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Communication networks influence agricultural technologies' diffusion: Evidence from improved maize (*Zea mays*) seeds varieties diffusion in the North of Benin, West Africa

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ABSTRACT: The adoption of innovations to improve yields and reduce poverty has become an important issue for the agricultural sector. However, in spite of all efforts implemented, the adoption of these technologies remains below the expected levels. This article aims to analyze the effects of communication networks on the adoption and diffusion of improved maize varieties promoted in the North of Benin in order to increase its productivity. Data were collected among maize producers identified with the snowball method in Nikki town. Logistic regression was carried out to analyze the influence of socio-relational, socio-economic and demographic factors on the adoption and diffusion of improved maize varieties. Software R version 3.4 was used for statistical data analysis. The Akaike Information Criterion (AIC) was used to choose the best model for predicting adoption and diffusion. Results show that rich men with a high degree of authority and power tend to have a high eigenvector centrality while men with a high degree of centrality and betweenness centrality tend to have a high level of education, a high area and a high degree of authority and power. In addition, a combination of socio-relational socio-economic and demographic variables predict better the probability of adoption (AIC=52.929) while socio-relational variables predict better the probability of diffusion (AIC=15.819). The study suggests that the diffusion of improved maize varieties at a large scale must involve persons who are rich, with a large agricultural land a good education level, and powers in their locality.

KEYWORDS: adoption, dissemination, social network, innovation, channels, West Africa.

1 INTRODUCTION

In West Africa, production factors of production play a decisive role in agricultural productivity. Therefore, the increase in production factors' productivity is an essential component of the success of any rural development strategy [1]. Indeed, in this region, agriculture represents nearly a quarter of the Gross Domestic Product (GDP) and employs about 70% of the population [2]. However, despite this production, nearly 828 million people suffer from food insecurity in 2021 [3]. The situation is only getting worse, especially with the adverse effects of climate change. Over the past several decades, the number of violent weather incidents in some sub-regions of Africa and the number of people affected by droughts and floods has increased sharply [4]. If no adaptation strategy is implemented to strengthen the sustainability, productivity, and resilience of agriculture, the situation could jeopardize the achievement of the sustainable development goals of eradicating hunger and poverty by 2030 [5].

In Benin, 1.09 million people representing 9.6% of the population are in food insecurity Among them, 0.7% are in severe food insecurity [6]. This undernourishment is largely due to the decline in food crops productivity, especially maize which represents 60% of national cereal production [7]). It already occupies about 40-50% of the area planted and nearly 20% of the population lives off its production [8].

Cereal crops such as maize, whose yields have steadily declined from year to year, appear to be the most affected by climate variability [9]. Reference [10] predict that maize will become a cash crop and provide food security better than any other crop. In northern Benin, for example, it is second only to cotton as a subsistence and cash crop [9]. The interest in investigations in northern Benin is explained by its diversified agricultural production, based on maize, and its very low agricultural productivity.

Farmers in this region mainly use traditional seeds. These are considered as the productivity of traditional agricultural systems [11] To avoid the importation of cereals and food aid, it is becoming necessary to increase maize productivity. Researchers and policymakers see improved varieties as an essential factor in this increase [5]. Thus, several projects and institutions such as the Agricultural Productivity Project in West Africa (PPAAO), have been implemented to better disseminate new improved maize varieties with higher productivity, pest and drought resistance and to support producers in their implementation [12]. Unfortunately, in spite of all efforts, these varieties are poorly adopted by farmers [13]. Reference [14] explains that the failure of producers to adopt innovations on a large scale is very often due to a lack of widespread diffusion of these innovations. According to [15], the process of diffusion encounters various forms of social resistance from actors within society and inadequate communication channels. Reference [16] report that the extension of improved maize varieties faces several problems such as inadequate communication channels, non-cooperation of some producers. Analyzing the process of innovation diffusion, [17] point out the crucial role played by communication's channels and social system. They show that the social system can be a barrier to innovation if it does not take into account norms, beliefs and, values of the environment. Exploring indicators of the technicality of livestock farmers and extension channels in dairy cattle farms in the central region of Algeria, [18] demonstrate the importance of channels in the adoption and dissemination of innovation. It emerges from their research that insufficient information flow is one of the factors that explain the low adoption of innovations and the inadequacy in the flow of information depends on the channel used. From a socio-anthropological point of view, a communication network is considered as social network, a network formed by a set of interacting social entities (actors) and the linkages (relations or edges) among them [19]. Indeed, according to these authors, anything can be imagined as a set of nodes and links that can be visualized and analyzed as a social network, a structure of social relationships. A social network is considered as a network of people or other social entities with the edges corresponding to their relationships or associations [20]. So, visualizing these networks lets observe behaviors, identify influence, and make predictions about how individuals or groups may act. Therefore, this article focuses on the case of improved maize varieties diffusion in Northern Benin to understand and analyze from a social network perspective, how communication networks influence the process of adoption and diffusion of this innovation.

2 MATERIAL AND METHODS

2.1 STUDY AREA

The study was implemented in Nikki's municipality in Northern Benin, a wooded savannah characterized by a humid climate of the southern Sudanese type (Fig. 1). The soils of the region appear to be the result of intense and deep weathering [21]. Highly cultivated, these soils are sensitive to erosion with significant constraints on agriculture. Nikki and its villages involved in the study were chosen with the help of the extension agents on the basis of the following main criteria: (i) importance of maize production (ii) dissemination of improved maize varieties distributed by the State, PPAAO, or INRAB (National Institute of Agricultural Research) over the three last years; (iii) existence of functional maize farmers' association; (iv) existence at least of one private agency supporting the dissemination of improved maize varieties.

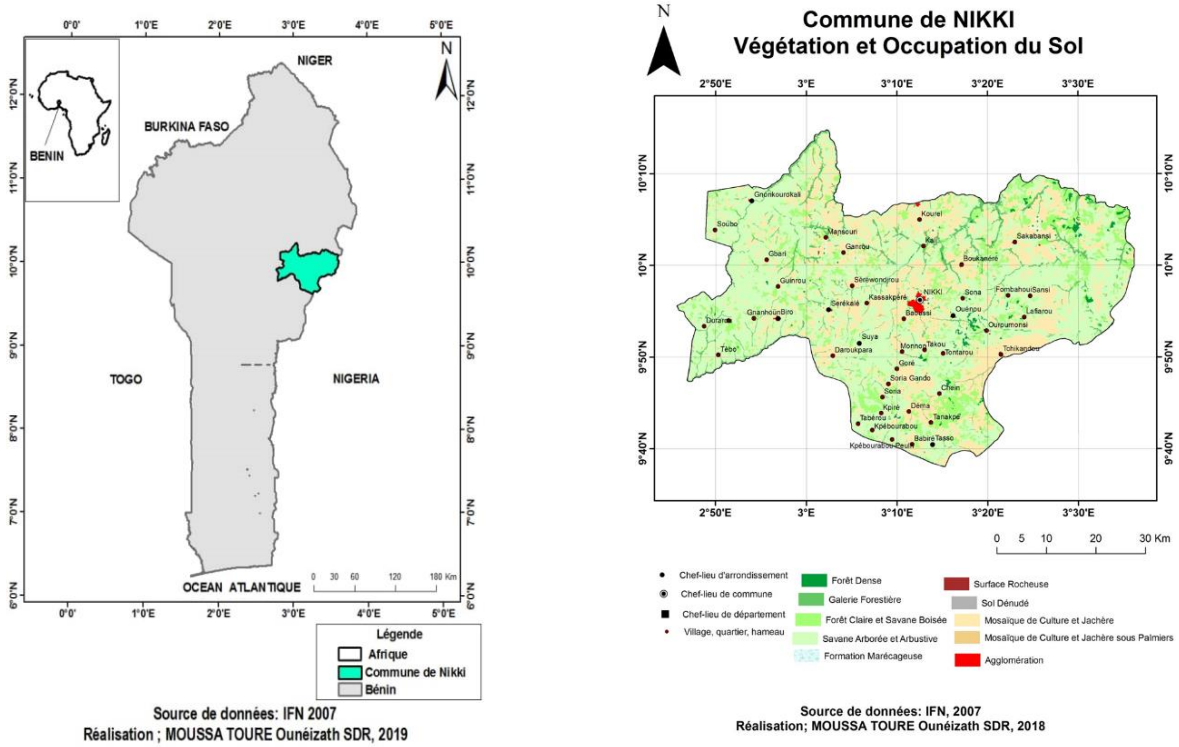

Fig. 1. Benin map showing the study area localization

2.2 METHODS OF DATA COLLECTION AND ANALYSIS

The snowball method was used in this work to identify farmers to be interviewed. The choice of this method is justified by the fact that firstly farmers who have adopted the improved varieties of maize were not well known and secondly, the study aims at drawing and analyzing the social network of farmers involved in the study. Indeed, Data collected were analyzed with social network and logistic regression analyses

2.2.1 SOCIAL NETWORK ANALYSIS

As reported by [20], many social network analyses have been investigated using centrality and similarity measures, two popular measurement methods in this field. According to the author, centrality measures are used to determine the relative significance of a node in a social network while similarity measures compute the similarity between two subgroups within a social network. With regard to the objectives of the study, centrality measures appeared more pertinent to analyze the communication network of Nikki producers involved in the implementation of improved varieties of maize. The sociogram representing this communication network was generated with UCINET software. The characterization and analysis of this network were carried out on the basis of network parameters and actors' parameters.

With regard to network parameters, an analysis of the sociographs' structure was done to detect the presence of cliques and chains. A clique is considered as a sub-set of a network in which the actors are more closely and intensely tied to one another than they are to other members of the network [22], [23],. It's a complete subgraph, a group of persons in which each person (node) is directly connected to all others [19]. According to [24, a clique put together persons having a common favorite, attributes, or goals. In opposite, a while a chain in a social network is a person' groups in indirect relationships

With respect to network parameters the number of nodes and links, the degree centrality, the network cohesion, fragmentation, and density of the network were used to analyze the entire network. These parameters are the typical measures in centrality measures as reported by [20]. Reference [25] define degree centrality as a measure of the number of connections an individual node has. This parameter of network analysis is used to estimate how an actor is linked to all the links in the communication network. People with a high degree centrality might be considered as more popular or important in the network. Indeed, as reported by [26], high centrality scores in social networks are often correlated with leadership, and good

communication among leaders is associated with efficiency. As to network cohesion, it refers to a measure of the connectedness and togetherness among actors within a network [27]). As to fragmentation, it is used to obtain the proportion of small groups or cliques existing in the communication network while the density of the network refers to the proportion of links present in the communication network. This parameter is used to measure the prevalence of dyadic linkage (relation between a pair of actors) of direct ties within the social network [27]. With regard to the analysis of the network's actors, the parameters used were related to centrality degree, eigenvector centrality, betweenness centrality, beta centrality, average reciprocal distance, and closeness centrality. shows meanings and variables linked to network and actors' parameters (table 1).

Table 1. Variables and meanings linked to network and actors parameters

Parameter	Variables	Meanings	Symbols/Calculation methods
Network parameters	Number of nodes (NN)	Represents the number of people in the network. Each node represents an actor	NN=Total of actors in the network
	Number of links (NL)	Represents a number of relations between the nodes	NL=Total of relations between the nodes
	Degree of centralization (DC)	Measures how a node is linked to the others	
	Network cohesion (NC)	Measures how an actor is together or unit in the network	
	Fragmentation (F)	Measures how an actor is separated in the network	
	Network density (ND)	Describes the percentage of the potential connections (PC) in a network that are actual connections (AC). PC is a connection that could potentially exist between two nodes regardless of whether or not it actually does	ND = AC / PC PC=n* (n-1) /2 [28]
Actors parameters	Degree centrality (Deg)	Number of edges the node has. It Measures the level of actor's involvement in the network. The higher the degree, the more central the node is. A sum of In-degree (number of edges others have initiated with a node) and Out-degree (number of edges a node has initiated with others)	Deg = OutDeg + InDeg [29], [30], [31]
	Eigenvector centrality	Measures the node's influence in the network while giving consideration to the importance of its neighbors. It's useful only when degree centrality is the same for two actors. An actor with few connections could have a very high EC if those few connections were to very well-connected others	OutStep + InStep [29], [30], [32]
	Betweenness centrality	Measures the extent to which a node plays this bridging role in a network. It's measures a person's role in allowing information to pass from one part of the network to the other Captures how much a given node is in-between others. The more people depend on a user to make connections with other people, the higher that user's betweenness centrality becomes	Betweness StepBetw [33], [34]
	Beta centrality	Indicates the relationship between power and centrality	OutBeta + InBeta
	Average Reciprocal	Small reciprocal suggests actors are closer to each other	OutARD + InARD [29], [32]
	Closeness centrality	Measures each individual's position in the network Capture the average distance between each node and every other node in the network Reveals how independent an actor is in the network	InClose+Outclose [34]

2.2.2 LOGISTIC REGRESSION ANALYSIS

The decision to adopt improved maize varieties is dichotomous; the producer can decide whether to adopt improved varieties of maize or not. The same is true with regard to the issue of diffusion's process when considering the decision of the producer to disseminate information on the improved variety of maize or not. For both variables, the following cases may occur Adoption vs Non-adoption and Diffusion vs No diffusion. Adoption and diffusion are qualitative dependent variables that can take the value 1 if the producer adopts the varieties or diffuses the information on these technologies and the value 0 if not, according to their social-relational, socio-economic, and demographic characteristics. Therefore, the model analyses these that most influence the adoption and diffusion of improved maize production seeds.

Software R version 3.4 was used for statistical data analysis. The dependent variables being binary, the binary regression was done. Three models were considered. The first model (1) took into account socio-economic and demographic variables (sex, age, socio-cultural group, main activity, seniority, education, religion, area, crops association) likely to influence either the adoption or diffusion of the improved variety of maize while the second model (2) was based on socio-relational variables described in table 1. Socio-relational variables included in the model are:

- Degree centrality: In-degree (InDeg) and Out-degree (OutDeg) Beta centrality: InBeta and OutBeta
- Closeness centrality: InCloseness and OutCloseness
- Betweenness centrality: Betweenness and StepBetw
- Average Reciprocal: InARD and OutARD
- Eigenvector centrality: InStep and OutStep
- Inloc and Outloc

The third model (3) combined the two previous categories of variables (socio-economic and demographic, and socio-relational).

- Adoption ~ Education + Seniority + Area + Inloc + OutBeta + OutStep + InARD + OutCloseness + InCloseness (1)
- Adoption ~ Outloc + OutBeta + OutStep + OutARD + InARD (2)
- Adoption ~ Education + Seniority + Area + Outloc + OutBeta + OutStep + OutARD + InARD (3)

These three models were compared to identify the best one for predicting the adoption and diffusion of improved maize varieties. Akaike Information Criterion (AIC) was used to choose the best model with the smallest AIC. The significance of each coefficient was verified with Wald test. Multiple Linear regression was done to study the influence of socio-economic and demographic variables (sex, age, seniority, education, income, cultivated area, degree of authority and power, income) on socio-relational variables (Degree of centrality, Eigenvector centrality, Closeness centrality, and Betweenness centrality). To take into account the correlation between the dependent variables, a multivariate analysis of variance (MANOVA) was performed on the variables presented in table 2.

Table 2. Description of variables used for multivariate analysis of variance

Variables		Modalities	Expected effects
Dependent variables	Adoption	1 if yes; 0 if not	
	Diffusion	1 if yes; 0 if not	
Independent variables	Sex	1 if men; 0 if women	±
	Age	Number	+
	Education	1 if educated; 0 if not	+
	Seniority	Number	+
	Area	Extent land	+
	Crops association	1 if member of a farmer's organization; 0 if not	±
	Income	Amount	±
	Authority and power	4 if very good power 3 if good power 2 if mean power 1 if low power	±

3 RESULTS

3.1 SOCIO-ECONOMIC, DEMOGRAPHIC, AND SOCIO-RELATIONAL CHARACTERISTICS OF PRODUCERS

It emerges from the study that 49 producers are involved in the implementation of improved maize varieties in Nikki municipality. The main socio-economic, demographic, and socio-relational characteristics of producers (Table 3) and the global communication network in which there are involved with regard to the adoption and diffusion of improved maize varieties (Figure 2).

Table 3. Socio-economic and socio-relational characteristics of producers

Variables		Percentage (%)
Sex	Men	85.53
	Women	14.47
Socio-cultural group	Bariba	88.68
	Peulh	9.02
	Others (Dendi, Mokole)	3.30
Network parameters	Actors (Nodes)	49
	Reciprocal links	1.3
	Density	5.3
	Degree centrality	31.4
	Fragmentation	43.0
	Average density	2.55
	Components	14

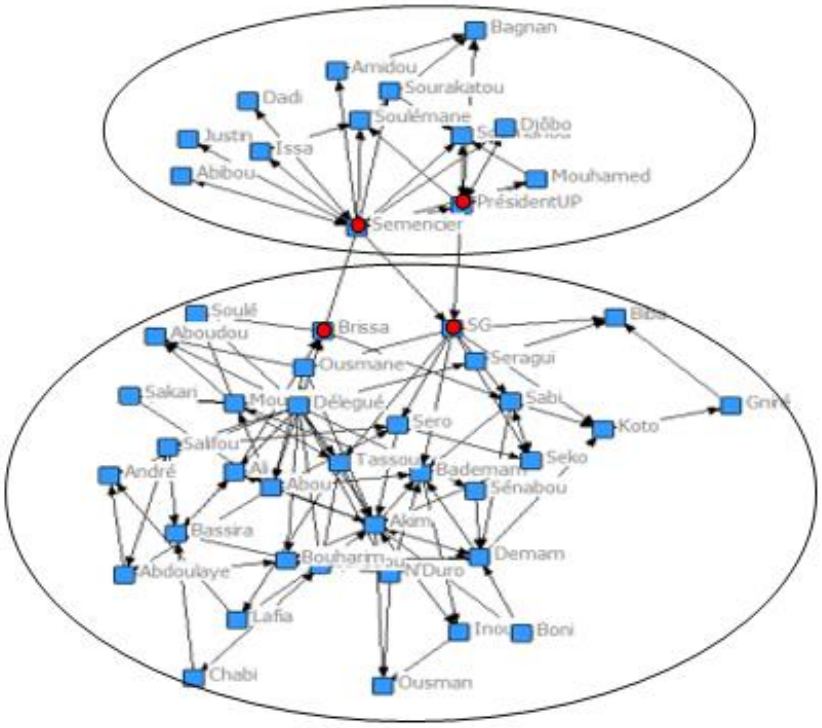

Fig. 2. Structure of the Global Communication Network of producers

Fig. 2 shows the structure of the Global Communication Network of producers. The network has 49 actors, with a reciprocal link of 1.3%. It also has an average density of 5.3%, a degree of centrality of 31.4%, and a risk of fragmentation of 0.430. Similarly, the network has an average degree of 2.551 and 14 components. Most of the actors are Bariba, and 14% are women. Thus, the density 5.3% of the network is low, which means that only 5.3% of the potential links between the 49 actors are effective. Nearly 95% of the links that should have been made are not, resulting in poor network cohesion. This is confirmed by the high probability of fragmentation of 4.3%, and that 94.7% of the links that should be formed are not. The network is also not too centralized because the relative degree of centrality of the most central actor is 31.4%. The Outdegree is much higher than Indegree (most actors have an arrow pointing to them that there are some that start from them). So even with this low rate of centralization, it is especially each actor who will ask others more than people come to ask them. It is therefore a network with less knowledge and many learners. The network is thus dominated by both recipients and information providers.

Two sub-networks maintained together by 4 key actors emerge from the analysis of the network: the Executive Secretary, Brissa a rich producer, the seed producer, and the leader (President) of the farmers' organization. These 4 actors are the brokers, who help to maintain the cohesion of the large network and avoid its disintegration in two.

3.2 INFLUENCE OF SOCIO-ECONOMIC AND DEMOGRAPHIC VARIABLES ON SOCIAL-RELATIONAL VARIABLES

presents the influence of socio-economic and demographic variables on socio-relational variables.

Table 4. Socio-economic and socio-relational characteristics of producers

	Degree centrality	p-value	Closeness centrality	p-value	Betweenness	p-value	Eigenvector centrality	p-value
(Intercept)	0,094		0,257		-0,022		14,537	
Sex	0,024	**0.003 ****	0,003	0.170	0,024	**0.001 ****	-2,747	**0.053**
Activity	-0,03	0.474	0,023	0.968	0,006	0.892	-2,742	0.815
Socio-cultural group	-0,039	0.412	-0,044	0.509	0,014	0.193	-6,794	0.786
Age	0,002	0.180	0,001	0.116	0,001	0.109	-0,084	0.921
Seniority	-0,002	**0.063**	0	0.715	-0,002	0.115	-0,015	0.649
Education	0,188	**4.8e-05 *****	0,028	**0.055**	0,064	**0.0001 *****	-5,399	**1.6e-06 *****
Area	0,0003	**0.039 ***	0,001	**0.041***	0,001	**0.0004 *****	0,349	**9.5e-06 *****
Cops association	-0,041	0.139	0,026	0.212	-0,012	0.2867	-0,565	0.673001
Autority and power	0,245	**9.50e-05 *****	0,025	**0.017***	0,083	**0.0019 ****	20,618	**2.0e-06 *****
Income	0	0.5414	0	0.316	0	0.8359	6.10-6	**0.0074 ****

**** Significant value at 1%; ** Significant value at 5%; * Significant value at 10%*

From the analysis of the table, it appears that rich men with a high degree of authority and power tend to have a high centrality eigenvector while men with a high degree of centrality and high betweenness centrality tend to have a high level of education, a high area and a high degree of authority and power. With regard to closeness centrality, it is mainly men with high area and a high degree of authority and power who tend to have a high closeness centrality.

Thus, the men most consulted (high degree of centrality) and most related to most two-way relationships in the network (Betweenness centrality) are people with a high level of education, a high area, and a high degree of authority and power. Therefore, they have a greater diversity of information sources and are able to compare them to get to know them better. Thus, they are the most informed, knowledgeable custodians of the network's knowledge. However, the people most indirectly and directly linked to each actor of the network (eigenvector centrality) through the traditional closure (the effect of my friend's friend is my friend) are rich (income), men with high education, high degree of authority, and power. So, they have the highest degree of oil stain of this fact potentially, they will disseminate the most information. In addition, the men most closely linked overall to the network's actors (closeness centrality) are men with a high area personality and a high degree of authority and power.

It appears that people who have direct influence may not have overall influence. In the case of diffusion, eigenvector and betweenness are most important than the degree of centrality. That means the influence of a node in the network and how much potential control an actor is more important than the actor's level of involvement in this case of diffusion.

3.3 FACTORS INFLUENCING THE ADOPTION OF THE IMPROVED MAIZE VARIETIES

Logistic regression suggests that the combination of socio-relational, socio-economic, and demographic variables best predicts the adoption of improved maize varieties (Table 5).

Table 5. Results of the test for significance of variables

Variables	Coefficient	p-value	AIC
Sex	1.429e+00	0.3026	**59,929**
Age	-1.988e-02	0.8096	
Socio-cultural group	-4.450e-01	1.0000	
Education	8.5442	**0.006244 ****	
Seniority	-0.3792	**0.006069 ****	
Area	0.4967	0.046968 *	
OutBeta centrality	1.2928	**0.005703 ****	
Closeness Centrality	155.2690	**0.001593 ****	
Closeness	-65.6245	0.003271 **	

*** Significant value at 5%; * Significant value at 10%*

In globality, the variable education, seniority, beta centrality, average reciprocal, and closeness centrality is the most significate.

3.3.1 EDUCATION, SENIORITY AND CULTIVATED AREA

The value of the correlation coefficient that reflects the unit effect of education on adoption is 8.5442 (p=0.006244<5%). Education therefore positively influences the likelihood of adoption of the improved maize production variety at the 5% threshold. So, more a producer has a higher level of education, more he is predisposed and openness to innovation.

The value of the correlation coefficient that reflects the unit effect of seniority on adoption is 0.3792 (p= 0.006069<5%). Seniority, therefore, has a negative influence on the probability of adoption of the improved maize variety at the 5% threshold. This result shows that a producer accumulates higher work experience, he is motivated to accept to produce improved varieties of maize. Indeed, the more work experience an individual has, the older he gets and the less he gets involved in new adventures, so he takes less risk.

The value of the correlation coefficient that reflects the unit effect of the area on adoption is 0.4967 (p=0.046968<5%). The sowing, therefore, has a negative influence on the probability of adoption of the improved maize variety at the 5% threshold. Indeed, the larger the area of an individual, the more predisposed and open he is to innovations.

3.3.2 OUT-BETA OR BETA CENTRALITY, MUTUAL RELATIONSHIP AND CLOSENESS CENTRALITY

The value of the correlation coefficient that reflects the unit effect of the Out beta on adoption is 1,2928 (p= 0.005703<5%). So, beta centrality influences the probability of adoption of the improved maize variety at the 5% threshold. Therefore, the more power/influence an individual has in an environment, the faster he or she gets the information. The more influential an individual is, the more open he is to innovation and the more risk he takes.

The value of the correlation coefficient that reflects the unit effect of InARD on adoption is 155.2690 (p= 0.001593<5%). The mutual relationship positively influences the probability of adoption of the improved maize variety at the 5% threshold. Indeed, the more mutual relationships there are in an environment, the more cohesive the environment, the more individuals influence each other and the more open they are to innovation.

The value of the correlation coefficient that reflects the unit effect of closeness centrality adoption is -65.6245 p=0.003271<5%). Closeness centrality negatively influences the likelihood of adoption of the improved maize production variety at the 5% threshold. This result shows that the more closely an individual is globally linked to the actors in a network, the less likely he is to adopt the improved maize variety. This is because this individual will not take enough risk because he or she will want to adopt innovation when the majority of the population is already equipped with it in order to analyze the performance of others. He is therefore part of the early majority.

3.4 FACTORS INFLUENCING THE DIFFUSION OF THE IMPROVED MAIZE VARIETIES

From the results of the logistic regression, it appears that the social-relational variables best predict the probability of diffusion of improved maize varieties (Table 6).

Table 6. Results of the test for significance of variables

Variables	Coefficient	p-value	AIC
(Intercept)	10.4266		**15,819**
OutBeta	57.56	0.0102175 *	
OutARD	6199.57	**0.0001742 *** **	
InARD	9631.29	**0.0001755 *** **	

*** Significant value at 1%; * Significant value at 5%.*

The socio-relational variables the model obtained after selection indicate that the variables OutBeta, OutARD and InARD positively influence the probability of diffusion of the improved maize variety.

3.4.1 BETWEENNESS CENTRALITY AND POWER

The value of the correlation coefficient that reflects the unit effect of the beta out on diffusion is 57.56 (p=0.0102175<5%). Beta-centrality positively influences the probability of diffusion of the improved maize production variety at the 5% threshold. Indeed, the more influence an individual has in an environment, the more he is solicited by these relatives and therefore the more information he disseminates

3.4.2 MUTUAL RELATIONSHIP

The value of the correlation coefficient that reflects the unit effect of InARD on diffusion is 6,199.57 (p=0.0001742 1%) <2e-16. The mutual relationship, therefore, has a positive influence on the probability of diffusion of the improved maize variety at the 1% threshold. Indeed, the more there is a mutual relationship between individuals, the more information is shared.

4 DISCUSSION

The study shows that education level has a positive influence on the adoption of improved maize seeds. These results are in line with [35] who stipulate that educational level, membership in a peasant organization, and market orientation positively affect the probability of innovation processes adopted. Reference [36], analyze factors affecting students' Value of co-creation to Institutionalize sustainability in Academic Structure in Iran and shows that self-efficacy and social capital impact the adoption of agricultural technology. However, some studies have shown that educational attainment can negatively determine the adoption of an innovation. Reference [4] studying the factors affecting the use of organic manure on farms in the Sahel region of Cameroon, concluded that the higher the level of farmers, the less likely they are to adopt this adaptation strategy in the face of declining fertility. In light of all these results we note that the level of education has a positive or negative influence on the adoption of an innovation, although, in the case of the adoption of improved maize seed, the influence is positive. Our results also show that the area sown has a positive influence on the adoption of improved maize seeds. These results are in line with [37] who in his research on socio-economic and institutional determinants of the adoption of improved maize varieties in south-central Burkina Faso points out that producers with large areas use improved varieties and thus have a positive impact on their adoption. In addition, reference [38] focuses on reflexivity and learning in system innovation processes and demonstrates that pro-environmental values and infrastructures of information and communication technology impact positively the innovation process. However, some authors like [39] have shown that the area sown has no effect on the adoption of improved maize varieties. Indeed, farmers with large areas tend to abandon the new variety because of the large number of workers to be used.

From all the above, we note that the area cultivated has no or a positive or negative influence on the adoption of agricultural innovation, although in our case the adoption of improved maize seed, the influence is positive. Similarly, our research shows that professional experience (seniority) has a negative influence on the adoption of improved maize seeds. [40] analyse the role of perceptions and preferences in adoption has shown that professional experience has a significant influence on the

adoption of agricultural innovations. In contrast, reference [41] reveals that professional experience has a negative impact on the adoption of innovation. It can be noted that work experience is generally recognized as a barrier to the adoption of innovations [42]. Although some studies do not find significant relationships between work experience and adoption [43], it can be considered that older operators take less risk than younger ones.

Betweenness centrality, mutual relationship, and closeness centrality are the socio-relational elements that significantly influence positively the adoption of improved maize varieties in the study area. Reference [44] confirms the significant influence of the relational/network on the adoption of an innovation, demonstrating that the relationships and structure of a network influence the behavior, attitude, belief, and knowledge of an individual. Reference [45] assessing personal innovativeness and social influences in the adoption of wireless Internet services via mobile technology, argues that relational influence and individual innovativity are the important determining potentials for the adoption of innovation or even the most important elements in the adoption decision. In addition, [46] analyzing the impact of social networks on hybrid seed adoption in India, concluded that social network plays an important role in the decision to adopt a technology.

From our research, it appears that the socio-relational data (Beta-centrality and mutual relationship) have a greater influence on the dissemination of improved maize seed. Reference [46] have deduced from their analysis that social network has a significant influence on the speed of diffusion. The results of [47] study on social networks and environmental outcomes are in line with ours: the social network has a direct impact on the behavior of individuals with regard to the conservation of the ecosystem is direct. Therefore, [48] demonstrated that the way social ties are formed in the network significantly influences the survival of the network and thus the diffusion of innovation. Considering the network obtained in our study area, the geographic proximity and leadership effect predominate in the way it was formed. Thus, the networks that formed by the effect of geographic proximity and leadership are less dense and less centralized. This results proves of brokers (individuals who connect two cliques) in maintaining a communication network as demonstrated by [49]. It appears that the network obtained in the case of our study is composed of two subgroups (clique), one characterized by the elderly and the other by young people linked by four. What will happen to this network when these four individuals disappear? Do cliques constitute a threat or an asset for a wide diffusion of innovations?

5 CONCLUSION

This study analyses the influence of communication networks on the adoption and dissemination of improved maize seeds (*Zea mays*) in North Benin. From our research, it appears that Rich Men (Income) with a high degree of authority and power tend to have a high eigenvector centrality while Men with a high degree of centrality and betweenness centrality tend to have a high level of education, a high area and a high degree of authority and power. Our research also shows that the combination of the two categories of variables (socio-relational; socio-economic and demographic) best predicts the probability of adoption with an AIC= 52,929; while socio-relational variables best predict the probability of diffusion with an AIC= 15,819.

To better spread innovation in an environment, it is necessary to reach people with a high degree of wealth, a high level of education, a large area is sown and a high degree of authority and power. It is the last one that can be used as an oil stain because it is directly and indirectly linked to a multitude of actors in the field.

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