INFLUENCE OF SOCIO-DEMOGRAPHIC FACTORS ON THE PRODUCTION SYSTEM OF KERSTING'S GROUNDNUT IN BENIN

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ABSTRACT

Socio-demographic factors are often responsible for the persistent neglect of orphan crops such as Kersting's groundnut (*Macrotyloma geocarpum*) in sub-Saharan Africa.The objective of this study was to investigate the influence of socio-demographic factors on production of Kersting's groundnut (KG), as a basis for informing policy and development efforts in Benin. Data were collected from 305 randomly selected respondents from three major KG growing areas of Benin (Zou, Collines and Plateau). Descriptive statistics, analysis of variance, ordered logit models and Kendall's coefficient of concordance were used to analyse data, rank and prioritise production constraints across socio-demographic clusters. Factors such as land tenure, farm size, farming experience, education level, age and location had significant positive influence on cultivated KG plot size. Similarly, gender, education level and membership to cooperative groups had positive effects on farmer-reported yield. Furthermore, location in the department of Zou had a negative effect on reported yield. Production activities (sowing and harvesting) were significantly influenced by gender and education level. The most significant constraints were damage due to transhumance, lack of quality seed, changing rainfall patterns, production complexity and poor access to credit and land. Strategic actions for boosting KG productivity should include use of improved varieties, sustainable seed system, appropriate crop management practices, and improved access to credit.

Key Words: Gender, *Macrotyloma geocarpum,* orphan crop

RÉSUMÉ

Les facteurs socio-démographiques sont souvent responsables de la négligence persistante des cultures orphelines telles que la lentille de terre (*Macrotyloma geocarpum*) en Afrique subsaharienne. L'objectif de cette étude était d'étudier l'influence des facteurs socio-démographiques sur la production de la lentille de terre, pour éclairer les efforts de politique et de développement au Bénin. Les données ont été collectées auprès de 305 répondants choisis au hasard dans trois grandes régions productrices

de lentille de terre du Bénin (Zou, Collines et Plateau). Statistiques descriptive, analyse de variance, regression logistique et coefficient de concordance de Kendall ont été utilisés pour analyser les données, classer et hiérarchiser les contraintes de production à travers les groupes socio-démographiques. Des facteurs tels que le régime foncier, la taille de l'exploitation, l'expérience agricole, le niveau d'éducation, l'âge et la localisation géographique ont eu une influence positive significative sur la superficie de lentille de terre cultivée. De même, le sexe, le niveau d'éducation et l'appartenance à des coopératives ont eu des effets positifs sur le rendement déclaré par les agriculteurs. De plus, la localisation dans le département du Zou a eu un effet négatif sur le rendement. Les activités de production (semis et récolte) étaient significativement influencées par le sexe et le niveau d'éducation. Les contraintes les plus importantes étaient les dégâts dus à la transhumance, le manque de semences de qualité, le changement du régime pluviométrique, la complexité de la production et le faible accès au crédit et à la terre. Les actions stratégiques pour stimuler la productivité de lentille de terre devraient inclure le développement des variétés améliorées, un système semencier durable, des pratiques de gestion des cultures appropriées et un meilleur accès au crédit.

Mots Clés: Genre, *Macrotyloma geocarpum,* culture orpheline

INTRODUCTION

Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal &Baudet], commonly known as "Doyiwé" in Benin, is an orphan legume crop cultivated across the West African savanna (Pasquet *et al.*, 2002). It is valued for palatability, nutrient density reputation (Ajayi and Oyetayo, 2009; Aremu *et al.*, 2011) and ability to thrive well in marginal crop production areas (Bampuori, 2007; Assogba *et al.*, 2015). Kersting's groundnut has recently gained considerable attention from researchers and other development practitioners owing to its potential to address food and nutrition securityin West Africa (Ayenan and Ezin, 2016). Listed among the 101 promising African orphan crops, promoted by the African Orphan Crops Consortium (AOCC), the species is undergoing substantial research and development activities in the major production countries, including Benin (Akohoue *et al.*, 2020; Kafoutchoni *et al.*, 2021), Burkina Faso (Coulibaly *et al.*, 2020; Nana *et al.*, 2020), Ghana (Adu-Gyamfi *et al.*, 2012) and Nigeria(Abiola and Oyetayo, 2015; Odo and Akaneme, 2021).

Though it was mostly based on anecdotal evidence with limited empirical and comparable information, socio-cultural contexts and demographic factors were linked with the conservation or gradual extinction of the species (Amuti, 1980). In this context, a deep analysis of socio-cultural and demographic impacts on Kersting's groundnut production could guide the development of adoptable technologies and innovative cultivation practices among smallholder farmers.

Recent investigations of the indigenous knowledge (Assogba *et al.*, 2015; Loko *et al.*, 2019) and on-farm practices in KG cultivation (Akohoue *et al.*, 2018) have lacked emphasis on the critical role of socio-demographic factors in the production of this crop. Yet, this would better inform breeders, researchers and policy-makers for tailored response to challenges of KG production among socio-demographic clusters. The objective of this study was to investigate the influence of socio-demographic factors on production of Kersting's groundnut, as a basis for informing policy and development efforts in Benin.

METHODOLOGY

Study area. The study was conducted in three departments of southern and central Benin (6°00'N - 12°50'N, 1°00 - 3°40'E), namely Collines, Plateau and Zou (Fig. 1). Departments are the first-level politico-administrative divisions of the country. Departments are subdivided into districts
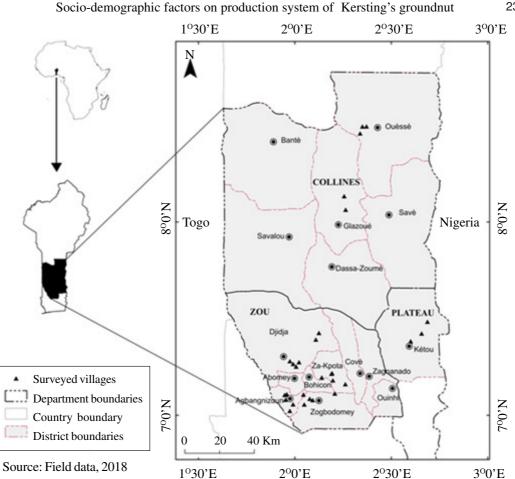
Figure 1. Map of the study area showing the surveyed villages.

(municipalities), which are second-level divisions.These three departments cover the main KG growing areas of Benin.

Southern Benin is located in humid zone and is characterised by subequatorial climate. The rainfall is bimodal, with two rainy seasons (March-July and September-November), separated by a long (December-February) and a short (July-August) dry season (Judex and Thamm, 2008). Mean annual rainfall varies between 900 mm in the West and 1100 mm in the East. Mean annual temperature varies between 25 and 29 °C; and relative humidity between 31 and 98% (Adomou, 2005). Soils in this region are either deep ferrallitic, or rich in clay, humus and minerals.

Central Benin falls into a sub-humid zone and is characterised by a bimodal rainfall regime,which gradually changes to unimodal northward from the latitude of Savè (Höllermann *et al.*, 2010). The mean annual rainfall varies from 1100 to 1200 mm; while the annual temperature ranges from 25 to 29 °C, and relative humidity varies between 31 and 98%. Soils are Ferruginous, with variable fertility (Adomou, 2011).

Sampling procedure. A multistage sampling procedure, combining purposive and random methods, was used to select the survey villages (Fig. 1). In each department, two to five of the major KG producing districts were

purposively selected. The selection of these districts followed a rapid rural appraisal (RRA) in each department, with the help of agricultural extension staff, together with local farmers' associations and opinion leaders. In each district, five villages were randomly selected from the list of KG producing villages.

To determine the sample size, a quick survey was conducted with 50 individuals randomly selected across each district to answer the question if they grew or had ever grown Kersting's groundnut. The proportion *p* of positive answers was used to compute the number *n* of farmers to sample in a given district, using the approach described by Dagnelie (1998):

$$n = \frac{U^2_{1-\alpha/2} \times p(1-p)}{d^2}$$

Where:

n = the number of farmers to sample in a selected district; $U_{1-\alpha/2}$ = the value of the normal random variable for a risk of α (for α = $0.05 U_{1-\alpha/2}$ = 1.96); d = the margin error of the estimation of any parameter to be computed from the survey and a value of 8% was considered.

In total, 305 respondents were involved in this study. All participants were at least 18 years old. The characteristics of the respondents are presented in Table 1. Approximately 54% of respondents were female. Young (age <35), adults (35≤age < 45) and old respondents (age >45) were equally represented. In general, respondents had medium size household comprising 6 to 10 people (54%) or small households consisting of less than 6 people (29%). Three main ethnic groups encountered in the region were represented as follows: Fon (73%), Mahi (22%) and *Nago* (4%). Around 75% of the respondents were illiterate, while about 17% attended primary school or alphabetisation courses, and 8% attended secondary school.

Over 80% of respondents had less than 15 years of experience in KG cultivation, and 89% of them did not belong to any farmers' cooperative (Table 1). Two third of the respondent owned or had easy access to a mobile phone; while the remaining third did not own a phone set. Land inheritance was the predominant mode of land tenure (43%); followed by donation (19%), renting (16%) and purchase (16%) (Table 1).

Data collection and analysis. Data were collected through face-to-face interviews using a semi-structured questionnaire. The thrust of the questionnaire was on the socio-demographic profiles of respondents, farm characteristics, and production constraints to production of KG in Benin. Interviews were conducted in the local languages, with the help of translators were found necessary.

All data collected were analysed using the R software version 4.0.1 (R Core Team, 2020). Respondent's socio-demographic characteristics and farm characteristics were summarised using descriptive statistics (mean and standard). Two multiple regression models were used to assess the socio-demographic factors influencing KG plot size and farmer-estimated yield, respectively. The explanatory variables used in these models, included department (Collines, Plateau and Zou),gender (female *versus* male), ethnicity (*Fon, Mahi* and *Nago*), education level (uneducated, primary school and secondary school), land tenure (donation, inheritance, purchase, renting and tenant farming) and farmers' cooperative membership (yes or no) as factors and age, household size, farm size and KG cultivation experience as covariate. For all models, only significant terms or terms included in a significant interaction were kept in the final model. For this purpose, all possible interactions were first included in the full models, and subsequently simplified using a stepwise-backward procedure, combined with F-tests to generate parsimonious models.

TABLE 1. Socio-demographic characteristics of respondents (in percentage)

Characteristic	Category	Departments			Overall
		Collines n=92	Plateau n=36	Zou n=177	
Gender	Female	74.73	61.11	41.24	53.62
	Male	25.27	38.89	58.76	46.38
Age category	Young (<35 years)	27.47	38.89	34.46	32.89
	Adult (35-45 years)	30.77	50.00	33.33	34.54
	Old (>45 years)	41.76	11.11	32.20	32.57
Household size	Small (<6 people)	30.77	16.67	31.07	29.28
	Medium (6-10 people)	56.04	61.11	52.54	54.61
	Large (>10 people)	13.19	22.22	16.38	16.12
Ethnicity	Fon	25.27	63.89	100	73.36
	Mahi	74.73	0.00	0.00	22.37
	Nago	0.00	36.11	0.00	4.28
Education level	Illiterate	75.56	80.56	74.01	75.25
	Primary school	14.44	11.11	18.64	16.50
	Secondary school	10.00	8.33	7.34	8.25
KG cultivation experience	Small (<6 years)	48.35	55.56	28.25	37.5
	Medium (6-15 years)	34.07	41.67	50.28	44.41
	Large (>15 years)	17.58	2.78	21.47	18.09
Member of a cooperative	No	93.41	100	84.75	89.14
	Yes	6.59	0.00	15.25	10.86
Phone ownership	No	43.96	27.78	27.68	32.57
	Yes	56.04	72.22	72.32	67.43
Land tenure	Donation	17.00	10.53	22.50	19.53
	Inheritance	61.00	13.16	39.50	42.90
	Purchase	6.00	31.58	18.00	15.98
	Renting	10.00	44.74	14.00	16.27
	Tenant farming	6.00	0.00	6.00	5.33

To investigate the socio-demographic factors affecting KG production activities (field preparation, sowing, and harvest), three ordered logit models (OLM) were built considering as outcome variable the time for field preparation, sowing and harvest, respectively. For unbiased parameter estimates, the OLMs were built upon the parallel regression assumption. OLMs were performed in the 'MASS' package (Venables and Ripley, 2002); while the parallel regression assumption was tested using the Brant test implemented in the 'brant' package (Schlegel and Steenbergen, 2020). For easier interpretation of the logit coefficients, odd ratios were derived by exponentiating the logit coefficients.

Kendall's coefficient of concordance (W) was used to identify and prioritise the constraints impeding KG productivity across

the different socio-demographic clusters. The Kendall's coefficient of concordance (Legendre, 2010) is given by the formula:

$$W = \frac{12S}{p^2(n^3-n)} - p^T \text{ (Legendre, 2010)}$$

Where:

W = the Kendall's coefficient of concordance; p = thenumber of respondents ranking the constraints; n = the number of constraints; and T = the correction factor for tied ranks defined as:

$$T = \sum_{k=1}^{m}(t_k^3 - t_k), ;$$

Where:

t_3=the number of ranks in each (k) of m group of ties; and S = the sum of squares statistics over the row sum of ranks (Ri) and is defined as:

$$S = \sum_{i-1}^{n}(R_i - R)^2$$

Where:

Ri=row sums of rank and R=mean of Ri.

The Kendall's W is positive and ranges from 0 (no agreement) to 1 (complete agreement). It was computed using the 'vegan' package (Oksanen *et al.*, 2019).

RESULTS AND DISCUSSION

Socio-demographic factors influencing production. The mean farm size was 3.52±0.12 ha; while plot size grown with KG was 0.53±0.02 ha (Table 2). Zou department had significantly (P<0.001) larger KG plots (0.59±0.02 ha) than Plateau department (0.56±0.05 ha). Collines department had the lowest plot size overall (0.40±0.03 ha). This finding confirms the folk observation that the

TABLE 2. Farm size, plot size, and farmer-reported yield for Kersting's groundnut in three main production areas in Benin

Characteristic	Department			Overall	P-value
	Collines	Plateau	Zou		
Farm size (ha)	3.71±0.21 (0.07-11.33)	3.28±0.30 (0.50-9.00)	3.47±0.16 (0.50-11.00)	3.52±0.12 (0.07-11.33)	0.331
KG plot size (ha)	0.40±0.03 (0.07-1.64)	0.56±0.05 (0.12-1.33)	0.59±0.02 (0.13-1.51)	0.53±0.02 (0.07-1.51)	**<0.001**
Farmer-reported yield (kg ha⁻¹)	192.20±13.42 (18.64-510.00)	192.38±21.33 (22.00-615.63)	159.49±8.80 (13.22-625.58)	172.98±7.00 (18.64-625.58)	0.052

Values between brackets are ranges while the value in bold represents the significant term

department of Zou is the number one Kersting's groundnut producer of Benin (Assogba *et al.*, 2016). Therefore, the department of Zou should be more strategic for efforts geared to promoting production of KG in Benin.

Overall, respondents reported that KG grain yield ranged from 13.22 to 625.58 kg ha^{-1}, depending on department, though the range did not vary significantly (P<0.05) across departments (Table 2).

Among the ten explanatory variables, five variables including department (farmer's location), land tenure, age, KG cultivation experience, and farm size were retained in the multiple regression of KG plot size, after stepwise selection. All these variables were significant determinants for KG plot size (Table 3). Regardless of gender and education level, farmers' age negatively affected KG plot size (Table 3); meaning that with increasing age, farmers tended to cultivate smaller KG plots. In contrast, for the Plateau and Zou departments, inherited land tenure, farming experience and farm size had positive and significant effects on KG plot size. Generally, farmers who inherited land dedicate larger plots to KG, suggesting that land availability was a determinant of production of the crop. On the other hand, the additional cost of land renting or purchase may become a determinant in attaining larger plots of KG, as the

TABLE 3. Socio-demographic factors determinants of Kersting's groundnut production and farmer-reported yields in Benin

Factors	KG Plot size			Farmer-reported yield		
	Coef.	SE	P-value	Coef.	SE	P-value
Intercept	-0.962	0.289	0.001***	0.18	0.025	<0.001***
Department Plateau	0.102	0.029	<0.001***	0.005	0.028	0.846
Department Zou	0.107	0.018	<0.001***	-0.051	0.02	0.010**
Land inheritance	0.775	0.311	0.013*	-	-	-
Land purchase	-0.293	0.419	0.485	-	-	-
Land renting	0.431	0.408	0.292	-	-	-
Land TF	0.252	0.531	0.635	-	-	-
Age	-0.198	0.092	0.032*	-	-	-
Experience	0.339	0.096	0.001***	-	-	-
Farm size	0.873	0.233	<0.001***	-	-	-
Gender Male	-	-	-	0.052	0.018	0.004**
Cooperative Yes	-	-	-	0.048	0.024	0.044*
Education Secondary	-	-	-	0.099	0.035	0.005**
Education Uneducated	-	-	-	0.034	0.022	0.132
Land inheritance: Farm size	-0.657	0.274	0.017*	-	-	-
Land Purchase: Farm size	0.279	0.368	0.448	-	-	-
Land Renting: Farm size	-0.395	0.36	0.273	-	-	-
Land TF: Farm size	-0.228	0.47	0.628	-	-	-
Multiple R^2	0.263			0.09		
Adjusted R^2	0.229			0.07		
P-value	<0.001***			<0.001***		

Coef = Coefficient, KG = Kersting's groundnut, SE = Standard error, TF = Tenant farming

production cost surges and the return on investment is unpredictable due to the erratic yields of the crop (Assogba *et al.*, 2016).

The strength of contribution of each selected factor based on the regression coefficients affirmed that farm size had the greatest contribution (0.873) to KG plot size, followed by land tenure (0.775), and KG cultivation experience (0.339). A significant interaction existed between inheritance as a land tenure and farm size (P=0.017), indicating that the effect of farm size depended on land tenure, irrespective of the departments (Table 3).

The second multiple regression model revealed that farmer's department, gender, farmer association membership and education level were significant determinants of farmer-reported yield (Table 3). Regarding the effect of gender, the model showed that male farmers were more likely to report higher KG yields than their female counterparts.This finding supports previous observations in Benin (Kinkingninhoun-Mêdagbé *et al.*, 2010), Malawi (Kassie *et al.*, 2015) and Kenya (Diiro *et al.*, 2018) that women farmers are often discriminated against about production resources, which negatively affects their productivity and income. Such findings imply that women Kersting's groundnut producers also have impaired access to production resources such as land, inputs and equipment. Consequently, they tend to realise lower yields than men farmers.

The negative effect of age on plot size was expected and confirms the previous observation that KG production requires intensive physical efforts (Assogba *et al.*, 2016), and is thus less adapted to declining capacity of elderly farmers, who could no longer cultivate large field. This is, however, contrasts with observations from Burkina Faso (Tamini, 1995), Togo (Mergeai, 1993) and Ghana (Amuti, 1980; Adu-Gyamfi *et al.*, 2011); whereby the crop was reported to be cultivated mainly by elderly people.

Membership to a farmer association positively influenced farmer-reported yield (Table 3). Kolade and Harpham (2014) showed that cooperatives provide a platforms where farmers can obtain advice from their peers, but above all benefit from periodic training from extension services. Surprisingly, only 10% of the interviewed KG producers belonged to cooperatives (Table 1). In this context, rural development actors and extension services should organise KG producers in order to enhance productivity.

Secondary education level had a positive effect on farmer-reported KG yields, implying that farmers who had attended secondary school or more were more likely to report higher yields. Attending school (primary or secondary) may enhance farmers' kills and enable them to objectively compare costs and benefits of different management practices and choose the more likely to improve their productivity. Because the majority (75%) of KG producers were illiterate, the implementation of farmers' field school programmes, along with a strong extension network in the production area will contribute to increasing the production of the crop in this region in Benin.

Factors affecting theproduction activities. The results of ordered logit models (OLM) for times of field preparation, sowing and harvesting are presented in Table 4. In the first OLM, none of the explanatory variables showed a significant effect on field preparation. In the second model, only gender (P = 0.028) and education (P = 0.013) level showed significant effects on time of sowing.Irrespective of the education level, male farmers were about 50% less likely than women to sow their field late. This discrepancy is due to the patriarchal nature of the Beninese society where women are discriminated and have limited access to and control of production resources (land, agriculture credit, information, extension services, training) and

TABLE 4. Parameter estimates from the ordered logit models of field preparation, sowing and harvesting times

Factors	Field preparation			Sowing			Harvesting		
	Coef	S.E.	OR	Coef	S.E.	OR	Coef	S.E.	OR
Department Plateau	0.256	1.876	1.292	0.352	0.751	1.422	0.717	1.188	2.049
Department Zou	-0.553	1.310	0.576	0.283	0.547	1.327	1.574	0.896	4.826
Gender Male	-1.335	0.762	0.263	-0.690*	0.313	0.502	0.236	0.407	1.266
FAM Yes	-0.441	0.854	0.643	-0.143	0.427	0.866	-0.172	0.552	0.842
Phone Yes	0.639	0.684	1.895	0.570	0.317	1.768	0.002	0.403	1.002
EthnyMahi	-0.595	1.362	0.552	0.183	0.570	1.201	-1.104	0.912	0.332
EthnyNago	-0.059	2.270	0.943	-0.331	0.829	0.718	-2.170	1.181	0.114
Education Primary	1.290	1.003	3.634	0.814	0.386	2.256	-1.172*	0.535	0.310
Education Secondary	2.351	1.227	10.498	1.208**	0.485	3.348	-0.394	0.696	0.675
Land Inheritance	0.039	0.926	1.040	-0.033	0.374	0.967	0.457	0.500	1.579
Land Purchase	-0.508	1.106	0.602	-0.831	0.480	0.436	0.292	0.642	1.340
Land Renting	-0.239	1.168	0.787	-0.221	0.515	0.802	0.466	0.681	1.594
Land Tenant farming	-1.568	1.424	0.208	-0.754	0.752	0.471	1.590	0.911	4.902
Age	0.036	0.029	1.037	0.012	0.012	1.012	-0.006	0.016	0.994
Household Size	-0.068	0.092	0.934	-0.052	0.043	0.950	0.053	0.055	1.055
Cultivation experience	-0.051	0.044	0.950	-0.009	0.020	0.991	-0.011	0.026	0.989
Farm Size	0.065	0.176	1.067	-0.075	0.077	0.928	0.037	0.098	1.038
Diagnostic									
LR (chi2)	15.25			29.07			39.66		
Pr (> chi2)	0.577			0.034*			0.001***		

*P<0.05; **P<0.01; ***P<0.001; FAM = Farmer association membership; LR = Likelihood ratio; OR = Odds ratio; S.E.= Standard error

equipment (Kinkingninhoun-Mêdagbé *et al.*, 2010; Saliou *et al.*, 2020) as discussed above. Many women have to assist their spouses to sow their fields first before they are allowed to sow their own field. Such delays affect the cropping calendar and subsequently the productivity of women farmers. A similar observation was made by Kinkingninhoun-Mêdagbé *et al.* (2010) that women in central Benin are intentionally marginalised by men in timely access to the ploughing equipment,a practice that discourage women from cultivating their own fields.

Regarding the education level, the odd of sowing late was 3.348 times higher for farmers who attended secondary school compared to uneducated farmers and those with primary education level (Table 4). Although this result is unexpected, it also makes a lot of sense. It is possible that farmers who attended secondary school intentionally delay sowing as an adaptation strategy to cope with changing rainfall pattern. Indeed, our data revealed that changing rainfall pattern was mainly ranked as a major constraint by farmers with a secondary education level (Fig. 3). Previous studies have shown that farmers with higher education are more likely to adjust their planting period to cope with delayed rainfall onset (Obayelu *et al.*, 2014; Ali and Erenstein, 2017).

Only, the education level was found to significantly (P = 0.029) affect harvesting of KG in Benin. The model revealed that the odd to harvest late was 0.310 times (69%) lower for farmers with primary education level compares to those who were uneducated or went to secondary school (Table 4).

Priority constraints to Kersting's groundnut production. Overall, 18 constraints to production of KG were identified across the study area. The most cited constraint was difficult harvesting (72.13%), followed by weeding (42.62%), lack of equipment (38.36%), lack of credit (36.07%) and cattle damage (30.16%). Low market price (1.64%), lack of labour (1.97%), production complexity (3.61%) and land access (3.61%) were constraints less frequently of citation. Based on farmers' rankings, lack of credit, complexity of the production, and difficult harvesting were respectively the three most pressing perceived constraints; while flooding, post-harvest storage, and changing rainfall pattern were perceived as of less importance. In general, 58.7% of the respondents agreed on the rankings (Kendall's W = 0.587; P<0.001).

Desegregated results revealed that production complexity was one of the highly ranked constraints, regardless of farmer's socio-demographic characteristics (Figs. 2 and 3). Production complexity was perceived by the respondents as the process involving many activities which required a lot of farmer attention; for instance, in average two weedings are performed, each accompanied by earthing-up for the pods produced underground. Besides, harvesting is even more technicalas plants have to be dug up carefully to ensure minimum harvest losses. This may also be one of the drivers of the high price of KG grains.Therefore, strategic investment in some form of mechanisation to alleviate on drudgery of labour-intensive KG field activities is highly recommended.

Lack of credit facilities was also an important bottle neck that should be addressed, particularly for women, youth (Fig. 2) and illiterate folks (Fig. 3). Women and the youth ranked production complexity, lack of credit and difficult harvesting as the three major constraints production of KG in Benin. Also, lack of credit was the most important constraint the illiterate respondents, followed by production complexity and difficult harvesting (Fig. 2). Credit is a catalyst of high agricultural productivity and a smallholder farmer's empowerment tool that have the potential to improve food security and combat extreme poverty (Awotide *et al.*, 2015; Akudugu, 2016). In the particular context of KG, credit is crucial to stimulate the production of the crop on a large scale with appropriate
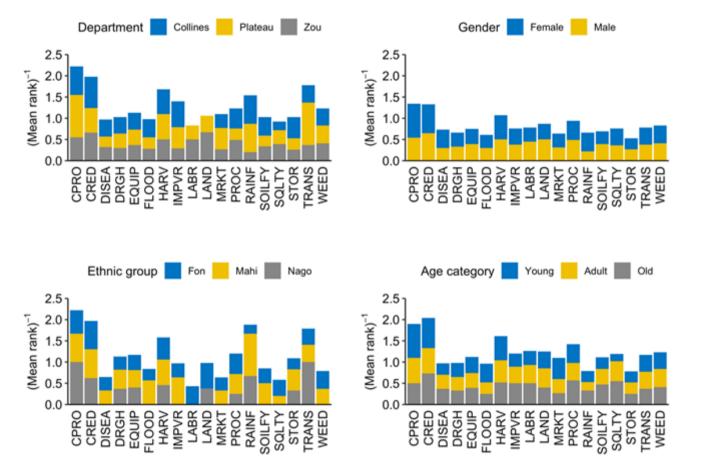
Figure 2. Perceived constraints hindering Kersting's groundnut production with respect to location and gender department, gender, sociolinguistic group, and age group. CPRO = Complexity of production; CRED = Lack of credit; DISEA = Disease and pest; DRGH = Drought; EQUIP = Lack of equipment; FLOOD = Flooding; HARV = Difficult harvest; IMPVR = Lack of improved varieties; LABR = Lack of labour; LAND = Land accessibility; MRKT = Poor market structuration; PROC = High production cost; RAINF = Changing rainfall; SOILFY = Low soil fertility; SQLTY = Lack of quality seed; STOR = Post-harvest storage; TRANS = Damage due to transhumance; WEED = Weed infestation
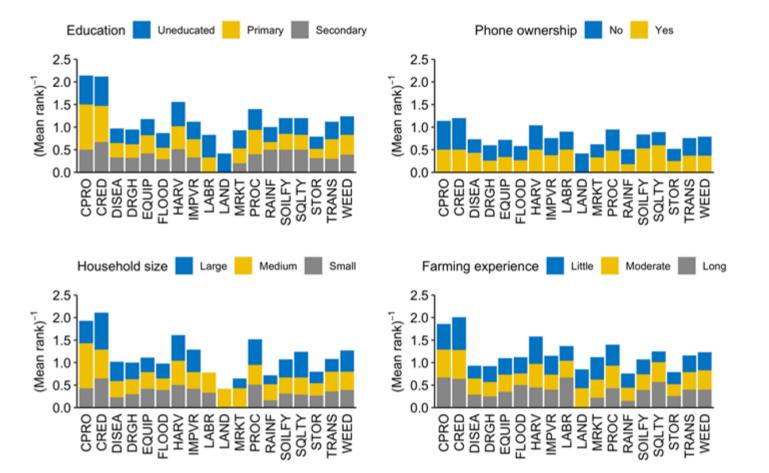
Figure 3. Perceived constraints hindering Kersting's groundnut production with respect to education level, phone ownership status, household size, and farming experience. CPRO = Complexity of production; CRED = Lack of credit; DISEA = Disease and pest; DRGH = Drought; EQUIP = Lack of equipment; FLOOD = Flooding; HARV = Difficult harvest; IMPVR = Lack of improved varieties; LABR = Lack of labour; LAND = Land accessibility; MRKT = Poor market structuration; PROC = High production cost; RAINF = Changing rainfall; SOILFY = Low soil fertility; SQLTY = Lack of quality seed; STOR = Post-harvest storage; TRANS = Damage due to transhumance; WEED = Weed infestation.

inputs and agronomic practice. But individual farmers are not often pool worthy, which limits their access to this vital resource. Stakeholders (government, NGOs, financial institution, etc.) should, therefore, encourage farmers to pool into cooperative groups to increase their credit worthiness to enable them to streamline loan application procedures and enhance assess to credit. To our knowledge, there was no cooperative of Kersting's groundnut growers in the three departments surveyed. Increasing farmers' credit worthiness is likely to increase their investment capacity and create suitable conditions for local employment in the agricultural sector, and cater for the problem of labour shortage.

Land accessibility was the most important constraint in the Zou department, particularly for *Fon* ethnic groups who dominated the region; as well as young and adult men (Fig. 2). Land is a critical production factor that enables smallholder farmers to access other production resources such as credit (Aoudji *et al.*, 2017). Relevant policy makers and institutions should improve farmers' access to agricultural lands in the region, without gender disparity, to boost KG production.

Changing rainfall pattern, was another an important constraint in the departments of Collines (particularly for *Mahi* ethnic group) and Plateau (Fig. 2), indicating that climate change effects, especially fluctuations in the rainfall seasonality might be more perceived by farmers from these departments. This constraint could be addressed through the development of improved varieties with high phenotypic plasticity that can adjust their phenology, namely the initiation of flowering, according to the environmental conditions they experience (Merilä and Hendry, 2014). However, phenotypic plasticity is a very complex trait (Zhang *et al.*, 2013) and the development of such varieties of KG will require to harness modern breeding techniques such as physiological breeding, marker-assisted selection (MAS) or genomic selection (GS). The use of such advanced breeding techniques necessitates first to develop genomic resources as suggested by Varshney *et al.* (2012).

The lack of quality KG seed is the most important constraint for farmers owing a mobile phone (Fig. 3), implying that due to their ability to possess purchasing power, these farmers are willing to buy quality seed. Seed scientists, in partnership with extension services and the private sector, should actively intervene in timely supply of quality seeds of new varieties to KG farmers.

CONCLUSION

This study shows that factors such as land tenure, producer's age, cultivation experience, farm size, gender, association membership, education level and the department where the producer is based are the most important drivers of Kersting's groundnut production in Benin. The most important socio-economic constraints affecting the production of KG are lack of credit facilities, low access to land, KG production complexity and lack of quality seed. Policy makers and relevant institutions should encourage farmers to form cooperative groups in order to increase their credit worthiness.

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