Premier article : Knowledge of *Afzelia africana* Sm & Pers (Fabaceae) and importance of functional traits measurement

Par : O. I. AMAHOWE, K. A. NATTA, S.BIAOU and S. S. H. BIAOU

Pages (pp.) 01-10.

Bulletin de la Recherche Agronomique du Bénin (BRAB) - *Numéro Spécial Écologie Appliquée, Faune, Flore & Champignons (EAFFC) – Décembre 2017*

Le BRAB est en ligne (on line) sur les sites web http://www.slire.net & http://www.inrab.org

ISSN sur papier (on hard copy) : 1025-2355 et ISSN en ligne (on line) : 1840-7099

Bibliothèque Nationale (BN) du Bénin

Institut National des Recherches Agricoles du Bénin (INRAB)

Centre de Recherches Agricoles à vocation nationale basé à Agonkanmey (CRA-Agonkanmey)

Programme Information Scientifique et Biométrie (PIS-B)

01 BP 884 Recette Principale, Cotonou 01 - République du Bénin

Tél.: (229) 21 30 02 64 / 21 13 38 70 / 21 03 40 59 ; E-mail : brabinrab@yahoo.fr / craagonkanmey@yahoo.fr

Knowledge of *Afzelia africana* Sm & Pers (Fabaceae) and importance of functional traits measurement

O.I. AMAHOWE[1], K. A. NATTA[2], S. BIAOU[2] and S. S. H. BIAOU[2]

Abstract

This literature review aimed to improve knowledge on a threatened species *Afzelia africana* Sm and Pers (Fabaceae). The species thrives across several regions in Africa, demonstrating it ecological plasticity. To date, many studies on the species, have been conducted mainly to describe the vegetation and species communities or to measure its structure. However, a huge gap of knowledge exists on the species ecology, and this may jeopardize its sustainable management. This review showed the importance of conducting studies that will help to understand disturbances and species adaptation to environmental stress. Therefore, assessment of threats, measurment of functional traits and demography of *Afzelia africana* are essential to understand the species life strategies and adapations.

Key words: *Afzelia africana*, ecological plasticity, disturbances, functional traits, adaptation

Connaissances de *Afzelia africana* Sm & Pers (Fabaceae) et importance de la mesure des traits fonctionnels

Résumé

Cette analyse bibliographiqu visait à améliorer les connaissances sur *Afzelia africana* Sm et Pers (Fabaceae), une espèce menacée. L'espèce est distribuée à travers plusieurs régions en Afrique, démontrant sa plasticité écologique. À ce jour, plusieurs études sur *Afzelia africana* ont été conduites principalement pour décrire la végétation et la composition floristique de ses habitats ou de mesurer sa structure. Cependant, un déficit de connaissance existe encore sur l'écologie de l'espèce et ceci peut remettre en cause sa gestion durable. Cette analyse a permis de montrer l'importance de conduire des études qui peuvent aider à mieux comprendre les perturbations et les stratégies d'adaptation de l'espèce aux stress environnementaux. Ainsi, l'évaluation des perturbations et la mesure des traits fonctionnels et de la démographie de *Afzelia Africana,* sont essentielles à la compréhension des stratégies de vie et d'adaptation de l'espèce.

Mots clés: *Afzelia africana*, plasticité écologique; perturbation, traits fonctionnels, adaptation

Introduction

In Sub-saharan forests, many plant species have gone to extinction due to various threats (Hilton-Taylor, 2000). Adomou *et al.* (2006) have identified 280 threatened plant species in Benin. Among these, *Afzelia africana* (Fabaceae) is found in the three main ecological regions (Sinsin *et al.,* 2004; Mensah *et al.,* 2014; Adjohossou *et al.,* 2016). *Afzelia* is also found in all the tropical African region including Western, Central and Eastern Africa (Orwa *et al.*, 2009), and is positioned as the most distributed among the seven species of Afzelia genus (Belgian Woodforum, 2005; Aubreville, 1950). It is only in 1798 that James Edward Smith has collected the species *Afzelia africana* in West African savanna and describeb it (Donkpegan *et al.,* 2014). Over the last years, the species has been undergoing loggings pressure due to the dramatic increasing of its timber value (https://www.foe.co.uk/page/different-types-wood-timber). As many tree fodder species, *Afzelia* tree is often pruned in unsustainable way to feed cattle during the dry season, when there is grass fodder

[1] MSc Ir. Ogoudjè Isidore AMAHOWE, Direction Générale des Eaux, Forêts et Chasse, BP. 393 Cotonou et Laboratoire d'Ecologie, de Botanique et de Biologie végétale (LEB), Faculté d'Agronomie (FA), Université de Parakou (UP), 03 BP 125 Parakou, Email : ogoudje.amahowe@gmail.com, Tél. : (+229) 94 50 78 90, République du Bénin

[2] Dr Ir. Kuyéma Armand NATTA, LEB/FA/UP, 03 BP 125 Parakou, E-mail : armand.natta@gmail.com, armand.natta@fa-up.bj, Tél. : (+229) 97 76 34 38, République du Bénin

BSc. Sevérin BIAOU, LEB/FA/UP, 03 BP 125 Parakou, E-mail : severinb.biaou@yahoo.fr, Tél. : (+229)95742003, République du Bénin

Dr Ir. Samadori Sorotori Honoré BIAOU, LEB/FA/UP, 03 BP 125 Parakou, E-mail : hbiaou@gmail.com, Tél. : (+229) 94 15 04 85, République du Bénin

shortage. Therefore, it has been positioned as a top tree fodder species in the whole West African region (Ouedraogo-kone *et al*., 2006). In Benin, the species shows better distribution under the Sudanian climate, and therefore many populations are found from the transition zone (Sudano-Guinean) to the dry Sudanian climatic zone (Adomou *et al*., 2005). Afzelia tree is also debarked by traditional healers to heal sicknesses (Kone *et al.,* 2004; Delvaux *et al.,* 2009). All these threats may affect the long term conservation of the species populations. Thus, *Afzelia africana* has been classified as vulnerable on the IUCN red list (IUCN, 1998) and in the national red list of threatened species in Benin. However, despite all the perceived importance and also threats on the species, there is still a huge gap of knowledge on the species ecology and its interaction with its environment and human activities. This situation may jeopardize its sustainable management. In this review, we filled this gap of knowledge by gathering necessary information from several literature sources and provide valuable information that can help to prepare the ground for the long-term conservation of the species.

Description of *Afzelia africana*

Afzelia africana is a timber tree species of a family Fabaceae. It can reach 18 m in height in savanna (Melorose *et al*., 2015), and 35 m in forest (Arbonnier, 2002). It bore massive branches and a gray bark, relatively cracked and lamellar, peeling in patches about 2 cm thick (Orwa *et al*., 2009), revealing light gray areas with pink slice to light brown granular with a sclerotic structure (Aaubreville, 1959; Anon, 1978; Arbonnier, 2002). Its leaves are oblong or lance shaped and oblong 5-15 x 3,5-8,5 cm (Akoegninou *et al.,* 2006). *Afzelia africana* has compound leaves which are larger than the leaves of others species of Afzelia genus (Donkpingan *et al*., 2014). It bears 3-8 pairs of opposed or subopposite leaflets, glabrous and glossy, dark green above, widely spaced on the rachis and an entire limb lacking translucent punctuations (Smith, 1798). The petioles are twisted with 6 to 10 mm in length (Ahouangonou, 1978a). *Afzelia africana* is a hermaphrodite tree with an inflorescence terminal panicle about 20 cm of length. The flowers are white, streaked with purple, three elliptic upper petals 10 to 12 mm of lenght, very fragrant and a lower petal with 2 lobes and striped red. As a legume, *Afzelia africana* produces glabrous pods which dimensions are about 10 to 18 cm x 6 to 8 cm and 2 to 5 cm of thickness, slightly rounded to two black valves. The pods contain 7 to 10 black seeds which has 2 to 3 cm of length with yellowy aril (Orwa, 2009; Bonou *et al*., 2009). Seedling are characterized by an epigeal germination. The hypocotyl size ranges from 7-16 cm of length and the epicotyl from 8-20 cm. The Cotyledons are fleshy and oblong and about 2 cm of length (Gerard et Louppe, 2011).

Geographical distribution and ecology

Afzelia africana is the one of the most widely distributed in Africa (Sacande, 2007). It thrives in the several countries: Benin, Burkina Faso, Cameroon, Central African Republic, Côte d'Ivoire, Ghana Guinea, Guinea-Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Togo, Uganda, Senegal, and Uganda (Aubreville, 1968; Arbonnier, 2002; Sacande, 2007). It shows great adaptation to the shift in environmental conditions. In dry areas, it is found on deep and well drained soil (Gerard, 2011). The main habitats of *Afzelia africana* are: dense humid semi-deciduous forests (Satabié, 1994), woodlands (Aubreville, 1937), gallery forests and mountainous vegetation (Akoègninou *et al*., 2006). The species spreads more in Sudanian savannas (Arbonnier, 2002). *Afzelia africana* is a legume species and known with its symbiotic association with ectomycorrhizal fungis (Redhead, 1968; Bâ et Thoen, 1990; Yorou *et al.,* 2008). *Afzelia africana* is a light demanding species (Sinsin *et al.,* 2004; Orwa *et al.,* 2009; Djodjouwin *et al.,* 2011), even though at sapling and seedling stage, the species can tolerate shade and develop under close canopy condition (Biaou *et al.,* 2011). Seedlings establishment and recruitment are challenging by many environmental pressures as well as climate stress particulary in ariod and semi-arid sudanian zones.

Anatomical characters and technological qualities

The synthesis of the anatomical characteristics of *Afzelia africana* was established on the basis of the anatomical characteristics decrsibed by Gerard et Louppe (2011). *Afzelia africana* wood presents well defined and distinct growth rings at the level of the vessels, the pores are disseminated with the simple perforations and fine intervessel punctuations (4-7µm) in staggered form, the alternate punctuation of polygonal shape. Radiovascular punctuations with distinct areoles; similar to intervessel punctuations in shape and size throughout the radius cell. The average tangential diameter of the lumen of the vessels is 100-200 µm. The species has an average tangential diameter of the lumen of the vessels of more than 200 µm; thin-walled fibers are not partitioned. The axial parenchyma in lozenge is anastomosed, the axial parenchyma in marginal or seemingly marginal bands.

The heartwood, orange-brown to golden-brown, becomes red-brown on prolonged exposure and sometimes presents dark bands. It is distinctly distinct from the sapwood, whitish to pale yellow and 8 cm thick. The thick of *Afzelia africana* heartwood is huge. The thread is normally straight, sometimes interlocked, the grain is medium to coarse but regular. The wood is slightly shiny once dried, gives off an odor of leather when planed (Gerard et Louppe, 2011). *Afzelia africana* wood is characterized by an excellent stability with low sensitivity to moisture changes, low shrinkage rates during drying (radial shrinkage and tangential shrinkage) (Donkpegan *et al*., 2014) and good natural durability (CIRAD, 2003; Onweluzo *et al*., 1995), a low fiber saturation point (19%), a compressive rupture contracture of 74MP (CIRAD, 2003) and a low sensitivity to changes in the hygrometric state. The wood is heavy (density of 0.8 $g.cm^{-3}$) (CIRAD, 2003) hard, moderately nervous and durable. According to Onweluzo *et al*. (1995) the mean density of *A. africana* to be 716 kg/m^3. The species is resistant to moisture and termites. It is on the other hand brittle and difficult to work. Treatments with preservatives are superfluous, even when used under conditions of permanent moisture or in places where wood-boring insects are common. Because of its good resistance to many chemicals and its great dimensional stability, it is often preferred to materials such as metals and synthetic products for tanks and precision equipment intended for industry (Gerard, 2011). A. africana is considered as first commercial grade lumber in Nigeria (Arowosege, 2010; Beak Consultants, 1999).

Phenology of *Afzelia africana*

Afzelia africana is probably entomophilous, zoochore (Gautier-Hion *et al*., 1985) and ballochore (Fandohan *et al.,* 2008). A. Africana's tree flourishes during small rainy season from March to April in Benin (Ahouangonou and Bris, 1997) and bats sometimes consume its flowers. The fruiting period covers six to eight months and fruit can remain on the tree for the next six months (Bationo *et al.,* 2001). *Afzelia africana* is a deciduous tree and leaves fall partially in Sudanian zone from November to February. Generally, Flowering takes place usually between March and April in West Africa and fruits mature around December or January in Benin (Ahouangonou and Bris, 1997). The time of seed dissemination is short and this often occurs in December and January. Indeed, following the phenological calendar of different fodder species (Wala, 2004; Petit *et al.,* 2001; Brisso *et al.,* 2007), palatable foliage availability with *Afzelia africana* showed a light advance comparing to *Pterocarpus erinaceus*. The latter one offers palatable foliage from December to May, while *Afzelia africana* operated from February to April. Petit *et al.* (2001) found longer pruning period in Sudan region of Burkina-Faso, where A. africana is pruned from February to July. Brisso *et al.* (2007) in the Wari-Maro forest Reserve, found that *Afzelia africana* is pruned from February to May. This long pruning period of the species may provide important service to the development of livestock, however in the meanwhile it may particularly have adverse effects on tree fitness and subsequently affect plant demographic performance.

Socio-ecological importance and impact of human pressure on *Afzelia africana*

In the Sudanian zone, human populations depend on natural resources and services provided by ecosystems and agroecological systems (Devineau *et al.,* 2009). Among these services, non-timber forest products (NTFPs) play an important role (Cunningham, 2001). Thus, *Afzelia africana* is a forest species for multiple purposes. It is used by local people to feeding livestock (Sinsin, 1993), traditional medicine (Adjanohoun *et al.,* 1989; Ahouangonou and Bris, 1997; Sinsin et *al*., 2002) and especially for its valuable wood (Ahouangonou and Bris, 1997; Bayer and Waters-Bayer, 1999). As a legume species, *Afzelia africana*'s leaves are rich in nitrogen and therefore are highy palatable for livestock especially the dry season (Petit and Mallet, 2001; Ouédraogo-Koné *et al*., 2008). The pod is used to make soap local (Egwujeh and Yusufu, 2015) very rich oil seeds are also used as a thickening agent (African Regional Workshop, 1996), such as necklaces that also serve other ornamental and ritual purposes (Gerard et Louppe, 2011). Castanets are made with the fruit. *Afzelia africana* is considered as sacred and healing tree in many regions (Delvaux *et al.,* 2009). Its wood is a beautiful orange-brown wood, one of the most exported toward Europe, Asia and United State (http://brencollc.com/doussie/). In addition, *Afzelia aficana* wood can also produce paper pulp by alkaline chemical processes with soda. Afzelia bark, leaves and roots are used in the treatment of diarrhea, cough, mental illness, gastrointestinal disorders, general pain (Arbonnier, 2002; Akinpelu *et al.,* 2008; Ouédraogo-Koné *et al.,* 2008). The decoction of the stem bark alone or in combination with other plants such as *Berlinia grandiflora, Bombax costatum* and *Burkea africana,* is administered orally in the treatment of edema, Epilepsy, intercostal neuralgia, dysmenorrhea, hyperthermic convulsions and failure to thrive (Adjanohoun et *al.,* 1989). Roots are used to heal Gonorrhea and trypanosomyasis (Arbonnier, 2002). In mixture with root of *Annona senegalensis*, they are used to combat high blood pressure (Ahouangonou and Bris, 1997).

Afzelia africana was cited among the edible species in Benin (Achigan-Dako *et al.,* 2010). Egwujeh and Yusufu (2015) have reported that the flour made with the aril cap of *Afzelia africana* seed, was appreciable in protein (5.69%), fat (18.5%), carbohydrates (63.91%), and fibre (5.4%). This important fibre amount may improve the capillaries of the bowel movement and preventing constipation. Fiber has been reported to control glycaemia and improve morbidity of diabetic patients (Odenigbo, 2001).

Disturbance, regeneration and population structure of A*fzelia africana*

Many woody species such as *Afzelia africana*, are overexploited because of important services they provide to mankind both at national and international levels. Particularly adult individuals of *Afzelia africana* are pruned to feed livestock during the dry seasons, whereas their seedlings survival and recruitment are highly challenged (Nacoulma *et al*., 2011; Stark, 1986). Therefore, other studies underlined a poor regeneration for Afzelia African in West African forests (Sokpon and Biaou, 2002; Sokpon *et al*., 2006; Sinsin *et al*., 2004). However, factors constraining regeneration success of *Afzelia africana* are still limitedly known.

Afz*elia africana* tree is also debarked mainly for medicinal purpose (Adjanohoun *et al*., 1989; Nacoulma *et al*., 2011; Mensah *et al*., 2014; Kone *et al*., 2004). Fire may make impact on stem that could be worsened by termite's attacks (Stark, 1986) and created wound and external cavities on the stem. Both defoliation and stem bark wound, create disturbance on individual tree, and this may affect plant performance and ecological strategies.

Disturbance patterns may vary with climatic conditions (Sinsin *et al*., 2004; Mensah *et al*., 2014). In semi-arid and arid zones, the species is facing harsh condition that could be somewhat attenuated by microenvironment offered by closed canopy conditions (Biaou *et al*., 2011). The species adapative strategy to the variation in microenvironmental condition needs to be documented. Harvesting can affect biological functions within plants (Nacoulma *et al*., 2017), an even demographic processes (Gaoue and Ticktin, 2010). Particularly, debarking can damage the phloem and therefore expose tree to dessication and pathogens attacks. This may affect nutrients transportation, photosynthesis and subsequently fruit production (Nacoulma *et al*., 2017). Pruning is a branch removal, reducing the photosynthesis area, which may lead to a reduction of photosynthesis outcomes and plant growth performance.

Functional traits and plant demography

Environmental changes (stress or disturbance) effects on plants demography (survival, growth and mortality) is widely discussed in functional ecology. One of the most important goals in functional ecology is to understand mechanism by which environmental filters affect the organism growth, survival and reproduction based on plants traits. This mechanism is often explained by relating traits to descriptors such as growth rate and survival. Poorter and Bongers (2006) found leaf traits as good predictors of plant performance of 53 co-occurring tree species. It appeared out that species with long-lived leaves have a low SLA reflecting nutrients conservation and the plant investment in leaf material toughness (Westbrook *et al*., 2011) and defense (Garnier and Navas, 2012). Such species are shade-tolerant, exhibit slow growth rate with a high capacity to survive and are metabolically less active whereas species with short-lived leaves are light-demanding as they are physiologically more active; grow rapidly with a low survival capacity. Light-demanding species are those that exhibit high SLA reflecting quick biomass production in an environment rich in resources (Garnier and Navas, 2012). The findings of Poorter and Bongers (2006) are consistent with that predicted by Williams (1957) evolutionary theory on population aging linked to their extrinsic mortality.

Rather than leaf traits, stems traits, especially wood density was elsewhere found to be a good predictor of plant performance. Rüger *et al.* (2012) explained how plant growth is sensitive to light and size by relating growth characteristics of Neotropical species to multiple functional traits (wood density, adult stature, seed mass, leaf traits) using hierarchical Bayesian model. Results exhibits wood density as a good predictor of plants growth characteristics. Species with low wood density grow fast till their largest size. Besides, maximum height was strongly related to intrinsic growth rates reflecting that tall species grow faster than short-statured one whereas leaf traits and seed mass were weakly related to intrinsic growth rates. In fact, wood density appears to be a central trade-off between species growth rate and defense capacity (Cornelissen *et al*., 2003). Muller-Landau (2004) and Kraft *et al.* (2010) have approved by showing that tropical trees with low wood density exhibit higher growth rate and mortality rate. This indicates that rather than investing in growth, plant prefers to invest into defense. However, Russo *et al.* (2010) have found no relationship between wood density and demographic rates (growth and mortality rates). Besides, Rüger *et al.* (2012) study contrasts the one of Poorter and Bongers, (2006) on plants performance based on leaf traits seem to be opposed. This may be possible as the study zones and analysis approaches were different. However, both of the studies express growth-mortality or growth-survival trade-offs. Further more, hydraulic conductivity was predicted to be better indicator of plant growth rate than wood density (Fan *et al*., 2012) showing that species with high hydraulic conductivity are faster-growing.

Parallel research to those discussed above addressed conditions of growth-mortality trade-off occurrence by relating growth rate of 103 tropical tree species from closed canopy forests to four key functional traits (Seed mass, LMA, WD, and Hmax) using multiple regressions, principal component and discriminant analysis (Wright *et al*.,2010). Light-demanding species were found to grow rapidly with rapid mortality rate whereas shade-tolerant species display low growth and low mortality rate. This study appear consistent to the one of Poorter *et al.* (2006). Above reviewed studies allowed to understand how traits trade-offs explain plant performance. Light appears as an extrinsic factor to light demanding species that may limit their growth. Russo *et al.* (2010) have demonstrated that xylem traits (vessel diameter and frequency) are good indicator of species growth. They showed that species with high vessel diameter and vessel frequency are faster-growing suggesting that plant growth is determined by its environment and physiology.

Species behaviors were known to be driven by disturbances (harvest and local practices) and this induce to vegetation dynamic. Thus, assessing responses of species to the harvests or practices made by local populations has become a subject of interest in ecology nowadays. Pausas *et al.* (2004) have assessed species responses to fire (postfire) using traits such as ability of species to resprout (translating the persistence of individuals) and ability of species to retain a persistent seed bank (translating persistence of populations). It was pointed out that postfire affect resprouters and non-resprouters growth and maturity. Juveniles of resprouters were slower-growing compared to juveniles of non-resprouters. Besides, resprouters' species mature slowly and live longer than non-resprouters. At other side, resprouters were found to be fewer but bigger and heavier seed producers with vertebrate-dispersed seed whereas non-resprouters produce more but small and dry seed that are wind-dispersed. Pausas *et al.* (2004) have just showed how post fire events affect species demography based on functional traits. Their study was then limited to a short-term vision on populations dynamic. Angert *et al.* (2007) showed how heterogeneity in responses strategies of species to environmental stress can help to predict populations dynamic by relating to leaf level carbon isotope discrimination and long-term demographic variation, growth parameters. They predicted that slow-growing species with high water-use efficiency would display low temporal variance in demographic success, whereas fast-growing species with low water-use efficiency would exhibit great temporal variance in demographic success.

Functional traits variation across ecological gradients

Species environment often shows a spatial and temporal variation which affects their biology and ecology. As consequence, it is possible to observe variation in the species morphological, physiological and phenological traits in this condition. Variation of functional traits across ecological gradients has been discussed throughout the literature. In a research article by Byron *et al.* (2002), it was tested whether leaf morphology at species level may reflect low rainfall and isotope composition of carbon 13 (d13C) rather than low phosphorus and nitrogen concentrations by relating LMA (Leaf Mass per Area) to leaf phosphorus (P) and nitrogen (N) along extensive rainfall gradients in southwestern Australia and the Cape of South Africa. LMA was higher in the regions of high rainfall and carbon stable isotope composition (d13C) than in those of low rainfall and carbon stable isotope composition (dC13). Altered trend was found by Gaoue *et al.* (2011) on *Khaya senegalensis* in West Africa. Variation of traits across ecological gradients was assessed elsewhere using insolation as a gradient vector. Ackerly *et al.* (2002) examined variation in leaf size and specific leaf area (SLA) in relation to the distribution of chaparral shrub species along insolation and elevation gradient. There was no consistent variation of SLA and leaf area across elevation. As for insolation gradient, habitats with high insolation exhibit lower SLA and leaf area. Traits variation is known to be driven by rainfall and insolation gradients as showed by the above studies. But how do traits vary across altitudinal gradient? Bresson *et al.* (2011) inform us on trait variations along altitudinal gradient by relating photosynthetic capacity of populations to different levels of altitude using linear regression. Populations with high elevation display higher photosynthetic capacity reflecting that populations combine adaptation and acclimation to survive under extreme conditions of their habitats. In other parallel study, populations of higher altitudes showed low values of plant height, individual seed length, individual seed mass, mass of seeds per fruit, total mass of seeds, the ratio [plant height / plant diameter] and the ratio [individual seed mass/number of seeds per fruit] (Marie, 2010). Traits variation across elevation gradient was also examined by relating traits such as ratio C/N of litter, SLA; ratio C/N of leaves and roots storage tissues of subalpine plants to the topographical gradient. Top-slope plants have higher leaves and litter C/N and down-slope one showed higher SLA (also found by Bai *et al.*, 2008). Roots of top-slope plants have more storage tissues than those of down-slope species. Bai *et al.* (2008) in addition to the above studies on altitudinal variation of functional traits have examined woody plant d13C variation across topoedaphic gradient by using subtropical savannah species. As results, species at low altitude have higher δ13C, plant water content (VWC) and leaf N_{area} and their soil was found to contain more water and clay. One of the spatial heterogeneity of species environment is variation in available resources. Similarly to the study of Bai *et al.* (2008), Russo *et al.* (2008) have examined variation of growth-mortality trade-offs across resources gradient rain forest trees. They predicted that fast-growing species have advantage to compete in rich-resources environment but are subjected to high mortality in poor-resources environment. Inversely, slow-growing species have a disadvantage to compete in rich-resources environment but are subjected to low mortality in poor-resources environment.

Functional traits are known to predict plants performance. But how does such prediction vary across gradients? Different authors in the literature have tried to address this question. Brenes-Arguedas *et al.* (2013) have showed how woody species performance and distribution vary according to ecological gradients. As results, wet-distribution species exhibit high growth rate and low photosynthetic capacity whereas dry-distribution species were found to be slow-growing with high CO_2 assimilation and photosynthetic capacity. This study was limited to the understory growth form of species. In a research article by Santiago *et al.* (2007), different trends in photosynthetic capacity and CO_2 assimilation were observed from lianna, tree, and understorey. Photosynthetic capacity and CO_2 assimilation were high in tree, moderate in liana and lowest in understorey. Anyway, variation of the two traits in lianna and tree across ecological gradients was not predicted. The slow growth of dry-distribution species noticed by Brenes-Arguedas *et al.* (2013) is probably reflected by higher LMA or lower SLA in higher arid zones (Gaoue *et al.*, 2011) as low SLA reflects low growth. Woody species performance was also found to vary across light gradient. Sterck *et al.* (2006) showed that leaf traits express growth-survival trade-off across different light environments by relating leaf trade-offs of species to the whole-plant performance. The coordination of SLA and photosynthetic capacity were strongly associated with species height growth rate in high light environment (gap) whereas leaf survival rate was found to determine species survival rate in low light environment (close canopy). This implies that in open canopy, species prefer investing their resources in quick biomass production by increasing their photosynthetic capacity. Conversely, in close canopy, species would rather invest in leaf defense for maintaining their leaves long-lived so that they can live longer. Mensah *et al.* (2014) have addressed how morphological traits at population level vary across ecological gradients and anthropogenic pressure level using *Afzelia africana* populations from West Africa. Traits such as basal area; mean diameter and mean height were good indicators of pressure and climatic variability on populations' structure. As whole, populations with high level of pressure exhibit within each climatic zone lower basal area, mean diameter and height compared to those with low level of pressure. Besides, populations from the Guinean zone showed higher values of measured traits than those from the Sudano-Guinean and Sudanian zones.

Conclusion

Afzelia africana is a large distributed species, showing a great plasticity to a wide range of environmental changes. Moreover the species is undergoing several human-induced disturbance that may affect its performance. Therefore, it is positioned as a good example to study the adaptive strategies of tropical tree species to environment and disturbance gradients. The species response to

ISSN sur papier (on hard copy) : 1025-2355 et ISSN en ligne (on line) : 1840-7099

environment and disturbance may imply morphological, physiological and ecological reactions. The assessment of disturbance pattern and their effect on a tropical species across a climate gradient, is fundamental to improve insight on how the species could respond to both climate and disturbance and this may provide guidance to design better management plan. Furthermore, functional traits appear as an excellent tool to measure the species response at tree level, which is critical to understand intraspecific trait variation and more the species adaptive strategies.

References

Achigan-Dako, E.G., M.W. Pasquini, F. Assogba-Komlan, S. N'danikou, H. Yédomonhan, A. Dansi, B. Ambrose-Oji, 2010: Traditional vegetables in Benin. Institut National des Recherches Agricoles du Bénin. Imprimeries du CENAP, Cotonou.

Ackerly, D.D., C.A. Knight, S.B. Weiss, K. Barton, K.P. Starmer, 2002: Leaf size, specific leaf area and microhabitat distribution of chaparral woody plants: contrasting patterns in species level and community level analyses. *Oecologia*, 130, 449-457.

Adjanohoun, E., V. Adjakidjè, M.R.A. Ahyi, L. Aké Assi, A. Akoègninou, J. Dalmeda, F. Akpovo, K. Boukef, F. Chadaré, G. Cusset, K. Dramane, J. Eyme, J-N. Gassita, N. Gbaguidi, E. Goudoté, S. Guinko, P. Houngnon, L. Issa, A. Keita, H.V. Kiniffo, D. Koné Bamba, A. Musampa Nseyya, N. Saadou, TH. Sodogandji, S. De Souza, A. Tchabi, C. Zinsou Dossa, Th. Zohoun, 1989 : Contribution aux études ethnobotaniques et floristiques en République Populaire du Bénin. ACCT, Paris.

Adomou, A.C., B. Sinsin, L.J.G. Van der Maesen, 2006: Phytoso-ciological and chorological approaches to phytogeography: a meso-scale study in Benin. *Syst. Geogr. Pl.,* 76, 155-178.

Adomou, M., P.V.V. Prasad, K.J. Boote, J. Detongnon, 2005: Disease assessment methods and their use in simulating growth and yield of peanut crops affected by leafspot disease. *Annals of applied biology*, 146(4), 469-479.

African Regional Workshop, 1996: Conservation and Sustainable Management of Trees project workshop held in Harare. Ahouangonou.

Ahouangonou, S., 1978a: Contribution à l'étude de la germination d'*Afzelia africana* (Caesalpiniacees). *Bulletin de la Recherche Agronomique du Bénin*, 15–18.

Ahouangonou, S., Bris, B., 1997: *Afzelia africana*. *Le Flamboyant*, 42, 7-10.

Akinpelu, D.A., O.A. Aiyegoro, AI. Okoh, 2008: In vitro antimicrobial and phytochemical properties of crude extract of stem bark of *Afzelia africana* (Smith). *Afr. J. Biotechnol*., 7, 3665-3670.

Akoègninou, A., W.J. Van der Burg, L.J.G. Van der Maesen., V. Adjakidjè, J.P. Essou, B. Sinsin, H. Yédomanhan, 2006: Flore analytique du Bénin. Backhuys publishers, Wageningen.

Angert, A.L., T.E. Huxman, G.A. Barron-Gafford, K.L. Gerst, D.L. Venable, 2007: Linking growth strategies to long-term population dynamics in a guild of desert annuals. *J. Ecol.,* 95, 321-331.

Anon, 1978: Mémento du forestier. Editions du Ministère de la Coopération française.

Arbonnier, M., 2002: Arbres arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD-MNHN. 2e édition, 576 p.

Arowosege, O.G.E, 2010: Lesser used wood species and their relevance to sustainability of tropical forests: 305-322. *In*: Kolade Adeyoju, S., Bada, S.O., (eds), Readings in Sustainable Tropical Forest Management.

Aubreville, A., 1937: Les forêts du Dahomey et du Togo. *Bull. com. Etu. His. Et Scientif. Afrique occidentale française*, 20, 1-112.

Aubreville, A., 1950: Flore forestière soudano-guinéenne. Orstom, Paris.

Aubréville, A., 1959 : La flore forestière de la Côte d'Ivoire.

Aubreville, A., 1968: Légumineuses-Césalpinioidées, Flore du Gabon. *Museum National d'Histoire Naturelle*, 15, 111-118.

Bâ, A. M., Thoen, D., 1990: First synthesis of ectomycorrhizas between *Afzelia africana* and native fungi of West Africa. *New Phytologist*, 114, 99-103.

Bai, E., T.W. Boutton, F. Liu, X.B. Wu, S.R. Archer, 2008: Variation in woody plant d13C along a topoedaphic gradient in a subtropical savanna parkland. *Oecologia*, 156, 479-489.

Bationo, B.A., S.J. Ouedraogo, S. Guinko, 2001, Longévité des graines et contraintes à la survie des plantules d'*Afzelia africana* Sm. dans une savane boisée du Burkina Faso. *Ann. For. Sci*., 58, 69-75.

Bayer, W., Waters-Bayer, A., 1999: La gestion des fourrages. CTA, Wageningen, Pays-Bas.

Beak Consultants and Geomatics International Inc., 1999: Forest Resources Study, Vol 11, Ondo and Ekiti States Forest Invdentory, Management, Planning and Recommendations, FORMECU, Abuja.

Belgian Woodforum, 2005: Fiche Essences/*Afzelia*. Un seul nom, plusieurs espèces.

Biaou S.S.H., M. Homengren, F.J. Sterck, G.M. Mohren, 2011: Stress-Driven Changes in the Strength of Facilitation on Tree Seedling Establishment in West African Woodlands. *Biotropica*, 43(1), 23–30.

Bonou, W., R.Glèlè Kakaï, A. E. Assogbadjo, H.N. Fonton, B. Sinsin, 2009: Characterisation of *Afzelia africana* Sm. habitat in the Lama Forest reserve of Benin. *Forest Ecology and Management*, 258, 1084-1092.

Brenes-Arguedas, T., A.B. Roddy, T.A. Kursar, 2013: Plant traits in relation to the performance and distribution of woody species in wet and dry tropical forest types in Panama. *Functional Ecology*, 27(2), 392-402.

Brisso, N., M. Houinato, C. Adandédjan, B. Sinsin, 2007: Dry season woody fodder productivity in savannas. Short communication. *Ghanaian Journal of Animal Science*, 23 (1), 181-185.

Brisson, M., N. Van de Velde, P. De Wals, M.C. Boily, 2007: The potential cost-effectiveness of prophylactic human papillomavirus vaccines in Canada. *Vaccine*, 25(29), 5399-5408.

CIRAD, 2003: “No Title.” CIRAD Forestry Department, 1-2.

Cornelissen, J.H.C., S. Lavorel, E. Garnier, S. Diaz, N. Buchmann, D.E. Gurvich,..., J. Pausas, 2003: A handbook of protocols for standardised and easy measurement of plant functional traits worldwide. *Australian journal of Botany*, 51(4), 335-380.

Cunningham, A.B., 2001: Applied Ethnobotany. People, Wild Plant Use and Conservation. People and Plants Conservation Manuals. Earthscan Publications Ltd, London.

Delvaux C., Sinsin B., Darchambeau F., Van Damme P. 2009. Recovery from bark harvesting of 12 medicinal tree species in Benin, West Africa. Journal of Applied Ecology 46: 703-712.

Devineau, J.-L., A. Fournier, S. Nignan, 2009: Ordinary biodiversity in western Burkina Faso (West Africa): what vegetation do the state forests conserve? *Biodivers. Conserv.,* 18, 2075–2099.

Djodjouwin, L., R. Glele Kakai, B. Sinsin, 2011: Caractérisation structurale des formations naturelles enrichies en essences forestières locales: cas des vertisols de la Lama (Benin). *Int. J. Biol. Chem. Sci.*, 5(4), 1628-1638.

Donkpegan, A.S.L., O.J. Hardy, P. Lejeune, M. Oumorou, 2014: “Un Complexe d’Espèces d’Afzelia Des Forêts Africaines d'Intérêt Économique et Écologique (Synthèse Bibliographique), 18(2), 233-246.

Egwujeh, S.I.D., Yusufu, P.A., 2015: “Chemical Compositions of Aril Cap of African Oak (*Afzelia africana*) seed.” Journal, European Science, Food

Fan, Z.X., S.B. Zhang, G.Y. Hao, S.J.W. Ferry, K-F. Cao, 2012: Hydraulic conductivity traits predict growth rates and adult stature of 40 Asian tropical tree species better than wood density. *J. Ecol.*, 100, 732-741.

Fandohan B., K.R. Glèlè, B. Sinsin, P. Dieter, 2008: Caracterisation Dendrométrique et Spatiale de Trois Essences Ligneuses Medicinales Dans La Forêt Classée de Wari-Maro Au Bénin. *Ivoir. Sci. Technol.*, 12, 173-186.

Gaoue, O. G., Ticktin, T., 2010: Effects of harvest of nontimber forest products and ecological differences between sites on the demography of African mahogany. *Conservation Biology*, 24(2), 605-614.

Gaoue, O.G., C.C.H. Orvitz, T. Ticktin, 2011: Non-timber forest product harvest in variable environments: modeling the effect of harvesting as a stochastic sequence. *Ecological Aplication*, 21 (5), 1604-1616.

Garnier, E., Navas, M.L., 2012: A trait-based approach to comparative functional plant ecology: concepts, methods and applications for agroecology. A review. *Agronomy for Sustainable Development*, 32(2), 365-399.

Gautier-Hion, A., J.-M. Duplantier, R. Quris, F. Feer, C. Sourd, J.-P. Decoux, G. Dubost, L. Emmons, C. Erard, P. Hecketsweiler, A. Moungazi, C. Roussilhon, J.-M. Thiollay, 1985: Fruit characters as a basis of fruit choice and seed dispersal in a tropical forest vertebrate community. *Oecologia*, 65(3), 324-337.

Gautier-Hion, A., J.M. Duplantier, R. Quris, F. Feer, C. Sourd, J.P. Decoux, G. Dubost, L. Emmons, C. Erard, P. Hecketsweiler, A. Moungazi, 1985: Fruit characters as a basis of fruit choice and seed dispersal in a tropical forest vertebrate community. *Oecologia*, 65(3), 324-337.

Gérard, J. & Louppe, D., 2011. *Afzelia africana* Sm. ex Pers. [Internet] Fiche de PROTA4U. Lemmens, R.H.M.J., Louppe, D. & Oteng-Amoako, A.A. (Editeurs). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l’Afrique tropicale), Wageningen, Pays Bas. <http://www.prota4u.org/search.asp>. Visité le 6 mai 2014.

Hilton Taylor, C., 2000: 2000 IUCN red list of threatened species (No. C/591.529 I9/2000).

IUCN/SSC Re-introduction Specialist Group, 1998: IUCN Guidelines for Re-introductions. IUCN.

Kone, W. M., K. K. Atindehou, C. Terreaux, K. Hostettmann, D. Traore, M. Dosso, 2004: Traditional medicine in North Côte-d’Ivoire: screening of 50 medicinal plants for antibacterial activity. *Journal of ethnopharmacology*, 93(1), 43-49.

Kraft, C., M. Peter, K. Hofmann, 2010: Selective autophagy: ubiquitin-mediated recognition and beyond. *Nature cell biology*, 12(9), 836-841.

Marie, B., I. Nacoulma, S. Traoré, K. Hahn, A. Thiombiano, 2011: Types on Population Structure and Extent of Bark and Foliage Harvest of *Afzelia africana* and Pterocarpus Erinaceus in Eastern Burkina Faso. *Impact of Land Use*, 3, 62–72.

Melorose, J., R. Perroy, S. Careas, 2015: "Arbres, Arbustes et Lianes Des Zones Sèches d'Afrique de l'Ouest". Statewide Agricultural Land Use Baseline.

Mensah, S., T.D. Houehanou, E.A. Sogbohossou, A.E. Assogbadjo, L.R. Glèlè Kakaï, 2014: Effect of human disturbance and climatic variability on the population structure of *Afzelia africana* Sm. ex pers. (Fabaceae-Caesalpinioideae) at country broad-scale (Bénin, West Africa). *South African Journal of Botany*, 95, 165-173.

Muller-Landau, H.C., 2004: Interspecific and Inter-site Variation in Wood Specific Gravity of Tropical Trees. *Biotropica*, 36(1), 20-32.

Nacoulma, B.M.I., A.M. Lykke, S. Traoré, B. Sinsin, A. Thiombiano, 2017: Impact of bark and foliage harvesting on fruit production of the multipurpose tree *Afzelia africana* in Burkina Faso (West Africa). *Agroforestry Systems*, 91(3), 565-576.

Nacoulma, B.M.I., K. Schumann, S. Traoré, M. Bernhardt-Römermann, K. Hahn, R. Wittig, A. Thiombiano, 2011: Impacts of land-use on West African savanna vegetation: a comparison between protected and communal area in Burkina Faso. *Biodiversity and Conservation*, 20(14), 3341-3362.

Odenigbo, U.M., 2001: Incorporation of *Afzelia africana* (Akparata) in dietary managements of type 2 diabetes mellitus in Nnewi, Nigeria. PhD Thesis.Department of Home Science, Nutrition and dietetics University of Nigeria, Nsukka.

Onweluzo, J.C, K.C. Onuoha, Z.A. Obanu, 1995: "A Comparative Study of Some Functional Properties of *Afzelia africana* and Glycine Max Flours", 54, 55–59.

Orwa, C., A. Mutua, R. Kindt, R. Jamnadassand, A. Simons, 2009: Agroforestree database: a tree species reference and selection guide version 4.0. World Agroforestry Centre ICRAF, Nairobi, KE.

Ouédraogo-Koné, S., C.Y. Kaboré-Zoungrana, I. Ledin, 2006: Behaviour of goats, sheep and cattle on natural pasture in the sub-humid zone of West Africa. *Livestock Science*, 105, 244-252.

Ouédraogo-Koné, S., C.Y. Kaboré-Zoungrana, I. Ledin, 2008: Important characteristics of some browse species in an agrosilvopastoral system in West Africa. *Agrofor. Syst.,* 74, 213-221.

Pausas, J.G., R.A. Bradstock, D.A. Keith, J.E. Keeley, GCTE (Global Change of Terrestrial Ecosystems) fire network, 2004: Plant functional traits in relation to fire in crown-fire ecosystems. *Ecology*, 85 (4), 1085-1100.

Petit, C.C., Lambin, E.F., 2001: Integration of multi-source remote sensing data for land cover change detection. *International Journal of Geographical Information Science*, 15(8), 785-803.

Petit, S., Mallet, B., 2001: The pruning of fodder trees: detail of a pastoral practice. *Trop. Woods For*., 4, 35-45.

Poorter, L., Bongers, F., 2006: Leaf traits are good predictors of plant performance across 53 rain forest species. *Ecology*, 87 (7), 1733-1743.

Poorter, L., L. Bongers, F. Bongers, 2006: Architecture of 54 moist-forest tree species: traits, trade-offs, and functional groups. *Ecology*, 87(5), 1289-1301.

Redhead, J.F., 1968: Mycorrhizal associations in some Nigerian forest trees. *Transactions of the British Mycological Society,* 51(3-4), 377-387.

Rüger, N., C. Wirth, S.J. Wright, R. Condit, 2012: Functional traits explain light and size response of growth rates in tropical tree species. *Ecology*, 93(12), 2626-2636.

Russo, R.M., A. Gallego, D. Comte, V.I. Mocanu, R.E. Murdie, and J.C. VanDecar, 2010: Source-side shear wave splitting and upper mantle flow in the Chile Ridge subduction region. *Geology*, 38(8), 707-710.

Russo, S.E., P. Brown, S. Tan, S.J. Davies, 2008: Interspecific demographic trade-offs and soil-related habitat associations of tree species along resource gradients. *Journal of Ecology*, 96, 192-203.

Sacande M. 2007. Afzelia africana Sacande. Seed Leaflet 118: 24-26.

Santiago, C., A. Ballesteros, L. Martinez-Muñoz, M. Mellado, G.G. Kaplan, G.J. Freeman, and J.M. Casasnovas, 2007: Structures of T cell immunoglobulin mucin protein 4 show a metal-Ion-dependent ligand binding site where phosphatidylserine binds. *Immunity*, 27(6), 941-951.

Satabié, B., 1994, Biosystématique et vicariance dans la flore camerounaise. *Bull. Jardin Bot. Nat. Belg.*, 63,125-170.

Sinsin, B., 1993: Phytosociologie, écologie, valeur pastorale, production et capacité de charge des pâturages naturels du périmètre Nikki-Kalalé au Nord-Bénin. Thèse de doctorat, Université Libre de Bruxelles, Belgique.

Sinsin, B., O. Eyog Matig, T. Sinadouwirou, A.E.Assogbadjo, 2002: Caractérisation écologique des essences fourrageres Khaya senegalensis Desr. et *Afzelia africana* Sm. suivant les gradients de latitude et de station au Bénin. Eyog Matig, O., O.G. Gaoue, Obel-Lawson (eds): 15-50. *In*: Development of Appropriate Conservation Strategies for African Forest Trees Identified as Priority Species by SAFORGEN Member Countries. SAFORGEN.

Sinsin, B., O.E. Matig, A. E. Assogbadjo, 2004: Dendrometric characteristics as indicators of pressure of *Afzelia africana* Sm. dynamic changes in trees found in different climatic zones of Benin. *Biodiversity & Conservation*, 13(8), 1555-1570.

Sinsin, B., O.E. Matig, A.E. Assogbadjo, O.G. Gaoué, T. Sinadouwirou, 2004: Dendrometric characteristics as indicators of pressure of *Afzelia africana* Sm. dynamic changes in trees found in different climatic zones of Benin. *Biodiversity & Conservation*, 13(8), 1555-1570.

Smith, J.E., 1798: The characters of twenty new genera of plants. *Trans. Linn. Soc.,* 4, 213-223.

Sokpon, N., Biaou, H.S., 2002: The use of diameter distribution in sustained-use management of remnant forests in Benin: case of Bassila forest reserve in North Benin. *Forest Ecology and Management,* 161, 13-25.

Sokpon, N., H.S. Biaou, C.O. Ouinsavi, O. Hunyet, 2006: Bases techniques pour une gestion durable des foreˆts claires du Nord-Benin : Rotation, diamètre minimal d'exploitabilite´ et régénération. *Bois For. Trop.,* 60, 45-57.

Stark, M.A., 1986: Relationship between fire and basal scarring on *Afzelia africana* in Benoue National Park, Cameroon. *Afr. J. Ecol.,* 24, 263-271.

Sterck, F.J., L. Poorter, F. Schieving, 2006: Leaf Traits Determine the Growth-Survival Trade-Off across Rain Forest Tree Species. *The American Naturalist*, 167(5), 758-765.

Wala, K., 2004: La végétation de la chaîne de l'Atakora au Bénin : Diversité floristique, phytosociologie et impact humain. Thèse de l'Université de Lomé. FDS/UL.

Williams, G.C., 1957: Pleiotropy, Natural Selection, and the Evolution of Senescence. *Evolution*, 11(4), 398-411.

Wright, S.J., K. Kitajima, N.J. Kraft, P.B. Reich, I.J. Wright, D.E. Bunker, R. Condit, J.W. Dalling, S.J. Davies, S. Díaz, B.M. Engelbrecht, 2010: Functional traits and the growth–mortality trade-off in tropical trees. *Ecology*, 91(12), 3664-3674.

Yorou, S.N., R. Agerer, S. Raidi, 2008: "Afzeliaerhiza beninensis" *Afzelia africana* Smith. *Descr. Ectomy*, 11(12), 1-8.