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Impact of Forage Management on Yield and Nutritional Quality of Cultivated Forages in North-Eastern Cambodia

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Abstract

Increasing beef prices present smallholders ready to intensify cattle production in Ratanakiri Province, Northeast Cambodia, with an opportunity to enhance their livelihoods. One promising intensification approach, which also reduces pressure on increasingly scarce grazing resources, is cultivating forages on-farm to feed fenced livestock. The objective of this study was to evaluate whether weeding and manuring of farm-grown forages result in higher yield and improved nutritional quality.

Above-ground biomass of cultivated forages (*Panicum maximum*, *Paspalum atratum*, *Brachiaria ruziziensis*, *B. ruziziensis* × *B. decumbens* × *B. brizantha* (*B.* hybrid), *Stylosanthes guianensis*) in Lumphat district (13°47´ - 13°60´N, 106°94´ - 106°99´E) were monthly determined destructively during the rainy season from June to September 2015. Forage grasses and the forage legume *S. guianensis* were cut at 6 ± 4 cm and 15 ± 7 cm above ground level, respectively. Samples of forages (n = 41) were analysed for their nutrient concentrations. On 20 smallholdings, forage plots of 0.01 ha were weeded monthly, manured with on average 0.24 t N ha^{-1} $month^{-1}$, and compared to 0.01 ha non-managed plots.

Maximum yields were measured in *P. maximum* and *P. atratum* (3.6 ± 1.5 t dry matter (DM) ha^{-1} $month^{-1}$), whereas *B. ruziziensis* had lowest (1.1 ± 0.6 t DM ha^{-1} $month^{-1}$; $P < 0.01$). The highest response to management was found in *P. maximum* and *B.* hybrid with an average increase of 0.8 t DM ha^{-1} $month^{-1}$ compared to non-managed forages ($P < 0.01$). Maximum crude protein (CP) concentrations were found in *S. guianensis* (128 ± 8 g kg^{-1} DM), followed by *B.* hybrid (98 ± 12 g kg^{-1} DM), *P. atratum* displaying the lowest concentrations (65 ± 8 g kg^{-1} DM; $P < 0.01$). Neutral detergent fiber concentrations were highest in *B. ruziziensis* (668 ± 16 g kg^{-1} DM; $P < 0.01$).

Due to intensity of labour in managing forages, selecting adapted forage species rather than intensifying the management of less well-adapted ones may achieve the yields and nutrition necessary to improve cattle productivity. Hence, *S. guianensis* and *B.* hybrid both rich in CP had the best potential to supplement rations for ruminants.

Keywords: Above-ground biomass yields, Cambodian smallholders, cultivated forages, nutritional quality

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Introduction

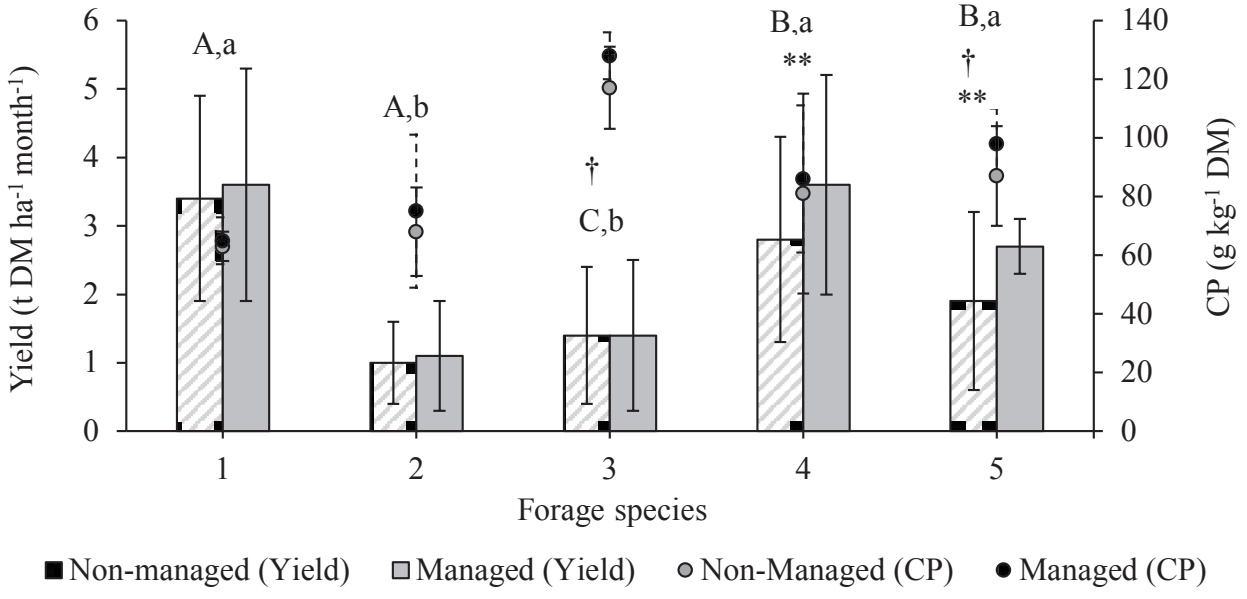
A strong increase in meat consumption in Asia is driving demand for regional livestock produce (Thornton and Herrero, 2014). However, productivity of livestock on smallholdings is generally low, and feeding animals appropriately is often a major challenge (Devendra and Sevilla, 2002). This is increasingly the case in areas of Ratanakiri Province in north-eastern Cambodia, where population growth and concessions of land, are putting pressure on traditional grazing land (Fox and Vogler, 2005). By planting productive and nutritious forages on small parcels of land on the farm and cut-and-carrying these to feed cattle, Cambodian farmers may be able to increase cattle productivity without relying on increasingly scarce natural resources (Young *et al*., 2014). Intensifying forage production through fertilisation, regular weeding and irrigation of improved forage species was a key initial step to substantially enhance livelihoods of smallholders, beside reforming cattle husbandry practises, introducing new breeds, and the opening of farmer clubs and trade networks (Stür and Khanh, 2010). Therefore, the objective of this study was to examine farm-grown forage systems on smallholder farms in Ratanakiri Province evaluating the effects of weeding and manuring the forages on yield and nutritional quality.

Material and Methods

The study was conducted on 20 farms in Lumphat district (13°47′ - 13°60′N, 106°94′ - 106°99′E; 121 m a.s.l.) of Ratanakiri Province, Northeast Cambodia, in 2015. The climate is monsoonal with mean annual precipitations and temperatures of 2,326 mm and 26 °C, respectively (1997 - 2014, Banlung). More than 95% of the rainfall occurs in the vegetation period from May until October. The dominant soil types of the study area are Gleysols and Acrisols (Someth *et al*., 2013). The farms in Au Toteng (n = 4), Pruok (n = 10), Chey Odom (n = 1) and Dei Lou (n = 5) were selected on the basis of their forage plots and the farmers' willingness to participate in trials on their land. Smallholders in this study raised between 5 and 30 cattle. These survived mainly by foraging wastelands, roadsides and forests. During the dry season, animals were grazed freely day and night, whereas during the rainy season, they were tethered or herded. By-products from crops grown in Lumphat district were only used for feeding livestock during the dry season. The leguminous forage species *Stylosanthes guianensis* cv. Ubon and the following four forage grasses were considered: *Brachiaria ruziziensis* cv. Ruzi, *B. ruziziensis* × *B. decumbens* × *B. brizantha* (*B*. hybrid), *Panicum maximum* cv. Mombasa, *Paspalum atratum* cv. Ubon. Experimental plot size on each farm was 0.02 ha, resulting in 0.004 ha forage species^{-1} farm^{-1}. On 0.01 ha month^{-1}, cattle manure with a mean equivalent of 0.24 t N ha^{-1} was applied and weeds were controlled manually. The remaining 0.01 ha were neither manured nor weeded. Values given in this text are expressed as mean ± standard deviation. The biomass of these forages was estimated in the beginning of June, July, August, and September by cutting the grasses and the legume to 6 ± 4 cm and 15 ± 7 cm above ground level in five representative areas of 1 m^2 each, respectively. The collected material of each species was weighed and dry matter (DM) concentrations were determined by drying the samples (n = 197) at 60 °C for 48 h. Samples (n = 41) pooled by farm, forage species and cutting time were analysed for crude protein (CP) concentration by the Dumas combustion method using an Elementar Vario MAX CN Analyser (Elementar Analysensysteme GmbH, Hanau, Germany). Neutral and acid detergent fibre (NDF and ADF) concentrations were estimated according to the methods of van Soest *et al*. (1991) using an ANKOM 2000 Fibre Analyser (ANKOM Technology Corp., Macedon, NY, USA). Data were analysed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Least squares means and standard error of the means of above-ground biomass and each nutrient concentration were calculated for each management and forage species using the Mixed Model procedure (Proc Mixed). The unreduced model consisted of the fixed factors species (species I to species V), management (managed and non-managed), their interaction, and the random factor (farm I to farm XX). For each fitted model, multiple comparisons of least squares means of species and management were done by the Kenward-Roger method.

Results and Discussion

Smallholders grew forages in small areas on non-cropped land close to the house. The available area per farm ranged from 3 to 25 ha. Most of the available land was covered by forests, followed by land area under cassava, cashew and rice. In this study, cultivating and maintaining forages on-farm increased the amount of labour involved in raising cattle compared to the traditional animal husbandry system. Contrarily, Dimang *et al*. (2009) reported that a cut and carry system decreased the work load associated with feeding cattle in the traditional systems. This may be explained by the sufficient availability of feed resources during the rainy season and by farmers giving priority to crop farming. Therefore, the herd sizes decreased by half from 2012 to 2015. Forage growth was mainly limited by water shortages during the dry season and water logging during the rainy season. Smallholders preferred *B*. hybrid and *P*. *maximum* to the other introduced forage species, confirming results of Ba *et al*. (2014). Maximum above-ground biomass of cultivated forages were measured in *P*. *atratum* and *P*. *maximum* with 3.6 ± 1.5 t DM ha^{-1} $month^{-1}$, whereas *B*. *ruziziensis* had the lowest yields with 1.1 ± 0.6 t DM ha^{-1} $month^{-1}$ (Fig 1). Low yields of *B*. *ruziziensis* were probably caused by inadequate nitrogen availabilty, affecting the photosynthetic activity and the root system adversely (Batista *et al*., 2014). This was confirmed by upcoming light green leaves and less tillers. The highest response to management occurred in *B*. hybrid and *P*. *maximum* when yields declined by about 0.8 t DM ha^{-1} $month^{-1}$ in the absence of regular plot management ($P < 0.01$; Fig 1). This highlights the sensitivity of *B*. hybrid and *P*. *maximum* to management, as also reported by Stür and Horne (1999). The forage legume *S. guianensis* showed significantly higher CP concentration of 128 ± 8 g kg^{-1} DM than the remaining forage species ($P < 0.01$; Fig 1). Managing *B*. hybrid and *S. guianensis* resulted in increased CP concentration from 87 ± 17 to 98 ± 12 g kg^{-1} DM and from 117 ± 14 to 128 ± 8 g kg^{-1} DM, respectively ($P < 0.01$; Fig 1). As discussed in earlier studies, low CP concentrations slightly inhibit DM intake of cattle, whereas high ones increase DM digestibility significantly (Riaz *et al*., 2014).



Mean (bars) and standard deviation (error bars); 1, *Paspalum atratum*; 2, *Brachiaria ruziziensis*; 3, *Stylosanthes guianensis*; 4, *Panicum maximum*; 5, *B. ruziziensis x B. decumbens x B. brizantha*; mixed linear model, n = 41, Kenward-Roger´s adjusted F-tests, $P < 0.05$; DM, ** $P < 0.01$; CP, † $P < 0.01$; DM between forage species, a-b denote significant difference at $P < 0.05$; CP between forage species, A-C denote significant difference at $P < 0.05$.

Fig. 1 Dry matter (DM) yields and crude protein (CP) concentrations of managed (monthly weeded and manured with approximately 0.24 t N ha^{-1} $month^{-1}$) and non-managed forages grown in Lumphat district during the rainy season from June to September 2015.

There were no significant changes in ADF and NDF values between managed and non-managed forages. Maximum ADF concentrations were measured in *S. guianensis* with 424 ± 69 g kg^{-1} DM, followed by *P. atratum* with 400 ± 55 g kg^{-1} DM, *P. maximum* with 388 ± 67 g kg^{-1} DM, *B. ruziziensis* with 357 ± 29 g kg^{-1} DM, *B.* hybrid displaying the lowest concentrations with 356 ± 73 g kg^{-1} DM. High ADF concentrations affect the DM intake and DM digestibility of cattle adversely (Riaz *et al*., 2014). Compared to NDF concentrations in *P. atratum* (620 ± 42 g kg^{-1} DM), *B.* hybrid (621 ± 43 g kg^{-1} DM), *S. guianensis* (625 ± 53 g kg^{-1} DM) and *P. maximum* (646 ± 43 g kg^{-1} DM), NDF concentration was significantly higher in *B. ruziziensis* (668 ± 16 g kg^{-1} DM; $P < 0.01$), reducing DM digestibility (Riaz *et al.*, 2014).

Conclusions and Outlook

This research showed that through weeding and manuring, *S. guianensis* increased nutritive value, *P. maximum* above-ground biomass, and *B.* hybrid nutritive value and above-ground biomass. However, during the rainy season, smallholders in this study rarely considered planted and managed forages as worth their long-term benefit. Therefore, participatory approaches may help to develop appropriate forage management strategies to come up to farmers´ expectations. Future research may focus on forage genotypes with ability for water-stress tolerance and water-use efficiency to provide better productivity during fluctuating water regimes. Furthermore, research may assist to reinforce privately or communally owned fenced pastures and agricultural cooperatives to reduce the amount of work involved in planting and managing forages.

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