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Assessing Biotic and Abiotic Constraints to Upland Rice Cultivation in Cameroon

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Authors' contributions

This work was carried out in collaboration between all authors. Author FAN designed the study and wrote the first draft of the manuscript. Authors DM L and CS collected data from the study sites and managed the literature search. Author PIT analyzed the data collected. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to investigate the major biotic and abiotic production constraints of upland rice varieties in the three rice development hubs of Cameroon. Fifty randomly selected farmers from each rice hub namely Ndop, Lagdo and Mbam were interviewed using a structured questionnaire. On-farm visits and group discussions with other rice farmers were used to substantiate information obtained from the individually interviewed farmers. It was observed that NERICA 3 and NERICA 8 were the dominant varieties widely cultivated by farmers with an average productivity of <1.0 t/ha. Birds, weeds, low soil fertility, disease and drought were the main culprits limiting upland rice production. The contribution of these constraints to total yield loss varied significantly ($p<0.05$) across the rice hubs and ranged from 10% to 40%. Several agronomic, chemical and physical control measures were used by farmers to address these constraints but the most innovative strategy was the use of plastic hawks to mimic normal hawks that are predators to birds. It is recommended that researcher-farmer trials should be conducted to facilitate the effective transfer of upland rice technology to farmers, particularly with respect to variety use, fertilizer

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application and harvesting time. This will undoubtedly facilitate adoption of upland rice technology and hence boost rice production in Cameroon.

Keywords: Lagdo; Mbam; Ndop; NERICA; Oryza sativa; rice hub.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is a globally important food crop particularly in Asia where it is staple food for millions of people [1]. In Africa, rice is increasingly becoming favorite food for urban dwellers, schools, colleges, universities and other social centers. In Cameroon, the total land area cultivated with rice in 2012 was estimated at 135 000 ha with a national production of approximately 139 000 tons [2]. Meanwhile the total demand in 2009 was estimated at 300 000 tons [3]. This clearly demonstrates that there is a huge deficit in rice production in Cameroon, although the country has the potential and suitable ecologies to attain self-sufficiency in rice production [4]. The bio-physical, climatic and socio-economic conditions necessary for an increase in rice production are favorable. Additionally, there is a rapidly growing domestic market for rice in Cameroon estimated at 25.7 kg/inhabitant/year [3] and a huge market potential in neighboring countries such as Nigeria, Gabon, Equatorial Guinea, Chad and Congo. Therefore, an increase in rice production can be an important strategy to ameliorate the household income of rice farmers and to reduce rural poverty in Cameroon. For this reason, the government of Cameroon has put in place a policy to develop the rice value chain in order to enhance the productivity and competitiveness of locally produced rice, which could write off imports and build safety stocks by 2018 [3]. One of the strategic options earmarked by the government to boost local rice production is the promotion of upland rice technology. Upland rice, which is sometimes called hill rice or dry-land paddy, implies that the water supply is by rainfall, sometimes complemented by the roots reaching directly into the water table at the lower end of the slope [5]. It is grown on the plains as well as on variably sloping land, at all altitudes [5].

Upland rice cultivation is possible in all the five agro-ecological zones of Cameroon. It is assumed that the technology will be easily adopted by farmers in Cameroon because of similarity to traditional food crops cultivation such as maize and beans, and no requirements on additional investment on irrigation. Furthermore, crop association is possible with upland rice. Thus, in Tonga in the Mbam hub of Cameroon for instance, upland rice varieties, notably NERICA 3 and NERICA 8, are cultivated in cocoa farms. Similarly in Ndop hub, upland rice is grown in association with leguminous crops such as common beans.

Despite the huge potential and widespread interest on upland rice cultivation in Cameroon, it is observed that an average farm productivity remains very low, approximately 1-1.5 tons/ha due to biotic and abiotic constraints [3]. Though some field surveys on upland rice production constraints have been conducted by IRAD in collaboration with Africa Rice Center in 2013 [6], much still needs to be done to identify the major upland rice production constraints, quantify losses due to these constraints and document management strategies used by farmers. As the Rice Development Hubs in Cameroon are highly heterogeneous in climatic, bio-physical and social economic conditions, it is likely that the magnitude of the effects of the different production constraints will differ with rice hubs. Thus the objectives of this study were to identify the major upland rice varieties suited to the different rice hubs in Cameroon, assess the production constraints and evaluate the strategies used by farmers to manage these constraints.

2. MATERIALS AND METHODS

2.1 Description of Survey Sites

This research was conducted across the three major rice development hubs in Cameroon, namely Lagdo, Ndop and Mbam [7].

2.1.1 Lagdo Rice Development Hub

The Lagdo Rice Development Hub is situated in the Northern part of Cameroon consisting of the Adamawa, North and Extreme North regions. The hub cuts across the Soudano-Sahelian and Guinea Savanna agro-ecological zones. Mean relative humidity and temperature are 67.3% and 22.0°C, respectively. Maximum and minimum temperatures are 10 and 34°C, respectively [8]. The rainfall pattern is mono modal, with a wet season which runs from April to October and dry

season from November to March [8]. Average annual rainfall is estimated between 300-1000 mm and highly variable, resulting to droughts [9,8]. The dominant soil types are vertisols, fluvisols and gleysols found in the floodplains and inland valleys [10]. These soils have high pH (6.7 - 7.0) and organic matter content (1.0 - 2.0 %) and are therefore very suitable for crop production [9] (WARDA, 2002). Improved rice production and post-harvest technologies are introduced in the hub by IRAD (Institute of Agricultural Research for Development) and SEMRY (Societe d'Expansion et de Modernisation de la Riziculture). The main food crops are rice, sorghum, maize, onion, cowpea, soya bean, sweet potato and yams whereas cotton is the main industrial crop in the hub. Animal production, particularly cattle rearing, is practiced by almost every household.

2.1.2 Ndop Rice Development Hub

This rice development hub is made up of the North West and West regions of Cameroon. It is situated between latitudes 5° 20' and 7° North and longitude 9° 40' and 11° 10' East of the Equator, with a surface area of about 17,910 km^2 [8]. Altitudes range from 300 to over 3000 masl. The climate is characterized by two main seasons: a dry season from November to mid March and a wet season from mid March to October. Average rainfall varies between 1300 – 3000 mm annually with a mean at 2000 mm. Minimum and maximum temperatures are estimated at 15.5°C and 24.5°C, respectively. The soils are variable but fluvisols and ultisols are dominant [10]. Rice production in the hub is concentrated within the Menchum Valley and the Mbo plain and is administered by the Upper Noun Valley Development Authority (UNVDA). Improved rice technologies are gradually being introduced by IRAD. Other food crops cultivated in the hub include maize, potato, vegetables, banana and yams. Animal production includes poultry birds, pigs, cattle and small ruminants.

2.1.3 Mbam Rice Development Hub

The Mbam Rice Development Hub is made up of the Center, South and East regions of Cameroon. The hub is an emerging hub, as rice production and post harvest activities are not so intense as in Lagdo and Ndop hubs. The Mbam hub is within the forest agro-ecological zone, characterized by a bimodal rainfall pattern with four seasons: long rainy season from September to November, long dry season from December to February, short rainy season from March to June and short dry season from July to August [11]. The average daily temperature is estimated at 23-24°C and the mean annual rainfall is situated between 1600 mm and 2000 mm. The dominant soils are ferralsols, which are generally acidic, low in organic carbon content, total nitrogen and deficient in exchangeable potassium and available phosphorus [12,11].

2.2 Data Collection and Analysis

Field surveys were conducted at the three main rice production hubs of Cameroon, namely the Lagdo hub (North regions), Mbam hub (Centre, South and East regions) and Ndop hub (North West and West regions) between September 2013 and March 2014. For each production zone, at least 50 randomly selected farmers were interviewed using a structured questionnaire. Additionally, more than three on-farm visits and group discussions were organized across the zones with other rice farmers to substantiate information obtained from the individually interviewed farmers. Each farmer was asked to list in a decreasing order of importance the main upland rice production constraints in his/her farm. Thereafter, the farmers were asked to attribute a percentage to each production constraint. Other information collected from the farmers included the upland rice varieties commonly grown in their farms and the average yields, and techniques to address rice production constraints.

Data obtained from the farmers, particularly on yield reduction due to biotic and abiotic constraints were submitted to one-way analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 11 for windows [13].

3. RESULTS AND DISCUSSION

3.1 Rice Varieties Cultivated in the Hubs

It was observed that the upland rice varieties cultivated differed with hubs (Fig. 1). Thus, NERICA 13 appeared to be cultivated only in Ndop Hub, NERICA 10 in Mbam Hub and IRA 112 and RISCOU in Lagdo Hub (Fig. 1). However, NERICA 3 and NERICA 8 were widely cultivated in all the three rice hubs.

Irrespective of the rice hub, NERICA 3 was the most widely cultivated upland rice variety, with a field coverage ranging between 45% and 55%. In Ndop Hub, NERICA 3 and NERICA 8 were the

most used varieties, respectively 55% and 30%. Similar results were observed in Mbam hub where the same varieties, NERICA 3 and NERICA 8, were mostly used by farmers. Meanwhile in Lagdo Hub, NERICA 3 and IRA 112 were the most widely cultivated varieties with field coverage of 45% and 23%, respectively.

Cameroon has five agro-ecological zones that differ widely in bio-physical and climatic conditions [12,4,10]. Thus, it is possible for certain crop varieties to adapt only to specific zones that present suitable growth conditions. Where similar varieties are grown across several agro-ecological zones, it is likely that such varieties have the capacity to adapt to a wide range of environmental conditions. This is the case with NERICA 3 that was present and dominant in all the three rice hubs.

3.2 Farmer Productivity in the Rice Hubs

Irrespective of the rice hub, approximately 50% of the farmers had a productivity of less than 1.0 t/ha while about 40% had a productivity of between 1-2 tons/ha (Fig. 2). These results are in line with the observations made by MINADER [3], who reported that average rice productivity in Cameroon was estimated at approximately 1 ton/ha. In the Lagdo, Mbam and Ndop rice hubs, only approximately 6%, 2% and 15%, respectively, of farmers recorded a productivity of over 2 tons/ha. This clearly demonstrates that on-farm productivity of upland rice varieties in Cameroon is far below the optimal production capacity of these varieties which is estimated at 3 - 4 tons/ha [9]. This low productivity is probably associated with poor cultural techniques, pests and diseases, poor soils, drought and floods [3].

3.3 Contribution of Production Constraints to Yield Loss

The contribution of the different production constraints to yield loss in upland rice differed with the hubs (Fig. 3), although birds, weeds and low soil fertility were dominant, irrespective of the hubs.

In the Lagdo hub of the Northern part of Cameroon, drought had the highest effect on yield loss (about 25%), while low soil fertility had the least (approximately 15%). Drought is very frequent in the Lagdo hub as the rains in this part of the country are erratic with mean of approximately 300 mm to 1000 mm annually [8]. Unlike drought, low soil fertility is not a major problem as the dominant soils are vertisols, which are known for their high fertility levels [8,10].

In the Ndop hub of the western part of Cameroon, weeds and low soil fertility were the major constraints to upland rice production jointly contributing to approximately 70% of the yield loss (Fig. 3). Drought had the lowest effect (about 3%) on yield. This part of the country records high rainfall (2000 mm to 3000 mm) that is more or less evenly distributed from March to October [8]. For this reason, it is unusual to experience drought as in the Lagdo hub, but weed infestation is crucial.

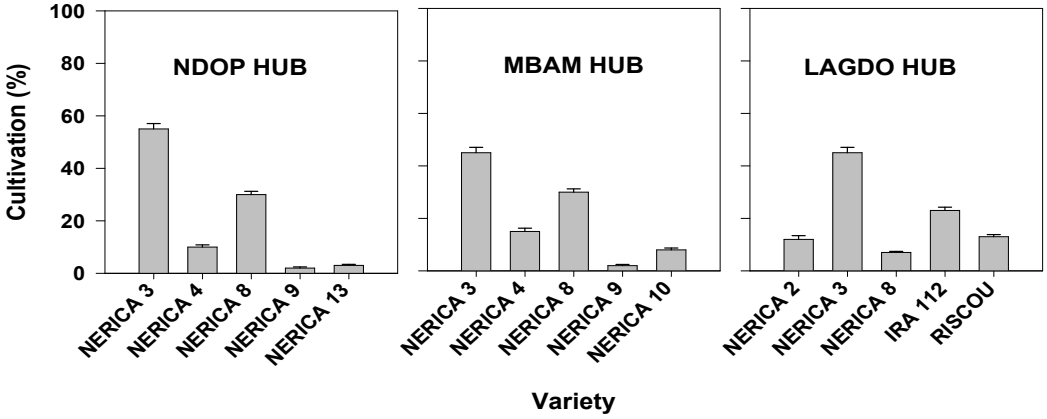

Fig. 1. Main upland rice varieties cultivated in the different rice development hubs of Cameroon. Bars are standard errors of the mean

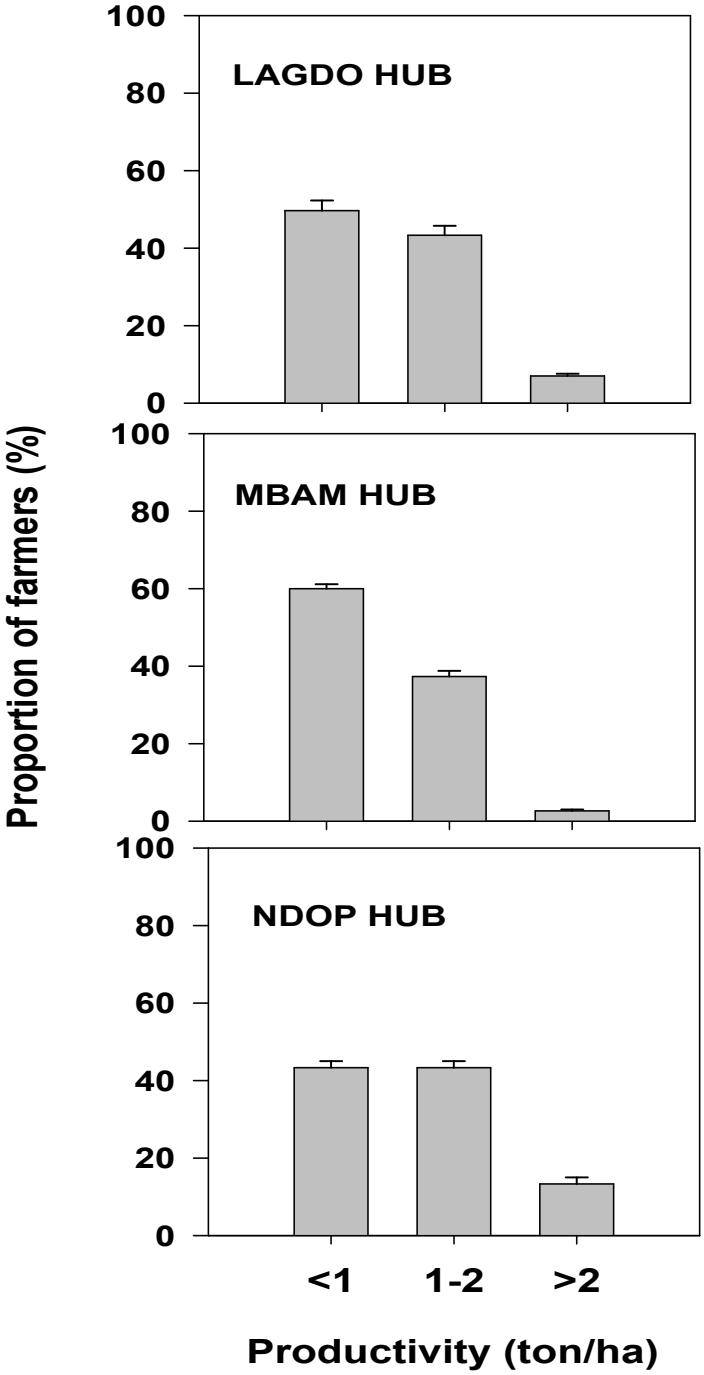

Fig. 2. Average productivity of upland rice varieties cultivated by farmers in the different rice development hubs of Cameroon. Bars are standard errors of the mean

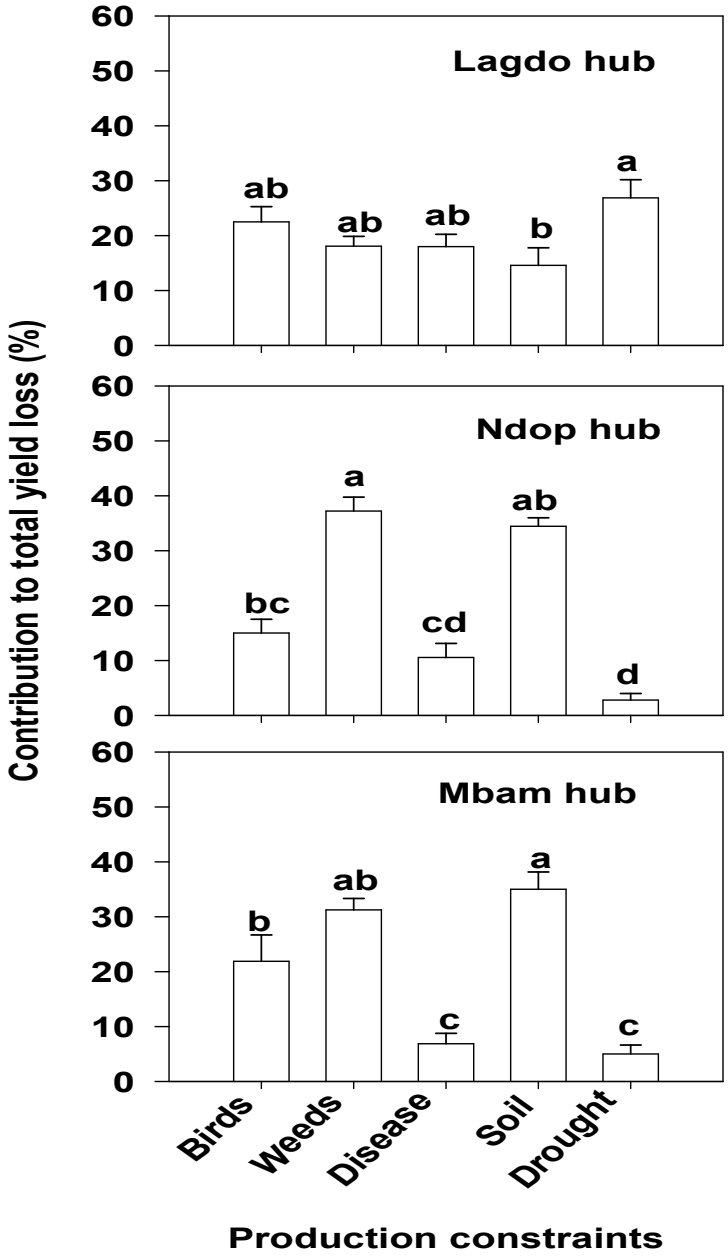

Fig. 3. Main constraints to upland rice production and their contribution to yield loss in the rice development hubs of Cameroon. Bars are standard errors of the mean. Means with the same letter in a rice hub are not significantly different (P<0.05) by Tukey

In the Mbam hub of the central part of Cameroon, poor soil fertility and weeds were the main culprits for the low rice productivity in the hub, contributing to over 60% of yield loss (Fig. 3). Disease and drought did not significantly affect rice yield, as they both contributed to only about 10% to yield loss. Low soil fertility is widely known to limit crop production in this part of Cameroon [14,12]. For this reason, strategies to enhance soil fertility such as the use of leguminous cover crops are highly recommended, particularly for smallholder farmers [15,14,16].

3.4 Strategies to Address Production Constraints

In this study, it was observed that the strategies used by farmers to address the major production constraints were similar across the rice development hubs. These strategies were physical such as the use of scare-crows to control birds, chemical such as the use of herbicides, agronomic such as crop rotation and genetic using resistant varieties (Table 1). However, the effectiveness of these strategies was influenced by the socio-economic and ecological conditions of the rice hubs. The present findings therefore underline the need for site- and system-specific targeting of strategies to address upland rice production constraints in Cameroon.

Table 1. Strategies adopted by farmers to address upland rice production constraints in Cameroon

Constraint	Control strategies
Birds	Children bird scarers Reflectings objects Plastic hawks to mimic normal hawks Scare crows Sounds Chemical control particularly for *Quelea*
Weeds	Manual weeding Chemical weeding before planting Cover crops
Disease	Resistant/Tolerant varieties Crop rotation
Low soil fertility	Incorporation of green manure Use of animal manure Fertilizer use
Drought	Early seeding Irrigation Use of early maturing varieties

4. CONCLUSION

We concluded that, although most upland rice varieties used by farmers in Cameroon differ with rice hubs, some varieties such as NERICA 3 and NERICA 8 are cultivated across the hubs. The productivity of these varieties is less than 1t/ha on average, due to biotic and abiotic factors particularly birds, low soil fertility, weeds, drought, pests and diseases. The magnitude of the effects of these production constraints vary from one hub to the next. Thus, drought was largely responsible for yield loss in the Lagdo hub (38%), weeds in Ndop hub (38%) and low soil fertility in Mbam hub (35%). Strategies used by farmers to address these production constraints were similar across the hubs and included scare crows, crop rotation, cover crop and short duration varieties. Though these measures are widely used by the farmers across the hubs, it is possible that the social, economic and ecological conditions of the hubs may influence the efficiency of the measures. Thus, studies are warranted to develop more efficient strategies to manage upland rice production constraints in the rice hubs of Cameroon.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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