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Endogenous Perceptions of the Use of *Parkia Biglobosa* Pods in Weed Control in the South Sudanian Zone of Burkina Faso

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ABSTRACT

Introduction: Alternative biological weed control methods in Burkina Faso are poorly understood and documented. Although some traditional control methods using plant organs exist, their adoption by populations remains very limited due to various challenges. This study aimed at identifying the use patterns of *Parkia biglobosa* pods, the populations' perceptions on the benefits resulting from use of *Parkia biglobosa* 's pods in weed control, the constraints and external factors that may limit the adoption of plant organs in weed control.

Materials and Methods: An ethno-botanical survey was conducted in Burkina Faso in three provinces (Comoé, Léraba, and Kénédougou) located in the South Sudanian zone, using semi-structured interview methods. On the basis of voluntary membership, 262 people were interviewed

Results: The results revealed that the main modes of *Parkia biglobosa* 's pods use are the burial of whole pods by plowing (FC = 45.8%), followed by spreading (FC = 20.3%) of pods in places more infested by weeds. The most mentioned advantages related to the use of *Parkia biglobosa*'s pods are its contribution in the fight against environmental pollution (FC = 63.0%), the improvement of agricultural yields (FC = 52.8%) and the improvement of soil structure (FC= 25.0%). The unavailability of *Parkia biglobosa*'s pods (FC = 51.7%) and the lack of suited equipment (FC = 47.6%) are reported to be the main constraints hindering the use of *Parkia biglobosa*'s pods by populations in weed control.

Conclusion: The benefits of Parkia biglobosa pods include reduced environmental pollution, improved crop yields, and improved soil structure. The scarcity of plant organs and lack of agricultural equipment are hampering the adoption of Parkia biglobosa pods for weed control. These findings could help better guide policymakers and projects aimed at promoting weed control methods.

Keywords: allelopathy, weed, pod, agroecosystem, cereals, biological control

INTRODUCTION

Agriculture is the primary economic sector in Burkina Faso, employing over 86% of the population.[1] A significant portion of the budget is devoted to this sector, as its development contributes to achieving food security. The main crops are millet, fonio, rice, sorghum and corn. These crops are sometimes intercropped with legumes such as cowpeas and/or peanuts. Sorghum, millet and corn account for approximately 80% of cereal production.[2] The production constraints for these crops in Burkina Faso are climatic hazards, poor soil conditions, and pests. Indeed, damage caused by climatic hazards such as floods, droughts and irregular rainfalls drastically affects cereals production. These scourges thus cause famine and accentuate poverty among vulnerable populations. As for soil poverty, it is partly due to excessive exploitation of vegetation and the collection of crop residues for other purposes. These anthropogenic actions are the factors of soil degradation.[3] Regarding crops enemies, the most important would-be insects, viral diseases and weeds. These pests not only affect yields but also the quality of the harvested product. The negative impacts due to weed is more significant. Indeed, weed greatly hampers agricultural yields especially in the South Sudanian phytogeographic zone of

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Burkina Faso.[4] In this area, the soil and climate conditions are favorable for their growth. Yield losses caused by weed competition in this region have been estimated between 41 and 75%.[5] Efficient control of weed or the reduction of the level of weed infestation on farm would help increase production to meet the food availability for populations. Weed control strategies are diverse, but essentially rely on the application of chemical herbicide molecules. The uncontrolled use of synthetic herbicides has drastic effects on the environment[3], particularly on water. The uncontrolled use of herbicides for systematic chemical weed control poses increasing ecological and health risks. Some studies that have examined these aspects[6,7] have even stated that abuses in the use of chemical herbicides are often due to poor product labeling and a lack of information. The use of chemical pesticides for weed control poses risks of human poisoning and environmental pollution. These risks can be reduced by raising awareness on the best agricultural practices, and training farmers' on the alternative weed control methods. Preliminary surveys carried out in 2018 in southwest Burkina Faso revealed that some farmers practice traditional weed control through the use of plants with herbicidal effects. Among the herbicidal plants, *Parkia biglobosa,* especially its pods are the most used. Therefore, a better understanding of the modes of use of *Parkia biglobosa*'s pods, the identification of the advantages related to their use as well as the factors limiting their large-scale adoption is necessary. Thus, the objectives of this study are (i) to identify the modes of use of *Parkia biglobosa*'s pods in the agricultural systems (ii) to determine the perceptions of populations on the advantages related to the use of *Parkia biglobosa*'s pods in weed control (iii) to identify the constraints and external factors limiting the use *Parkia biglobosa*'s pods in weed control.

MATERIALS AND METHODS

Site of the study

The study area covers the administrative provinces (Figure 1) of Comoé (10° 36' N, 4° 45' W), Léraba (10° 40' 00" N, 5° 12' 00" W), and Kénédougou (11° 25' 00" N, 5° 00' 00" W). These three provinces are located in the South Sudanian phytogeographic sector of Burkina Faso. The vegetation consists of a mosaic of gallery and riparian forests, treed, wooded, and shrub savannahs. It includes some of the densest forest formations in the country. In terms of floristic diversity, it is the richest area in Burkina Faso. The analysis of climate patterns based on rainfalls and thermal weather stations in the closest towns to the study sites (Figure 2) shows that the rainy period lasts seven (7) months and the peak rainfall is reached in August with more than 300 mm. The local population is made up of more than 15 ethnic groups, the main ones being the Turka, the Goin, the Senufo and the Peulh. Dioula is the main language spoken. Agriculture and livestock farming are the main socio-economic activities practiced by the populations of the Cascades and Hauts-Bassins regions.

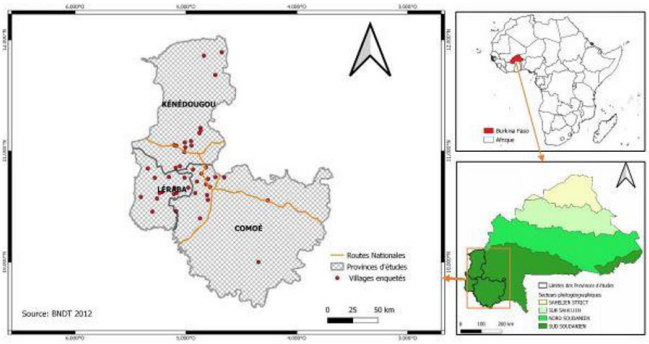

Figure 1: Location of the study sites.

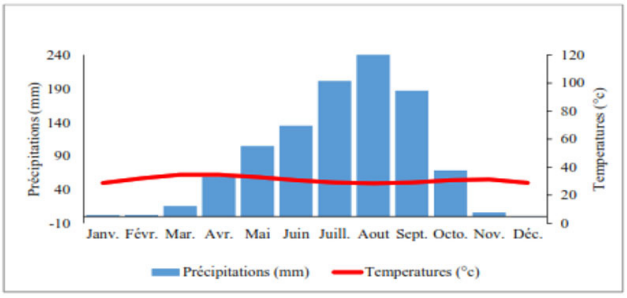

Figure 2: Variations in cumulative rainfall and temperature from 2014 to 2024.

Source: National Meteorological Directorate General (2024)

Survey Sites

The surveys were conducted in 18 villages in the Comoé province, 14 villages in the Léraba and Kénédougou provinces. These farming villages and hamlets are predominantly populated by the Turka and Dioula ethnic groups, and their selection was justified by the local population's knowledge of traditional weed control methods in crop production. These sites are also areas where farmers primarily grow two improved varieties of maize, notably Wari and Bondofa.

Sampling

Simple random sampling was used to select the interviewees. This technique ensures good representativeness of the population because it gives everyone an equal chance of being selected. The sample size was determined using the normal approximation of the binomial distribution [8]:

$$N = \frac{u^2 1-\frac{a}{2} Pi\,(1-Pi)}{\delta^2} \quad (1)$$

N = number of producers to be surveyed; Pi = percentage of producers who responded yes; μ1-α/2 = 1.96 represents the value of the normal random variable for a risk α equal to 0.05; δ^2 = expected margin of error for any parameter to be estimated from the survey and is 5%. The application of this

formula resulted in a sample of 207 producers. Table 1 shows the distribution of the study sample by province.

Table 1: Distribution of the study sample by province

Provinces	Number of respondents
Comoé	91
Léraba	87
Kénédougou	84
Total	262

Data Collection

Data collection took place from July 2020 to October 2022 in two (02) phases. The first was an exploratory phase and the second a collection phase. The first phase identified agricultural practices based on the use of *Parkia biglobosa'*s organs. After harvesting, the pods are preserved (photo 1), followed by the pulp and seeds being extracted from the husks or pods. These pods (photo 2) are used by local populations in biological weed control. During the second phase, perceptions and methods of using pods in agricultural systems were collected through questionnaires and individual semi-structured interviews. Inclusion criteria for respondents were based on age (>30 years), volunteering, field ownership, and the use of traditional plant-based practices in weed control. The information sought from these respondents focused on socio-demographic characteristics (sex, age, socio-cultural groups, level of education, membership of a group, number of years of experience in agricultural production, etc.), their perceptions on the constraints of using *Parkia biglobosa*'s pods in agricultural systems as well as the modes of use.

Photo 1: *Parkia biglobosa*'s pods stored in a shed

Photo 2: *Parkia biglobosa*'s pods

Statistical Analysis

Respondents' responses were expressed as a percentage (%) for each parameter. To better understand the age variable, we divided the respondents into age groups. Thus, all respondents aged between 30 and 50 years were classified as adults; those aged between 51 and 70 were classified as elderly; and those over 70 years were classified as seniors. Regarding respondents' perceptions of the constraints, benefits, and exogenous determinants that could stimulate the adoption of *Parkia biglobosa*'s pods in agricultural systems, the following indices were calculated:

Relative frequency of citation (RF) determined using the following formula [1]

$$FC=\frac{N}{Nt}\,x100 \qquad (2)\ ;$$

N represents the number of times the factor was cited and Nt the total number of respondents. After coding with Microsoft Excel software, all collected data were analyzed using R software version 3.6.1. Depending on the type of calculated variable, linear ANOVA (parametric test) and Kruskal Wallis test (non-parametric test) were performed. Shapiro test (normality) and Bartlett test (homogeneity) of the variance were initially checked. The separation of the means was performed using Tukey test, when the P value was significant. The significance threshold was of 5%.

RESULTS

Socio-demographic characteristics of the respondents

The socio-demographic characteristics of the respondents are shown in Table 2. The gender distribution revealed that the surveyed population consisted of 76.9% males compared to 23.1% females in the Comoé province, and 78.6% versus 77.01% males in the Kénédougou and Léraba provinces, respectively. The majority of the respondents were elderly in the Comoé (67.03%) and Léraba (59.8%) provinces. In the Kénédougou province, the elderly category (46.4%) was more represented. The analysis of the results shows a significant variation in the level of knowledge ($p = 0.002$) based on the respondent's age. The majority of respondents from the Comoé (57.1%) and Léraba (58.6%) provinces had no formal education, although some spoke French. In the Kénédougou province, only 14.9% had a higher education level. Similarly, respondents having a post-primary level of education represented 14.28% and 14.9% in the Comoé and Léraba provinces, respectively. Regarding the source of information, respondents in the Comoé (92.3%) and the Léraba (95.4%) provinces acquired information through learning.

Table 2. Socio-demographic characteristics of the respondents

	Comoé		Kéné-dougou		Léraba		Chi-square
	N	%	N	%	N	%	
Gender							
Man	70	76.9	66	78.6	67	77.0	0.0793
Women	21	23.1	18	21.4	20	23.0	
Age group							
Adults	14	15.4	19	22.6	14	16.1	0.0021
Old	61	67.0	26	31.0	52	59.8	
Elders	17	18.7	39	46.4	21	24.1	
Level of study							
Not in school	52	57.1	35	40.2	51	58.6	0.0037
Primary	18	19.8	21	24.1	16	18.4	
Post-primary	13	14.2	15	17.2	13	14.9	
Superior	8	8.8	13	15.0	7	8.0	
Sources of knowledge							
Learning	84	92.3	84	100	83	95.4	0.0671
Reading	7	7.7	0	0	4	4.6	

Considering the overall level of education of the respondents, 68% of the surveyed population do not have formal education (Figure 3). The others (32%) were divided between primary (18%), post-primary (8%) and higher education (6%).

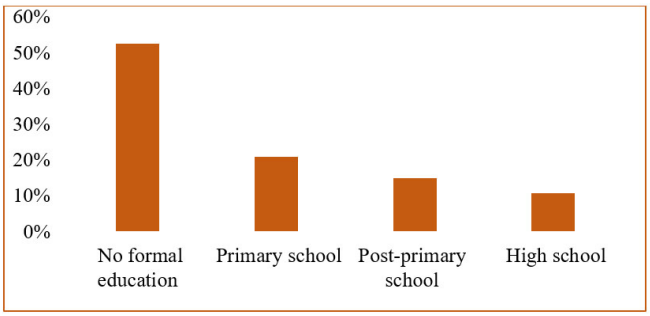

Figure 3: Different educational profiles of the people surveyed

Uses of Parkia biglobosa's pods in agro ecosystems

The main uses of *Parkia biglobosa*'s pods in agricultural systems are presented in Figure 4. The analysis revealed that the main method of use is the burying (45.8%) of whole pods in the soil by plowing at the beginning of the rainy season, before planting the crop. The types of burial (Figure 5) encountered are direct ridge burial (36.7%), where the whole pods are placed between the old ridges, covered with soil, and thus enclosed in the new ridge, and flat plowing (41.6%). Some respondents (20.3%) preferentially spread the pods in areas with high *Striga spp.* infestations. Furthermore, 8.4% of respondents first process the organs into powder before use.

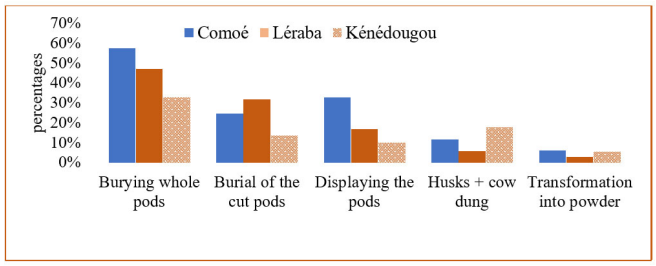

Figure 4: Modes of use of *Parkia biglobosa*'s pods in agro ecosystems

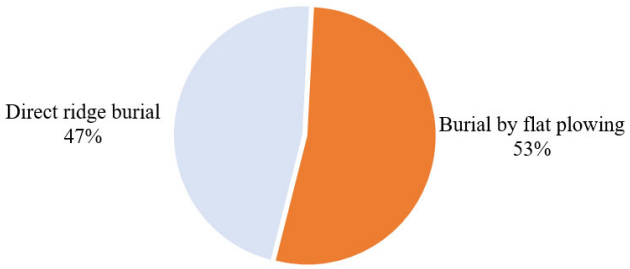

Figure 5.: Types of burial of *Parkia biglobosa*'s pods in agro-ecosystems

Benefits of Using Parkia biglobosa's pods

Table 3 presents data on the benefits of using *Parkia biglobosa*'s pods. The results showed that the use of *Parkia biglobosa*'s pods helps combat environmental pollution according to 63.0% of the respondents, contributes to improving agricultural yields for 52.8% of the respondents. 25.0% of the respondents reported that *Parkia biglobosa*'s pods improves soil structure while 19.5% of the interviewees suggested that they helps increase the amount of soil nutrients. Loosening soil structure (3.4%) and improving the life of microorganisms (2.8%) are the weakest benefits reported by the respondents. Contribution to soil aeration and reduced erosion are not considered as benefits of using *Parkia biglobosa*'s pods by the populations of Comoé province. In the Léraba Province, no one mentioned the increase in soil nutrients, the reuse of organic materials, the fertilization of land, or the promotion of soil microorganisms as benefits resulting from the use of *Parkia biglobosa*'s pods in weed control.

Table 3: Benefits of using *Parkia biglobosa*'s pods

Benefits	Comoé	Léraba	Kénédougou	Total (%)
	FC (%)	FC (%)	FC (%)	
Combats air and water pollution	71.6	51.8	65.7	63.0
Improves productivity	47.1	43.9	67.5	52.8

Table 3: *(Continued)*

Benefits	Comoé	Léraba	Kénédougou	Total (%)
	FC (%)	FC (%)	FC (%)	
Increases nutrients	33.8	-	23.4	19.1
Reuse organic materials	22.6	-	10.5	11.0
Generates income	19.4	11.6	7.5	12.8
Builds crop resilience	12.4	3.8	-	5.4
Limits erosion	-	17.6	6.8	8.1
Improves soil structure	38.9	21.3	14.7	25.0
Fertilizes land	28.9	-	21.5	16.8
Strengthens the local economy	11.7	3.7	7.3	7.6
Promotes the life of soil organisms	8.4	-	-	2.8
Loosens the soil	6.5	3.7	-	3.4
Contributes to soil aeration	-	11.5	17.5	9.7

Constraints to the Use of Parkia biglobosa's Pods in Agro ecosystems

Producers reported several constraints (Table 4) related to the use of *Parkia biglobosa*'s pods in agricultural systems. These constraints remain the same in the three study provinces ($p>0.05$). The analysis of the results shows that the main constraints are the increased workload (64.2%), followed by the unavailability of pods at a certain time of the year (58.3%), the lack of agricultural equipment (56.2%), and the difficulty of transporting these organs to the fields (43.1%). However, the least constraints (<10%) are related to the inappropriate use (4.5%), the lack of knowledge of the effect of the *Parkia biglobosa*'s pods in agricultural productions (3.8%), and the decomposition time considered too long (3.3%).

Table 4: Constraints Related to the Use of *Parkia biglobosa*'s Pods

Constraints	Comoé	Léraba	Kénédougou	Total (%)
	FC (%)	FC (%)	FC (%)	
Difficult to transport to fields	39.5	51.4	38.3	43.1
Lack of communication and promotion	12.5	6.9	21.4	13.6
Inappropriate uses	1.6	4.5	7.5	4.5
Lack of knowledge about the effect of pods	-	2.7	8.6	3.8
Long decomposition periods	6.5	-	3.4	3.3
Unavailability	58.9	71.3	44.7	58.3
Land tenure insecurity	-	5.6	13.7	6.4
Low efficiency	9.6	19.4	6.5	11.8
Difficult to process	13.5	9.7	10.7	11.3
Poverty	10.8	6.9	8.6	8.8
Increased workload	61.5	59.7	71.3	64.2
Labor shortage	31.8	20.5	13.2	21.8
Lack of agricultural equipment	63.3	47.9	57.4	56.2

Exogenous Factors for the Adoption of Parkia biglobosa's Pods in Agroecological Systems

The results of the surveys on exogenous factors likely to encourage the use of *Parkia biglobosa*'s pods in agro ecosystems are shown in Figure 6. The results show that the main exogenous factors are pod availability (51.7%) and equipment availability (47.6%). The incentive policy for agricultural product prices (3.9%) and the structure of stakeholders involved in production chains (4.8%) are considered by the respondents to be the weakest factors for the adoption of pods in agricultural systems.

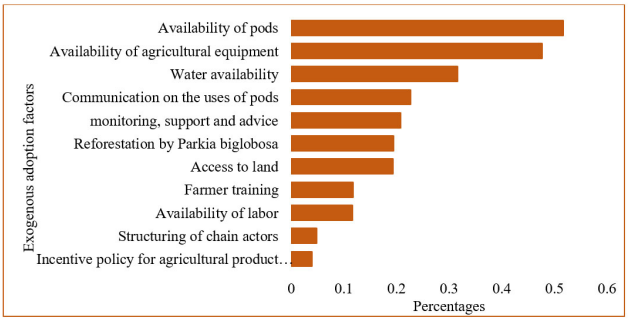

Figure 6: Exogenous factors driving the use of *Parkia biglobosa*'s pods.

DISCUSSION

The interviewees, mostly women, were unwilling to take part in the interviews. This ascertainment is likely due to sociocultural constraints[9] that require them to seek their

husband's advice before making any comments on any subject during a survey. Men were more knowledgeable about the uses of *Parkia biglobosa*'s pods in agricultural systems. Women were generally less informed. The preponderance of men suggests that traditional weed control using *Parkia biglobosa*'s pods is mostly practiced by men and could justify their responsibility as fathers. Indeed, field work requires more physical efforts, which men are more likely to be able to exert. In contrast, the marketing and preservation of agricultural products are more often reserved to women.[10]

The respondents had a low level of education and several of them acquired experience from others. This acquisition of knowledge on traditional weed control through the use of pods would attest that the transmission of knowledge in the study area is part of the family heritage. Furthermore, the low level of education of farmers in relation to classical studies would be the fact that traditional weed control through the use of *Parkia biglobosa*'s pods does not require prior training at school.[1] Findings on medicinal plants by[11] in Cameroon and [12] in DR Congo showed the low level of education (≤10%) of the respondents. This could constitute a constraint in the adoption of innovations and technologies' transfer for increasing agricultural production.[13]

To mitigate weed emergence on the fields, *Parkia biglobosa*'s pods are buried when plowing or cut into pieces and then spread on the soil surface. These forms of use are reported in several studies carried out on plants with herbicidal effects in Burkina Faso[11] , Maroc [14], Tunisia [15] and Senegal.[16] It should also be noted that burial would be beneficial rather than harmful. Indeed, as much as it could facilitate the release of certain active ingredients often present in plants' organs in the form of glycosides, it could also fertilize the soil. Pods spread on the surface have advantages and disadvantages depending on the ecological zone. Thus, on sloping soil (< 1%), it reduces the risks of soil erosion and increases carbon storage in the surface horizon due to the absence of ploughing. In accordance with previous work[17], environmental protection against pollution, improvement of agricultural yields and soil structure were revealed as the main benefits of using *Parkia biglobosa*'s pods in agro ecosystems. These results demonstrate that populations are aware of the harmful effects of synthetic chemical herbicides. However, these perceptions differ from previous observations by [18], who estimated that the use of *Parkia biglobosa*'s pods in agricultural systems is perceived as the main source of monetary income and job creation. Economic factors include the income generated by rural activity. Other authors[19] estimated that in addition to inhibiting the germination of weed grains, *Parkia biglobosa*'s pods fertilize the soil and improve production.

Nevertheless, it can be considered that the three key benefits cited by producers in the three provinces correspond well to their specific advantages. Increased working time, unavailability of organic matter and lack of appropriate agricultural equipment are major constraints faced by farmers in the adoption of *Parkia biglobosa*'s pods for increasing agricultural yields. The lack of equipment is a constraint that deserves to be highlighted, as it has already been shown that it can constitute a significant constraint to the adoption of new agricultural technologies, particularly in the case of agroecology.[20] Furthermore, this constraint could be explained by the fact that the respondents have few financial means to acquire agricultural equipment. Similarly, the high costs of drilling by populations would justify the presence of water as a condition that could encourage the adoption of the use of *Parkia biglobosa*'s pods in agro ecosystems improvement by producers. This perception corroborates the results of [12] in Mali on the adoption of baobab vegetable beds. Other conditions, such as access to land, are perceived by the respondents as encouraging the adoption of *Parkia biglobosa*'s pods use in agricultural production. This could be explained by the strong pressure on land due to the population exponential growth.

CONCLUSION

The objective of this study was to identify the various traditional uses of *Parkia biglobosa*'s pods for weed control. It appears that burying and spreading are the common uses of these organs in agro ecosystems. Populations' perceptions of the benefits of this form of biological weed control are limited to combating environmental pollution, improving agricultural yields, and improving soil structure. However, increased workload, the unavailability of plant organs at certain times of the year, and a lack of agricultural equipment hinder the adoption of these plant organs for weed control. These results therefore call for the promotion of new biological weed control methods. Policymakers still need to make efforts to provide farmers with agricultural equipment. Researchers must also make information available to the public. Group initiatives should also be encouraged to generalize knowledge about these plant organs used in biological control of weed during crop production. Failing this, a structuring of the actors involved in the field should be considered.

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CONFLICT OF INTEREST

All authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION:

SS conceptualized and designed the study, coordinated data collection, and interpreted the results. TC analyzed the data and participated in reading of the manuscript. TMS and OYSR reviewed and read the final manuscript.

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