass competition. Generally slow to establish. Planting Time: Sow seeds in April to July every year..

2. *Fertilizer application*

- Fertilizer Application: For 1 hectare, apply 10-15 tons of organic fertilizer or decomposed manure, along with 80-100 kg of NPK 5:10:3. Apply all manure and NPK as base fertilizer.
- Efficient in extracting phosphorus from the soil and grows quite well without fertilizer, but may require 20 kg/ha P in P deficient soils.
- Weeding: 25-30 days after planting, weed using a hoe and till the soil. Avoid the use of herbicides; instead, manually remove weeds through hoeing and tilling..

3. *Harvesting*

Harvesting Guidelines:

- The first harvest should be conducted after 60 days, when the grass reaches a height of 50-80 cm. Choose a cutting position from the base to about 15 cm high to promote the healthy growth of sprouts at the base and prevent stem rot.

Subsequent harvests can be done after 40-45 days during the rainy season or 50-55 days in the dry season. Stylo can be utilized in two main ways: it can be used for cutting and carrying, or it can be planted on grazing lands for cattle to graze directly.

- Fresh consumption: It can be directly consumed by cattle in combination with grasses or agricultural by-products.

Making silage to store for winter: Stylo can be mixed with grasses at the proportion of 15-20% to produce silage for the winter and dry seasons when forages and natural grasses are scarce.

6. Appendix 4: Technical guideline for planting, managing, and harvesting rice bean

1. *Establishment*

- 1 hectare needs 10-15 kg seeds
- Sow seeds at the beginning of the rainy season, from April to July every year.
- Prepare the soil well, do weeding, plant in holes, about 5 cm deep, sow 3 seeds/hole, distance 1 m x 1 m if planted alone and 1 x 2 m if intercropped with corn.

2. *Fertilizer application*

- Amount of fertilizer needed: 80-100 kg NPK 3:10:5 for basal application when planting.
- 25-30 days after planting, weeding is needed, do not use herbicides to spray.

3. *Harvest*

- Rice bean seeds can be used as food for humans, and the stems and leaves can be used as animal feed.
- Fresh leaf stems can be cut 60 days after planting. Choose a cutting position from the base to a height of about 20-30 cm to help the sprouts under the root develop well and prevent the root from rotting. Leaf stems can be used to feed animals directly or mix with other grasses at the proportion of 15%-20% to make silage.
- Seeds can be harvested and dried for food.