Sixième article : The impact of farmers' perception on agricultural technology adoption: the case of botanical extracts in vegetable production in Benin

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Sommaire

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Informations générales

Le Bulletin de la Recherche Agronomique du Bénin (BRAB) édité par l'Institut National des Recherches Agricoles du Bénin (INRAB) est un organe de publication créé en mai 1991 pour offrir aux chercheurs béninois et étrangers un cadre pour la diffusion des résultats de leurs travaux de recherche. Il accepte des articles originaux de recherche et de synthèse, des contributions scientifiques, des articles de revue, des notes et fiches techniques, des études de cas, des résumés de thèse, des analyses bibliographiques, des revues de livres et des rapports de conférence relatifs à tous les domaines de l'agronomie et des sciences apparentées, ainsi qu'à toutes les disciplines du développement rural. La publication du Bulletin est assurée par un comité de rédaction et de publication appuyés par un conseil scientifique qui réceptionne les articles et décide de l'opportunité de leur parution. Ce comité de rédaction et de publication est appuyé par des comités de lecture qui sont chargés d'apprécier le contenu technique des articles et de faire des suggestions aux auteurs afin d'assurer un niveau scientifique adéquat aux articles. La composition du comité de lecture dépend du sujet abordé par l'article proposé. Rédigés en français ou en anglais, les articles doivent être assez informatifs avec un résumé présenté dans les deux langues, dans un style clair et concis. Une note d'indications aux auteurs est disponible dans chaque numéro et peut être obtenue sur demande adressée au secrétariat du BRAB. Pour recevoir la version électronique pdf du BRAB, il suffit de remplir la fiche d'abonnement et de l'envoyer au comité de rédaction avec les frais d'abonnement. La fiche d'abonnement peut être obtenue à la Direction Générale de l'INRAB, dans ses Centres de Recherches Agricoles ou à la page vii de tous les numéros. Le BRAB publie par an normalement deux (02) numéros en juin et décembre mais quelquefois quatre (04) numéros en mars, juin, septembre et décembre et aussi des numéros spéciaux mis en ligne sur le site web : http://www.slire.net. Un thesaurus spécifique dénommé « TropicAgrif » (Tropical Agriculture and Forestry) a été développé pour caractériser les articles parus dans le BRAB et servir d'autres revues africaines du même genre. Pour les auteurs, une contribution de quarante mille (40.000) Francs CFA est demandée par article soumis et accepté pour publication. L'auteur principal reçoit la version électronique pdf du numéro du BRAB contenant son article.

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Indications aux auteurs

Types de contributions et aspects généraux

Le Bulletin de la Recherche Agronomique du Bénin (BRAB) accepte des articles scientifiques, des articles de synthèse, des résumés de thèse de doctorat, des analyses bibliographiques, des notes et des fiches techniques, des revues de livres, des rapports de conférences, d'ateliers et de séminaires, des articles originaux de recherche et de synthèse, puis des études de cas sur des aspects agronomiques et des sciences apparentées produits par des scientifiques béninois ou étrangers. La responsabilité du contenu des articles incombe entièrement à l'auteur et aux co-auteurs. Le BRAB publie par an normalement deux (02) numéros en juin et décembre mais quelquefois quatre (04) numéros en mars, juin, septembre et décembre et aussi des numéros spéciaux mis en ligne sur le site web : http://www.slire.net. Pour les auteurs, une contribution de quarante mille (40.000) Francs CFA est demandée par article soumis et accepté pour publication. L'auteur principal reçoit la version électronique pdf du numéro du BRAB contenant son article.

Soumission de manuscrits

Les articles doivent être envoyés par voie électronique et/ou en trois (3) exemplaires en version papier par une lettre de soumission (*covering letter*) au comité de rédaction et de publication du BRAB aux adresses électroniques suivantes : *E-mail :* ***brabpisbinrab@gmail.com***. Dans la lettre de soumission les auteurs doivent proposer l'auteur de correspondance ainsi que les noms et adresses (y compris e-mail) d'au moins trois (03) experts de leur discipline ou domaine scientifique pour l'évaluation du manuscrit. Certes, le choix des évaluateurs (*referees*) revient au comité éditorial du Bulletin de la Recherche Agronomique du Bénin.

Les manuscrits doivent être écrits en français ou en anglais, tapé/saisi sous Winword ou Word ou Word docx avec la police Arial taille 10 en interligne simple sur du papier A4 (21,0 cm x 29,7 cm). L'auteur doit fournir des fichiers électroniques des illustrations (tableaux, figures et photos) en dehors du texte. Les figures doivent être réalisées avec un logiciel pour les graphiques. Les données ayant servi à élaborer les figures seront également fournies. Les photos doivent être suffisamment contrastées. Les articles sont soumis par le comité de rédaction à des lecteurs, spécialistes du domaine. Pour qu'un article soit accepté par le comité de rédaction, il doit respecter certaines normes d'édition et règles de présentation et d'écriture. Ne pas oublier que les trois (3) **qualités fondamentales d'un article scientifique** sont la **précision** (supprimer les adjectifs et adverbes creux), la **clarté** (phrases courtes, mots simples, répétition des mots à éviter, phrases actives, ordre logique) et la **brièveté** (supprimer les expressions creuses).

Titre

On doit y retrouver l'information principale de l'article et l'objet principal de la recherche. Le titre doit contenir 6 à 10 mots (22 mots au maximum ou 100 caractères et espaces) en position forte, décrivant le contenu de l'article, assez informatifs, descriptifs, précis et concis. Il comporte les mots de l'index *Medicus* pour faciliter la recherche sur le plan mondial. Il est recommandé d'utiliser des sous-titres courts et expressifs pour subdiviser les sections longues du texte. Ils doivent être écrits en minuscules, à part la première lettre et non soulignés. Toutefois, il faut éviter de multiplier les sous-titres. Le titre doit être traduit dans la seconde langue donc écrit dans les deux langues.

Auteur et Co-auteurs

Les initiales des prénoms en majuscules séparées par des points et le nom avec 1ère lettre écrite en majuscule de tous les auteurs (auteur & co-auteurs) sont écrits sous le titre de l'article. Immédiatement, suivent les titres académiques (Pr., Prof., Dr, MSc., MPhil. et/ou Ir.), les prénoms écrits en minuscules et le nom écrit en majuscule, puis les adresses complètes (structure, BP, Tél., e-mail, pays, etc.) de tous les auteurs. Il ne faut retenir que les noms des membres de l'équipe ayant effectivement participé au programme et à la rédaction de l'article. L'auteur principal est celui qui a assuré la direction de la recherche et le plus en mesure d'assumer la responsabilité de l'article.

Résumé

Un bref résumé dans la langue de l'article est nécessaire. Ce résumé doit être précédé d'un résumé détaillé dans la seconde langue (français ou anglais selon le cas) et le titre sera traduit dans cette seconde langue. Le résumé est : un compte rendu succinct ; une représentation précise et abrégée ; une vitrine de plusieurs mois de dur labeur ; une compression en volume plus réduit de l'ensemble des idées développées dans un document ; etc. Il doit contenir l'essentiel en un seul paragraphe de 200 à 350 mots. Un bon résumé a besoin d'une bonne structuration. La structure apporte non seulement de la force à un résumé mais aussi de l'élégance. Il faut absolument éviter d'enrober le lecteur dans un amalgame de mots juxtaposés les uns après les autres et sans ordre ni structure logique. Un résumé doit contenir essentiellement : une courte **Introduction** (**Contexte**), un **Objectif**, la **Méthodologie** de collecte et d'analyse des données (**Type d'étude**, **Echantillonnage**, **Variables** et **Outils statistiques**), les principaux **Résultats** obtenus en 150 mots (**Résultats importants et nouveaux pour la science**), une courte discussion et une Conclusion(**Implications de l'étude en termes de généralisation et de perspectives de recherches**). La sagesse recommande d'être efficacement économe et d'utiliser des mots justes pour dire l'essentiel.

Mots-clés

Les mots clés suivront chaque résumé et l'auteur retiendra 3 à 5 mots qu'il considère les plus descriptifs de l'article. On doit retrouver le pays (ou la région), la problématique ou l'espèce étudiée, la discipline et le domaine spécifique, la méthodologie, les résultats et les perspectives de recherche. Il est conseillé de choisir d'autres mots/groupes de mots autres que ceux contenus dans le titre.

Texte

Tous les articles originaux doivent être structurés de la manière suivante : Introduction, Matériel et Méthodes, Résultats, Discussion/Résultats et Discussion, Conclusion, Remerciements (si nécessaire) et Références bibliographiques. Le texte doit être rédigé dans un langage simple et compréhensible.

Introduction

L'introduction c'est pour persuader le lecteur de l'importance du thème et de la justification des objectifs de recherche. Elle motive et justifie la recherche en apportant le background nécessaire, en expliquant la rationalité de l'étude et en exposant clairement l'objectif et les approches. Elle fait le point des recherches antérieures sur le sujet avec des citations et références pertinentes. Elle pose clairement la problématique avec des citations scientifiques les plus récentes et les plus pertinentes, l'hypothèse de travail, l'approche générale suivie, le principe méthodologique choisi. L'introduction annonce le(s) objectif(s) du travail ou les principaux résultats. Elle doit avoir la forme d'un entonnoir (du général au spécifique).

Matériel et méthodes

Il faut présenter si possible selon la discipline le **milieu d'étude** ou **cadre de l'étude** et indiquer le lien entre le milieu physique et le thème. **La méthodologie d'étude** permet de baliser la discussion sur les résultats en renseignant sur la validité des réponses apportées par l'étude aux questions formulées en introduction. Il faut énoncer les méthodes sans grands détails et faire un extrait des principales utilisées. L'importance est de décrire les protocoles expérimentaux et le matériel utilisé, et de préciser la taille de l'échantillon, le dispositif expérimental, les logiciels utilisés et les analyses statistiques effectuées. Il faut donner toutes les informations permettant d'évaluer, voire de répéter l'essai, les calculs et les observations. Pour le matériel, seront indiquées toutes les caractéristiques scientifiques comme le genre, l'espèce, la variété, la classe des sols, etc., ainsi que la provenance, les quantités, le mode de préparation, etc. Pour les méthodes, on indiquera le nom des dispositifs expérimentaux et des analyses statistiques si elles sont bien connues. Les techniques peu répandues ou nouvelles doivent être décrites ou bien on en précisera les références bibliographiques. Toute modification par rapport aux protocoles courants sera naturellement indiquée.

Résultats

Le texte, les tableaux et les figures doivent être complémentaires et non répétitifs. Les tableaux présenteront un ensemble de valeurs numériques, les figures illustrent une tendance et le texte met en évidence les données les plus significatives, les valeurs optimales, moyennes ou négatives, les corrélations, etc. On fera mention, si nécessaire, des sources d'erreur. La règle fondamentale ou règle cardinale du témoignage scientifique suivie dans la présentation des résultats est de donner tous les faits se rapportant à la question de recherche concordant ou non avec le point de vue du scientifique et d'indiquer les relations imprévues pouvant faire de l'article un sujet plus original que l'hypothèse initiale. Il ne faut jamais entremêler des descriptions méthodologiques ou des interprétations avec les résultats. Il faut indiquer toujours le niveau de signification statistique de tout résultat. Tous les aspects de l'interprétation doivent être présents. Pour l'interprétation des résultats il faut tirer les conclusions propres après l'analyse des résultats. Les résultats négatifs sont aussi intéressants en recherche que les résultats positifs. Il faut confirmer ou infirmer ici les hypothèses de recherches.

Discussion

C'est l'établissement d'un pont entre l'interprétation des résultats et les travaux antérieurs. C'est la recherche de biais. C'est l'intégration des nouvelles connaissances tant théoriques que pratiques dans le domaine étudié et la différence de celles déjà existantes. Il faut éviter le piège de mettre trop en évidence les travaux antérieurs par rapport aux résultats propres. Les résultats obtenus doivent être interprétés en fonction des éléments indiqués en introduction (hypothèses posées, résultats des recherches antérieures, objectifs). Il faut discuter ses propres résultats et les comparer à des résultats de la littérature scientifique. En d'autres termes c'est de faire les relations avec les travaux antérieurs.

Il est nécessaire de dégager les implications théoriques et pratiques, puis d'identifier les besoins futurs de recherche. Au besoin, résultats et discussion peuvent aller de pair.

Résultats et Discussion

En optant pour **résultats et discussions** alors les deux vont de pair au fur et à mesure. Ainsi, il faut la discussion après la présentation et l'interprétation de chaque résultat. Tous les aspects de l'interprétation, du commentaire et de la discussion des résultats doivent être présents. Avec l'expérience, on y parvient assez aisément.

Conclusion

Il faut une bonne et concise conclusion. Il ne faut jamais laisser les résultats orphelins mais il faut les couvrir avec une conclusion étendant les implications de l'étude et/ou les suggestions. Une conclusion ne comporte jamais de résultats ou d'interprétations nouvelles. On doit y faire ressortir de manière précise et succincte les faits saillants et les principaux résultats de l'article sans citation bibliographique. Elle fait l'état des limites et des faiblesses de l'étude (et non celles de l'instrumentation mentionnées dans la section de méthodologie). Elle suggère d'autres avenues et études permettant d'étendre les résultats ou d'avoir des applications intéressantes ou d'obtenir de meilleurs résultats. La conclusion n'est pas l'endroit pour présenter la synthèse des conclusions partielles du texte car c'est une des fonctions du résumé. Il faut retenir que la conclusion n'est pas un résumé de l'article.

Références bibliographiques

Il existe deux normes internationales régulièrement mise à jour, la :

- **norme Harvard** : **-i-** West, J.M., Salm, R.V., 2003: Resistance and resilience to coral bleaching: implications for coral reef conservation and management. *Conservation Biology*, 17, 956-967. **-ii-** Pandolfi, J.M., R.H. Bradbury, E. Sala, T.P. Hughes, K.A. Bjorndal, R.G. Cooke, D. McArdle, L. McClenachan, M.J.H. Newman, G. Paredes, R.R. Warner, J.B.C. Jackson, 2003: Global trajectories of the long-term decline of coral reef ecosystems. *Science*, 301 (5635), 955-958.
- **norme Vancouver** : **-i-** WEST, J.M., SALM, R.V., (2003); Resistance and resilience to coral bleaching: implications for coral reef conservation and management. *Conservation Biology*, vol. 17, pp. 956-967. **-ii-** PANDOLFI, J.M., et al., (2003); Global trajectories of the long-term decline of coral reef ecosystems. *Science*, vol. 301 N° 5635, pp. 955-958.

Il ne faut pas mélanger les normes de présentation des références bibliographiques. En ce qui concerne le Bulletin de la Recherche Agronomique du Bénin (BRAB), c'est la norme Harvard qui a été choisie. Les auteurs sont responsables de l'orthographe des noms cités dans les références bibliographiques. Il faut s'assurer que les références mentionnées dans le texte sont toutes reportées dans la liste des références et inversement. La bibliographie doit être présentée en ordre alphabétique conformément aux deux (2) exemples donnés ci-dessus comme suit : nom et initiales du prénom du 1er auteur, puis initiales du prénom et nom des autres auteurs ; année de publication (ajouter les lettres a, b, c, etc., si plusieurs publications sont citées du même auteur dans la même année) ; nom complet du journal ; numéro du volume en chiffre arabe, éditeur, ville, pays, première et dernière page de l'article. Dans le texte, les publications doivent être citées avec le nom de l'auteur et l'année de publication entre parenthèses de la manière suivante : Sinsin (1995) ou Sinsin et Assogbadjo (2002). Pour les références avec plus de deux auteurs, on cite seulement le premier suivi de « *et al.* » (mis pour *et alteri*), bien que dans la bibliographie tous les auteurs doivent être mentionnés : Sinsin *et al.* (2007). Les références d'autres sources que les journaux, par exemple les livres, devront inclure le nom de l'éditeur et le nom de la publication. Somme toute selon les ouvrages ou publications, les références bibliographiques seront présentées dans le BRAB de la manière suivante :

Pour les revues :

Adjanohoun, E., 1962 : Etude phytosociologique des savanes de la base Côte-d'Ivoire (savanes lagunaires). *Vegetatio*, 11, 1-38.

Grönblad, R., G.A. Prowse, A.M. Scott, 1958: Sudanese Desmids. *Acta Bot. Fenn.*, 58, 1-82.

Thomasson, K., 1965: Notes on algal vegetation of lake Kariba..*Nova Acta R. Soc. Sc. Upsal.*, ser. 4, 19(1): 1-31.

Poche, R.M., 1974a: Notes on the roan antelope (*Hippotragus equinus* (Desmarest)) in West Africa. *J. Applied Ecology*, 11, 963-968.

Poche, R.M., 1974b: Ecology of the African elephant (*Loxodonta a. africana*) in Niger, West Africa. *Mammalia*, 38, 567-580.

Pour les contributions dans les livres :

Whithon, B.A., Potts, M., 1982: Marine littoral: 515-542. *In*: Carr, N.G., Whitton, B.A., (eds), The biology of cyanobacteria. Oxford, Blackwell.

Annerose, D., Cornaire, B., 1994 : Approche physiologique de l'adaptation à la sécheresse des espèces cultivées pour l'amélioration de la production en zones sèches: 137-150. *In* : Reyniers, F.N., Netoyo L. (eds.). Bilan hydrique agricole et sécheresse en Afrique tropicale. Ed. John Libbey Eurotext. Paris.

Pour les livres :

Zryd, J.P., 1988: Cultures des cellules, tissus et organes végétaux. Fondements théoriques et utilisations pratiques. Presses Polytechniques Romandes, Lausanne, Suisse.

Stuart, S.N., R.J. Adams, M.D. Jenkins, 1990: Biodiversity in sub-Saharan Africa and its islands. IUCN–The World Conservation Union, Gland, Switzerland.

Pour les communications :

Vierada Silva, J.B., A.W. Naylor, P.J. Kramer, 1974: Some ultrastructural and enzymatic effects of water stress in cotton (*Gossypium hirsutum* L.) leaves. Proceedings of Nat. Acad. Sc. USA, 3243-3247.

Lamachere, J.M., 1991 : Aptitude du ruissellement et de l'infiltration d'un sol sableux fin après sarclage. Actes de l'Atelier sur Soil water balance in the Sudano-Sahelian Zone. Niamey, Niger, IAHS n° 199, 109-119.

Pour les abstracts :

Takaiwa, F., Tnifuji, S., 1979: RNA synthesis in embryo axes of germination pea seeds. Plant Cell Physiology abstracts, 1980, 4533.

Thèse ou mémoire :

Valero, M., 1987: Système de reproduction et fonctionnement des populations chez deux espèces de légumineuses du genre *Lathyrus*. PhD. Université des Sciences et Techniques, Lille, France, 310 p.

Pour les sites web :

http:/www.iucnredlist.org, consulté le 06/07/2007 à 18 h. - http:/www.cites.org, consulté le 12/07/2008 à 09 h.

Equations et formules

Les équations sont centrées, sur une seule ligne si possible. Si on s'y réfère dans le texte, un numéro d'identification est placé, entre crochets, à la fin de la ligne. Les fractions seront présentées sous la forme « 7/25 » ou « (a+b)/c ».

Unités et conversion

Seules les unités de mesure, les symboles et équations usuels du système international (SI) comme expliqués au chapitre 23 du Mémento de l'Agronome, seront acceptés.

Abréviations

Les abréviations internationales sont acceptées (OMS, DDT, etc.). Le développé des sigles des organisations devra être complet à la première citation avec le sigle en majuscule et entre parenthèses (FAO, RFA, IITA). Eviter les sigles reconnus localement et inconnus de la communauté scientifique. Citer complètement les organismes locaux.

Nomenclature de pesticides, des noms d'espèces végétales et animales

Les noms commerciaux seront écrits en lettres capitales, mais la première fois, ils doivent être suivis par le(s) nom (s) communs(s) des matières actives, tel que acceptés par « International Organization for Standardization (ISO) ». En l'absence du nom ISO, le nom chimique complet devra être donné. Dans la page de la première mention, la société d'origine peut être indiquée par une note en bas de la page, p .e. PALUDRINE (Proguanil). Les noms d'espèces animales et végétales seront indiqués en latin (genre, espèce) en italique, complètement à la première occurrence, puis en abrégé (exemple : *Oryza sativa* = *O. sativa*). Les auteurs des noms scientifiques seront cités seulement la première fois que l'on écrira ce nom scientifique dans le texte.

Tableaux, figures et illustrations

Chaque tableau (avec les colonnes rendus invisibles mais seules la première ligne et la dernière ligne sont visibles) ou figure doit avoir un titre. Les titres des tableaux seront écrits en haut de chaque tableau et ceux des figures/photographies seront écrits en bas des illustrations. Les légendes seront écrites directement sous les tableaux et autres illustrations. En ce qui concerne les illustrations (tableaux, figures et photos) seules les versions électroniques bien lisibles et claires, puis mises en extension jpeg avec haute résolution seront acceptées. Seules les illustrations dessinées à l'ordinateur et/ou scannées, puis les photographies en extension jpeg et de bonne qualité donc de haute résolution sont acceptées. Les places des tableaux et figures dans le texte seront indiquées dans un cadre sur la marge. Les tableaux sont numérotés, appelés et commentés dans un ordre chronologique dans le texte. Ils présentent des données synthétiques. Les tableaux de données de base ne conviennent pas. Les figures doivent montrer à la lecture visuelle suffisamment d'informations compréhensibles sans recours au texte. Les figures sont en Excell, Havard, Lotus ou autre logiciel pour graphique sans grisés et sans relief. Il faudra fournir les données correspondant aux figures afin de pouvoir les reconstruire si c'est nécessaire.

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The impact of farmers' perception on agricultural technology adoption: the case of botanical extracts in vegetable production in Benin

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Abstract

Although alternatives to chemical pesticides such as botanical extracts have been found to significantly reduce pest and disease attacks, their adoption is still limited. The socioeconomic and institutional factors remain the largely analyzed factors in the literature. Little is known, however, about the role played by producer's perceptions. Drawing on the Heckman selection model, the article analyzes on the one hand factors explaining vegetable farmers' perceptions of alternatives to chemical pesticides and assesses on the other hand their impact on the decision to adopt or not these alternatives in Benin. Results show that the adoption of alternatives to chemical pesticides is limited by the negative perceptions towards the specific attributes of the botanical extracts by vegetable farmers. Despite their recognized insecticidal effects, their slow actions, difficulties in preparing the plant extracts, the high number of treatments required, and the specificity of their effects regarding insects and diseases are likely to be factors that work against a positive perception of these alternatives.

Key words: Perception, adoption, biopesticides, botanical extracts, vegetables, Benin.

Impact de la perception des producteurs sur l'adoption des technologies agricoles: cas des extraits aqueux botaniques utilisés dans la production maraîchère au Bénin

Résumé

Malgré les performances démontrées des alternatives aux pesticides chimiques de synthèse, dont les extraits de plantes, leur adoption reste encore très limitée. Les facteurs les plus conventionnellement analysés comme déterminant cette adoption sont les caractéristiques socio-économiques et démographiques du producteur, les facteurs institutionnels ; les perceptions des producteurs étant le plus souvent omis dans ces études. Partant du modèle de sélection de Heckman, l'article a utilisé les données collectées auprès de 198 maraîchers pour analyser d'une part, les facteurs explicatifs des perceptions des maraîchers des alternatives aux pesticides chimiques, que sont les extraits de plantes, et évaluer d'autre part l'impact de ces perceptions sur l'adoption ou non de ces alternatives au Bénin. Les résultats ont montré que l'adoption des alternatives aux pesticides chimiques restait limitée par la perception négative qu'avaient les maraîchers desdites alternatives. Malgré leurs effets insecticides reconnus, leurs actions jugées trop lentes, leur préparation trop pénible, et le nombre élevé de traitements requis semblent constituer des facteurs qui jouent en défaveur d'une perception positive de ces alternatives.

Mots clés : Perceptions, adoption, biopesticides, extraits botaniques, maraîchage, Bénin.

INTRODUCTION

Agriculture is the core driver of the economy in many developing countries. Vegetable farming contributes significantly to food security and poverty reduction (Uusiku *et al.*, 2010), especially in urban and peri-urban areas where this outreach agricultural activity is becoming more and more important nowadays. According to FAO estimations, vegetable production occupies about 40%of city dwellers in Africa (FAO, 2012) and as such represent, for many people, an income and employment sources, and contributes to their livelihoods (Moustier, 2004; Shackleton *et al.*, 2009; Moustier, 2010; Ayerakwa, 2017).Vegetables such as tomato, pepper, and onion are the necessary constituents of food preparation. Because of their vegetal protein, vitamins, minerals, and trace elements content, vegetables are of great nutritional value and meet the nutritional needs of the populations whose staple diet is chiefly composed of carbohydrates (Uusiku *et al.*, 2010; Kamga *et al.*, 2013; Icard-

Vernière *et al*., 2015). As such, they contribute significantly to combat successfully household food and nutritional insecurity (Tesfaye *et al*., 2008).

Benin has a high potential for vegetable production as a consequence of various favorable factors to growing these crops, such as climate and soil (MAEP, 2011; Kpéra *et al*., 2017). Vegetable production in Benin employs about 4% of the active population and contributes about 15% to national wealth (Tokannou and Quenum, 2007; RNIB, 2008). In urban and peri-urban zones, vegetable production stands out as an important revenue-generating activity for the hundreds of producers (Tokannou and Quenum, 2007; FAO, 2012). For example, it is the main source of revenues for more than 600,000 farmers (Fanou *et al*., 2004), and allows indirectly several tens of thousands of families to live (Singbo *et al*., 2004). However, despite this importance, outreach vegetable production remains limited by several factors including attacks by insect pests and pathologies. It is this situation that pushes vegetable farmers to use anarchically and abusively chemical pesticides in order to limit damages. The utilization of cotton pesticides is sometime observed (Adekambi and Adegbola, 2008). Such practices have consequences on the health of consumers because of the presence of the residues in the vegetables and on the environment through contamination of the water table (Amoussougbo, 1993). For example, in 1999, the number of dead people attributed to the contamination by chemical pesticides of vegetables produced in association with cotton in northern Benin is estimated to be 87 (PEDUME Benin, 1999).

Alternatives to chemical pesticides including plant extracts is experimented and promoted in order to reduce these harmful effects of chemical pesticides (Fanou *et al.,* 2004). Despite all these demonstrated performances of plant extracts and biopesticides and recognized by producers themselves, their adoption is still very limited. Their adoption rate is estimated to be 33% in 2008 (Adekambi and Adégbola, 2008). The producer's decision to adopt a technological innovation depends on some complex factors. The most conventionally analyzed factors are the socio-economic and demographic characteristics of the producer, institutional factors such as access to extension, to inputs, to market, and to (micro-)credit (Feder *et al*., 1993; Adegbola and Gardebroek, 2007). The most often omitted factor in these studies is the producer's perception of the characteristics of the innovation to which (s)he is exposed. The few studies on the subject and for other crops have demonstrated the influence farmers' perceptions of the attributes of the proposed technologies (nutritional quality, yield, efficiency against pests/insects, purchase price, availability, etc.) have on their decision to adopt them or not (Adesina and Zinnah, 1993; Sall *et al.* 2000; Adégbola and Gardebroek, 2007). To bridge this gap, the present study intends to examine the impact of vegetable producers' perceptions of the widely disseminated botanical extracts on their adoption. The research questions to which the study tries to answer are the following: What are vegetable farmers' perceptions of the widely disseminated botanical extracts? What are the factors influencing the formation of these perceptions? What is the impact of these vegetable farmers' perceptions on the adoption of botanical extracts? Documenting these perceptions as well as factors affecting their formation is all the more important that it would facilitate the development and transfer of appropriate technologies. The rest of this paper is organized as follows. Section 2 presents the conceptual and empirical frame, and the data collection approach. Section 3 presents the results and discussions. Finally, the conclusion of the study is presented in Section 5.

METHODOLOGY

This section presents the method of analysis used in the study. On the one hand, it explains the method used to identify and analyze factors that influence the formation of vegetable farmers' perceptions. On the other hand, the present section describes the method used to estimate the impact of the farmers' perceptions on the adoption of biopesticides and/or botanical extracts.

Analytical framework

Analysis of the determinants of vegetable farmers' perceptions

In order to identify and analyze factors that are responsible of vegetable producers' perceptions regarding biopesticides and/orbotanical extracts, the model of Lancaster (1966) was considered. According to this model, goods are not direct objects of utility, but rather a set of attributes or characteristics from which derives the utility. The utility indicator (*U*) was not actually observable but is supposed to be at the origin of the observable vectors of perceptions (y) expressed by vegetable farmers which were, either bad (0), either also good (1) or better (2) than those they had about the same characteristics but on the alterative technology (chemical pesticides in the specific case of the

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study). Since y was expressed as an ordinal number, like Maddala (1983), an "Ordored Probit" was applied because linear probability models for discrete dependent variables would have led to biased and inconsistent estimated coefficients (Wooldridge, 2002). The Ordored Probit was defined using the method of the maximum likelihood and is specified as follows:

$$y = \begin{cases} 0 & \text{si } U \leq 0 \\ 1 & 0 < U \leq \pi \\ 2 & U > \pi \end{cases} \quad (1)$$

Where π was the limit of the variable or the cut-off point of the relative perception for each type of characteristics and attributes.

Studies on the factors influencing the formation of perceptions indicated that the perceptions of the attributes of a given innovation were determined by various factors such as socioeconomic and demographic variables and the availability of information for decision making (Adégbola, 2008; Guerin, 1999; Negatu and Parikh, 1999). Thus, the study assumed that vegetable farmers' perceptions of the different attributes of botanical extracts depend on the following variables:

- ***Gender of the vegetable farmer (SEXE).*** This variable takes the value 1 when the surveyed farmer is a man and 0 if not. It is generally argued that sex of the farmer affects its perception about technological innovations (e.g., Nkamleu and Manyong, 2005; Mehar *et al.*, 2016). Several studies have shown that there was significance correlation, positive or negative, between farmer' gender and its perception about agricultural technologies (ex. Yegbemey *et al.*, 2014; Acema *et al.,* 2016), while other found no significant effect. In the present study, the hypothesis was that men are more likely to appreciate botanical extracts and/or biopesticides. In fact, male producers have more chance to have access to accurate and updated knowledge on botanical extracts and/or biopesticides, contrary to their women counterparts. Hence, extension and research agents tend to work with men rather than women. The variable SEXE was therefore supposed to be positively correlated with the perceptions of attributes of botanical extracts and/or biopesticides.
- ***Number of years of experience in vegetable production (EXPER)***. This variable was included in the models estimated as an indicator of the maturity of the vegetable farmer in his/her ability to make decisions. The extant studies showed that the higher the farming experience the more knowledge and technical ideas about how an innovation the farmer can gain and the more positive its perception about such innovation must be (Adégbola, 2008; Rahman, 2003; Pullaila *et al.*, 2018). The study therefore assumed that the number of years of experience of the vegetable farmer should be positively correlated with the perceptions of the attributes of botanical extracts and/or biopesticides.
- ***Contact with extension (CONT).*** The contact of vegetable farmers with the extension services (CONT = 1) will for sure allow them to have accurate knowledge (benefits) of botanical extracts (e.g., Fosu-Mensah *et al.*, 2012). Extension services improve perception about agricultural technologies through enhancing farmers' awareness and knowledge on technology attributes (Di Falco *et al.*, 2011). Maddison (2007) reported that farmers who enjoy extension advice were likely to improve their perception of climate change. In other words, access to extension showed positive and significant effect on farmers' perception. CONT takes the value 0 when the vegetable farmers declare having no contact with the extension services. The contact with extension was supposed to influence positively vegetable farmers' perceptions.
- ***Membership of a vegetable farmers' association (MECAS)***. This variable shows the level of idea exchanges between vegetable farmers of the same association. Prior studies showed that the perception level of farmers is significantly correlated with the probability of being member of farmers' associations (e.g., Petcho *et al.*, 2019). The vegetable farmer who has no

contact with extension can however have concise and adequate information on botanical extracts from his/her peers of the association. MECAS is dichotomic and takes the value 1 if the vegetable farmer is member of a vegetable farmers' association and 0 if not. Membership of an association is supposed to affect positively the perceptions of the attributes of botanical extracts and/or biopesticides.

- ***Level of education (EDUF)***. The study assumes that the variable EDUF would influence positively vegetable farmers' perceptions. It has been shown that education of the farmer strongly and positively affected their perception about agricultural technologies (e.g., Asrat and Simane, 2018). Education was more likely to enhance the thinking capability and awareness of farmers about agricultural technologies and hence would definitely lead to positive perception towards those technologies (Belay and Hamito, 2004; Deresa *et al.*, 2009; Asrat and Simane, 2018). Education gives the ability to perceive and interpret innovations in a perpetual dynamic environment (Rahman, 2003). Moreover, Chianu *et al.* (2006) have also affirmed that the level of education influences very often producers' point of view.

Analysis of the impact of farmers' perceptions on the adoption of botanical extracts

One of the objectives of the study was also to assess the impact of the perceptions of the attributes (y_{ij}) on the adoption rate of botanical extracts. The vegetable farmer' perception (y_{ij}) is endogenous because highly conditioned by the socioeconomic and demographic characteristics (ex., Sall *et al.,* 2000; Adegbola and Gardebroek, 2007) as we discussed in the previous section. In order to correct potential bias due to endogeneity, the Heckman selection method (Heckman *et al*., 2006) was adopted. Drawing on Vella and Verbeek (1999), Wooldridge (2002) and Adegbola (2008), the model used is specified as follows:

$$E\{A_i / z_i, y_{ij}\} = \eta_0 + \eta\ y_{ij} + X_i\beta + \rho_{1j} y_{ij} \frac{\phi(z_i\theta)}{\Phi(z_i\theta)} + \rho_{2j}(1-y_{ij}) \frac{\phi(z_i\theta)}{1-\Phi(z_i\theta)} \quad (2)$$

Equation (2) was estimated in two steps. First of all, factors determining vegetable farmers' perceptions of biopesticides and/or aqueous extracts were analyzed using an ordered probit (equation (1)). The estimated parameters $\hat{\theta}$ were then used to generate the selectivity bias terms involving two ratios, known as inverse Mill's ratio $\frac{\phi(z_i\ \theta)}{\Phi(z_i\ \theta)}$ and $\frac{\phi(z_i\ \theta)}{1-\Phi(z_i\ \theta)}$. The two selectivity terms were then interacted respectively with y_{ij} and $(1-y_{ij})$. These two newly created variables were included in the adoption equation [(Equation (2)] as well as the different perception variables. The impact model of farmers' perceptions [(Equation (2)] was estimated using a probit model.

Drawing on the literature on adoption studies of agricultural technologies, the following variables were supposed to influence the decision of vegetable farmers to adopt or not to adopt botanical extracts and/or biopesticides:

- ***Number of years of experience in vegetable production (EXPER)***. It is a continuous variable and a proxy of the age of the vegetable farmer. In fact, it was difficult to say *a priori* if the age of the vegetable farmer can influence positively or negatively the adoption of botanical extracts and/or biopesticides. In fact, some studies (Adegbola and Adekambi, 2008; Sall *et al*., 2000; Ainembabazi and Mugisha, 2014) have shown that aged producers can adopt more easily technologies than youths. Other findings such as those of Zegeye *et al.* (2001) and Ouédraogo (2003) led to an opposite conclusion. For the firsts, aged producers can have accumulated lot of assets or by preference can have access to credit because of their age or access to land or can have significant labor. And young producers, who can have a vast planning horizon, can be ready to take risks. Therefore, the sign expected from the variable number of years of experience of the vegetable farmer cannot be defined in advance.
- *Contact with extension services (CONTACT)*. A positive correlation was expected between the adoption and the variable CONTACT. In fact, vegetable farmers' contact with extension services and or research agent was an indicator of exposition to information on the

innovations (Adegbola and Gardebroek 2007; Adegbola *et al*., 2006). This could allow vegetable farmers to have some knowledge of botanical extracts and/or biopesticides introduced and thus to develop a positive attitude towards them.

- ***Level of education of the vegetable farmer (EDUF)*.** Education increases the ability of the vegetable farmer to use efficiently inputs and to choose the best technology amongst a certain number of alternatives. Moreover, educated producers were generally predisposed to accept innovations compared to illiterate producers used to traditional practices (ex. Zhou *et al*., 2008). Thus, the study assumed that educated vegetable farmers will be more aware of the harmful effects of chemical pesticides and for this reason will adopt practices that are neither harmful to the user nor to the consumer of vegetable products. This variable takes the value 1 when the vegetable farmer is educated and 0 if not.
- ***Gender of the vegetable farmer (SEXE)*.**This variable takes the value 1 when the surveyed farmer is a man and 0 if not. The possibility often suggested concerning the variable SEXE was that men farmers have more access to land and for this reason can experiment several technologies at the same time (Adegbola *et al.,* 2006). It was therefore expected that the adoption of botanical extracts and/or biopesticides would be positively influenced by the sex of the vegetable farmer.
- ***Distance from the village to the main town (DIVIPE)***. It is a proxy variable of vegetable farmers' access to the market. It was determined as the distance in kilometers separating the village of the vegetable farmer to the main town in the zone. It was argued that vegetable farmers who were close to markets behave positively towards new technologies. A negative correlation was therefore expected between the variable DIVIPE and the adoption of botanical extracts and/or biopesticides.
- ***Cultivated acreage (SUPCULT)***. It informs about the size of the farms studied. The hypothesis suggested was that the bigger the farm was the lower the probability to adopt biopesticides and/or botanical extracts would be.
- ***Participation in a specific training in market gardening (FORMAT)***. It is a binary variable and a proxy of the level of competence of the human capital. It was often admitted that individuals who participated in a given training on an innovation generally tend to adopt it. A positive effect of this variable was therefore expected on biopesticides and/or botanical extracts.
- ***Perceptions of attributes of botanical extracts and/or biopesticides (PERCEP$_j$)***. In addition to the socioeconomic and demographic characteristics of vegetable farmers, the adoption of botanical extracts also depends on their perceptions of the attributes of botanical extracts known (used or not) compared to those of the pesticides usually used. (e.g., Sall *et al*., 2000; Adégbola and Gardebroek, 2007; Elemasho *et al*., 2017). For example, Elemasho *et al.* (2017) found that the more positive the perceptions of farmers that the food crops produced could be lost at post harvest stages, the higher the adoption rate of the selected post-harvest technologies packages with. Ervin and Ervin (1982) also found that farmers who perceived high level of soil erosion were likely to invest in conservation measures. Furthermore, Asafu-Adjaye (2008) stated that the more positive the perception of erosion problems the higher the adoption rate of a certain soil conservation practice(s). If farmers are unable to recognize the importance of agricultural technology attributes, it is more likely that they will develop negative perceptions and therefore will be hesitant to adopt them. In the same way, vegetable farmers who are aware of the potential health hazards of chemical pesticide use, will likely consider botanical extracts as alternatives for pest control and therefore will develop positive perceptions about them. These perceptions of vegetable farmers have for sure some influence on the adoption of botanical extracts. Farmers'perceptions of the effectiveness of the actions of botanical extracts (ACTION), the difficulty of their preparation (DIFFICULTP), and the number of treatments required (NBRTRET) were supposed to be positively correlated with their adoption.

Choice of the study zone and data collection

The data were collected in 2008 from 198 vegetable farmers randomly selected in eight municipalities (Table 1). These municipalities are located in six departments of the country, namely, Atlantique, Littoral, Oueme, Mono, Borgou and Alibori as they are urban and peri-urban zones where indigenous/local and exotic vegetables are produced year-round. In each of the selected department, the study focused on the municipalities where vegetable production was a main activity and occurred at any seasons of the producing year. The major vegetable production sites were identified and selected within each municipality with the help of extension service agents. The data were collected in two phases. In the first phase, focus-group discussions were organized in order to identify the attributes on which vegetable farmers based their selection of pesticides. In total, six attributes were identified as potentially important to vegetable farmers choosing a given pesticide and are related to the speed of action of the product, its efficiency duration, its action spectrum, the number of treatments it requires, its availability and its purchase price.

Table 1. Distribution of the surveyed farmers per study zone

Department	Commune	Sex of the farmer				Together	
		Male		Female			
		Number	Rate (%)	Number	Rate (%)	Number	Rate (%)
Atlantique	Ouidah	22	65	12	35	34	100
Littoral	Cotonou	35	92	3	8	38	100
Ouémé	Sèmè-Kpodji	21	84	4	16	25	100
	Porto-Novo	15	75	5	25	20	100
Mono	Grand-Popo	24	80	6	20	30	100
Borgou	Parakou	8	53	7	47	15	100
Alibori	Karimama	21	100	0	0	21	100
	Malanville	15	100	0	0	15	100
Total		**161**	**81**	**37**	**19**	**198**	**100**

The second phase was the collection of quantitative data at the individual level. The six attributes identified during the first phase of the data collection were presented to the interviewed vegetable farmers. They were requested on the one hand to hierarchize these different attributes based on their importance in the decision to adopt or not to adopt; and on the other hand to compare, for each of the attributes, the botanical extracts with chemical pesticides that they usually use. These comparisons were done by using a 3-scale score 1-3: **1** when the vegetable farmer thinks that botanical extracts were less good than chemical pesticides; **2** when (s)he thinks that there was no difference between them in terms of the attributes assessed; and **3** when (s)he thinks that botanical extracts were better than chemical pesticides. The other information collected were related to (i) socioeconomic and demographic characteristics of the interviewed vegetable farmers, (ii) appreciation of their level of knowledge of the botanical extracts, and (iii) identification of the factors determining their perception and adoption of the botanical extracts.

RESULTS

Socioeconomic characteristics of the interviewed vegetable farmers

Table 2 contained descriptive statistics of the variables for adopters and non-adopters of botanical extracts. Farmer characteristics such as gender of the vegetable farmer, level of education, participation in training, distance to the nearest main road, vegetable farming experience, the cultivated acreage, and farmers' perception towards the number of treatments required for botanical extracts did not significantly ($p > 0.05$) differ between adopters and non-adopters of botanical extracts, while their contact with extension, membership of a vegetable farmers' association, perceptions towards the effectiveness of the actions, and perception towards the difficulty of the preparation of botanical extracts differed significantly ($p < 0.05$) by adoption state. On average, the interviewed vegetable farmers were a 7.94 km walk away from the nearest main road. All vegetable farmers in the non adopter group were members of farmer organizations as compared to farmers in the non-adopter group (62.60%). Surprisingly, vegetable farmers who adopted botanical extracts had somewhat less access to extension office as compared to the proportion of non-adopters who did have access to extension services. High proportion of non-adopters (95.6%) as compared to adopters (75%) argued that the actions of botanical extracts were not rapid and instantaneous on pests and diseases as compared to those of chemical pesticides.

Table 2. Major plants used in the preparation of aqueous extracts

Characteristics	Adoption of botanical extracts (N = 198)		P-value
	Adopters	Non-adopters	
Sex of the vegetable farmer; being male (SEXE)	81.30%	81.30%	0.995
Level of education (EDUF)	62.60%	81.30%	0.137
Training (FORMAT)	9.30%	0.00%	0.201
Membership of a vegetable farmers' association (MECAS)	62.60%	100.00%	0.003
Contact with extension (CONT)	73.70%	100.00%	0.022
Distance from the village to the main town in Km (DIVIPE)	9.222 (5.890)	6.665 (5.511)	1.828
Number of years of experience in vegetable production (EXPER)	14.187 (7.713)	12.972 (9.703)	0.237
Cultivated acreage in (SUPCULT)	0.469 (0.770)	0.464 (0.688)	0.976
Perceptions towards the effectiveness of the actions	0.375 (0.718)	0.044 (0.205)	0.000
Perception model about the difficulty of their preparation	0.312 (0.602)	1.181 (0.643)	0.000
Perception model about the number of treatments required	0.062 (0.25)	0.154 (0.456)	0.431

p < 0.01 significance at 1%, p < 0.05 significance at 5%, and p < 0.1 significance at 10%

Vegetable farmer perceptions of botanical extracts

Almost all the interviewed vegetable farmers recognized that botanical extracts, like chemical pesticides, can be used to control pests and diseases in vegetable production. The ordinal ranking of the importance values of major plants used in the preparation of botanical extracts was assessed and the degree of agreement between the interviewees' rankings of the plants used was measured using the Kendall's coefficient of Concordance (W). The ranks were based on a Likert scale ranging from 1 = completely unimportant to 5 = very important. The results showed that, as agreed upon by the vegetable farmers (Table 3), the leaves and pollen grains of neem and papaya leaves were ranked first and second, respectively, as the most used plants in the preparation of botanical extract against pests and diseases in the vegetable production (Table 3). Banana and pepper leaves were ranked third and fourth, respectively.

Table 3. Major plants used in the preparation of aqueous extracts

Plants and parts of plants used	Average rank	Rank
Leaves and grains of neem	3.112	1
Papaya leaves	3.939	2
Banana leaves	4.175	3
Pepper leaves	4.180	4
Hyptis leaves	4.185	5
Tobacco leaves	4.198	6
Garlic	4.211	7
Kendall' test of concordance	***0.245****	

***** significance at 1%**

The adoption level of the botanical extracts was measured by asking vegetable farmers if they ever tried applying at least one of these botanicals to control pests and diseases in their vegetable production. Only 65 vegetable farmers out of the 198 surveyed said yes, that was about 33%, reported that they tried them at least once. Many reasons were given by vegetable farmers to justify the low utilization of botanical extracts (Table 4). The main reason for the low adoption level of the botanical extracts by the vegetable farmers was because of their slowness in the actions in controlling vegetable pests and diseases. Hence, they argued that the actions of botanical extracts on pests and diseases were slow, contrary to those of chemical pesticides that were rapid and instantaneous. As agreed upon by the vegetable farmers, the difficult preparation of the botanical extracts and the high number of treatments required to control pests and diseases were ranked second and third, respectively, as the main reason for the low utilization level of botanical extract in controlling pests and diseases in the vegetable production. The difficulty of preparing botanical extracts and their non-availability on the market at a proper time, were serious obstacles to and may be the other reason for the decreasing interest in their utilization by vegetable farmers. The number of treatments required for controlling pests and diseases was also deemed high by vegetable farmers.

Vegetable farmers argued that there were also other, not less important reasons for not using botanical extracts. Among these reasons, there was the size of their plots. Such a reason might be in correlation with the difficulty of preparing botanical extracts and their non-availability at a proper time, since farming on a large farm size requires substantial quantity of botanical extracts for the treatments. However, what were the factors that contributed to the formation of vegetable farmers' perceptions of botanical extracts?

Table 4. Reasons limiting the utilization of botanical extracts

Reasons	Average rank	Rank
Slowness in the actions	3.677	1
Difficult to prepare	4.061	2
High number of treatments required	4.104	3
Non-availability	4.265	4
Efficiency duration	4.343	5
Specificity to pests	4.899	6
Size of the farms	4.987	7
Expensiveness compared to the other treatment products	5.664	8
Kendall's test of concordance	0.133***	

***** significance at 1%**

Determinants of vegetable farmers' perceptions of botanical extracts

In order to identify and analyze the major factors determining the perceptions that vegetable farmers had towards botanical extracts, only the first three reasons that, according to vegetable farmers, limit the adoption of botanical extracts were retained for inclusion in the regression analyses. These reasons represented the perceptions of vegetable farmers towards botanical extracts: perception about the effectiveness of the actions of botanical extracts, perception about the difficulty of their preparation, and perception about the number of treatments required.

The estimation results of the ordored probit models for the different perceptions were presented in table 5. In general, the global significance tests of the fitted different models are significant at least at 5%, with large χ^2 and a very small p-value for goodness of fit. These results indicated that the model fitted the data very well. The fitted models, taken globally, therefore explained 15%, 34%, and 14% of the whole variability for the perceptions about the effectiveness of the actions of botanical extracts, about the difficulty of their preparation, and about the number of treatments required, respectively.

Except the variable years of vegetable farming experience, the different independent variables included in the different models had the predicted signs. When interpreting the results for the individual idepednant variables, the gender of the farmer was significant in explaining vegetable farmers' perceptions ($\beta = 0.859$, p-value < 0.01 for the perception model about the effectiveness of the actions of botanical extracts; $\beta = 0.581$, p-value < 0.05 for the perception model about the difficulty of their preparation; $\beta = 0.250$, p-value > 0.1 for the perception model about the number of treatments required). There were mixed results where the gender-based perceptions of the effectiveness of the actions of botanical extracts and the difficulty of their preparation are concerned and the gender-based perception the number of treatments required was not concerned.

Except for two perception variables (namely the perception model about the difficulty of their preparation and the perception model about the number of treatments required; β = -0.299, p-value > 0.1 for the perception model about the difficulty of their preparation; β = 0.416, p-value > 0.1 for the perception model about the number of treatments required), having received formal education increased the chance of having positive perceptions towards the effectiveness of the actions of botanical extracts (β = 0.859, p-value < 0.01 for the perception model about the effectiveness of the actions of botanical extracts) as compared to not having formal education.

As expected, we also found that vegetable farmers who had had contact with extensions services reported positive perceptions towards the perception about the effectiveness of the actions of botanical extracts (β = 0.704, p-value < 0.01) and the perception about the difficulty of their preparation (β = 1.133, p-value < 0.01); the contact with extension services did not have significant influence on the perception model about the difficulty of their preparation towards the difficulty of their preparation (β = -0.170, p-value > 0.1). Being member of vegetable farmers' association, influenced positively farmers' perception of the number of treatments required in the study area (β = 0.912, p-value < 0.01), but did not significantly affect the perception about the effectiveness of the actions of botanical extracts (β = -0.064, p-value > 0.1) and the perception about the difficulty of their preparation (β = -0.101, p-value > 0.1).

Contray to our expectation, the variable years of vegetable farming experience had negative and signficant influence on the perception towards the effectiveness of the actions of botanical extracts (β = -0.327, p-value < 0.05) and the perception towards the difficulty of their preparation of botanical extracts (β = -0.244, p-value < 0.05); its influence on the the perception model about the number of treatments required was also negative but not significant (β = -0.230, p-value < 0.05).

Table 5. Factors determining the formation of vegetable farmers' perceptions of aqueous extracts and/or biopesticides

Characteristics	Effectiveness of the actions		Difficulty of the preparation of botanical extraxcts		Number of treatments required	
	Estimated coefficients	Standard error	Estimated coefficients	Standard error	Estimated coefficients	Standard error
Sex of the vegetable farmer (SEXE)	0.859***	0.276	0.581**	0.249	0.250	0.423
Log of the number of years of experience in vegetable production (EXPER)	-0.327**	0.128	-0.244**	0.111	-0.230	0.142
Level of education (EDUF)	0.969***	0.232	-0.299	0.185	0.416	0.354
Contact with extension (CONT)	0.704***	0.228	-0.170	0.163	1.133***	0.430
Membership of a vegetable farmers' association (MECAS)	-0.064	0.209	-0.101	0.164	0.912***	0.340
/cut1	1.569***	0.392	-1.413***	0.279	2.87***	0.644
/cut2	2.321***	0.392	0.103***	0.276	3.549***	0.681
Log pseudo likelihood	-145.285		-192.975		-71.483	
Wald chi2(5)	47.52***		11.92**		23.83***	
R^2	0.153		0.340		0.137	

***, **, *** show respectively the significance at 10%, 5% and 1%**

Impact of vegetable farmers' perceptions on the adoption of botanical extracts

One of the factors affecting farmers' decision to adopt agricultural innovation was their perception of the attributes of that agricultural innovation vis-à-vis that of the alternative (or old) technology. The estimation results of the probit model analyzing the impact of vegetable farmers' perceptions on the adoption of botanical extracts were presented in table 6.

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Table 6. Estimation results of the probit model of the impact of vegetable farmers' perceptions on the adoption of aqueous extracts and/or biopesticides in Benin

Characteristics	Estimation		Marginal effects	
	Coefficients	Robust Standard error	Marginal effects	Robust Standard error
Constant	7.824*	4.114	-	-
Perceptions of the effectiveness of the actions (ACTION)	-0.603	2.138	-0.207	0.736
Perception of the difficulty of their preparation (DIFFICULTP)	-13.821**	6.573	-4.759	2.235
Perception of the number of treatments required (NBRTRET)	-2.381*	1.332	-0.820	0.456
Log of number of years of experience in vegetable production (EXPER)	-0.993	0.705	-0.342	0.240
Contact with extension services (CONTACT)	0.473	0.625	0.154	0.192
Level of education of (EDUF)	-0.305	0.931	-0.107	0.331
Sex of the farmer (SEXE)	3.007*	1.707	0.498	0.128
Cultivated acreage (SUPCULT)	-0.025	0.158	-0.008	0.054
Distance from the village to the main town (DIVIPE)	-0.01541	0.021	-0.005	0.007
Participation in a specific training in market gardening (FORMAT)	0.622***	0.232	0.210	0.076
ACTION * fxbeta1	1.112	2.222	0.382	0.764
(1- ACTION) * Fxbeta2	-0.256	0.896	-0.088	0.308
DIFFICULTP * fxbeta1	6.236*	3.546	2.147	1.209
(1- DIFFICULTP) * Fxbeta2	-11.505**	4.804	-3.962	1.631
NBRTRET * fxbeta1	4.682	4.387	1.612	1.512
(1- NBRTRET) * Fxbeta2	-0.908*	0.519	-0.312	0.177
Log pseudo likelihood	-87.975			
Wald chi2 (16)	57.83***			
Pseudo R^2	0.211			
Correct prediction rate (%)	77			
Chi2 for the common significance test of selection variables (H0: coefficients of the six terms of selection = 0)	15.63**			
Number of observations	198			

***, **, *** show respectively the significance at 10%, 5% and 1%**

fxbeta = $\frac{\phi(z_i\,\theta)}{\Phi(z_i\,\theta)}$ **and Fxbeta =** $\frac{\phi(z_i\,\theta)}{1-\Phi(z_i\,\theta)}$**, the two selectivity terms**

The likelihood test statistics ($Wald\ \chi^2(15) = 57.83$) was significant at the threshold of 1%; the variables included in the model contribute significantly to explaining the adoption of botanical extracts by vegetable farmers.

In order to test the selection bias, the Wald test was established. From the result it can be concluded that the null hypothesis according to which the coefficients of the six selection variables introduced in equation (2) are all null must be rejected at the threshold of 1%. The hypothesis of the presence of selection bias suggested in the theoretical part of this study was therefore confirmed. Therefore, the specified model was the most appropriate. The coefficients of the predicted perception variables included in the model reflect their impact on the probability to adopt or not botanical extracts.

The results showed that the predicted perception about the difficulty of the preparation of botanical extraxcts (DIFFICULTP) was found to be negatively and significanlty correlated with the adoption decision (β = -13.821, p-value < 0.05). The predicted perception about the number of treatments required (NBRTRET) was also found to be negatively and significanlty correlated with the adoption decision, but at 10% probability (β = -2.381, p-value < 0.1). However, no significant impact of the predicted perception about the effectiveness of the actions of botanical extracts on the adoption decision was observed.

As for the other factors included in the adoption model, the results showed that the gender of the vegetable farmer (β = 3.007, p-value < 0.1) and participation in training on vegetable farming (β = 0.622, p-value < 0.01) was also found to be significantly related to the adoption decision about botanical extracts, but positively.

DISCUSSION

Formation of the vegetable farmer's perceptions of botanical extracts

The study examines factors that contribute to perception formation about botanical extracts among vegetable farmers. Understanding such factors can contribute to enhance the development and the transfer of adequate agricultural technologies to farmers. The perception formation is found to be signficantly related to the gender of the farmers. Male vegetable farmers are more likely to show positive perceptions towards effectiveness of the actions of botanical extracts and the simplicity of their preparation than female vegetable farmers do. This relation can be related to the fact male vegetable farmers, especially those who ae married use female labor (their wives and or girls) intensively for the preparation of botanical extracts. The significant influence of the vegetable farmer' gender on their perception formation is similar to that Qureshi *et al*. (2012) on consumer perception in response to a marketing stimuli.

As expected, having received formal education have positive and significant infuence on vegetable farmers' perceptions, specifically on perception towards the effectiveness of the actions of botanical extracts. It seems that those with formal education report positive perception towards the effectiveness of the actions of botanical extracts than those without formal education.This result indicates that having formal education is an important factor that shapes vegetable farmers' perception of new technologies including botanical extracts. This finding is similar to the result reported by Rahman (2003) and Chianu *et al*. (2006). They reported that farmers with formal education are more likely to show positive perception about agricultural innovations than others, gives them the ability to perceive and interpret innovations in a constant dynamic environment. In fact, formal education influences farmers' point of view about technologies and it allows them to grasp all the benefits of botanical extracts. Therefore, they acquire the know-how in the interpretation of the innovations in a constant dynamic environment.

Our finding also indicate positive and significant correlation between contact with extensions services and perceptions towards the effectiveness of the actions of botanical extracts and about the difficulty of their preparation. This is to be expected because farmers who are constantly in contact with extension agents are more likely to have better access to information on new technology such as botanical extracts, are likely to be better knowledgeable about the technology, and are more likely to display positive perceptions about the technology. Our results are consistent with the findings of Deressa *et al*. (2011) and Negatua and Parikhb (1999) who reported significant and positive correlation between farmers' perception and contact with. This shows the importance of access to information in the perception change process. In fact, if accessing to information is decisive in the adoption process of agricultural innovations (Adégbola and Adékambi, 2008), it is also decisive in the formation of the perceptions vegetable farmers have on botanical extracts. Extension service agents can thus, through information they bring (benefits compared to chemical pesticides) influence positively vegetable farmers' perception on botanical extracts.

Being member of vegetable farmers' associations showed a significant and positive association with perception, especially with farmers' perception of the number of treatments required. Farmers' organizations are sources of (new) information and knowledge exchange between members. This finding is in line with those of Maddison (2006) and Deressa *et al*. (2011) who reported positive and significant influence of contact with peers and farm-to-farm extension, here farmers' organizations, on perception of climate change.

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Contrary to the previous findings and to our expectation, we find that vegetable farmers with higher years of vegetable farming experience tend to display negative perceptions about botanical extracts. In addition to indicate that farming experience is find to be an important factor that shapes farmer's perceptions, our result also points out that vegetable farmers with higher experience display negative perceptions towards botanical extracts than those with less experience. The probable reason for the negative relationship between vegetable farming experience and perception can be due to the fact that perception is experience-specific; that is, it is not the number of years of experience, but prior experiences with technologies used which may shape their perceptions. This finding is similar to that reported by Slegers (2008) that bad previous experience with seasons was significantly found to be responsible to farmers tend to portray different season types.

Impact of farmers' perceptions on the adoption of botanical extracts

The results show that 33% of vegetable farmers do not adopt the botanical extracts in the period 2008. The main reasons for this are the slowness in the actions in controlling vegetable pests and diseases, the difficult preparation of the botanical extracts and the high number of treatments required to control pests and diseases. Farmer perception of the difficulty of the preparation of botanical extracts and of the number of treatments required show a significant and negative association with the adoption decision. Thus, we conclude that the difficulty of the preparation of botanical extracts and of the number of treatments required are the main factors that lead to low adoption. As expected, farmers' perception of the attributes of the new technology matter when it comes to new technology adoption. As such, farmers' perception towards new technologies is crucial in the adoption decisions. This finding is similar to those of Adesina and Zinnah(1993), Adesina and Baidu-Forson (1995), and Sall *et al*. (2000) who reported that farmer perceptions of the technology attributes play a crucial role in driving adoption decisions. Overall, vegetable farmers' perception of the difficulty of the preparation of botanical extracts and of the number of treatments required of botanical extracts played a crucial role in their decision to adopt. This means that these perceptions play an important role in farmers' choice of alternatives to chemical pesticides in vegetable. Our results confirm the claim by Negatua and Parikhb (1999) that farmers' perception about wheat varieties is a critical factor for adoption.

Another interesting result obtained from the estimation of the selection model is that participation in any training in vegetable farming has a positive and significant influence on the probability of the adoption of botanical extracts by vegetable farmers. This confirms the hypothesis according to which training strengthens and improves the knowledge and know-how of individuals and makes them adopt a favorable behavior vis-à-vis innovations. The perception study of maize producers on improved storage and conservation systems implemented by Adégbola (2008) in Benin led to similar results. Moreover, male vegetable farmers tend to adopt these botanical extracts more than their female counterparts.

CONCLUSION

The main objective of our study is to provide insights into the impact of farmers' perception of technology-specific attributes on the adoption decision of botanical extract in vegetable production in Benin. The most critical result of the present study is the role farmer perception could play in affecting adoption. Our study of a sample of Beninese vegetable farmers suggests that perception about botanical extracts has a very significant effect on their adoption. Vegetable farmers' perceptions about the difficulty of the preparation of botanical extracts and of the number of treatments required are the two most important technology-specific attributes affecting the adoption decision.

It is, however, the case that most vegetable farmers suspect that preparing botanical extracts is a tedious task, and that botanical extracts are slow in actions in controlling vegetable pests and diseases, are not all available on the market at a proper time, and require high number of treatments for controlling pests and diseases. All these reasons could be serious obstacles to and may be the other reason for the decreasing interest in the utilization of botanical extracts by vegetable farmers.

The results suggest that the promotion of botanical extracts in order to increase their adoption rate goes inevitably through improving farmers' knowledge of pesticide risk and dangers. To do this, policy makers, scientists and development support organizations should make available ready-for-use alternatives to chemical pesticides, such as botanical extracts, and/or intensify extension services in this regards. Group initiatives should also be encouraged in order to generalize information / knowledge on alternatives for biological controls. In the absence of formal education, literacy programs for illiterate vegetable farmers should be envisaged.

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