



Comprehensive Perception Approach of Adoption: Innovative Wrap & Plant Technology for Nematodes Management on Yam

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ABSTRACT

A new agricultural practice, wrap & plant technology, was experimented in yam fields on three different sites in the centre-north of Benin. These sites were "Savalou", site 1, "Savè", site 2 and "Glazoué", site 3. The research sought to highlight the perception of various actors from the vegetative to the culinary phases. Two improved practices were introduced: treatment A (wrapping of seed yam cv. Klatchi with banana-fibre paper, impregnated with micro-doses of abamectin), treatment B (wrapping of seed yam of cv. Klatchi using banana-fibre paper alone). On the basis of a Comparative Appraisal Index (CBI), that is, the practice introduced was well appreciated by enumerators if the difference in perception scores of characteristics was greater than zero. In terms of results, treatment A seemed to be the most popular practice on sites 1 and 2. On site 3, treatment B seemed to substitute for A. While in the first two sites, the sensory characteristics of dishes and the agro-morphological descriptors constituted a main component of favourable perception, the descriptors from agro-morphological and harvest phases were very much important at site 3. In terms of the decision to adopt a treatment, it depended significantly amongst other socioeconomic characteristics of the respondents on the sex, number of years of experience, membership in an association, level of education, other income generating activity and the site. For future expansion of introduced practices, agricultural research needs to address socioeconomic characteristics and to improve agro-morphological descriptors.

Keywords: Abamectin, actors, *Dioscorea* spp. nematode management, sensory selectivity, Benin

INTRODUCTION

Yam (*Dioscorea* spp.), is one of the root crops mainly cultivated in West Africa where it is well-suited [1]. Benin is the fourth producing country after Nigeria, Ghana and Ivory Coast, where it reveals its potential as the second food crop following cassava with a national production figure of 2.650.498 tons in 2015 [2]. This crop plays on two sides: subsistence as well as market crop [3]. However, recent prospection realized in West Africa revealed that nematodes actually constrained the production and the conservation of yam [4; 5]. It was reported that nematodes significantly affected quantity (post harvest losses that are in the order of 100%) and quality (market value) of yam tubers, prompting to secondary perishing and rapid deterioration [6; 7].

Nematodes like *Scutellonema bradys*, *Meloidogyne* spp. and *Pratylenchus* spp. which were considered the most predatory for yam tubers are present in Benin [8]. The on-going cultivating system, based on the vegetative multiplication, was likely to perpetuate nematode attacks. In the situation that any innovative way to control nematodes was observed, researchers endeavoured lately to test innovations found elsewhere following a R-D approach. Here to for, the use of Abamectin and paper made of fibres from pseudo-trunks of banana in order to control nematodes was then introduced as an agricultural innovation. The only variety of yam selected at this stage was "Klatchi" cultivar. Although [9] claimed that the new technology allows to improve yam productivity, the research team postulated to investigate the extent to which such a technology would be appropriated by various actors. Given the background of the nematode attacks depicted by [4] and [7], it seems unlikely that producers and end-users disagree with the need for such an innovation. As stated by [10] in the case of adoption of an open innovation in computer sciences, the context is foremost and overriding, implying the locality of emergence, the knowledge flows amongst other bottlenecks. The originality of the present research stemmed not only from its dimension as "productivity enhancing technology", but mainly from its dimension as "quality enhancing technology", novel dimension in the agricultural fields in developing countries in general, and in Benin in particular. However, care is to be taken to spread trials over regions and even countries.

The paper is then organized into four sections. The first one deals with the theoretical background of the research, while the second presents materials and methods. The third section provides insights on the results and the fourth section discusses the main findings.

THEORETICAL BACKGROUND OF THE RESEARCH

R-D approaches and setbacks

R-D, R&D or Research and Development approach in the agricultural research sector made its way in Benin from the 1980s onwards [11]. Several approaches were to be considered. One important approach to be mentioned was the one initiated by a French funded project. It was very pragmatic and worked out solutions after participatory diagnoses. It is a time consuming approach based on a village level inventory of problems, and priority setting. Within a period of a few years, the bulk of data collected could not be handled by the staff members on their own. It suffered when scaled up, as there was no leverage at local levels to replicate actions. A second important approach that should be mentioned was the one initiated by a Dutch funded project, "Research Applied in the Real Environment". This was endorsed by the International Institute of Tropical Agriculture, which assigned scientific expertise in order to transfer new agricultural technologies into farmers' fields. Although this approach worked out innovative ways in getting partnerships between researchers and farmers, it also suffered from timely data collection and analyses. A further important approach to be mentioned was the "Farmer Field School (FFS)" [12]. As an informal successful tool for first-hand adult education, it rather failed to plan the costs of restitution to the other farmers.

Quantity versus quality enhancing agricultural technologies

Most actors preferred quantity enhancing technology rather than quality enhancing one [13]. People's choice was biased towards technologies that improve the quantities harvested. The post harvest losses amounted sometimes to 40-100% and were largely explained by qualitative characteristics that were not accounted for during the research period [14]. That was the rationale of why researches aiming at productivity enhancement targeted nowadays the post

harvest period and not yields from the outset. Improving characteristics of crop to post harvest pests became essential.

Comprehensive Perception Approach of Adoption

The originality of the present approach is its R-D orientation. Because of that, it is: i) much more difficult to achieve than the other one, and ii) much less scientific. This is to assert that research experiments under Researcher's Management followed a rigorous pathway wherein they were clearly designed with follow-up and monitoring from the research team. It was stated that even amongst researchers themselves, it did appear a great deal of incoherence [12]. Therefore, under the Researcher's Management, several flaws marked the approach due to the poor understanding of it by the research partners, farmers for instance [11]. When research experiments were under Farmer's Management, on the contrary, most scientific assumptions were relaxed and "scientificity" here consisted more or less than catching-up and rectifying undue actions of farmers. There was a great deal of effort to go in order to ensure that farmers considered experiments their own matters from the outset. The rationale explaining the flaw derived from that 100% of research materials were given to farmers by researchers and experiments scarcely engaged the logic of farmers. Farmers were only asked to contribute their lands. The other rationale explaining the flaw stemmed from the absolute indifference on the side of researchers to depart from the research conduct, being it on research stations or in farmers' fields [13]. Following the tradition, farmers usually responded to signals that are still unknown for researchers, adaptations to climate change for instance [15]. Unless relaxation was made of scientific design and conduct of research experiments, research experiments under farmer's Management would be realistic and ever reflected the very complex context of farmers [11].

MATERIALS AND METHODS

Here was an ex ante evaluation research grounded in quality rather than quantitative improvement. It aimed at exploring conditions and circumstances that could lead to improved practices in yam cropping in Benin and elsewhere, Togo and Ghana for instance, notwithstanding managerial and territorial aspects as claimed by [16].

Materials and Experiment Zones

Two improved practices were introduced in yam cropping: treatment A (the wrapping of seed yam cv. Klatchi with banana-fibre paper impregnated with micro-doses of abamectin), treatment B (the wrapping of seed yam of cv. Klatchi using banana-fibre paper alone). These two practices were opposed to farmers' practices, treatment FP. The banana paper used in Wrap & Plant technology was produced at the Forest Biomaterials Department, North Carolina State University, Raleigh, NC, USA, by additive-free, mechanical processing of banana fibres. The details of banana fibre processing and characterization of the paper are described by [17].

Seventeen yam producers were involved in the experiments on the three sites. In addition to those producers and for the sake of socioeconomic survey, nineteen other enumerators were selected following the indicated profiles:

Yam producers not involved in experiments, mainly male producers (n= 4);

Yam traders present on most local yam markets, mainly female traders (n= 5);

Yam food retailers with experience in various yam dishes, mainly female actors (n= 5); and,

Yam consumers, mainly female actors (n= 5).

Three production zones were targeted at the centre of Benin, Savalou, Savè and Glazoué districts, the so-called experiment sites 1, 2 and 3, respectively.

Data Collection

Data collection was based on a survey document that covers socioeconomic characteristics of the enumerators. Then, data were collected on the perception of various actors with respect to agro-morphological descriptors, the difficulties entailed when harvesting yam tubers, the state of the processing and the gustative quality of derivative meals. It is of interest to recall here that in the absence of measures regulating Agriculture and agri-food sectors [18] in Benin, the team of researchers rely upon the findings on the innocuous nature of abamectin on human health from [17] at the North Carolina University. The present survey aimed at comparing descriptors from the innovative treatments A and B with the so-called farmers' treatment (FP). Almost thirty-six (36) descriptors were concerned by the three phases: vegetative, harvest, food processing and tasting. Enumerators then compared the improved yam practices with their own so-called farmers' practices (FP) through semi-structured interviews of individual respondents. The gathering of enumerators in order to investigate agricultural experiments happened two times: (1) at harvest, the harvesting phase; (2) after conservation and during food processing and tasting, the processing and tasting phase. One important criterion that was set in order to validate perception data was enumerators' consistency with respect to the two research phases. If an enumerator failed to participate in one phase (maybe he/she was not available, or he/she asked relatives to answer on his/her behalf), his/her data sheet was withdrawn. In order to hold a high score of participation, communication and motivation of participants very much involved field assistants. Scores of each descriptor varied from -2 for the least appreciated descriptors to +2 for the most appreciated descriptors (-2, -1, 0, +1 and +2, respectively). An important point to stress was the unique nature of the panel over the three sites throughout the two phases of data collection.

Methods: Data Processing and Analysis

Data processing and analysis were based on a Comparative Appraisal Index (CBI), that is, the practice introduced was well appreciated if the difference in perception scores of characteristics with respect to farmer's practice was greater than zero. For each enumerator investigated and for each treatment, the index of comparative assessment (ICA) of the treatment introduced and the reference treatment was determined by the difference in perception scores from both (Score[introduced treatment] – Score[reference treatment]) for each of the descriptors of evaluated perception.

For a given treatment, the introduced treatment was well-liked (compared to the reference treatment) if $ICA > 0$; according to [19].

Treatment A or B could probably be adopted if its Ig is greater than zero ($Ig \geq 0$) (1).

Ig is an index of overall appreciation. This was determined per respondent, per site and for all three sites using the step by step canonical "discriminant" analysis.

It was then possible to determine who could adopt the introduced treatment in the future (probable adopter = 1 and probable non adopter = 0). Then, was established the relationship

between the adoption of a treatment by an enumerator and his/her socioeconomic characteristics using a binary logistic regression.

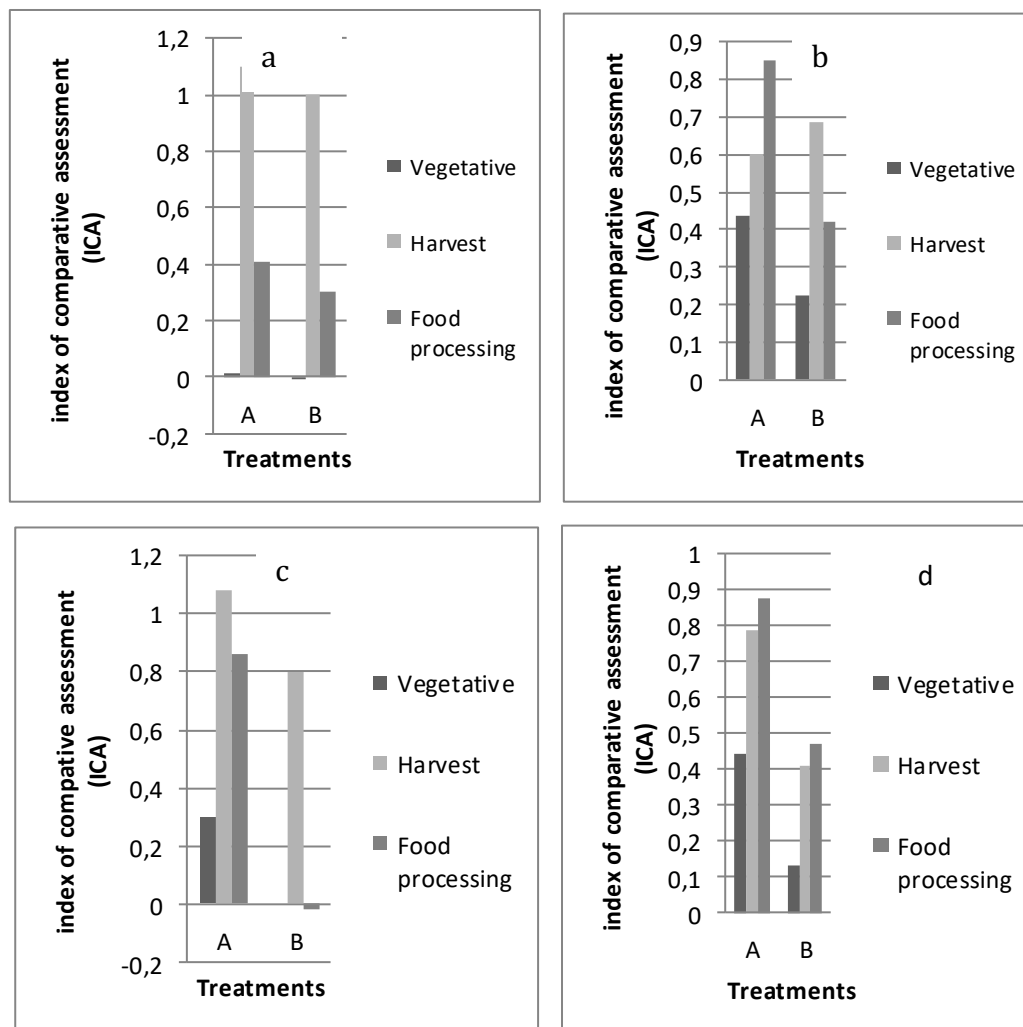
RESULTS

Enumerators were 50% females and 50% males. They all lived in the villages of experiments (94%) or in the very close environment of those villages (6%). They were from diverse socio-cultural groups: At Houin (Glazoué), they were in majority Mahi (62.5%) [20]. At Gobé (Savè), they were Kobago (19%), Idatcha (33.3%), Fon (24%) and Nago (17%) [21]. At Agbadogbo (Savalou), they were almost Lokpa (86%) [22].

Convergence or Divergence of enumerators' perception on yam descriptors from treatments A&B and referent practices

Perception analysis of the introduced treatments as compared to the referent revealed for the three sites that treatment A and probably treatment B was more appreciated than the so-called farmers' practices (FP) (figure 1). The comparative advantage of those innovative treatments was more pronounced at harvest and at food processing phases in the ascendant order, respectively. This tendency was observed in each experiment site.

Figure 1 depicts the perception of surveyed actors (enumerators) on introduced practices in comparison to their referent on three experiment sites and on all three sites altogether. What is striking here is that there is only one panel of enumerators over the three sites



Source: Calculated from field data (2017-2018)

Figure 1: Perception of enumerators on introduced practices in comparison to the referent on three experiment sites

Legend: Treatment A (the wrapping of seed yam cv. Klatchi with banana-fibre paper, impregnated with micro-doses of abamectin); Treatment B (the wrapping of seed yam of cv. Klatchi using banana-fibre paper alone).

(a): Savalou or site 1; (b): Glazoué or site 2; (c): Savè or site 3; (d): All three sites together.

Socioeconomic Determinants of the Likelihood of enumerators' Adoption of two innovative treatments (A & B) on yam

The binary logistic regressions (Table 1) showed that the probability (future decision) of adoption of both treatments would depend significantly on the number of yam varieties already adopted, the experience in years of an enumerator for treatment A; and membership to a farmers' organization, for treatment B, on site 1. On site 2, on the contrary, number of yam varieties already adopted alone, for treatment A, while, membership to a farmers' organization, experience in years of an enumerator, participation in an evaluation on yam in the past and number of yam varieties already adopted, for treatment B, determined adoption. On site 3, number of yam varieties already adopted and educational level of an enumerator, for treatment A; while participation in an evaluation on yam in the past, for treatment B, were socioeconomic

determinants of adoption. On all three sites, socioeconomic determinants of the likelihood of adoption were sites, number of yam varieties already adopted, sex of an enumerator and experience in years of an enumerator, for treatment A, and enumerator having other revenue generating activities, for treatment B.

Table 1 depicts the effects of socioeconomic characteristics of surveyed actors on the overall adoption probability of two innovative treatments A and B on yam.

Experiments are on three sites: site 1, site 2 and site 3. Table 1 indicates that results of experiments differ from one site to the other. So are the socioeconomic characteristics inciting or not to adopt the innovations.

Table 1: Effects of socioeconomic characteristics on the overall adoption probability of two innovative treatments A and B on yam

Sites	Treatment	Variables	ddl	Prob.
Site 1	A	Number of yam varieties already adopted	1	0,000
		Experience in years of an enumerator	1	0,001
	B	Membership to an peasant organization	1	0,001
Site 2	A	Number of yam varieties already adopted	1	0,002
	B	Membership to an peasant organization	1	0,030
		Experience in years of an enumerator	1	0,029
		Participation in an evaluation on yam in the past	1	0,000
		Number of yam varieties already adopted	1	0,040
Site 3	A	Number of yam varieties already adopted	1	0,000
		Educational level of an enumerator	3	0,001
	B	Participation in an evaluation on yam in the past	1	0,004
All three sites together (Sites 1, 2&3)	A	Sites	2	0,000
		Number of yam varieties already adopted	1	0,001
		Sex of an enumerator	1	0,020
		Experience in years of an enumerator	1	0,000
	B	Having other revenue generating activities	1	0,048

Source: Computed from field data, 2017/18

Note: only variables with significant effect on adoption are presented.

Legend: treatment A (the wrapping of seed yam cv. Klatchi with banana-fibre paper, impregnated with micro-doses of abamectin); Treatment B (the wrapping of seed yam of cv. Klatchi using banana-fibre paper alone).

Site 1: Savalou, Site 2: Glazoué, Site 3: Savè.

The relative chances of adoption (odds ratio) of treatments derived from binary logistic regression models revealed that Treatment A had 1.1 chances to be adopted than treatment B. On each site, treatment A was more likely to be adopted than treatment B, mainly on site 3 where treatment A had 3.0 chances to be adopted than treatment B. Besides, traders were more likely to adopt treatments than actors in the food retailing business on sites 2 and 3, and producers (on site 2); while enumerators, with membership to a farmer's organization, were more likely than those without membership (on sites 2 and 3); and those with no educational level were more likely to adopt than educated enumerators (on site 1).

The results revealed that on site 3, treatment A is more likely to be adopted than on site 2 (more importantly because of quantitative performance of treatment B) or site 1; while membership to a farmers' organization implies more chance of adoption of treatment B than otherwise. Besides, producers were more likely to adopt treatment A than actors in the food retailing business (on site 2), technicians (on site 1), yam traders and actors in food retailing business (on site 3); and treatment B than technicians (on site 2).

Probability of adoption of treatments A&B by site and for all three sites

The results of the probability of adoption of treatments A&B by site and for all three sites are summarized in table 2. It appeared that treatment A had the highest probability (more than 0.5), while treatment B had the lowest probability (about 0.1).

Table 2 depicts the probability of surveyed actors to adopt the two agricultural innovations following the sites.

It demonstrates that ecological variability is the rule rather than the exception.

Table 2: Probability of adoption of treatments A&B by site and for all three sites

Sites	Treatment	Probability of adoption
Site 1	A	0.714
	B	0.005
Site 2	A	0.375
	B	0.625
Site 3	A	0.666
	B	0.033
Three sites altogether (Sites 1, 2&3)	A	0.667
	B	0.104

Source: Computed from field data, 2017/18

Legend: treatment A (the wrapping of seed yam cv. Klatchi with banana-fibre paper, impregnated with micro-doses of abamectin); Treatment B (the wrapping of seed yam of cv. Klatchi using banana-fibre paper alone).
Site 1: Savalou, Site 2: Glazoué, Site 3: Savè.

On both sites 1 and 3, there was no doubt that treatment A took the lead given the respective probabilities of adoption. However, the probability score of treatment B on site 2 stroke attention.

DISCUSSION

The discussion is threefold: *Variations of yam descriptors perceived, socioeconomic characteristics and adoption, and probability of adoption.*

Variations of yam descriptors perceived by enumerators following the sites

Recall that the panel of enumerators was maintained from one site to the other along the three sites. This was to control the perception side of the experiments on all three sites. It was also to induce a cooperative perspective of the diffusion of the so-called agricultural innovation as found elsewhere [23] as much as the platform for improving agricultural production [24]. But, unexpectedly, enumerators varied their perception on both treatments, notably on site 2, in

contradiction to what was found by [13; 25; 26] while assessing four Chinese hybrid maize varieties based on three different panels of enumerators. This finding appealed to the ecological variability of site 2 compared to sites 1 and 3, implication that was acknowledged by [27] in similar circumstances. It should be advocated here that soil, vegetation and climate analyses would expel more clearly this ecological variability. Stretching the arguments, reference [28] claimed that not only actors matter, but so-called spatial and environmental heterogeneities would probably prompt to the relaxation of actors' adoption model. Thus, piloting new agricultural practices on three different sites should not only reveal end-users' sensitivities but also ecological variability [27]. Those authors also underlined that agricultural innovations suffer as well from the varied cultivation practices of actors as from ecological variability. That is the rationale why they put more emphasis on genetic agricultural innovations than those implying cultivation practices. That is an old debate expounded by [29] in the French countryside of the 19th century. The lesson to be learned here is that adoption measures should be streamlined according to managerial and territorial lines [16].

Socioeconomic characteristics and adoption of agricultural innovations

Like other agricultural technologies/innovations documented in the literature, some socioeconomic characteristics inciting or not to adoption were as follows: competence, experience, associative spirit and gender [25; 26; 30; 31]. The present results corroborate those of the literature, but hardly shed light on the variability observed by the panel of enumerators on treatments A and B following spatial gradients [32]. According to [28] on the one side, and [32] on the other side, adoption analysis of agricultural innovations should be founded on two matrices of data: the first one linking socioeconomic characteristics of actors (backward linkages) to the descriptors of agricultural innovation and the second one linking the demand side conditions of actors (forward linkages) on the market and the regulatory constraints to the descriptors of agricultural innovations. In the same vein, reference [33] revealed in Benin that not only the availability of Targeted Staggered Control (TSC) pesticide mattered, but more importantly the delivery of this pesticide at the right time and along with the institutional factors that contributed to the right use of the technology. The lesson to be learned from those schemes is the need for a two-fold system of simultaneous equations that evaluate the eligibility of an agricultural innovation to adoption.

Probability of adoption of agricultural innovations

While inquiring ex ante into the adoption of agricultural innovations, it appeared rational to ensure a high level of probability score, superior to 0.5, before eliciting the eligibility of an innovation to adoption [25; 26]. This was the case of the four Chinese hybrid maize varieties that are not yet in the pipeline of agricultural extension in Benin. Otherwise, like in the case of the present innovation on site 2, various descriptors of treatment A should be amended and rectified before one could boost or incite actors to adoption [13]. The question is whether at this stage, in addition to the socioeconomic characteristics intrinsic to actors of the panel of enumerators at the backward of the innovation, are they other conditions at the forward of the innovation such as market and regulatory constraints perceived by the panel of enumerators? According to [32], the answer is negative because well-known researchers failed to recognize those flaws in a recent past. However, references [25; 26], working out the probability of adoption of four Chinese hybrid maize varieties on similar sites, found that the panel of enumerators put forward market conditions in order to mitigate their adhesion to the new agricultural innovations. More importantly, reference [34] advocated the price case in the

adoption of Hevea in Ivory Coast; whereas reference [35] targeted financial services implying discount rates and administrative processes amongst others as hindering factors for the diffusion of agricultural innovations in Africa. The question arises whether there is a comfortable perspective of artificial intelligence for agricultural innovations in Africa as claimed by [36] and [37]. The lesson to be learned is that in addition to socioeconomic characteristics of actors, there are more regulatory and market constraints that contribute to adoption decision.

CONCLUSION

The perceptive evaluation of different phases, vegetative, harvest, food processing of tubers, and tasting of yam food, led only to the comparative advantage of treatments A and B over the farmers' practices. The first limit to be stressed here was relative to yam conditioning and conservation that were not evaluated. Treatments A and B well behaved. Treatment A (the wrapping of seed yam cv. Klatchi with banana-fibre paper, impregnated with micro-doses of abamectin), took the lead and this following most phases. On the contrary, treatment B (the wrapping of seed yam of cv. Klatchi using banana-fibre paper alone) was much less appreciated because of its low performance at harvest and food processing phases.

The vegetative phase of treatments A and B should still be improved in order to complete the basket of choice for actors.

The harvest phase needs more attention, because insufficiently satisfactory.

The food processing and tasting phases are rather satisfactory.

The perceptive evaluation confirmed that yam is one basic food at the centre of Benin. Nonetheless, the lesson to be learned derived from integrating actors' preference from the research station or at the farmers' fields in order to reduce the time span between the identification of an agricultural innovation and the time it gets to farmers' fields. The rescheduling of the agricultural innovation transfer to farmers is a priority in the developing countries in general and in Benin in particular. The rationale is the strong linkages with development issues in general and food security in particular. However, the main bottlenecks of massive production of quality-orientated yam are availability of seed yam and an adequate seed policy as well as the supply of banana-fibre paper impregnated with abamectin.

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