

Overall performances of *Leucaena leucocephala* and *Morus alba* in high-density shrub fodder banks at maturity in western Burkina Faso Running head: Performance of High-density fodder banks for livestock feeding

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Abstract

The objective of this work was to carry out a long-term monitoring of shrub fodder banks (SFB), established under the real-low-input-farm conditions of Burkina Faso, characterised by a Sudano-Sahelian climate type with wide variations in rainfall. The SFBs, which were planted in 2016-2017 with *Leucaena leucocephala* (LL) and *Morus alba* (MA) at a high-density (20,000 plants/ha), were monitored from 2016/2017 to 2021 for their biomass (fodder) production, chemical composition and nutritive value of the edible forage, and their impacts on soil carbon content. The average annual forage production of LL for the 6 SFBs (1, 2, 3, 4, 5 and 6) was 11.4 ± 2.12 t DM/ha/year while that of MA was 3.8 ± 1.2 t DM/ha/year for the 3 SFB (1, 2, and 3). Such differences are likely related to higher adaptive capacity for LL in such climatic conditions. The high nutritive value observed in both fodder resources agreed with available literature worldwide. Crude protein was higher in LL (19% vs. 17%), but dry matter digestibility (65% vs 77%) were superior in MA. Soil carbon increased during the five monitored years, which is an interesting result for these poor, low fertility soil conditions. Our results demonstrate the technical and environmental feasibility for establishing this low-input agroforestry technology in these conditions, as an agroecological alternative to overcoming feed shortages for local livestock farming. However, the successful management of a SFB relies on the selection of the right species, the protection provided, and the management during the establishment and fodder production periods, with suitable cutting frequency and appropriate post-harvest management.

Introduction

In West Africa, livestock farmers need additional fodder sources to adequately feed their animals without the risk of damaging the fragile local ecosystems. They traditionally rely upon natural resources (spontaneous herbaceous plants, fodder trees and shrubs), crop residues (cereal straw, legume tops) and several feed concentrates that are more or less locally available.

Traditionally, during difficult periods, farmers used seasonal mobility strategies towards areas with pastoral resources (Dongmo et al. 2012). Nowadays, these strategies are limited by the expansion and fragmentation of cultivated land as part of the population growth process, as well as by seasonal variations in rainfall that are exacerbated by climate change effects. During the dry season, locally produced crop residues do not provide enough supplementary feeds to sustain ever increasing herds, and acquiring external feeds is often expensive, beyond the resources of the low-income small-scale farmers. To face these multiple challenges that constrain animal, and more specifically dairy production, livestock farmers must adapt their feeding practices by exploring new ways of producing supplementary fodder resources on their farms. They also need public policy supports in order to find ways for accessing land for fodder, pasture and animal feed production at an affordable cost (Dongmo et al. 2012).

In that context, improving forage and feed autonomy becomes a priority. Fodder production options are known to include herbaceous and/or woody fodder crops grown as shrub fodder banks (SFB; Bayala et

al. 2022). In the Sudano-Sahelian zone, spontaneous woody fodder plants provide a rich source of fodder during the dry season, when the nutritive value of herbaceous forage in the savannah declines (Klein et al. 2014). In addition to provide fodder of good nutritive value, planting woody fodder species could help to reduce pressure on native trees and shrubs through pruning on rangelands during the dry season (Bayala et al. 2022), while also providing ecosystem services such as soil fertility improvement through soil carbon sequestration (Wezel et al. 2000), increased wildlife biodiversity (Tacon et al. 2000), traditional pharmacopoeia, fuelwood, timber and handicraft wood (Klein et al. 2014). In the humid tropics, SFB is considered as an agroforestry technology that involves planting high-density fodder trees/shrubs to yield large quantities of protein-rich fodder. In these regions this technology has shown potential for improving livestock feeding both as green or, conserved, dried fodder (González-García and Martín-Martín 2016; Bayala et al. 2022). In the relatively dry savannah areas of West Africa (i.e. Burkina Faso), our previous research (Sib et al. 2019; 2020) has shown the suitability and potential for establishing SFB.

The objective of this work is to report performance of SFBs under the Western conditions of Burkina Faso, in terms of biomass production and nutritive value, and their impact on soil conditions during the exploitation period until they reached maturity.

Material and methods

SFB planting sites

Full details and information regarding the establishment phase of SFBs planted on six livestock farms located in the provinces of Houet and Tuy (located between latitudes 11 and 12°N and longitudes 3 and 4°W in the Haut-Bassins region of western Burkina Faso) have been previously reported by Sib et al. (2019; 2020). In summary, these two provinces have a southern Sudanese climate with an annual rainfall pattern of between 800 and 1,000 mm, defined by a rainy season from June to October and a dry season from November to May. Figure 1 shows the progression of climate variables recorded over the six years of monitoring from 2016 to 2021. The vegetation consists of grassy and wooded savannahs, and gallery forests along waterways. In terms of soil type, leached tropical ferruginous, ferralitic and poorly developed soils predominate. In the six SFBs sites, soils are predominantly sandy, with pH values ranging from 5.2 to 6.5, average organic matter content of 0.5% and low levels of available phosphorus (2 to 7.2 mg/kg; Sib et al. 2019).

Field structure for establishing each shrub fodder bank

Six SFBs were established (625 m² each) from 2016 (SFB 1, 2 and 3) to 2017 (SFB 4, 5, and 6) under real-farm conditions, relying on volunteer local farmers. A high density of plants was used (20,000 plants/ha) allowing a spacing frame of 1 m between rows and 0.5 m between plants. The SFB 1 to 3 consisted of one block of *Leucaena leucocephala* (0.03125 ha) and one block of *Morus alba* (0.03125 ha). In SFBs 4 to 6 we had one block of *Leucaena leucocephala* (0.03125 ha) and one block of mixed *Gliricidia sepium*

and *Albizzia lebbeck* in SFB4, *Albizzia lebbeck* and *Samanea saman* in SFB 5 and 6. A living fence consisting of *Gliricidia sepium*, *Albizzia lebbeck*, *Samanea saman*, and *Acacia nilotica* was established around the SFB, with an average width of 0.5 m. This was surrounded by metal URSUS fencing (Sib et al. 2020). In SFBs 4 to 6, the described species mixture is the result of the absence of *Morus alba* plants due to poor germination of seeds of this species in the nursery. Fodder production in mixed blocks in SFBs 4 to 6 and live fences were not evaluated in this study.

In order to maximize the technology mastery and adoption around this innovative approach, a consultation framework was set up with the volunteer farmers who accepted to establish SFBs. Annual meetings were carried out in order to discuss SFB management, needs and performances (e.g. organic amendment, protection against termites, mulching, cutting rates, potential storage and conservation techniques to be mobilized, protection with living fences, yields).

Managing the establishment and exploitation of shrub fodder banks

There are two main periods involved in the establishment of the SFBs: the installation period (juvenile stage) and the exploitation period (Growth and maturity phases) (Fig. 2). Overall SFBs started production one year after their installation when the plants had reached an average height of 2 m and an average diameter of 2 cm. The first three SFBs (1, 2 and 3), installed in 2016 (year 1), went into production in 2017 (year 2), except for SFB 1 (bushfire occurrence), which was replanted in 2017 (under reconstitution and therefore considered in year 1). SFBs 4, 5 and 6, installed in 2017 (year 1), started production in 2018 (year 2) at the same time as SFB 1 (Fig. 3). SFBs 2 and 3 have a total of 5 years of production, while SFBs 1, 4, 5 and 6 have a total of 4 years of production in 2021 (Fig. 2). Managing the exploitation phase of the SFBs for livestock feeding on each farm involved three main groups of activities: fodder harvest, SFB maintenance and post-harvest fodder management

The exploitation period began with an implementation of a sequence of three cuts per year : i) an initial “standardization” cut at a height of 120 cm (12 months after planting); ii) a second cut at a height of 50 cm (15 months; fodder from these two first cuts made in the rainy season was dried and stored for later distribution to animals in the dry season); and iii) a third cut at a height of 50 cm at 18 months during the cool dry season (used for green distribution following a cut and carry system). This harvest regime (three cuts/year) was applied during the first two years of the exploitation period in SFB 2 and 3 and in the first year of exploitation in SFB 1, 4, 5, and 6 (Fig. 3).

However, starting from the third year of SFBs 2 and 3, and the second year of the other SFBs, based on the experience gained from the three-cuts regime, it was decided to discontinue the “cut and carry” sequence (harvesting in December during the cool dry season corresponding to the third cut). This decision was made due to the fact that, starting from the cool dry season, the plants began to experience water stress caused by the lack of precipitation. This observation indicated that this strategy weakened the plants during the extended dry season that followed.

The SFB maintenance consisted of regular manual weeding (twice a year) to prevent weed competition, replacement of dead plants, maintenance of fences (including live fences), and maintenance of firewalls to prevent bushfires. The peculiarity of this maintenance in year 1 was the use of a single application of soil amendments, in particular, park yard (2.5 t MS/ha) and mulching (10 t MS/ha) at the end of the rainy season to prevent soil desiccation and to control termites.

These maintenance activities were carried out with a gradient of degrees of care by the experimental farmers depending on their priorities, workload, and interests.

Given that the fodder harvesting period falls in the rainy season, post-harvest management of the SFBs is important in order to avoid fodder losses. During the first three years of exploitation of the SFBs, volunteer farmers struggled to dry and store the fodder harvested during the rainy season, as they lacked adequate infrastructure to do so. This led to high fodder losses. As a result, they requested and were granted support to build sheds and acquire equipment (tarpaulins, bags) in order to better manage the large quantities of fodder produced during the rainy season.

Data collection and analysis

Annual monitoring of fodder production

We monitored fodder production from the establishment 2017/2018 until 2021 i.e. during 5 ans pour les SFBs 2 and 3, and 4 ans pour les SFBs 1, 4, 5 et 6 (Fig. 3).

To assess fodder production, the fresh forage produced was on each occasion weighed and converted to dry matter (DM) per hectare (kg DM/ha), once the DM percentage of a representative sample of edible forage per cut and SFB was determined. For each species, DM was determined as the difference between fresh and dry weight after the sample had been oven-dried at 60°C for 48 hours. The average DM percentage was 36% and 30% for *Leucaena leucocephala* and *Morus alba*, respectively.

The annual fodder production for each species was obtained by summing production results from each cutting period of the year. In the data analysis, the SFB 2 and 3 data series were compared with each other as they began production one year before the other SFB. In contrast, SFB 1, which was installed simultaneously with SFB 2 and 3, was severely affected by a bush fire, requiring replanting in the second year, corresponding to the year of installation of SFB 4, 5 and 6. The latter (SFB 1, 4, 5 and 6) which started production in the same year were also compared. We compared the average total annual fodder biomass production of each species (*Leucaena leucocephala* and *Morus alba*), according to the SFB site, age, and harvesting season (rainy and cool dry) using two-way ANOVAs in each instance on XLSTAT (Addinsoft-Paris France). For *Morus alba*, only the three SFBs (1, 2 and 3) where this species was installed were taken into account. Whenever a significant difference was found ($p < 0.05$), the ANOVA was followed by a Newman-Keuls test in order to classify the means into homogeneous subsets.

Forage chemical composition and nutritive value

To determine the chemical composition of SFB forages, samples of edible forage (leaves and tender stems) were collected for each species ($n = 2$; *Leucaena leucocephala* and *Morus alba*) at each cutting ($n = 3$; C1, C2, C3) during the different seasons ($n = 2$; rainy and cool dry) from 2017 to 2021.

The analyses of chemical composition (dry matter (DM), mineral content (ash, MM), crude protein (CP), fiber content (Cellulose Content (CC); NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin), DM (DMD) degradability) were performed by using near-infrared spectrophotometry (NIRS) (Bastianelli et al. 2018).

In order to compare the chemical composition of both fodder species, six key parameters were retained (DM, CP, NDF, ADF, ADL, DMD) and compared by site (SFBs) and harvesting season (rainy and cool dry) using one-way ANOVAs in XLSTAT (XLSTAT 2019.4.1.63353). Whenever a significant difference was found ($p < 0.05$), the ANOVA was followed by a Newman-Keuls test in order to classify the means into homogeneous subsets.

Soil analyses

To study the influence of SFBs on soil carbon storage capacity throughout time, in 2021 soil samples were collected in five SFBs (1, 2, 3, 4, and 5) except SFB 6 because in this SFB we missed data from the establishment period. In each block in the SFBs, three sites were sampled. Soil carbon contents obtained under the SFBs were compared with those obtained before the SFBs were established.

The methodology adopted consisted of taking soil samples along the diagonal of each section. Samples were taken at three points per block and samples from the same horizon were mixed to form a composite sample, i.e. two composites per block (one composite for the 0–20 cm horizon and one composite for the 20–40 cm horizon). These samples were then dried in ambient air (33 C). The total carbon of each soil sample was measured following the Walkley and Black method (1934).

Results and discussion

Changes in fodder production according to the site, age, season, and cutting periods

The average annual fodder production of *Leucaena leucocephala* in SFB 2 and 3 were respectively 13.4 ± 2.6 t DM/ha/year and 8.8 ± 1.7 t DM/ha/year from 2017 to 2021. In SFBs 1, 4, 5 and 6, the average annual fodder production was respectively 12 ± 2.46 t DM/ha/year, 14 ± 3.61 t DM/ha/year, 10.8 ± 1.18 t DM/ha/year and 9.3 ± 1.18 t DM/ha/year (Fig. 4). Statistical analyses showed a significant difference between SFB 2 and 3 ($p < 0.05$ for *Leucaena leucocephala*), while no difference was found between SFB 1, 4, 5 and 6.

Morus alba recorded 4.9 ± 0.96 t DM/ha/year, 3.9 ± 0.80 t DM/ha/year, and 2.5 ± 1.45 t DM/ha/year respectively for SFB 1, 2 and 3 (Fig. 4) and the Newman-Keuls test found a significant difference

between average annual biomass obtain in the three SFBs.

According to age for *Leucaena leucocephala* species, between the first year of production for SFB 2 and 3 and the second year of exploitation, the annual average fodder production increased by about 5 tDM/year before declining steadily from year 3 to year 5. In SFBs 1, 4, 5 and 6, the upward trend was also noted, with an annual average increase of 1.15 t DM/year between year 1 of production and year 2, before it declines steadily until year 4 of production. Overall, the average production of *Leucaena leucocephala* from the first to the fourth year of SFBs production was: 11 t DM/ha/year, 13.4 t DM/ha/year, 10.5 t DM/ha/year and 10.7 t DM/ha/year, respectively (Fig. 5).

The same observation was made for *Morus alba*, with an increase from the first to the second year of production, i.e. an average annual increase of around 2 t DM/year before starting a regular decline. The overall average production of *Morus alba* from the first to the fourth year of SFBs production was: 3 t DM/ha/year, 4.9 t DM/ha/year, 3.9 t DM/ha/year and 3.2 t DM/ha/year, respectively (Fig. 5).

This increment is consistent with results obtained in other edaphoclimatic conditions and reported in studies by Tewari et al. (2004). However, from the third year onwards, a steady decline in the average annual fodder production was noted for both species. With regard to age, the ANOVA did not show any significant difference between the average annual production for both species.

When comparing the average production per season, the ANOVA showed significant differences between average yields achieved in the rainy season to those achieved in the cold dry season for both species. But in the two cases fodder production volumes gradually declined from rainy season to cold dry season (Fig. 6).

There could be two reasons for this. Firstly, the frequency of harvest per year (number of cuts) was reduced from 3 to 2 starting from the third year for SFBs 2 and 3, and from the second year in the case of SFBs 1, 4, 5 and 6. This led to fodder production no longer being considered in cut 3 (in the cool dry season). We decided to drop the third cut in the cool dry season because it provided little biomass and weakened the SFBs, which is physiologically explained by the fact that in the cool dry season plants fight for survival by slowing down their growth and leaf production. A cut performed during this period would likely disrupt this physiological response. We also found in SFBs 2 and 3 that plants harvested during this period were more exposed to termite attacks especially for *Morus alba* and therefore more vulnerable.

Conversely, according to the findings of González-García and Martín (2016), under Cuba's wetter tropical conditions (1300–1500 mm per year, with a rainy season concentrating 80% of rainfall from May to October and a dry season running from November to April with occasional rainfall) and on richer soils than those of Burkina Faso (organic matter: 4.3%, nitrogen: 0.1% and available phosphorus of 23 mg/kg, reported by Sib et al., 2019), a 60-days pruning interval in the rainy season and every 90 days in the dry season were found to be the optimal seasonal patterns for shrub fodder bank yields and forage quality. Bayala et al. (2022) also suggested a 3-month pruning interval for *Gliricidia sepium*.

The second reason could be the halt in regular organic amendments to SFBs after the establishment stage. As the SFBs were planted on generally sandy soils with low nitrogen (N) (ranged from 0.3 to 0.9% in the first 0–20 cm and from 0.3 to 0.6% in the 20–40 cm layers) and phosphorus (P) contents (ranged from 3.67–7.25 mg/kg soil and 1.9–3.42 mg/kg soil on the 0–20 cm and 20–40 cm) (Sib et al. 2019), soils were amended with organic manure only at the establishment period (at a rate of 2,500 kg/ha), whereas regular inputs of organic manure would provide a constant supply of nutrients that would improve SFB productivity (González-García and Martín 2016). Given the high density of 20,000 plants/ha, and with fast-growing species such as *Leucaena leucocephala* and *Morus alba* (González-García et al. 2009; Karatassiou et al. 2008), competition between plants could quickly set in from the second or third year onwards, contributing to a reduction in forage yields per plant if no fertiliser was applied. This lack of organic amendment was particularly noticeable in *Morus alba*, resulting in poor establishment (frequent drying out in the dry season and recovery in the rainy season) and high mortality due to water stress and termites (Sib et al. 2019). These are definitely not ideal conditions for a non-leguminous species such as *Morus alba* which are better adapted to more fertile soils with good content of organic matter (Datta 2002).

Fodder chemical composition of *Leucaena leucocephala* and *Morus alba*

The CP, NDF, ADF, ADL contents, and the *in vitro* digestibility values for *Leucaena leucocephala* and *Morus alba* fodder did not vary significantly in relation to SFB site and age. However, these indicators were significantly different between the rainy and the cool dry seasons ($p < 0.05$) except for *Morus alba* DM, OM, ADL contents (Table 1). A significant difference ($p < 0.05$) was also observed when comparing composition of *Leucaena leucocephala* and *Morus alba*, with *Leucaena leucocephala* containing more DM, OM, CP, NDF, ADF and ADL (Table 1). Conversely, *in vitro* DMD was higher in *Morus alba* ($77 \pm 2\%$), indicating that this species is more digestible than *Leucaena leucocephala* ($65 \pm 2\%$), a tannin-rich legume (Archimede et al. 2016). *Leucaena leucocephala* is a forage tree legume considered to have a high nutritive value despite the high tannin content (Shelton, 2001). Our results showed that the CP content of *Leucaena leucocephala* was higher than in *Morus alba* regardless of the season (19% vs. 17% for *Leucaena leucocephala* and *Morus alba*, respectively). However, *Morus alba*, a non-leguminous forage species, had the advantage of displaying lower NDF and ADF contents, which made it more digestible than *Leucaena leucocephala* (Table 1).

Our results show that possible differences can be found in the forage quality of the same plant species when comparing contrasting climatic seasons. According to González-García et al. (2009) and Liliane and Charles (2020), water is an essential input that directly affects crop production and indirectly impacts the availability of nutrients in those crops. The drop in CP during the dry season could be related to the lower leaf/stem ratio and the rise in cell wall constituents (González-García et al. 2009) such as ADF and NDF, which discriminate the efficient use of plant resources even when they are protein-rich (Archimede et al. 2016).

Given that the fodder harvesting period falls in the rainy season (the highest production period), this justifies looking for adequate post-harvest management of the SFBs in order to avoid losses and especially preserve the quality of fodder harvested during this period for later use during the dry season.

Table 1
Chemical composition and *in vitro* digestibility of DM (%) of *Leucaena leucocephala* and *Morus alba* in relation to season

	DM (%)	OM (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	In vitro DM digestibility (%)
<i>Leucaena leucocephala</i>							
RS	34b	91b	20a	35b	23b	13a	66a
CDS	39a	93a	14b	39a	27a	9b	59b
Average	36,5 ± 4	92 ± 1	17 ± 4	37 ± 3	25 ± 3	11 ± 3	62,5 ± 5
p-value	< 0.0001	0.030	< 0.0001	0.017	0.002	< 0.0001	0.0002
<i>Morus alba</i>							
RS	30	88	18a	28b	17b	5	80a
CDS	31	86	13b	35a	22a	5	66b
Average	30,5 ± 1	87 ± 1	15,5 ± 4	31,5 ± 5	19,5 ± 4	5	73 ± 10
p-value	0.276	0.422	< 0.0001	0.000	0.008	0.386	< 0.0001

DM: Dry Matter; OM: Organic Matter; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; RS Rainy Season, CDS: Cool Dry Season

a, b, c: values in columns with different letters differs at $p < 0.05$

Changes in soil carbon contents

From 2016 to 2021, the proportion of carbon found in soils under the SFBs changed, and this was observed in all SFBs. The average increase in carbon between the two periods was 64% in the layer 0–20 cm, and 85% between 20 and 40 cm (Fig. 8). This increase may be due to: the added organic manure at establishment (at a rate of 2.500 kg/ha), input of leaf litter, root turnover and potentially higher levels of soil microbes (Bernoux and Chevalier 2013). The study by Doumbia et al. (2020) in Mali showed that planting *Gliricidia sepium* in the corridor increased the organic carbon and total nitrogen content in the soils between the alleys by 5% after three years. Similarly, this study also showed that the application of mulch produced from *Gliricidia sepium* on crops allowed to maintain and improve the physical and chemical properties of soils (Diouf et al., 2008; Smethurst et al., 2017; Doumbia et al., 2020; Kuyah et al., 2019). According to Dimobe and Bayala (2023) shea agroforestry parks contribute significantly to carbon

sequestration in soils. However, the sequestration of agroforestry systems could vary from one system to another. The study of Fané et al. (2022) showed that the fallow system for example sequesters more carbon than the agroforestry system planted because in general tree plantations are poorly maintained and are carried out in inappropriate spaces, this limits the production of above-ground biomass that serves as mulch and enriches the soil through the action of soil microorganisms.

Conclusion

Our results confirm that shrub fodder banks (SFBs) are a viable approach to enhancing forage production under the Western climatic conditions of Burkina Faso and can maintain high fodder production for a species such as *Leucaena leucocephala* (about 11 t DM/ha/year), of high nutritive value (17–22% CP) with minimal external inputs under such fluctuating and harsh climatic conditions with poor soils. *Leucaena leucocephala* achieved better fodder production performance compared to *Morus alba* (3.8 t DM/ha/year; 14–18% CP), which may likely be due to less adaptive capacity of *Morus alba* under such conditions. In terms of forage nutrient content, our results showed that crude protein content remained unchanged over time. From an environmental perspective, our findings also showed that establishing SFBs have contributed to increasing soil carbon storage and therefore improving soil quality under the SFBs.

The successful management of an SFB depends on the selection of the right species, protection, management during establishment and forage production, with appropriate cutting frequency and post-harvest management.

Declarations

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Conflict of interest. The authors declare that they have no conflict of interests.

Author Contribution

O.S., E.V., E.G.G. ont participé à la conception et à la planification de l'étude ; O.S., F.S., J.M.D. ont recueilli les données ; O.S., E.V. et E.G.G ont analysé, interprété les données et O.S. a rédigé la première version du manuscrit ; OS, EV, EGG, M.H.A. P.K.K. D.D. J.M.D. et S.S. ont participé à la révision du manuscrit.

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Figures

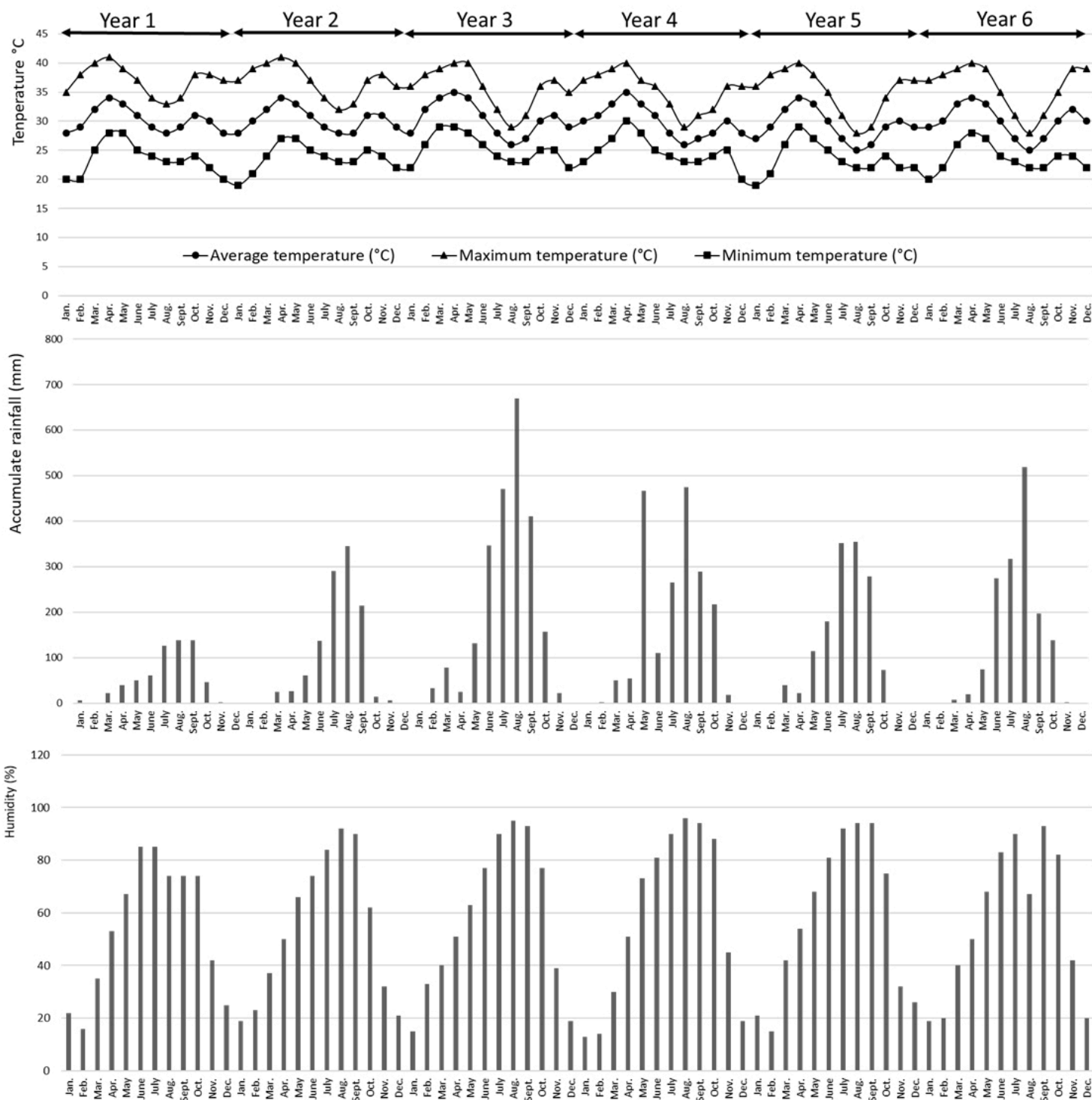


Figure 1

Average temperature, rainfall and relative humidity in Bobo-Dioulasso (Hauts-Bassins, Burkina Faso) and its surrounding area from 2016 to 2021.

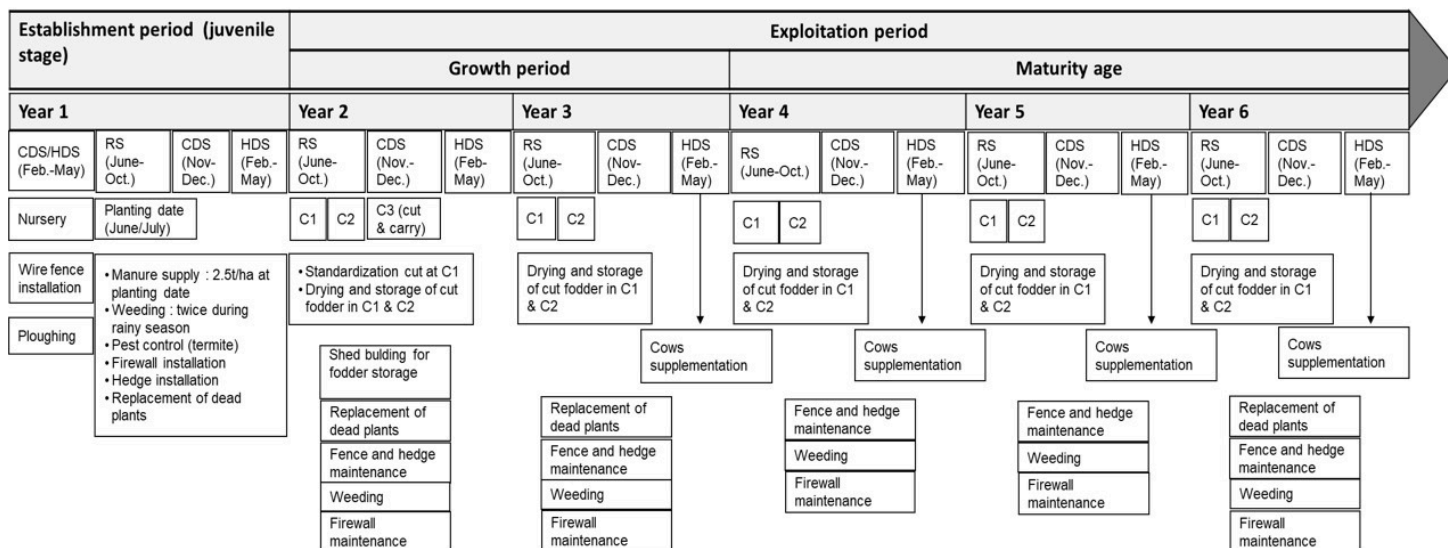


Figure 2

Stages in the life of a shrub fodder bank, from establishment to exploitation periods under the study conditions

Establishment period (juvenile stage)		Exploitation period											
	Year 1 (2016)	Year 2 (2017)			Year 3 (2018)			Year 4 (2019)		Year 5 (2020)		Year 6 (2021)	
SFBs	Jun-Jul	Jul	Sep	Dec	Jul	Sep	Dec	Jul	Sep	Jul	Sep	Jul	Sep
SFB 2	Establishment	Growth						Maturity					
		x	x	x	x	x	x	x	x	x	x	x	x
SFB 3	Establishment	Growth						Maturity					
		x	x	x	x	x	x	x	x	x	x	x	x

Establishment period (juvenile stage)		Exploitation period									
SFBs	Year 1 (2017)	Year 2 (2018)			Year 3 (2019)		Year 4 (2020)		Year 5 (2021)		
SFB 1 Establishment (bushfire occurrence)	Establishment/ Reconstitution	Growth					Maturity				
		x	x	x	x	x	x	x	x	x	x
SFB 4	Establishment	Growth					Maturity				
		x	x	x	x	x	x	x	x	x	x
SFB 5	Establishment	Growth					Maturity				
		x	x	x	x	x	x	x	x	x	x
SFB 6	Establishment	Growth					Maturity				
		x	x	x	x	x	x	x	x	x	x

Figure 3

Forage biomass production monitoring schedule for the six SFBs

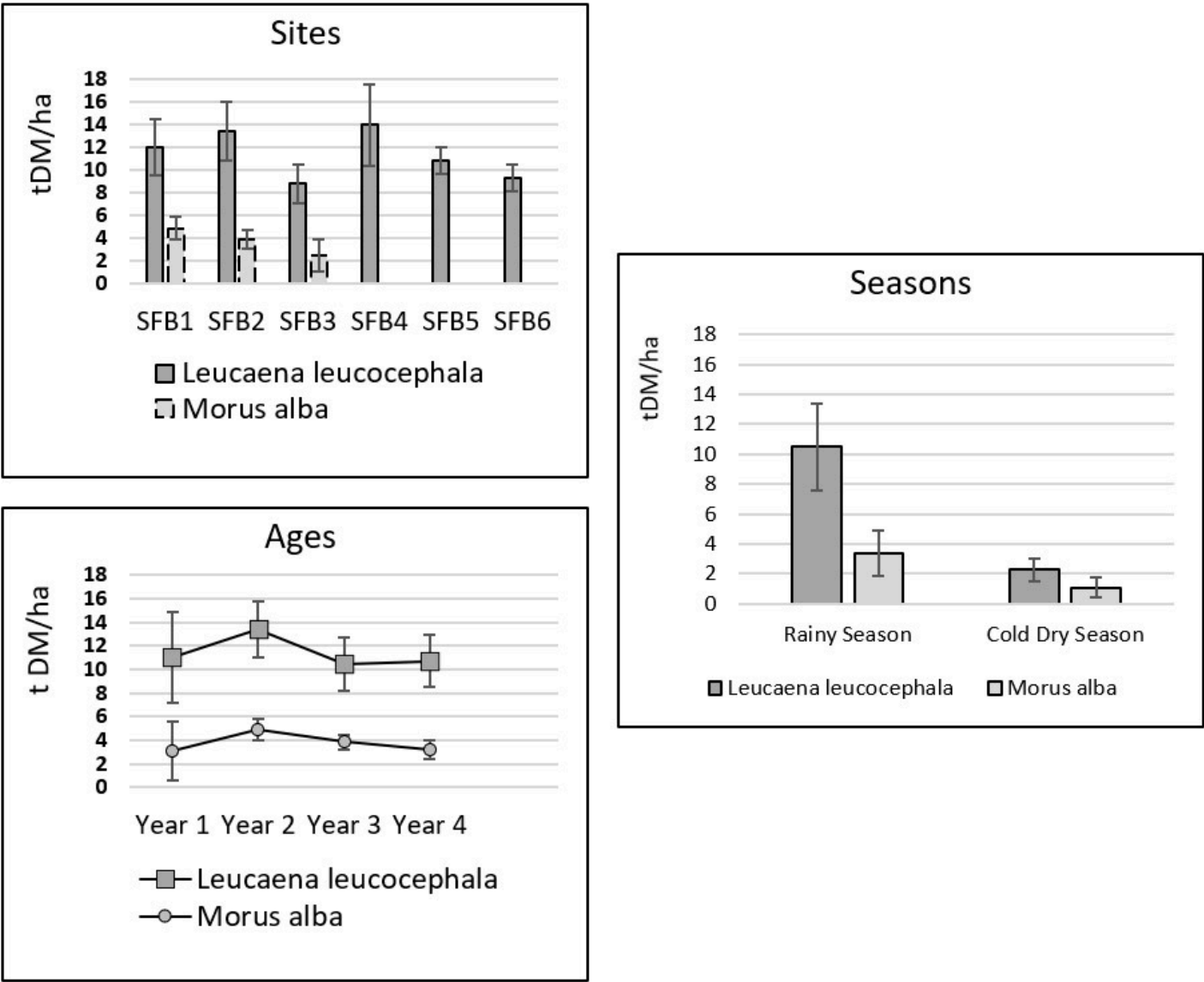


Figure 4

Average annual forage biomass production by species and sites ; Average annual forage biomass production by ages and species; Average annual forage biomass production by seasons and species

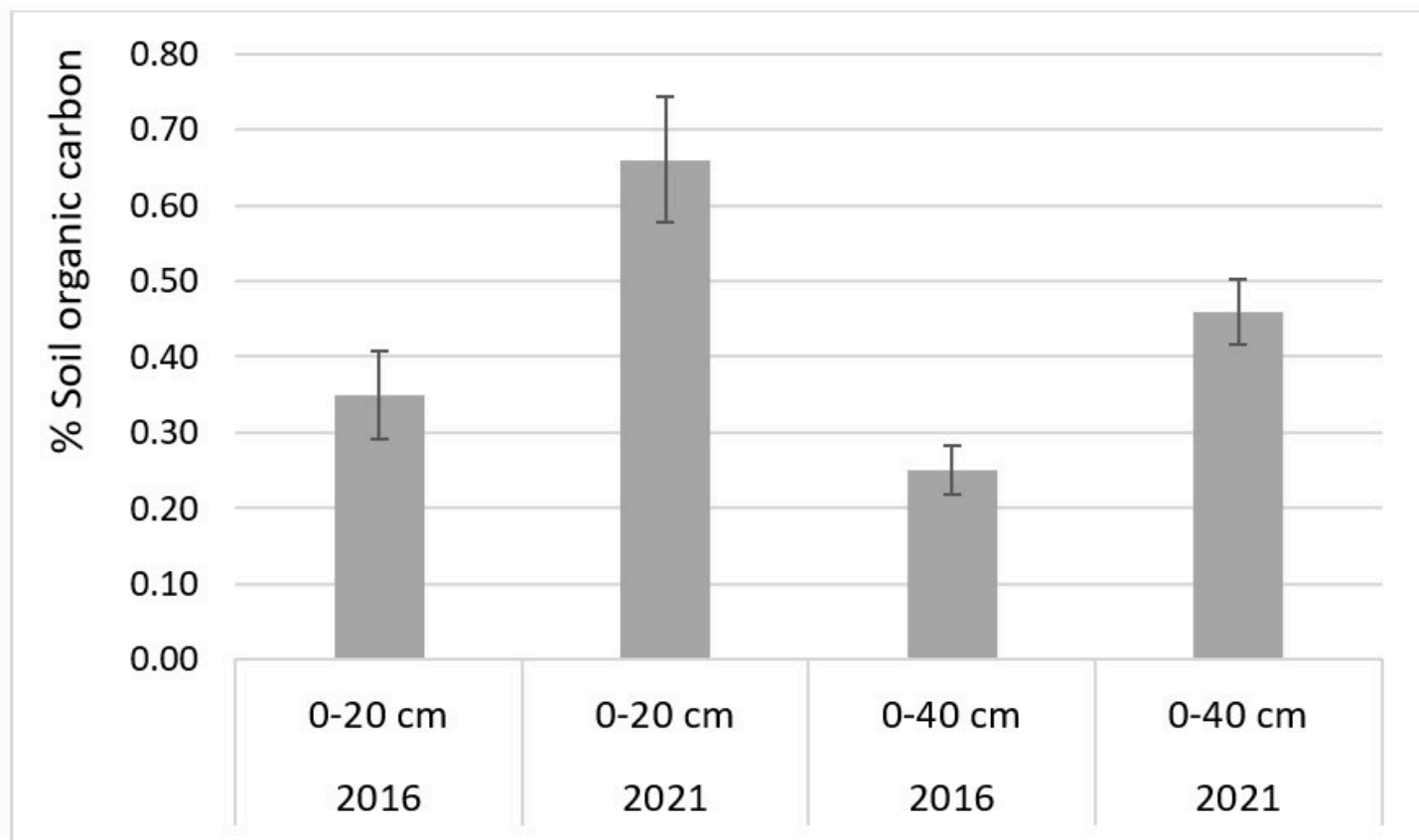


Figure 5

Changes in soil carbon content under shrub fodder banks