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Phenology and fruit production of *Piliostigma reticulatum* (DC), Hochst., an agroforestry forage species in the Sahel

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ABSTRACT
In central Burkina Faso, *Piliostigma reticulatum* is a more and more adopted agroforestry species by farmers but is increasingly over exploited because of the use of its pods as forage. Therefore, understanding its phenology and fructification becomes urgent for a better management of existing parks. The flowering and fructification stages of two populations (41 trees of 10 years old obtained from stumps and 35 planted trees aged 4 years) were monitored every two days on the same fallow during three consecutive years. Physical parameters of each tree were measured and the pods harvested at maturity, counted, dried and weighted. The fruit production of *P. reticulatum* happens once a year during the rainy season. Old trees' flowering as well as their fruit formation started earlier than for younger ones. These stages (flowering and fruit formation) started in July but August is the most determining month because of the regular and sufficient rainfall during this period. Sixty percent of trees aged 10 to 12 years reached 100 % flowering stage while only about 12 % of 4 to 6 years old trees reached this stage. Fifty-six percent of plants aged 10 to 12 years reached 100 % fruit formation stage whereas only 12 % of trees aged 4 to 6 years could reach this stage. The old populations produced more pods than less aged ones (8 kg against 1 kg). Pod production was determined by the magnitude of the tree's crown, which was strongly correlated with the pod weight (R^2= 0.77) and their number (R^2= 0.75).
Keywords: Flowering; Pod production; Rainfall; Agroforestry; *Piliostigma reticulatum*

INTRODUCTION

Burkina Faso is a Sahelian country with a weak economy driven by agriculture. The annual rainfall is low and erratic [1]. Trees' parkland is the traditional production system which provides the populations with wood and by-products of trees.

However, some agroforestry species that were previously neglected are nowadays being revalorised in traditional agroforestry parklands of the central plateau of Burkina Faso [2]. These species are spared by farmers depending on the needs of populations: fuel wood, pharmacopoeia, shade, soil protection and enrichment. *Piliostigma reticulatum,* a species that is plentiful in the Central Plateau of Burkina Faso, is greatly used for animal feeding [3], traditional pharmacopoeia, handcrafting [4, 5], and as fertilising tree [6]. Moreover, the harvest of pods by agro-pastoralists and women constitute an important activity for income generation in many villages of the Central Plateau.

Despite the growing interest of *P. reticulatum* for the use of its pods in animal feeding in Sahelian countries, studies on the biology of the sexual reproduction and on the fruit formation are scarce and even missing. Indeed, studies on *P. reticulatum* dealt with fodder value of pods [7, 8, 3, 5] and the medicinal use of the tree's by-products [9, 10, 11, 12, 5, 6].

Taking into account the great agroforestry potentialities of this species [13, 14], it appears an urgent need to study the phenology in order to plan the utilisation, *i.e.* to balance the needs in term of animal feeding with the production potential of the species. The better knowledge of *P. reticulatum* species would allow a better management of its populations through applications of sylvicultural practices that take into account the populations needs. This study aims to allow a good management of *P. reticulatum* species through a comprehensive knowledge of its phenological calendar and its fruit production capacity in this region of the country where population density is very high [15].

METHODOLOGY

Study site

The study was conducted within the park of the agricultural research station of INERA at Saria village, located 80 km South-West of the capital Ouagadougou (Figure 1). Geographic coordinates are 12°16'N latitude, 2°09'W longitude, and 300 m altitude. The climate is north-Sudanian type and characterised by two contrasted seasons: a long dry season from October to May and a rainy season from June to September. The average annual rainfall is 800 mm with considerable spatial and temporal variations. Rainfall during the three years study (Figure 2) illustrates well these rainfall variations. The annual temperature averages 28°C with monthly maxima reaching 40°C (March-April). Saria village is densely populated, with 102 inhabitant /km [16]. Agriculture remains the major activity with sorghum and millet as main staple crops.

The major soils are of *ferric lixisol* type with granite as parent material. These soils are poor in phosphorus, organic carbon, and exchangeable bases [1]. The vegetation is classified as north-Sudanian type [17], and is characterised as a savannah with annual Graminaceae, trees and shrubs. The main tree species are *Vitellaria paradoxa* Gaertn.f., *Lannea microcarpa* Engl. Et Krause, *Tamarindus indica*, *Azadirachta indica* A.Juss. Shrubs are mainly dominated by thickets and Combretaceae species such as *Guiera senegalensis* J.F.Gamel., and *Combretum nigricans* Lepr. Ex Guill. et Perr. The herbaceous stratum is made up of *P. reticulatum*. *Loudetia togoensis* Hubb., *Dactyloctenium aegyptium* Beauv., *Cymbopogon giganteus* Chiev. and *Andropogon gayanus* Kunth.

Study material

The study was conducted on a fallow of 10 years old where the dominant species is *P. reticulatum* followed by *Guiera senegalensis* J. F. Gmel., and *Azadirachta indica* A. Juss. From this fallow, 41 naturally regenerated trees (obtained from stumps) of *P. reticulatum* and 35 planted trees of 4 years old (age of the first year fructification) were selected. Stumping and plantation are two sylvicultural practices commonly used by rural populations. Naturally regenerated trees possess several shoots and are generally tall while planted trees have only one trunk, a strait port but are of small height. *P. reticulatum* is a species that conserves its leaves along the whole year.

Data collections

The study of the phenology concerned the trees' flowering and the fructification, two determinant phenophases during the production cycle of the species. The method of Grouzis and Sicot [18], which consists in a regular follow-up of the different phases of the phenology, was used. The measurements were done every two days during the three consecutive years (2005, 2006, and 2007) on the planted trees of 4, 5 and 6 years and on the trees obtained from stumps of 10, 11 and 12 years old.

Measurements concerned the three following phenological stages:

- Stage 1: corresponds to the starting of flowering or fructification of each tree, *i.e.* when the first flowering bud or the first pod appears.
- Stage 2: corresponds to 50 % flowering or fructification, *i.e.* when about half of the tree crown surface is covered of flowers or fruits.
- Stage 3: corresponds to 100 % flowering or fructification, *i.e.* when the whole crown surface is covered of fully bloomed flowers or pods.

Fruit biomass was determined at harvest time. At maturity, fruits of each selected tree of *P. reticulatum* were entirely harvested; the pod numbers were determined and the fruit dry weight registered using a balance with 0.001 g precision. On each harvested tree, the plant height, the East-West and North-South diameter of the crown, the number of stem and the circumference at 5 cm from the soil surface, were measured.

Data analyses

Data were computerised using Excel and analysed with SPSS 13.0 software. Anova tests and regression analyses were used to establish the effect of plant physical parameters on fruit production while Duncan test determined significant differences among means at $p \leq 0.05$.

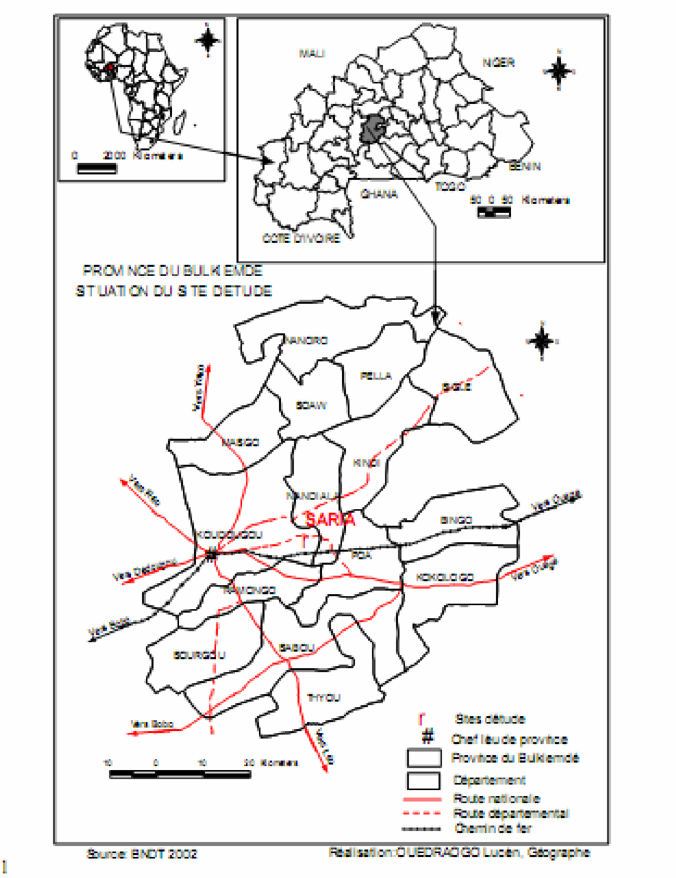

Figure 1: Localisation of the study site

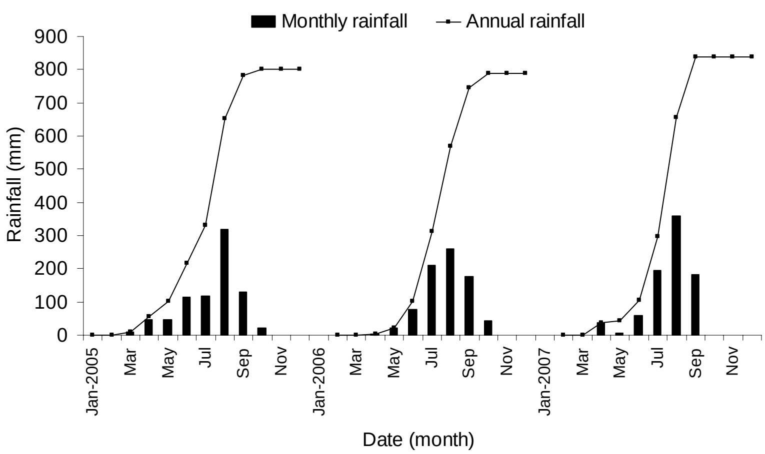

Figure 2: Rainfall per month at Saria research station from 2005 to 2007

RESULTS

Plant flowering

P. reticulatum flowering occurs once every year during the rainy season (Figure 3a, b, c). The flowering starts earlier for old trees (10, 11, 12 years) than for younger trees (4, 5, 6 years old). During the first study year, *P. reticulatum* flowering started at the 3rd decade of July for 4 years old trees while from the first decade of the same month for the 10 years old trees (Figure 3a).

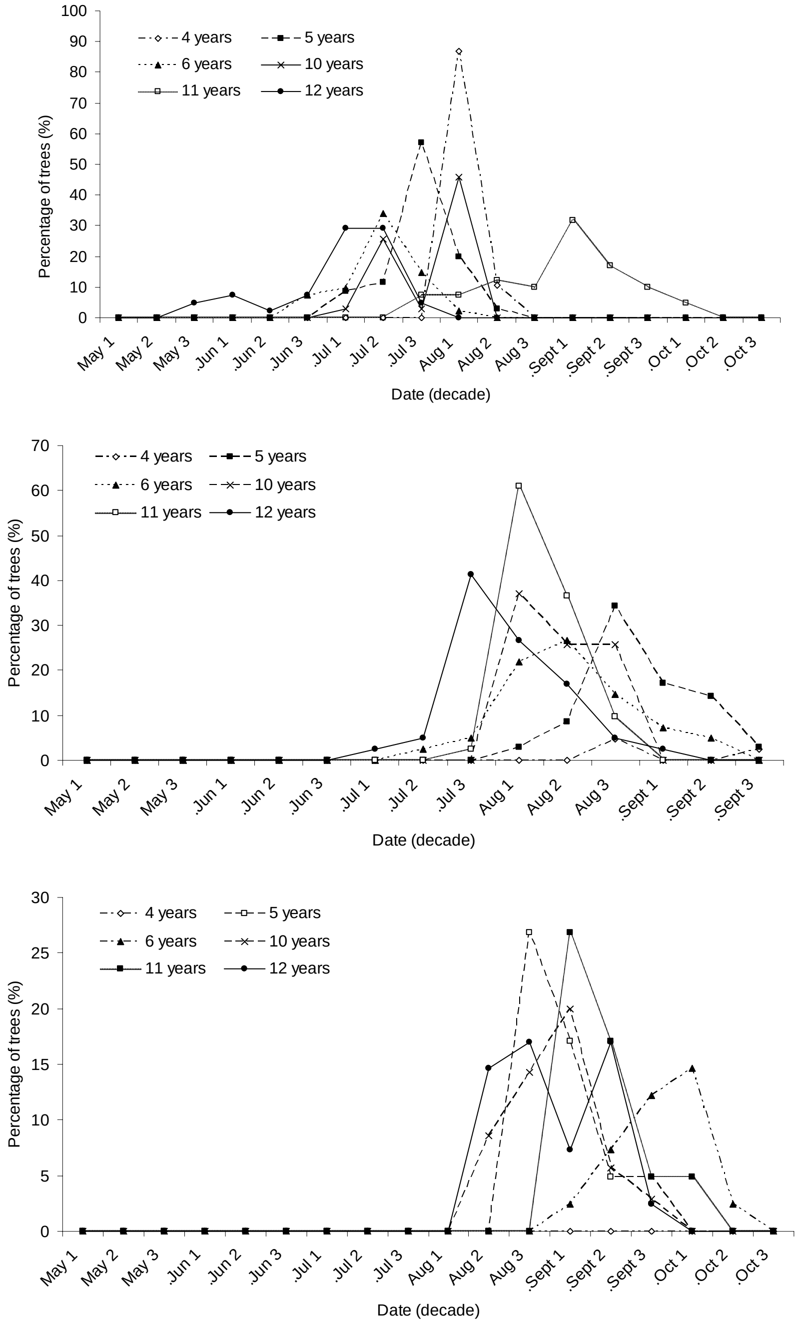

Figure 3: Phenological spectre of flowering as indicated by (a) beginning of flowering, (b) 50 % flowering and (c) 100 % flowering.

During the second study year, flowering of trees aged 5 years started from the first decade of July whereas older trees (11 years) started flowering from the second decade of May. During the 3rd year, flowering of trees aged 6 years started from the 3rd decade of June while during the same season, trees aged 12 years started flowering from the first decade in the same month.

The flowering time for young trees of *P. reticulatum* was short, lasting for about 70 days with a greater number of flowers during the first decade of August. During the same rainy season, flowering period of old trees is long (90 days) with a peak during the first decade of August. The populations of plants under flowering also vary depending on the trees' age (Table 1). During the first year flowering of the species, few plants reach the stage of 50 % flowering (Figure 3b) and no tree could reach the stage of 100 % flowering (Figure 3c). Plants of 5 and 6 years old did not show significant differences for the trees' population that reached 50 % or 100 % flowering. However, the population of 6 years old trees that reached 100 % flowering was 38.9 % higher than the population of 5 years old trees. These trees (5 and 6 years old), showed better flowering rate than the trees aged 4 years (26 to 39 % of 6 years old trees could reach the 3rd stage while nil for 4 years old trees). Plants populations of 10, 11, and 12 years old that reached 50 % and 100 % flowering stage were not statistically different. About 60 % of plants of 10 to 12 years old reached the stage of 100 % flowering. Regardless of the trees' age, the end of the flowering period was the same during the same year (Figure 3c). In 2005 (first study year), the flowering of trees ended at the 3rd decade of September while in 2006, trees' flowering ended at the 3rd decade of October. The same trend (the second one) was observed during the 3rd year.

Fructification stage

Fruit formation of *P. reticulatum* occurred 3 to 4 days after flower bud appearance. During the same rainy season, plant fructification was earlier for older trees as compared to younger trees. The fructification stage started from the first decade of July for trees of 10 years old while for trees of 4 years old, this stage started during the 3rd decade of the same month. Fructification for trees aged 11 years started from the 3rd decade of June while for younger plants (5 years old) fruit formation occurred earlier, during the first decade of July and during the second decade of the same month for trees aged 6 years (Figure 4a).

However, regardless of the age of *P. reticulatum* trees, the end of the fructification was similar within the same rainy season (Figure 4c); this happened during the 3rd decade of September in the first year, during the 3rd decade of October in the second year, and during the first decade of November in the 3rd year. The greatest number of 4 years old trees (22 %) was in fructification during the first decade of August, while for older trees (10 years), the greatest number of plants under fructification (64 %) was observed during the second decade of August. Populations of 5 years old trees under fructification were maximum (27 %) during the 3rd decade of July while for trees aged 11 years, the maximum population of *P. reticulatum* under fructification (80 %) was observed during the second decade of August. The fructification rate varies greatly at its commencement for young trees as well as for old ones (Table 2).

At 50 % fruit formation, plant populations of 5 and 6 years old did not differ significantly but were significantly higher than populations of 4 years old trees. Populations of old trees (10 to 12 years old) were not significantly different at 5 % probability. At 100 % fructification stage, populations of 5 and 6 years old trees did not differ significantly but were higher than populations of trees aged 4 years. Populations of older trees did not show significant differences. Globally, number of trees of 10 years old with 100 % fructification was almost two times that of trees aged 4 to 6 years.

Table 1: Populations of *P. reticulatum* trees at three different levels of flowering (in % of the initial population)

Trees 'age (year)	*Population at initial flowering stage (%)*	*Population at 50 percent flowering stage (%)*	Population at 100 percent flowering stage (%)
4	100	11.4 [a]	0.0 [a]
5	100	80.0 [b]	25.7 [b]
6	100	82.7 [b]	38.9 [b]
10	100	92.7 [c]	61.0 [c]
11	100	97.5 [c]	58.5 [c]
12	100	99.6 [c]	58.3 [c]

Treatments (trees) with the same letter are not statistically different at $p = 0.05$.

Table 2: Populations of *P. reticulatum* trees at three different levels of fructification (% of the initial population)

Trees' age (year)	*Population at initial fructification stage (%)*	*Population at 50 percent fructification stage (%)*	Population at 100 percent fructification stage (%)
4	57.1 [a]	11.4 [a]	02.9 [a]
5	71.4 [a]	48.6 [a]	25.7 [a]
6	46.2 [a]	43.7 [a]	38.8 [a]
10	80.5 [b]	58.5 [b]	53.7 [b]
11	95.4 [b]	63.4 [b]	61.0 [b]
12	73.0 [b]	58.3 [b]	53.5 [b]

Treatments (trees) with the same letter are not statistically different at $p = 0.05$.

Table 3: Population of *P. reticulatum* by type of tree (%)

Trees age (year)	Trees "producers" (%)	Trees "non producers" (%)	
		Trees without any pod	Trees with very small pods
4	41.1	56.9	2.0
5	67.6	32.3	0.1
6	55.8	38.7	5.5
10	77.5	19.8	2.7
11	73.1	17.1	9.8
12	80	12.5	7.5

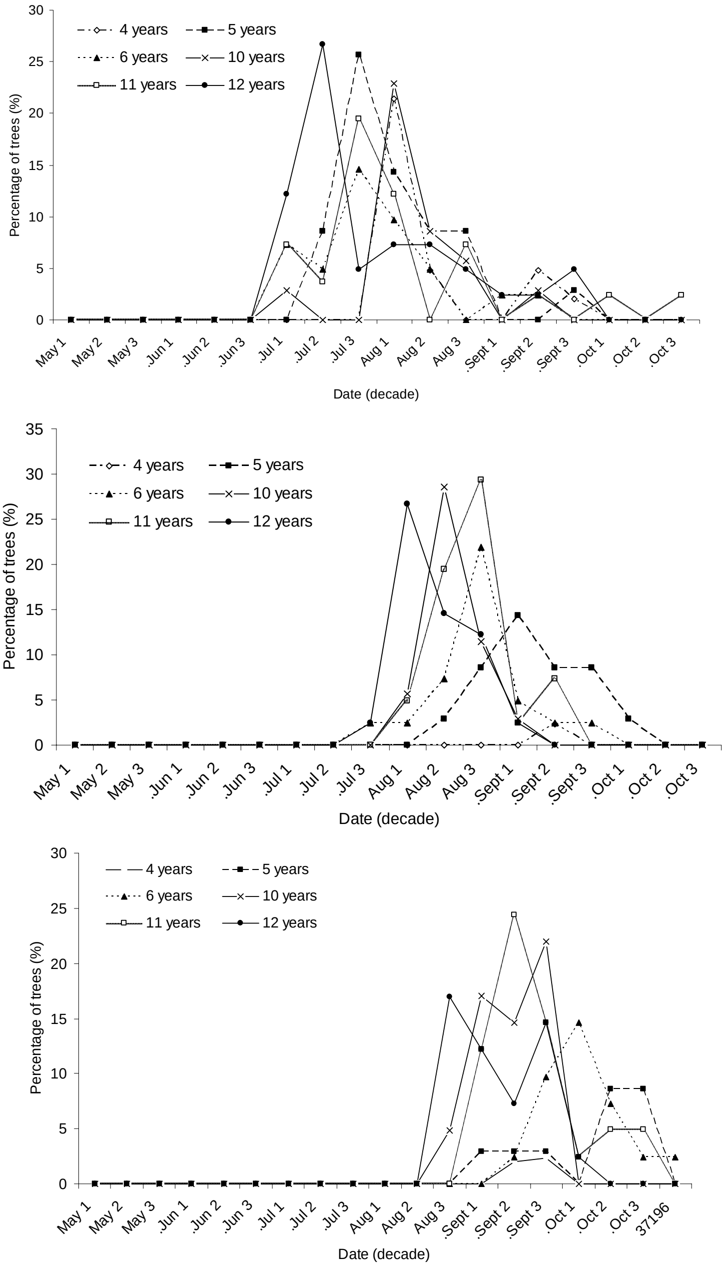

Figure 4 : Phenological spectre of fructification as indicated by (a) beginning of fructification, (b) 50 % fructification and (c) 100 % fructification.

Fruit production

Observations on the phenology of fructification showed that there are several types of P. *reticulatum* trees: *(i)* trees completely unproductive considered as male plants, *(ii)* trees producing thick pods considered as female plants and *(iii)* few trees with small pods that are oblate and sometimes without grains. The percentage of trees "producers" or female plants varies according to the years and plant age (Table 3). The latter are morphologically similar to male plants. Male plants are clump, with several leaves that are smaller and more coloured than female plants. The flowering of male trees started early; male inflorescences are long and abundant and their flowering lasted until the end of the rainy season. Female trees loose more leaves, which are slightly larger and with more holes than the male plants. Female inflorescences are short and not much abundant. About 36 % of *P. reticulatum* trees were unproductive.

Fruit production and fruit weight vary according to the age of plants with important standard deviations (Figure 5). The Duncan test of homogeneity at p= 0.05 for pods yields showed two groups that were statistically different according to plant ages (Table 4): a first group of plants aged 4 to 6 years and a second group of plants aged 10 to 12 years. Pod yields for 4 and 6 years old trees did not differ significantly as well as pod yields for trees aged 10 and 12 years. From the beginning of fruit production until 6 years old, the rate of fruit production by *P. reticulatum* was very low while from 6 to 10 years old, an exponential increase of pod production was observed (*i.e.* about 8 times the initial yield). The pod production of *P. reticulatum* stabilised (Plateau shown in the curves) between 10 and 12 years old.

There was a significant correlation between the number of pods and the diameter of the trees' crown (75 %), the trees' age (53 %), trees circumference (52 %) and plant height (51%). However, only the crown diameter explains better the variation of pod weight (60 %) and pods number (56 %). Moreover, analyses revealed a significantly positive correlation between the pod weight and the crown diameter (r = 77 %), the trees' age (58 %), the trees' circumference at 5 cm from the soil (57 %), and the trees' height (52 %). The relation obtained at P=0.05 is as follows:

Pod weight (Y) = 0.05 x dh – 5.903 with R^2 = 0.7; n= 76; dh = diameter of tree crown (1)

Pod number (Y) = 3.85 x dh – 548.075 with R^2 = 0.75; n= 76; dh = diameter of tree crown (2)

Table 4: Pod production of *P. reticulatum* as related to trees' age

Trees' age (year)	*Number of pods*	*Pods dry weight (kg)*
4	05.40 ± 13.11 [a]	0.10 ± 0.22 [a]
5	41.83 ± 69.51 [a]	0.68 ± 1.06 [a]
6	105.62 ± 123.73 [a]	1.87 ± 2.19 [a]
10	516.00 ± 587.35 [b]	6.54 ± 6.91 [b]
11	552.46 ± 617.14 [b]	7.32 ± 7.37 [b]
12	672.51 ± 710.40 [b]	8.92 ± 8.94 [b]

Where there are significant differences, treatments (trees) with the same letter are not statistically different at *p = 0.05*.

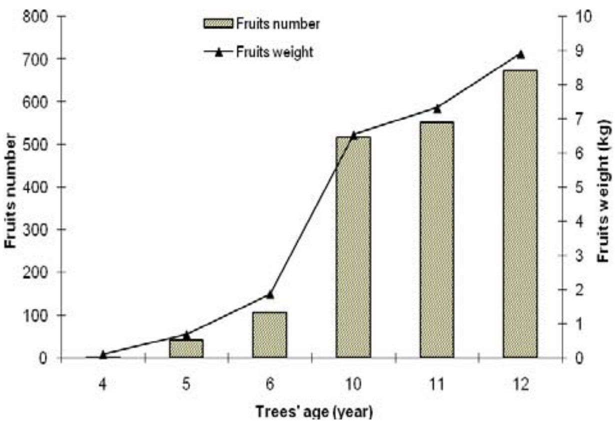

Figure 5: Pod yields of *P. reticulatum* as related to trees' age.

DISCUSSION

Plant flowering

It has been reported that *P. reticulatum* is a yearly flowering species. Flowering period staggered from the second decade of May to 3rd decade of July. *P. reticulatum* flowering started at the end of the dry season after the fall of plant leaves [4]. Our own observations showed that the fall of leaves, which concerned mainly old leaves, is only partial and occurred between March and April. In general, *P. reticulatum* maintained its foliage during the whole year thanks to a progressive renewal of leaves. Flowering of this species is influenced as for most tropical species [19, 20, 21] by the commencement of the rainy season and sustained by the rainfall regularity. It starts soon after the first rains occurrence. The month of August, characterised by a well distributed rainfall, is the optimal period for the flowering of *P. reticulatum*. The flowering time of *P. reticulatum* varies from three to four months depending on the rainy season patterns. At maturity (from 4 years old), all trees of *P. reticulatum* bloom. The first year flowering is characterized by a low production of flowers. However, from the second year flowering, the production of flowers becomes more important and remains at this level during the following year. The production of flowers for old trees (10 to 12 years) is more important than for trees of 4 to 6 years old; however, the age factor does not influence the evolution of trees' flowering. Flowering of *P. reticulatum* proceeds by stages (4 to 6 years and 10 to 12 years).

Plant fructification

P. reticulatum fructification evolves weakly of 4, 5 to 6 years and 10, 11 to 12 years. The small growth of *P. reticulatum* above ground biomass [22], could explain this evolution. The transformation of flower buds of *P. reticulatum* into pods was fast. There was a great variability of the different stages of fructification in relation to the age of trees and to the rainy season. Indeed, during the same rainy season, the fructification of *P. reticulatum* starts late for young trees as compared to old ones. The fruit formation started in July. The end of the fructification period was not related to the age of trees but instead, was related to the ending time of the rainy season. August, the most regular rainy month in Burkina Faso, was the most determinant period for *P. reticulatum* fructification. Indeed, the maximum number of trees reached the fructification stage during this month. As for the flowering period, the fructification period staggered over 3 to 4 months. The rainfall pattern is a key factor that influences the different stages of the fructification stages [21]. The productivity of *P. reticulatum* depended on the importance of female trees' flowers. According to Yélémou [14], about 40 % of *P. reticulatum* trees are unproductive. Female trees produce female flowers that evolved into thick, large and circular grain-filled pods. Male trees produce a lot of flowers. These male flowers fall much during the rainy season due to the wind but mainly because of the anthesis. Few of these male trees can evolve into "aborted" fruits that are small, flat and very light, with sometimes very flat grains. Under dry tropical climate, the oldest trees of *P. reticulatum* reach flowering and fructification stages very early and can produce interesting amount of fruits; indeed, these early flowering and fructification allow early and good maturation of pods, mainly when the scarcity and irregularity of the rainfall are taking into consideration.

Fruit production

The fruit production of *P. reticulatum* is important. The fruit production characterises the seminal potential for the renewal through regeneration of the forestry clump [23]. Moreover, the duration of the phenophases and the fruit production are relevant information for determining the available non-woody forest products, which are used as food and forage during food shortage periods.

The fruit productivity of *P. reticulatum* was related to the magnitude of the trees crown. At plants maturity, the crown importance determines the abundance of the flowers therefore of the fruits. The important standards deviations mean an important variability of production between same age trees, due to trees morphology. The fact that the species is dioic [24] decreases its productivity. In addition male flowers are found on female feet [24]. Male feet are non producers and carry a lot of male flowers. Some of these non producers' feet carry hermaphrodic flowers that evolve to give very small pods [24]. The number of hermaphrodic flowers varies according to years and may be dependent on the rainy season conditions.

Pod yields for young and old populations of trees were not statistically different in this study. This may be due to the low variation between trees' crown from year to year during the study period. For the farmer, the management of *P. reticulatum* trees should take into account the magnitude of the crown in relation to the pod production. The pruning or the cutting of trees' leaves is a common solution to the shading effect of the trees' crown on crop yields [25], while for the animal breeder, obtaining a maximum production of pods is a major issue. The young trees produced not much until 6 years old. The maintenance of *P. reticulatum* in parklands should go for at least 10 years, period from when the contribution of the species for livestock forage becomes important. Indeed, according to Zoundi [26], a Fulani race ox (commonly found in the Central Plateau) under semi-intensive breeding system, eats voluntarily 350 to 400 g food ration. In view of that, one unit tree of *P. reticulatum* could provide the needs of foods for 22 days. However, the stagnation of pod production could be a good reason for the pruning of *P. reticulatum* trees by animal breeders in order to revive the increase in pod production.

CONCLUSION

P. reticulatum is a yearly flowering species. The reproduction period, which occurred after the fall of the leaves, started with the rainy season during July for old trees and during August for young ones. This period staggered over 3 to 4 months depending on the rainy season. The evolvement of flowers into pods occurred 3 to 4 days after flowers appearance. Fruit formation began immediately after flowering, which lasted from the 3rd decade of May to the 3rd decade of October. The flowering and fructification reach the peak in August regardless of the trees age. The flowering and fructification steps depend on the rainfall patterns. A shortage or lack of rain led to a slowdown of the flowering and fructification processes. Pod production of *P. reticulatum* was important and increases by steps in relation to the trees' age. However, male trees contributed in reducing significantly the productivity that was greatly related to the importance of the trees' crown. The specific uses expected from the tree should be taken into account when applying sylvicultural practices. A comprehensive study on the morphology and anatomy of flowers would give more insight on the nature or type of grains. Also, a long term study of the fruit productivity would provide guidance for a sustainable sylvicultural use of this species by rural populations.

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REFERENCES

1. Zougmoré R., Mando A., Stroosnijder L. 2004. Effect of soil and water conservation and nutrient management on the soil-plant water balance in semi-arid Burkina Faso. *Agricultural Water Management* 65: 103-120.
2. Yaméogo G., Yélémou B., Traoré D. 2005. Pratique et perception paysannes dans la création de parc agroforestier dans le terroir de Vipalogo (Burkina Faso). *Biotechnol. Agron. Soc. Environ*. 9: 241- 248.
3. Zoundi S.J,, Nianogo A.J., Sawadogo L. 1996. Utilisation de gousses de *Piliostigma reticulatum* (D.C.) Hochst. Et de feuilles de *Cajanus Cajan* (L.) Millsp. en combinaison avec l'urée pour l'engraissement de moutons Djallonké type mossi et du sud au Burkina. *Tropicultura* 14: 149- 152.
4. Arbonnier M. 2002. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. 2e édition, CIRAD, Montpellier, France, 573 pp.
5. Kabore A., Tamboura H.H., Belem A.M.G., Traore A. 2007. Traitements ethno-vétérinaires des parasitoses digestives des petits ruminants dans le plateau central du Burkina Faso. *Int. J. Biol. Chim. Sci.* 1: 297-304.
6. Yélémou B., Bationo B., Yameogo G., Millogo-Rasolodimby J. 2007. Gestion traditionnelle et usage de *Piliostigma reticulatum* (D.C.) Hochst. dans le plateau

central du Burkina Faso. *Bois et Forêt des Tropiques* 291: 55-65.

7. Roussel J. 1995. Pépinières et plantations forestières en Afrique tropicale sèche. ISRA-CIRAD, Montpellier, France, 199 pp.
8. Baumer M. 1995. Arbres et arbrisseaux nourriciers en Afrique occidentale. CTA, ENDA, Dakar, 260 p.
9. Fortin D., Lo M., Maynart G. 1990. Plantes médicinales du Sahel. CECI- ENDA, Dakar, Sénégal, 278 p.
10. Malgras D. 1992. Arbres et arbustes guérisseurs des savanes maliennes. Karthala, ACCT, Paris, France, 478 p.
11. Burkill H.M. 1995. The Useful Plants of West Tropical Africa. Royal Botanic Gardens, Kew, UK, 315 p.
12. Nacoulma/Ouedraogo O.G. 1996. Plantes médicinales et pratiques médicinales traditionnelles au Burkina Faso. Cas du plateau central. Tome II. PhD dissertation, Faculté des Sciences et techniques, Université de Ouagadougou, Ouagadougou, Burkina Faso, 261 p.
13. Diack M., Sene M., Badiane A.N., Diatta M., Dick R.P. 2000. Decomposition of a native Shrub, *Piliostigma reticulatum*, litter on soils of semiarid Senegal. *Arid soil research and rehabilitation* 14: 205-218.
14. Yélémou B. 2006. Biologie et productivité de *Piliostigma reticulatum* (DC), Hochst., sur sol ferrugineux tropical à la station de recherche expérimentale de Saria (zone phytogéographique nord soudanienne). Mémoire de DEA, Université de Ouagadougou, Ouagadougou, Burkina Faso, 63 p.
15. INSD 1997. Recensement général de la population et de l'habitation du Burkina Faso du 10 au 20 Décembre 1996. INSD, Ouagadougou, Burkina Faso, 12 p.
16. Bationo B.A., Yélémou B., Ouédraogo S.J. 2004. Le neem (*Azardirachta indica* A. Juss), une espèce exotique adoptée par les paysans du Centre-Ouest du Burkina Faso. *Bois et Forêts des Tropiques* 282: 5-10.
17. Grouzis M., Sicot M. 1980. A method for the phenological study of browse populations in the Sahel: the influence of some ecological factors. In: Le Houérou H.N. (eds) Browse in Africa: the current state of knowledge. International Symposium on Browse in Africa, Addis Ababa, April 8-12. ILCA, 233-240.
18. Fontes J., Guinko S. 1995. Carte de la végétation et de l'occupation du sol du Burkina Faso. Note explicative. Ministère de la coopération française, Toulouse, France, 66 p.
19. Janzen D.H. 1967. Synchronization of sexual reproduction of trees within the dry season in central America. *Evolution* 56: 841-854
20. Smythe N. 1970. Relationships between fruiting seasons and seed dispersal methods in neotropical forest. *Amer. Nat.* 104: 26-35
21. Kambou S. 1997. Etude de la biologie de reproduction de *Anogeissus leiocarpus* (DC) Guill. et Perr. au Burkina Faso. PhD dissertation, Université de Ouagadougou, Ouagadougou, Burkina Faso, 188 p.
22. Yélémou B., Yameogo G., Millogo/Rasolodimby J., Hien V. 2007. Germination sexuée et dynamique de développement de *Piliostigma reticulatum* (D.C.) Hochst, une espèce agroforestière du Burkina Faso. *Sécheresse* 18: 185-92.
23. Ganaba S., Bayala J., Yaméogo K.M., Yaméogo J.T., Ouadba J.M. 2006. Impact des aménagements anti-érosifs sur la phénologie, la transpiration et la productivité fruitière ligneuses en zone subsahhélienne du Burkina Faso. *Etudes flor. Vég. Burkina Faso* 10: 49-62.
24. Yélémou B., Yameogo G., Bationo BA., Millogo/Rasolodimby J., Hien V. 2008. Biologie florale et mode de reproductionsexuée de *Piliostigma reticulatum* (D.C.) Hochst. *Int. J. Biol. Chem. Sci*. 2 (3): 281- 291.
25. Bayala J., Mando A., Ouédraogo S.J., Teklehaimanot Z. 2003. Managing *Parkia biglobosa* and *Vitellaria paradoxa* prunings for crop production and improved soil properties in the sub-sudanian zone of Burkina Faso. *Arid Land Research and Management* 17: 283-296.
26. Zoundi S.J., Tiendrebeogo J.P., Traoré S., Lalba A. 2004. Embouche ovine en zone soudano sahélienne du Burkina Faso. Une alternative pour une amélioration de la sécurité alimentaire. *RASPA* 2: 170-174.