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Full Length Research Paper

The influence of rice cultivar and sorghum planting date on crop yield in lowland rainfed double cropping systems in Northern Cameroon

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Double cropping of rice and dry season sorghum on vertisols can significantly increase cereal availability for farmers both for food security and income generation. The objective of the study was to evaluate the influence of rice cultivar and dry season sorghum planting date on crop yield in lowland rainfed double cropping systems in Northern Cameroon. Over two years, the three rice cultivars evaluated were NERICA 56, SEBOTA 281-2 and SEBOTA 70. These were followed by the local sorghum variety called *''Guelendeng''*, sown at three different dates. All rice cultivars were able to grow and provide a yield. Their paddy production was between 5.7 and 7.6 t ha^{-1}. Introducing rice in the rainy season did not hinder the production of subsequent dry season sorghum whose grain yields ranged between 540 and 811 kg ha^{-1}. The choice of rice cultivar has a significant impact on both individual crop yield and the double cropping system yield. However, the need for adequate fertilization for the cereal double cropping system, the availability of short cycle rice cultivars and indicators for the determination of the best transplanting period for dry season sorghum as second crop are main challenges.

Key words: Double cropping, lowland rainfed rice, dry season sorghum, transplanted sorghum, vertisols, food security.

INTRODUCTION

Introducing rice in agricultural systems in Cameroon is a major concern common among farmers, especially in the Far North Region where cereal production is often under deficit (ACDIC, 2006; Gnassamo and Kolyang, 2002), famine and low income (Njomaha, 2004). The country moved from self-sufficiency in rice production to dependence on imports which amount to nearly 400 thousand tons yearly and account for 87% of the needs (Goufo, 2008).

About 95% of the population eats rice at least once a week in Cameroon (ACDIC, 2006), but little is done to improve domestic production. National rice production was estimated at 65 000 tons over 50 000 ha with the Far

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North Region ensuring 85% of total production.Rice is mainly produced under irrigation (87%) and rainfed lowland (9%); the rest is cultivated under upland conditions where the sole water supply is rainwater (Goufo, 2008).

Rice under irrigation in the Far North Region of Cameroon is mainly produced by the large state corporation named ''Société d'Expansion et de Modernisation de la Riziculture de Yagoua'' (SEMRY). Smallholders rely on rainfall for rice cultivation and the planting season in most locations occurs at the start of the rainy season. Mechanized rice cropping has been a key component of the irrigated system, while manual rice farming is used for rainfed lowland and upland systems (Yerima and Van Ranst, 2005). Approximately 1,000 ha of land are regularly planted rice by some 11,000 traditional farmers in the Far North Region (MINADER, 2009). Farmers are becoming more and more interested in rice production and have a new opportunity to revitalize their production with improved cultivars (Bouzinac et al., 2009; Nguyen, 2003).

Some 30 rice cultivars including NERICA and SEBOTA varieties have been initially supplied for trial in upland and rainfed lowland ecosystems in the Far North Region of Cameroon between 2000 and 2004 by the Project named ''Développement Paysannal et Gestion des Terroirs''. The trend was furthered by Projet Eau Sol Arbre and ''Projet de conservation des Sols au Nord Cameroun''. Most of the introduced cultivars are early maturing and their reported grain yields stand between 2.5 and 6 t ha^{-1} (Goufo, 2008). These projects were operating under the aegis of the ''Société de Développement du Coton'' (SODECOTON), in an attempt to promote crop diversification in the cotton producing area of the country. Cotton is the main cash crop in the Far North Region of Cameroon and rainfed sorghum is the most consumed cereal by local people. Dry season sorghum (*Sorghum bicolor* (Linn.) Moench) locally called ''*Muskwari''*, is a reliable back-up against the failure of rainfed sorghum (Vernier et al., 1987; Abolgo, 2005). About 46% of households produce dry season sorghum as the sole crop on farms, averaging 1.4 ha (Njomaha, 2004).

Dry season sorghum is transplanted on heavy clayed vertisols at the beginning of the dry season and uses residual water from the soil profile to complete its cycle (Ambassa-Kiki et al., 1996; Seignobos and Moukouri, 2000). Vertisols and associated soils cover about 800 000 ha in the Far North Region of Cameroon alone (Brabant and Gavaud, 1985). They are regarded as places where rice can be introduced, without using the land reserved for other food crops (Gnassamo and Kolyang, 2002).

Their potential for rice production is high, but they are difficult to manage. Vertisols characteristically swell and become sticky when wet and they shrink, become hard and crack extensively when dry (Hamasselbé and Volper, 1987). They are difficult to cultivate with simple implements and have a narrow moisture range within which land tilling operations can easily be accomplished (Ambassa-Kiki et al., 1996). As a result, large land tracks of vertisols in the Far North Region of Cameroon are left flooded and abandoned during the rainy season, and sown with dry season sorghum on residual moisture of non-tilled soil, at the end of rains (Ambassa-Kiki et al., 1996). This practice is well established in Northern Cameroon since the 19^{th} century (Couty, 1987) and contributes significantly to food security (Seignobos and Moukouri, 2000; Gnassamo and Kolyang, 2002). A system that would jeopardize dry season sorghum production may not be accepted by local farmers (Abolgo, 2005).

The period within which dry season sorghum can be successfully transplanted is also short and is determined empirically by farmers based on the pattern of last rains (Mathieu, 2000; Gnassamo and Kolyang, 2002). It is important to investigate farming systems that could benefit farmers both for food security and income generation. This paper examines the possibility of growing rice and sorghum in double culture cropping pattern on vertisols in the Far North Region of Cameroon.

MATERIALS AND METHODS

Production site

Experiments were conducted in 2009 and 2010 at Balaza, some 30 km away from Maroua, the main city of the Far North Region of Cameroon. The site is lowland, traditionally used only for dry season sorghum production. The coordinates of the center of the experimental plots are 10.69748°N and 14.45320°E. The altitude is 359 m. Monthly precipitations (Table 1) and soil characteristics (Table 2) are typical of lowland rice growing sites.

Crop varieties

The three rice varieties used in this experiment are NERICA 56, SEBOTA 70 and SEBOTA 281.2 (Table 3). They were selected based on their production potential and contrasting growing cycles (PCS ESA II, 2009). They need less than 120 days to be harvested (Bouzinac et al, 2009; WARDA, 2008). The sorghum variety is ''*Guelendeng*''. The main distinctive feature of this local variety is its short cycle and suitability for late plantings.

Treatments and experimental design

The factors evaluated were the yields of three rice cultivars and of dry season sorghum subsequently transplanted at three different dates. The experimental design was a randomized complete block design with 20 replicates for rice cultivars evaluation. Part of the experimental set up was subsequently used to evaluate dry season sorghum production as second crop in the system. Treatments were the 9 combinations of previous rice cultivars and sorghum transplanting dates replicated 4 times. The experimental units were 5 × 8 m (40 m^2). Spacing was 1.5 m between blocs and 1 m between adjacent experimental units.

Table 1. Monthly precipitations at Balaza in 2009 and 2010.

Year	Variable	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2009	Rainfall (mm)	0	0	0	75	0	79	187	238	58	78	0	0	715
	NRD	0	0	0	1	0	5	12	14	9	6	0	0	47
2010	Rainfall (mm)	0	0	0	0	0	76	203	274	191	31	0	0	775
	NRD	0	0	0	0	0	8	9	11	9	5	0	0	42

NRD: Number of rainy days; source: PCS/ESAII, SODECOTON (2009, 2010).

Table 2. Characteristics of vertisols at Balaza from the analysis of a composite soil sample taken at a depth of 0 to 20 cm.

Characteristics	Value
Sand	17
Total silt	43
Clay	40
Soil pH	
pH-water	5.42
pH-KCl	4.68
Organic matter and nitrogen	
Organic carbon (%)	2.04
Organic matter (%)	3.5
Total nitrogen (g/kg)	1.85
C/N	11
Exchangeable cations (meq/100 g of soil)	
Calcium	1.23
Magnesium	0.69
Potassium	0.38
Sodium	0.28
Sum of bases	2.59
Exchangeable acidity (meq/100 g of soil)	
H+Al (AE)	0.14
Al^{+++}	0.09
H^{+}	0.05
CEC (meq/100 g of soil)	
Effective CEC	2.73
S/CECE (%)	95
CEC pH7	19.58
Base saturation (%)	13
Available phosphorus	
Bray II (mg/kg)	62.6

Cropping practices

A non selective herbicide (glyphosate) was applied over the experimental units before planting. Rice was seeded on June 27th in 2009 and July 3rd in 2010 at 20 × 20 cm.

Rice seeds were directly hand planted on non tilled vertisols after their cracks were closed following the first rains. Holes of 5 cm depth were opened using a sharp stick and 5 to 7 rice seeds were dropped into planting holes. Then, 15 days after emergence, 150 kg ha^{-1} of urea was linearly applied on rice experimental units. This was followed 30 days later by the application of 200 kg ha^{-1} of NPK fertilizer 22-10-15. Rice plots were hand weeded twice during the growing season.

After rice harvest, sorghum was transplanted at 1 × 1 m in experimental units. In 2009, sorghum nurseries were planted on August 25th and September 1st; in 2010, the planting dates of nurseries were August 10th and 17th. Sorghum was transplanted on November 10th, 16th and 22nd in 2009 and on November 7th, 13th and 19th in 2010. No fertilizer was applied to dry season sorghum and its weeding was not necessary.

Data collection and analysis

Rice yields were estimated from 1 m^2 subplots at the centre of experimental units. Sorghum yields were obtained from the two central lines of experimental units. Yields from experimental units were translated to amounts per hectare and analyzed. The grain humidity at storage of SEBOTA 70, SEBOTA 281.2 and NERICA 56 were 8, 7.1 and 7.6%, respectively. Data were introduced on Excel sheets, and then transferred to statistical analysis system (SAS) software for analysis. The probability level was 5% for significant differences and 1% for the highly significant differences.

RESULTS

Paddy rice production

Rice was the first crop in the system and all the cultivars under study were able to grow and provide yield on vertisols. Paddy rice yields were between 5.7 and 7.6 t ha^{-1} (Table 4).

The analysis of variance indicates a highly significant interaction between years and cultivars for rice production. The two SEBOTA cultivars produced more paddy than NERICA 56 in both years. Between the SEBOTA cultivars, SEBOTA 281.2 produced significantly more rice than SEBOTA 70 in 2009. Their production was similar in 2010. In general, yields were higher in 2010 compared to those obtained in 2009.

Table 3. Characteristics of the rice cultivars used in the experiment.

Rice cultivars	Plant characteristics		
	Aptitude	Length of crop cycle (days)	Yield potential (t ha^{-1})
SEBOTA 281.2	Upland, lowland or irrigated	115-120	10
SEBOTA 70	Lowland or irrigated	95-100	12
NERICA 56	Lowland or irrigated	85-100	7

Source: Bouzinac et al (2009) and WARDA (2008).

Table 4. Mean paddy yields with standard deviations of three rice cultivars NERICA 56, SEBOTA 281.2 and SEBOTA 70 obtained in 2009 and 2010.

Years (Y)	Rice cultivars (R)	Rice paddy yield	
		Mean* (kg ha^{-1})	Standard deviation
2009	NERICA 56	5707^{c}	238
	SEBOTA 281.2	7391^{a}	236
	SEBOTA 70	6564^{b}	219
2010	NERICA 56	7133^{b}	203
	SEBOTA 281.2	7473^{ab}	188
	SEBOTA 70	7657^{a}	204

*Mean with the same letters are not significantly different; Y x R: Significant at the 1% level.

Table 5. Mean dry season sorghum yield with standard deviations from three transplanting dates of the local variety ''Gueleldeng'' in 2009 and 2010 on Vertisols at Balaza in the Far North Region of Cameroon.

Year (Y)	Transplanting date (T)	Dry season sorghum yield	
		Mean* (kg ha^{-1})	Standard deviation
2009	10th November	593^{a}	49
	16th November	708^{a}	70
	22nd November	691^{a}	52
2010	7th November	772^{a}	58
	13th November	811^{a}	32
	19th November	540^{b}	46

*Mean with the same letters are not significantly different; Y x T: Significant at the 5% level.

Grain sorghum production

Sorghum was the second crop in the system after rice. In 2009, the second and third sowing dates provided higher yields. During the following year (2010), the best yields were obtained with the first and second sowing dates (Table 5). Sorghum yields also tended to be higher in 2010 compared to 2009, except for the third sowing date. These trends result in a high significant interaction between years and sorghum dates of transplanting for grain production.

DISCUSSION

Paddy yields of the three varieties of rice tested (5.7 to 7.6 t ha^{-1}) are higher than the 3 to 6 t ha^{-1} obtained under upland rainfed conditions in the Far North region of Cameroon by local farmers (DRADR-EN, 2010). In rice demonstration plots on vertisols at Balaza the year before, paddy yields of 4.42, 5.63 and 5.37 t ha^{-1} were obtained for SEBOTA 70, SEBOTA 281.2 and NERICA 56, respectively (PCS ESA II, 2009). These yields are lower, as compared to those obtained with the same varieties under more favorable conditions. SEBOTA 281.2 produced 10 t ha^{-1} of paddy rice in the Lake Alaotra area in Madagascar where rainfall is 1000 to 1200 mm over 6 months (Bouzinac et al., 2009). In the far North Region of Cameroon, rainfall was 715 and 775 mm in 2009 and 2010, respectively. Under irrigated conditions, SEBOTA 70 yielded 12 t ha^{-1} (Bouzinac et al., 2009), while NERICA varieties produce 5 to 7 t ha^{-1} of grain (WARDA, 2008).

Yields in 2010 were higher compared to those recorded in 2009, probably due to better moisture conditions. The occurrence of relatively more rains during the last month in 2009 helped SEBOTA 281.2 to be more productive. This cultivar has a relatively longer cycle and thus could better benefit of the available moisture at the end of the growing season. In 2010, fewer precipitations (Table 2) occurred in the last rainy month (October) and the SEBOTA cultivar with a shorter growing cycle (SEBOTA 70) had a better performance. The shrinkage of the rainy season in the Far North Region of Cameroon was documented from compiled records of the beginnings and ends of successive rainy seasons since 1940 (Beauvilain, 1995). There is a need for crops and cultivars with short growing cycles. These can be found among the NERICA and SEBOTA rice cultivars. The cultivar SEBOTA 281.2 performed well in both years. The choice of rice cultivar has a significant impact on both individual crop yield and the system yield, when overall grain production was considered. Moreover, cultural practices that prolong rice cycle should be avoided. Application of 120 kg N ha^{-1} to NERICA varieties delays maturity by 4 days, compared to zero-N fertilizer application (WARDA, 2008).

However, low rates of fertilizer application would jeopardize the sustainability of this double cropping system. Both rice and dry season sorghum need large amounts of nitrogen depending on crop yield (Sys et al., 1991). In extensive dry sorghum production systems, the crop is not fertilized. Nutrients are mainly provided by natural processes such as sedimentation, nitrogen fixation, and atmospheric deposition. Research on agricultural practices has demonstrated that fertilization at planting or transplanting has no significant effect on dry season sorghum yield in Northern Cameroon (Barrault et al., 1972; Carsky et al., 1995). This was explained by low soil moisture during the dry season (Carsky et al., 1995). Dry season sorghum could better benefit of the residual fertilizer applied to rice as first crop in the double cropping system. The annual application of 150 kg ha^{-1} of urea and 200 kg ha^{-1} NPK 22-10-15 (for a total of 113 kg N ha^{-1}) as presently recommended for rice production would not sustain both rice and dry sorghum needs in a long term. In this double crop cereal system (rice-sorghum), N fertilizer applications need to be substantial to prevent soil fertility rundown. Further work should determine adequate fertilizer levels for the rice-sorghum double cropping systems that ensure a positive nutrient balance for a sustained production.

After paddy rice harvest, it was possible to grow a sorghum crop on vertisols. Subsequent dry season sorghum grain yields ranged between 540 and 811 kg ha^{-1}. Thus, producing rice in the rainy season did not prevent subsequent dry season sorghum production on lowland vertisols. Farmers' dry season sorghum yields in sole cropping vary from 0 to more than 3 t ha^{-1} in Northern Cameroon, depending on soil and climatic conditions; but the average yield is 600 kg ha^{-1} (Barrault et al., 1972). Reported mean yields of dry season sorghum grown as sole crop under experimental conditions vary from 500 to 1500 kg ha^{-1}. Given the paddy yields obtained in both years, sustained production of rice on available vertisols would limit the annual rice deficits in Cameroon which was estimated at 400 thousand tons (Goufo, 2008).

Double cropping of rice and sorghum is interesting for local farmers because the system maintains the production of the traditional staple food (sorghum) and can provide enough rice for households consumption or commercialization (Abolgo, 2005; Gnassamo and Kolyang, 2002). Rainfed sorghum is dominant but growing dry season or transplanted sorghum on vertic soils is an opportunity to strengthen farm food security. Some farmers succeed in generating a surplus. Income-based strategies increasingly involve the sale of surplus grain. Dry season sorghum is overall; the most appreciated cereal and is sold in larger proportions at a higher price, especially when it is supplied to towns (Madi, 2000).

Another interesting feature of the system is that grain production is increased without need for additional land. This form of agricultural diversification, although in an embryonic state in the Far North Region of Cameroon, also deserves a particular attention because of the possibility of crop failure. The risk of failure is mainly on dry season sorghum, the second crop in the system, and farmers are reluctant to miss its transplanting period (Abolgo, 2005). Since the preference of local farmers is on dry season sorghum, the few who produce rice spread the risk by using less than 30% of available vertisols for double cropping (Gnassamo and Kolyang, 2002).

Dry season sorghum production is mainly determined by soil water content at transplanting, and because most of its growing cycle occurs during the dry season, one would suggest the adoption of early transplanting. However, early sowing of sorghum after rice did not guarantee the best yield. In 2010, the higher yields were obtained with the two early sowings while late sowings provided the best results in 2009. The time for transplanting dry season sorghum is determined empirically by growers after the last rains, when the soils are still moist to ensure seedling regrowth, but dry enough to avoid seedling decay (Abolgo, 2005). Abundant water from rains is not favorable to dry season sorghum establishment, and low soil moisture with late plantings is not desirable as seedlings and plants thrive to complete the growing cycle.

Monitoring soil moisture to determine the best transplanting period was suggested but there is high uncertainty on the occurrence of the last rains (Mathieu, 2000). One of the solutions adopted by local farmers is the use of successive plantings in nurseries (Abolgo, 2005; Barrault et al., 1972). The success of dry season sorghum requires good co-ordination of the nursery plant production period and the replanting date. Farmers perform staggered sowing in nurseries every 5 to 10 days from August onwards to obtain seedlings suitable for transplantation throughout September and October (Barrault et al., 1972). Another possibility under investigation is the use of mulch from preceding rice tops to maintain soil moisture for longer period (CEDC, 2010). Efforts are still needed to identify relevant indicators that can help in the determination of the best transplanting period of subsequent dry season sorghum in the double cropping system.

Conclusion

The objective of the study was to examine the possibility of rice and sorghum production in double culture on lowland vertisols in the Far North Region of Cameroon. The three rice cultivars NERICA 56, SEBOTA 281-2 and SEBOTA 70 were suited for lowland rainfed production on vertisols. As first crops in the system, they produced 5.7 to 7.6 t ha^{-1} of paddy. In both years, cultivar SEBOTA 281.2 performed well. The choice of rice cultivar has a significant impact on both individual crop yield and the system yield. Subsequent dry season sorghum grain yields ranged between 540 and 811 kg ha^{-1}. Hence, producing rice in the rainy season did not hinder the following dry season sorghum production. The adoption of double cropping of rice and dry sorghum production on vertisols can significantly increase the availability of cereals in the Far North Region of Cameroon where cereal shortages, famine and low income are common among farmers. However, the need for adequate fertilization for the cereal double cropping system, the availability of short cycle rice cultivars and indicators for the determination of the best transplanting period for subsequent dry season sorghum are the main challenges.

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REFERENCES

Abolgo P (2005). Valorisation des *Karé* par la double culture Riz-*Muskuwaari* à Barlang dans la Province de l'Extrême Nord Cameroun. Mémoire d'Ingénieur Agronome. Université de Dschang. Dschang, Cameroon. p. 75.

ACDIC (2006). Food sovereignty in Cameroon: a study based on the rice sector. Association Camerounaise de Défense des Intérêts des Consommateurs, Yaoundé, Cameroun.

Ambassa-Kiki R, Aboubakar Y, Boulama T (1996). Zero-tillage for rice production on Cameroonian Vertisols. Soil. Tillage Res. 39(1):75-84.

Barrault J, Eckebil JP, Vaille J (1972). Point des travaux de l'IRAT sur les sorghos repiqués du Nord- Cameroun. Agronomie Tropicale. 27(8):791-814.

Beauvilain A (1995). Tableau de la pluviométrie dans les bassins du Tchad et de la Bénoué, de la création des stations à Décembre 1994. Ndjamena, Centre national d'Appui à la Recherche (CNAR). Documents pour la recherche.°3 : 103.

Brabant P, Gavaud M (1985). Les sols et les ressources en terres du Nord Cameroun. Carte et notice explicative N° 130. MESRES-IRA, Yaoundé. ORSTOM, Paris. Ed. De l'ORSTOM, Paris. p. 285.

Carsky RJ, Ndikawa R, Singh L, Rao MR (1995). Response of dry season sorghum to supplemental irrigation and fertilizer N and P on Vertisols in northern Cameroon. Agricultural water management 28(1):1-8.

CEDC (2010). Rapport de la campagne agricole. Centre d'Etude de l'Environnement et du Développement au Cameroun, Maroua. p. 174.

Bouzinac S, Taillebois J, Seguy L (2009). La Saga SEBOTA : les riz poly-aptitudes SEBOTAS créés dans et pour les systèmes de culture durables en semis direct sur couverture végétale (SCV) permanente au service des rizicultures alternatives permanentes diversifiées, ''propres'' et à faible coût. CIRAD, France. p. 116.

Couty P (1987). La production agricole en Afrique subsaharienne : manières de voir les façons d'agir. Cahier des sciences humaines, vol 23, N° (3-4), ORSTOM. pp. 391-408.

DRADR-EN (2010). Rapport annuel des activités : compte d'exploitation du riz à l'unité d'appui aux projets et aux investisseurs. Délégation Régionale de l'Agriculture de l'Extrême Nord, Cameroun. p. 42.

Gnassamo J, Kolyang (2002). Mutations agricoles : adoption du riz pluvial dans les plaines Tupuri, *In* Jamin JY., Seiny Boukar L., Floret C (eds.). Savanes africaines : des espaces en mutation, des acteurs face à de nouveaux défis, Actes du colloque, mai 2002, Garoua, Cameroun. PRASAC, N'Djamena – CIRAD, Montpellier, France.

Goufo P (2008). Rice Production in Cameroon: a Review. Res. J. Agric. Biol. Sci. 4(6):745-756.

Hamasselbé A, Volper S (1987). Le riz pluvial dans la province du Nord – Cameroun. IRAD-CIRAD. p. 40.

Madi A (2000). Les prix des produits et le système productif dans la zone cotonnière de l'Extrême Nord Cameroun. Cahiers Agricultures 9:125-130.

Mathieu B (2000). Le sorgho repiqué au Nord Cameroun: De l'analyse des pratiques culturales à l'accompagnement technique des producteurs. CIRAD-DPGT, France. p. 102.

MINADER (2009). Stratégie nationale de développement de la riziculture au Cameroun. Yaoundé. p. 21.

Nguyen VN (2003). Recent developments in rice production in Sub-Saharan Africa and the dissemination of NERICA. Paper presented on October 6th, 2002.at the FAO Japanese Symposium on food security in Africa, Nihon University, Fujisawa, Japan.

Njomaha C (2004). Agricultural change, food production and sustainability in the far North of Cameroon. Phd Thesis, Leiden University. p. 245.

PCS ESA II (2009). Rapport d'activités. Campagne agricole 2008. SODECOTON, Garoua, Cameroon. pp.103

Seignobos C, Moukouri HK (2000). Potentialités des sols et terroirs agricoles. Atlas de la Province de l'Extrême Nord Cameroun. MINREST, INC-IRA, Paris. pp. 77-87.

Sys C, Van Ranst E, Debaveye J (1991). Land evaluation part II: Methods in land evaluation. Belgium, General Administration for Development Cooperation. p. 247.

Vernier P, Aboubakar Y, Tchari B (1987). The upland rice-sorghum muskwari double cropping system in Cameroon. Preliminary experiments. Agronomie Tropicale 42(4):280-288.

WARDA (Africa Rice Center)/FAO/SAA (2008). NERICA®: the New Rice for Africa – a Compendium. EA Somado, RG Guei and SO Keya (eds.). Cotonou, Benin: Africa Rice Center (WARDA); Rome, Italy: FAO; Tokyo, Japan: Sasakawa Africa Association, 210 p.

Yerima PK, Van Ranst E (2005). Major soil classification systems used in the tropics: Soils of Cameroon. pp. 237-246.