

1 **Assessing biotic and abiotic constraints to upland rice cultivation in** 2 **Cameroon**

4 **Abstract**

5 The promotion of upland rice technology is a strategic option by the government of
6 Cameroon to boost local rice production and reduce exports. However, upland rice is
7 associated with biotic and abiotic production constraints. This study was conducted
8 to identify the major upland rice varieties cultivated in the three rice development
9 hubs of Cameroon namely Ndop, Mbam and Lagdo, evaluate the main production
10 constraints and note the strategies used by farmers to address these constraints.
11 Fifty randomly selected farmers from each rice hub were interviewed using a
12 structured questionnaire. On-farm visits and group discussions with other rice
13 farmers were used to substantiate information obtained from the individually
14 interviewed farmers. It was observed that NERICA 3 and NERICA 8 were the
15 dominant varieties widely cultivated by the farmers with an average productivity of
16 <1.0 t/ha. Birds, weeds, low soil fertility, disease and drought were the main culprits
17 limiting upland rice production in the hubs. The contribution of these constraints to
18 total yield loss varied significantly ($p<0.05$) across the rice hubs and ranged from
19 10% to 40%. Several agronomic, chemical and physical control measures were used
20 by farmers to address these constraints but the most innovative was the use of
21 plastic hawks to mimic normal hawks that are predators to birds. It is recommended
22 that researcher-farmer trials be conducted to facilitate the effective transfer of upland
23 rice technology to farmers particularly with respect to variety use, fertilizer application
24 and harvesting time. This will undoubtedly ease adoption of upland rice technology
25 and hence boost rice production in Cameroon.

26 Key words: Lagdo, Mbam, Ndop, NERICA, *Oryza sativa*, rice hub

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28 INTRODUCTION

29 Rice (*Oryza sativum* L.) is a globally important food crop particularly in Asia where it
 30 is staple food for millions of people (Shimono, 2011). In Africa, rice is increasingly
 31 becoming favorite food for urban dwellers, schools, colleges, universities and other
 32 social centers. In Cameroon, the total land area cultivated with rice in 2012 was
 33 estimated at 135 000 ha with a national production of approximately 139 000 tons
 34 (FAO, 2014). Meanwhile the total demand in 2009 was estimated at 300 000 tons
 35 (MINADER, 2009). This clearly demonstrates that there is huge deficit in rice
 36 production in Cameroon, although the country has the potential and suitable
 37 ecologies to attain self-sufficiency in rice production (IRAD, 2013). The bio-physical,
 38 climatic and socio-economic conditions necessary for increase rice production are
 39 favorable. Additionally, there is a rapidly growing domestic market for rice in
 40 Cameroon estimated at 25.7 kg/inhabitant/year (MINADER, 2009) and a huge
 41 market potential in neighboring countries such as Nigeria, Gabon, Equatorial Guinea,
 42 Chad and Congo. Therefore, an increase in rice production can be an important
 43 strategy to ameliorate the household income of rice farmers and reduce rural poverty
 44 in Cameroon. For this reason, the government of Cameroon has put in place a policy
 45 to develop the rice value chain in order to enhance the productivity and
 46 competitiveness of locally produced rice, which could write off imports and build
 47 safety stocks by 2018 (MINADER, 2009). One of the strategic options earmarked by
 48 the government to boost local rice production is the promotion of upland rice
 49 technology. Upland rice, which is sometimes called hill rice or dry-land paddy,
 50 implies that the water supply is by rainfall, sometimes complemented by the roots

51 reaching directly into the water table at the lower end of the slope (Raemaekers,
52 2001). It is grown on the plains as well as on variably sloping land, at all altitudes
53 (Raemaekers, 2001).

54 Upland rice cultivation is possible in all the five agro-ecological zones of Cameroon.
55 It is assumed that the technology will be easily adopted by farmers in Cameroon
56 because of similarity to traditional food crops cultivation such as maize and beans,
57 and do not require additional investment on irrigation. Furthermore, crop association
58 is possible with upland rice. Thus, in Tonga in the Mbam hub of Cameroon for
59 instance, upland rice varieties notably NERICA 3 and NERICA 8 are cultivated in
60 cocoa farms. Similarly in Ndop hub, upland rice is grown in association with
61 leguminous crops such as common beans.

62 Despite the huge potential and widespread interest on upland rice cultivation in
63 Cameroon, it is observed that average farm productivity remains very low,
64 approximately 1-1.5 tons/ha due to biotic and abiotic constraints (MINADER, 2009).
65 Though some field surveys on upland rice production constraints have been
66 conducted by IRAD in collaboration with AfricaRice Center in 2013 (CIDA-IRAD,
67 2013), much still needs to be done to identify the major upland rice production
68 constraints, quantify losses due to these constraints and document management
69 strategies used by farmers. As the Rice Development Hubs in Cameroon are highly
70 heterogeneous in climatic, bio-physical and social economic conditions, it is likely
71 that the magnitude of the effects of the different production constraints will differ with
72 rice hubs. Thus the objectives of this study were to identify the major upland rice
73 varieties suited to the different rice hubs in Cameroon, assess the production
74 constraints and evaluate the strategies used by farmers to manage these
75 constraints.

76 MATERIALS AND METHODS

77 Description of survey sites

78 This research was conducted across the three major rice development hubs in
79 Cameroon namely Lagdo, Ndop and Mbam (Ndindeng, 2012).

80 Lagdo Rice Development Hub

81 The Lagdo Rice Development Hub is situated in the Northern part of Cameroon
82 consisting of the Adamawa, North and Extreme North regions. The hub cuts across
83 the Soudano-Sahelian and Guinea Savanna agro-ecological zones. Mean relative
84 humidity and temperature are 0.673 and 22.0 °C, respectively. Maximum and
85 minimum temperatures are 10 and 34 °C, respectively (Goufo, 2008). The rainfall
86 pattern is mono modal, with a wet season which runs from April to October and dry
87 season from November to March (Goufo, 2008). Average annual rainfall is estimated
88 between 300-1000 mm and highly variable, resulting to droughts (WARDA, 2002;
89 Goufo, 2008). The dominant soil types are vertisols, fluvisols and gleysols found in
90 the floodplains and inland valleys (Tabi et al., 2013). These soils have high pH (6.7 -
91 7.0) and organic matter content (1.0 - 2.0 %) and are therefore very suitable for crop
92 production (WARDA, 2002). Improved rice production and post-harvest technologies
93 are introduced in the hub by IRAD (Institute of Agricultural Research for
94 Development) and SEMRY (Societe d'Expansion et de Modernisation de la
95 Riziculture). The main food crops are rice, sorghum, maize, onion, cowpea, soya
96 bean, sweet potato and yams whereas cotton is the main industrial crop in the hub.
97 Animal production particularly cattle rearing is practiced by almost every household.

98 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 km² (Goufo, 2008). 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 (Tabi et al., 2013). 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.

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 (Ngome et al., 2013). 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 (Yerima and van Ranst, 2005; Ngome et al., 2013).

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 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 (SPSS, 2008).

RESULTS AND DISCUSSION

Rice varieties cultivated in the hubs

It was observed that the upland rice varieties cultivated differed with hubs (Figure 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 (Figure 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 (Yerima and van Ranst, 2005; IRAD, 2013; Tabi et al., 2013). 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.

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 (Figure 2). These results are in line with the observations made by MINADER (2009), 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 (WARDA, 2002). This low productivity is probably associated with poor cultural techniques, pests and diseases, poor soils, drought and floods (MINADER, 2009).

Contribution of production constraints to yield loss

The contribution of the different production constraints to yield loss in upland rice differed with the hubs (Figure 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 (Goufo, 2008).

Unlike drought, low soil fertility is not a major problem as the dominant soils are vertisols, which are known for their high fertility levels (Goufo, 2008; Tabi et al., 2013).

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 (Figure 3). Drought had the least 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 (Goufo, 2008). For this reason, it is unusual to experience drought as in the Lagdo hub, but weed infestation is crucial.

In the Mbam hub of the centre 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 (Figure 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 (Hauser and Nolte, 2002; Yerima and van Ranst, 2005). For this reason, strategies to enhance soil fertility such as the use of leguminous cover crops are highly recommended particularly for smallholder farmers (Becker, 2004; Hauser and Nolte, 2002; Ngome et al., 2011).

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.

CONCLUSION

The promotion of upland rice growing is a strategic option by the government of Cameroon to boost rice production, ameliorate household income for farmers and write off rice imports. This option is limited by a number of biotic and abiotic constraints particularly birds, weeds, low soil fertility, drought, pests and diseases. The magnitudes of the effects of these constraints differ with hubs, as the latter is highly heterogeneous in bio-physical and climatic conditions. Similarly, upland rice varieties adapt differently in rice hubs, though NERICA 3 was observed to adapt well in all the three hubs. While local measures are put in place by farmers to address the production constraints such as the use of scare crows, crop rotation, cover crop and

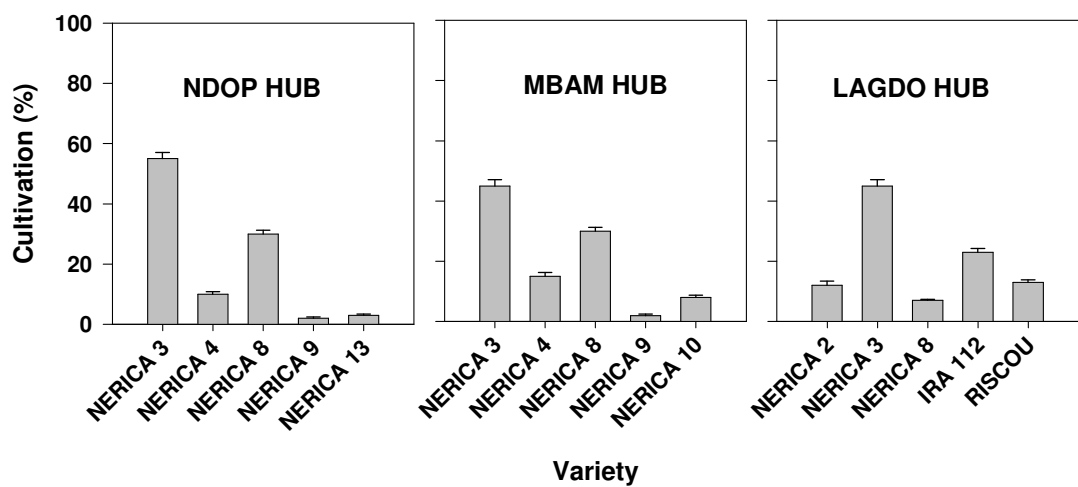
short duration varieties, it is important to note that these measures can only be effective if they consider the social, economic and ecological conditions of the hubs. Thus, more studies are warranted to develop more efficient strategies to manage upland rice production constraints in the rice hubs of Cameroon.

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269 Figure 1: Main upland rice varieties cultivated in the different rice development hubs of
270 Cameroon. Bars are standard errors of the mean.

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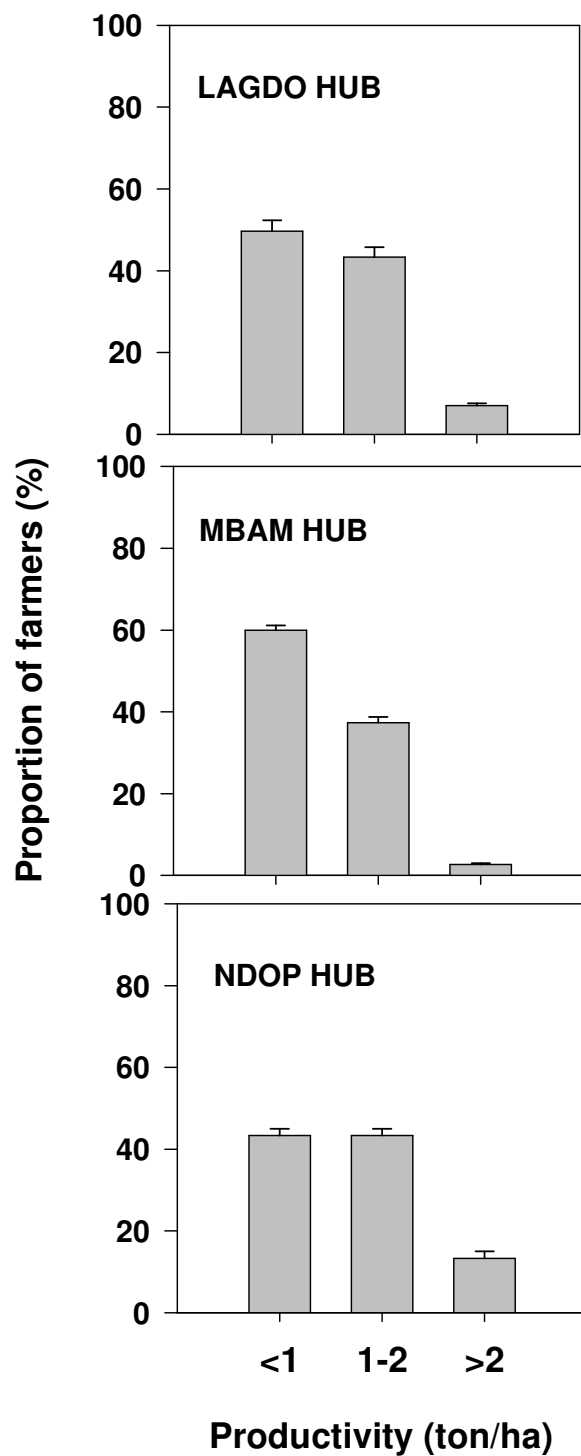
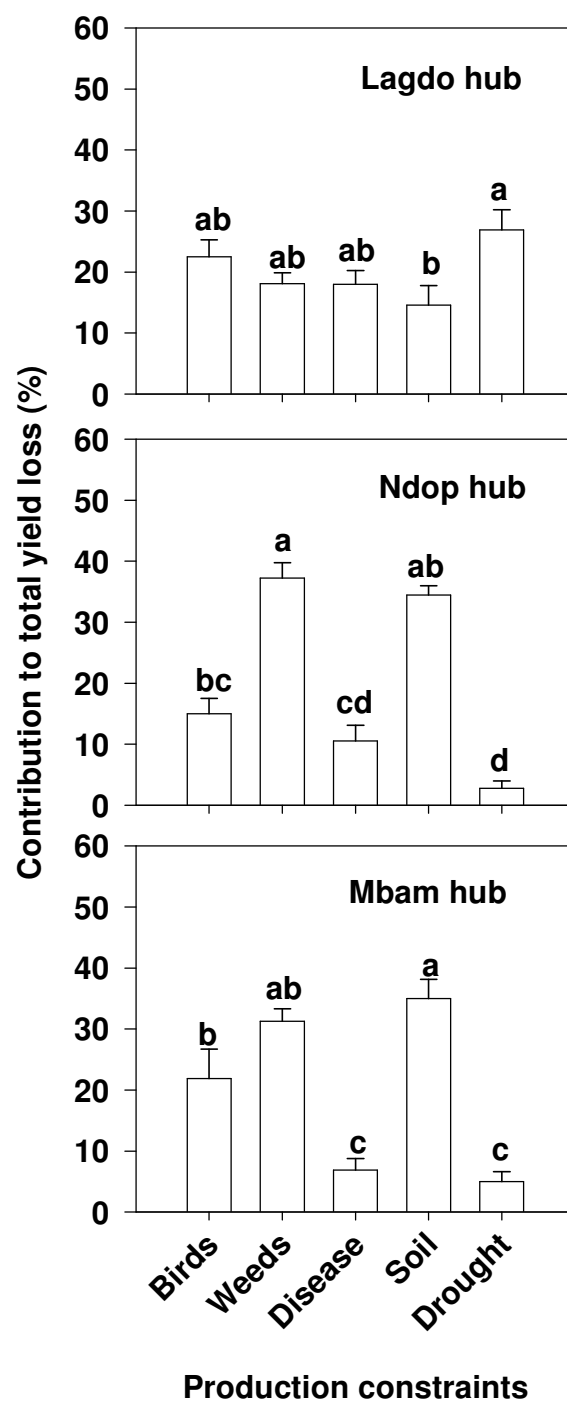


Figure 2: Average productivity of upland rice varieties cultivated by farmers in the different rice development hubs of Cameroon. Bars are standard errors of the mean.



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

281 Table 1: Strategies adopted by farmers to address upland rice production constraints in
282 Cameroon

Constraint	Control strategies
Birds	Children bird scarers
	Reflectings objects
	Plastic hawks to mimic normal hawks
	Scare crows
	Sounds
	Chemical control particularly for <i>Quelea</i>
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

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