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SOMMAIRE / INHOUD / SUMARIO

ARTICLES ORIGINAUX/OORSPRONKELIJKE ARTIKELS/ARTICULOS ORIGINALES

Etude comparative de quatre niveaux de puissance de traction en travail du sol des petites exploitations maraîchères

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Keywords: Soil structure- Low power mechanisation- Small-scale vegetable production

Résumé

Les effets de quatre catégories de puissances de traction utilisées en travail de sols sablo-argileux et argilo-sableux des exploitations maraîchères de taille limitée de la région du Sahel tunisien, sur leur état structural, ont été étudiés à l'aide de mesures sur champ. Les puissances qui ont été appliquées, correspondaient à un tracteur standard, un tracteur moyen, un mini-tracteur et un motoculteur, de puissances nominales respectives 59, 33, 22 et 6 kW. Le travail du sol a été réalisé par la même catégorie d'outils pour tous les engins envisagés, à savoir, le labour à la charrue à socs et versoirs et la reprise du labour au rotavator. L'état structural du sol a été caractérisé par la mesure de la résistance à la pénétration d'une pointe au moyen d'un pénétromètre et de la masse volumique apparente sèche en utilisant un densimètre à cylindres. Les résultats ont montré qu'après passage des engins, la masse volumique et la résistance à la pénétration du sol étaient faibles. Entre les traitements, il n'y a pas de différence significative dans les couches travaillées des deux sols. L'ensemble des traitements a donné dans les profondeurs travaillées, un état structural meuble indiqué par un émiettement élevé en surface. Cet émiettement est occasionné par les cultivateurs à lames rotatives en forme de L, actionnées à partir de prises de force tournant à régime constant (540 tr/min). La différence au niveau de la vitesse d'avancement au labour et la forme des versoirs semblent sans effet sur les paramètres mesurés. Vu la complexité, il faut effectuer une étude techno-économique comparative afin de déterminer tous les avantages et désavantages de l'emploi des différentes puissances.

Summary

Comparative Study of Four Traction Power Levels for Seed Bed Preparation in Small-scale Vegetable Production

The effects of four different traction power categories on soil structure was measured in the field during seed bed preparation experiments in a sandy clay soil and a clayish sand soil used for vegetable production. The power categories investigated corresponded to a standard tractor of 59 kW, a medium power tractor of 33 kW, a low power tractor of 22 kW and a two-wheeled tractor of 6 kW. In each experiment, seed bed preparation was carried out using a mouldboard plough and a rotary cultivator, respectively. Soil structure was characterised by measuring the resistance against vertical penetration of a cone by means of a penetrometer and the apparent dry density by means of a cylindrical densimeter. For both soils, the results showed a porous soil state without any significant difference among the four power levels. All different methods of tillage used were giving the same structure in the top layer. The soil crumbling was done using a PTO driven cultivator. Also, the measured parameters did not differ significantly over the depth of the worked area. Also the differences in work speed and equipment used don't have any influences on the measured parameters. The complexity asks for a detailed technical-economical investigation in order to define the advantages and disadvantages of the use of small power mechanisation for seed bed preparation.

Introduction

Dans la région du Sahel tunisien groupant les gouvernorats de Sousse, Monastir et Mahdia, où l'on rencontre les périmètres irrigués de maraîchage, les exploitations sont souvent de taille réduite. La majorité de ces exploitations sont inférieures à 2 ha et sont constituées généralement de deux ou trois parcelles différentes. En outre, les agriculteurs pratiquent plusieurs cultures de plein champ ou sous serres sur la même parcelle, ce qui cause un phénomène de parcellement au sein de la même exploitation (1).

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Par ailleurs, les problèmes d'héritage qui sont essentiellement à l'origine de la réduction de la taille des terrains, ne cessent d'accroître le morcellement des exploitations. Dans certains périmètres, on assiste à des superficies voisines à quelques ares (2).
En ce qui concerne les opérations culturales conduites dans les périmètres irrigués de maraîchage, seul le travail du sol est entièrement motorisé. Les autres opérations sont soit manuelles, soit à traction animale. Mais à ce niveau, le travail réalisé ne répond pas souvent au désir de l'exploitant, et sa durée est généralement longue (1).
A un autre niveau, bien que l'utilisation de la traction mécanique moyennant les tracteurs classiques à roues de puissance relativement élevée (50 à 60 kW) offre plusieurs avantages pour l'agriculture en général (10), elle présente de nombreux problèmes dans le cas des parcelles de taille réduite, à savoir:

- mauvaise adaptation de la taille des engins aux surfaces travaillées, rendant les opérations pénibles et difficiles, réduit les rendements des matériels, fatigue le conducteur et cause des coûts élevés (11);
- les pneus équipant les tracteurs sont inadaptés à une utilisation sur sol ameubli de sorte que leur passage laisse des ornières profondes (15);
- difficulté de travailler la totalité de la surface sous serre à cause de la taille importante du matériel, ce qui réduit la surface utile effectivement travaillée;
- compaction des sols accrue suite à la succession des passages surtout en cultures intensives où le sol contient toujours une certaine humidité (14), etc.

Actuellement l'application de la petite motorisation dans les pays développés (Japon, pays sud européens,…) a permis de surmonter la plupart des problèmes posés par la mécanisation classique au niveau des petites exploitations (7).
Ainsi, l'étude des possibilités d'introduction de la petite motorisation (motoculteur, motohoue,…) dans les petites exploitations de la région du Sahel tunisien se justifie pour les raisons sus-indiquées. Il s'avère donc utile d'évaluer l'état structural réalisé par des machines de plusieurs niveaux de puissance de traction utilisé en travail du sol des parcelles de taille limitée (12). Le travail du sol change les caractéristiques physiques de ce dernier (8). Travailler le sol, c'est lui faire subir des contraintes momentanées à l'aide d'outils appropriés (13). Le rôle essentiel du travail du sol est d'obtenir un état structural permettant une bonne germination et un développement racinaire indispensable à une bonne alimentation de la plante. Il vise l'enfouissement des débris végétaux superficiels, l'ameublissement de la couche arable, la formation du lit de semence, la répartition de la terre fine et des mottes, la maîtrise de la propagation des mauvaises herbes, des parasites et des maladies, l'incorporation des amendements et des fertilisants, etc (6, 17).

L'objectif de ce travail consiste à étudier et comparer pour deux types de sol du Sahel tunisien, les effets de quatre puissances de traction utilisant la même catégorie d'outils de travail du sol sur son état structural. Les outils utilisés correspondent à la charrue à socs et versoirs agissant sur le sol par fendillement et retournement employée pour le labour, et le cultivateur rotatif agissant par sectionnement appliqué pour la reprise du labour (4, 6).

Matériel et méthodes

Le dispositif expérimental comprend un facteur traitement qui est caractérisé par le niveau de la puissance nominale du tracteur relié à une technique de travail du sol, et deux variables mesurées à savoir le profil de la résistance du sol à la pénétration d'une pointe conique (5) et le profil de la masse volumique apparente sèche du sol (3, 18).
La technique de travail du sol testée, correspond à un labour moyennant une charrue à socs et versoirs et deux reprises du labour utilisant le cultivateur rotatif.
Les quatre traitements étudiés sont:
-traitement 1 (T1): travail du sol à une profondeur moyenne de labour de 21 cm pour le sol SA, et 17 cm pour le sol AS, au moyen d'un tracteur standard d'une puissance nominale de 59 kW;
-traitement 2 (T2): travail du sol à une profondeur moyenne de labour de 16 cm pour le sol SA, et 15 cm pour le sol AS, au moyen d'un tracteur d'une puissance nominale de 33 kW;
-traitement 3 (T3): travail du sol à une profondeur moyenne de labour de 13 cm pour le sol SA; et 15 cm pour le sol AS, au moyen d'un mini-tracteur d'une puissance nominale de 22 kW;
-traitement 4 (T4): travail du sol à une profondeur moyenne de labour de 13 cm pour le sol SA; et 13,5 cm pour le sol AS, au moyen d'un motoculteur d'une puissance nominale de 6 kW.
La vitesse moyenne de labour des traitements T1, T2, T3 et T4 était respectivement de 1,5- 2,4- 3,0 et 1,5 km/h dans le sol SA; et de 2,0- 2,9- 3,3 et 1,3 pour le sol AS. Le régime de la prise de force des engins de traction était de 540 tr/min lors des opérations de reprise du labour par cultivateurs rotatifs.
Les spécifications essentielles des outils de travail du sol (charrues, rotavators) utilisés dans chaque traitement sont présentées dans les tableaux 1 et 2.

Les essais ont été effectués au cours de la campagne agricole 2002, sur deux parcelles situées dans le domaine de l'Ecole Supérieure d'Horticulture et d'Elevage de Chott-Mariem (Sousse, Tunisie) la première caractérisée par une pente de 1,6% sur un sol sablo-argileux (SA) de précédent cultural pommes de terre, et la deuxième marquée par une pente de 1,5% sur un sol argilo-sableux (AS) en jachère depuis une année (9).
L'état initial des parcelles avant travail du sol était

Tableau 1
Spécifications essentielles des charrues

traitement	nombre de corps	largeur de travail (m)	type de versoir
1	3	1,05	cylindro-hélicoidal
2	3	0,90	cylindrique
3	3	0,80	cylindrique
4	1	0,27	cylindrique

Tableau 2
Spécifications essentielles des cultivateurs rotatifs

traitement	nombre de couteaux	forme	largeur de travail (m)	régime de rotation (tours/min)
1	28 (4* x 7**)	L	1,3	240
2	28 (4 x 7)	L	1,4	240
3	28 (4 x 7)	L	1,2	216
4	24 (4 x 6)	L	0,6	167

* nombre de couteaux par flasque

**nombre de flasques

caractérisé par un état homogène avec une résistance du sol à la pénétration moyenne de 11,6 et 13,3 daN/cm^2, une masse volumique apparente moyenne de 1650 et 1640 kg/m^3 et une teneur en eau pondérale de 11,0% et 7,3% sur l'horizon 0-40 cm pour les sols SA et AS respectivement.

Les parcelles utilisées présentaient des dimensions de (5 x 50) m^2, ce qui signifie que les dimensions du terrain étaient de (60 x 50) m^2 (Figure 1). Le dispositif expérimental consiste en 12 blocs pour chaque sol.

L'état structural du sol était caractérisé par deux mesures à savoir la résistance du sol à la pénétration et masse volumique apparente.

La résistance du sol a été mesurée à l'aide d'un pénétromètre à lecture directe enfoncé à vitesse régulière (pénétromètre statique). Les mesures de la résistance du sol sont réalisées tous les 5 centimètres sur une profondeur de 30 centimètres. Elles sont effectuées pour les trois répétitions (blocs) de chaque traitement. L'appareil utilisé comprend une tige graduée en centimètres et d'une longueur de 50 cm qui se termine par une pointe conique de 30° d'angle au sommet et de 3,2 cm^2 de section. Cette tige est reliée à la poignée de poussée par un anneau dynamométrique de force 500 daN qui se déforme lors de l'enfoncement de la tige dans le sol. Un comparateur situé au cœur de l'anneau permet la lecture des déformations. Les valeurs de lecture sur le comparateur sont traduites ensuite en valeurs de pression après étalonnage de l'appareil à l'aide d'une balance de précision.

La masse volumique apparente du sol a été mesurée à l'aide de prélèvements de volume de sol au moyen d'un cylindre métallique de 5 cm de hauteur et de diamètre enfoncé dans le sol par l'intermédiaire d'une douille porte-cylindres, d'une tige et d'un marteau. La méthode consiste à enfoncer dans le sol un cylindre pour en retirer un volume de 100 cm^3 de terre. Après séchage à l'étuve à 105 °C pendant 24 heures on obtiendra le poids sec de la terre. Cette mesure a été réalisée tous les 10 cm sur une profondeur de 40 cm.

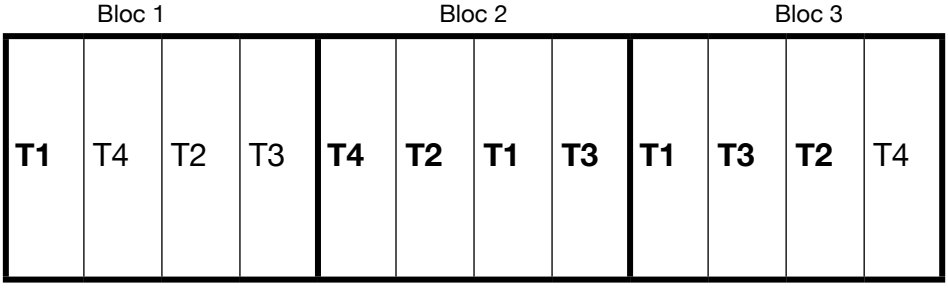
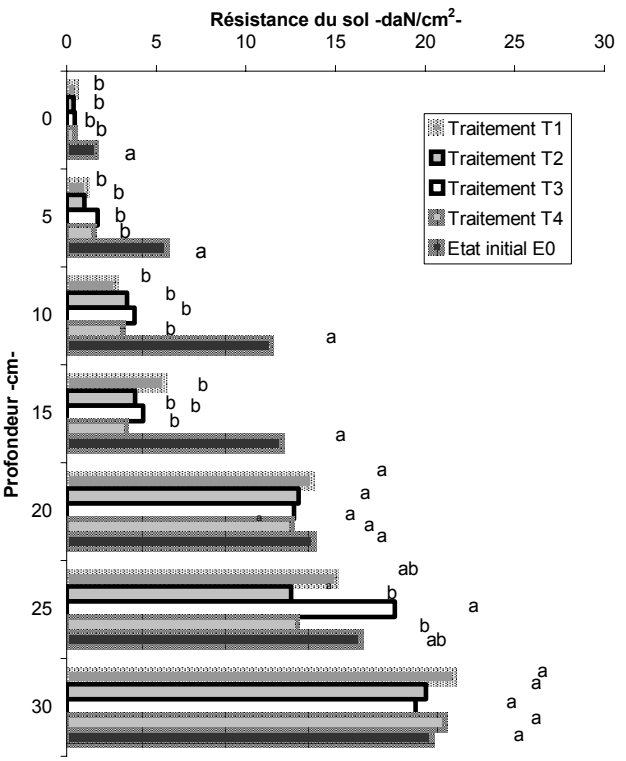


Figure 1: Schéma du dispositif expérimental.

Elles sont effectuées pour les trois répétitions de chaque traitement.
Donc sur chaque bloc, la résistance à la pénétration a été mesurée à sept profondeurs et la masse volumique apparente à quatre profondeurs.
Pour le traitement statistique des données, on a utilisé la méthode de l'analyse de la variance, moyennant le logiciel SAS (16). Les moyennes portant la même lettre ne diffèrent pas significativement au seuil de 5%.

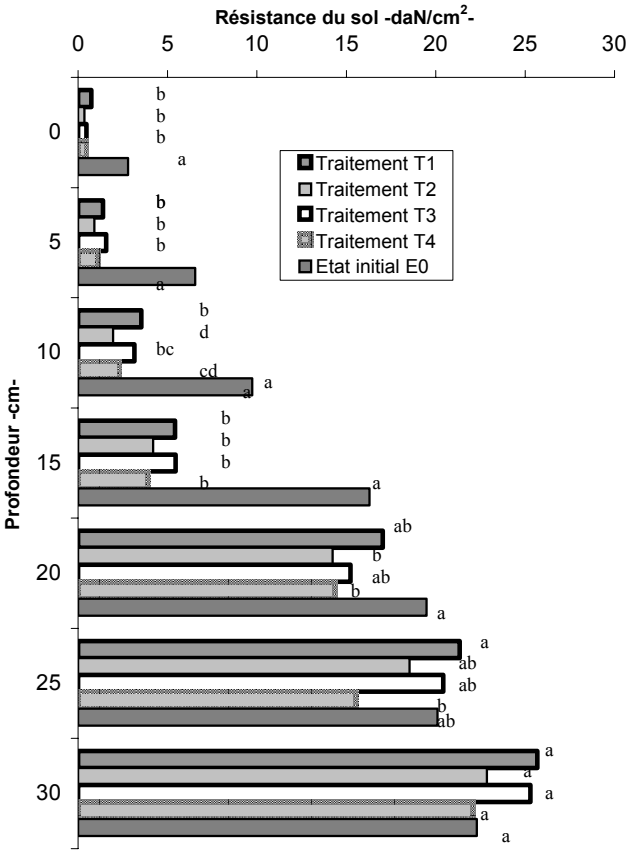
Résultats – discussion

L'examen des profils pénétrométriques moyens (Figures 2 & 3) des différents traitements dans les deux types de sol par rapport à l'état initial, a permis de mettre en évidence une diminution de la résistance à la pénétration dans la zone travaillée après passage des différents outils.
La tendance à la diminution de la résistance à la pénétration dans les horizons travaillés, a démontré l'objectif du travail du sol en général. Les mesures de pénétrométrie reflètent la force de cohésion favorisant la formation d'agrégats.
Les valeurs de la résistance à la pénétration comparées à l'état initial par niveau de profondeur dans le cas du sol SA (Figure 2), montrent un effet hautement significatif du facteur traitement sur la résistance du sol sur les profondeurs allant de 0 à 15 cm. Au niveau de ces profondeurs, les quatre traitements ne différaient pas significativement entre eux. Au niveau de la profondeur 20 cm, il s'est avéré que l'effet traitement sur le paramètre résistance du sol était absent. Cette profondeur représentait la profondeur moyenne traitée par le traitement T1, mais elle était nettement supérieure aux limites réalisées par les trois autres. Au niveau de 25 cm de profondeur, des différences significatives ont été observées entre les traitements T3 et T1 et les deux autres. Mais à cette profondeur, les traitements T3 et T1 ne différaient pas significativement de l'état initial. Par contre, les différences entre les traitements T4 et T2 par rapport à l'état initial, pourraient être dû à des écarts d'humidité dans cet horizon. Finalement, la profondeur 30 cm ne reflétait aucun effet du traitement sur la résistance du sol puisqu'on est loin de la profondeur travaillée par les outils ou influencée par la compaction.
En considérant le sol AS (Figure 3), un phénomène similaire à celui du sol SA s'est produit au niveau des profondeurs 0, 5 et 15 cm. Il s'agissait d'un effet hautement significatif du facteur traitement sur la résistance du sol à la pénétration comparé à l'état initial mais sans différence significative entre les traitements. A 10 cm de profondeur, on a assisté à un effet hautement significatif du facteur traitement sur la résistance du sol, mais aussi à des différences significatives entre les traitements. Au niveau de la profondeur 20 cm, l'effet



Les moyennes portant la même lettre ne diffèrent pas significativement au seuil de 5%.

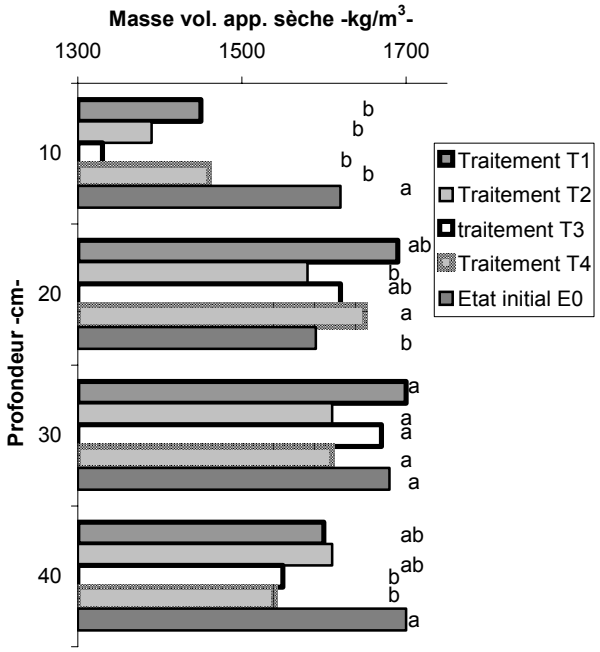
Figure 2: Profils pénétrométriques moyens du sol SA pour l'état initial et après les différents traitements.



Les moyennes portant la même lettre ne diffèrent pas significativement au seuil de 5%.

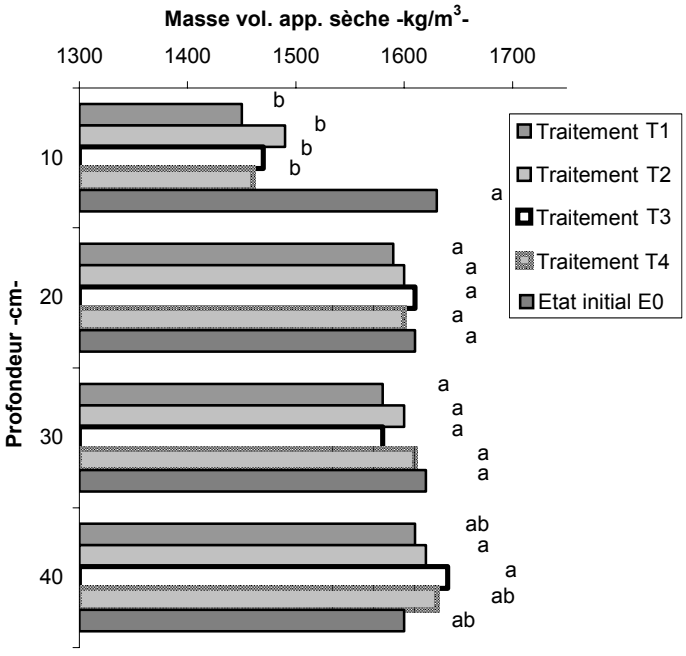
Figure 3: Profils pénétrométriques moyens du sol AS pour l'état initial et après les différents traitements.

traitement sur la résistance du sol est apparu, mais des différences entre les traitements ont été enregistrées.
Les traitements T2 et T4 étaient différents des autres. A la profondeur 25 cm, les traitements n'avaient pas d'effet significatif sur la résistance du sol. Le traitement T4 était caractérisé par une faible moyenne, et il a semblé que les traitements T1 et T3 ont provoqué un tassement du sol en profondeur. Au niveau de la profondeur 30 cm, on a remarqué que les constatations pour le sol SA étaient identiques, c'est-à-dire absence de l'effet traitement sur la résistance du sol. Les traitements T1 et T3 étaient toujours à l'origine du tassement du sol en profondeur.
En ce qui concerne la masse volumique apparente sèche (Figures 4 & 5), l'examen des profils moyens des quatre traitements par rapport à l'état initial, a montré une diminution de la masse volumique apparente des sols dans la zone travaillée après passage des outils.
Dans les deux types de sol, les profils moyens des différents traitements présentaient des allures croissantes tout le long de la profondeur de travail concernée. Donc, le travail du sol moyennant les quatre niveaux de puissance, en diminuant la masse volumique apparente a augmenté par conséquent la porosité structurale de chacun des sols considérés. Ainsi le travail du sol a présenté l'avantage de permettre une meilleure occupation du sol par le système racinaire de la plante. Cependant, on doit signaler que l'emploi de la méthode des cylindres d'acier enfoncés dans le sol par l'intermédiaire d'une douille porte-cylindres, d'une tige et d'un marteau, n'était pas homogène dans les horizons travaillés. Cette dispersion des résultats reflétait le manque de cohésion dans le cas du sol sablo-argileux et la faible humidité dans le sol argilo-sableux.
La comparaison des valeurs de la masse volumique apparente sèche du sol SA (Figure 4) par niveau de profondeur, a démontré l'effet hautement significatif du facteur traitement sur la masse volumique du sol à la profondeur 10 cm. Le traitement T4 se distinguait des trois autres par une moyenne relativement élevée qui pourrait être due à la faible profondeur de labour (13 cm) réalisée par ce traitement. Au niveau de 20 cm de profondeur, il y avait absence de l'effet traitement sur la masse volumique du sol. Ceci pourrait résulter de la faible profondeur (< 20 cm) réalisée par tous les engins sans exception. Cependant, on doit signaler une augmentation de la masse volumique du sol par rapport à l'état initial produite par les traitements T1, T3 et T4, indiqués par des moyennes élevées. Au niveau de l'horizon 30 cm, les traitements ne présentaient ni effet sur la masse volumique du sol ni différence entre eux. Le même phénomène s'est manifesté au niveau de la profondeur 40, mais les traitements T3 et T4 se distinguaient des autres par des moyennes plus faibles.
En considérant le sol AS (Figure 5), la comparaison des valeurs de la masse volumique apparente sèche à 10 cm de profondeur, a mis en évidence un effet hautement significatif du facteur traitement sur ce paramètre. Mais les quatre traitements ne différaient pas significativement entre eux. En revanche, au niveau des horizons 20, 30 et 40 cm, il y a eu absence de l'effet traitement sur la masse volumique du sol. Ces horizons n'étaient pas atteints par la totalité des outils lors de passage des engins, car les profondeurs de travail réalisées étaient inférieures à 20 cm. Cependant, au niveau de l'horizon 40 cm, les



Les moyennes portant la même lettre ne diffèrent pas significativement au seuil de 5%.

Figure 4: Profils moyens des masses volumiques apparentes sèches du sol SA pour l'état initial et après les différents traitements.



Les moyennes portant la même lettre ne diffèrent pas significativement au seuil de 5%.

Figure 5: Profils moyens des masses volumiques apparentes sèches du sol AS pour l'état initial et après les différents traitements.

quatre traitements étaient marqués par des moyennes supérieures à celle de l'état initial, ce qui semblait mettre en évidence un effet de tassement du sol en profondeur suite aux passages de l'ensemble tracteur-outils.
Bien que sur le plan état structural réalisé, les différentes puissances utilisées se soient montrées similaires, l'étude de l'impact de ces différentes puissances sur l'aspect tassement du sol devrait être considéré de façon plus détaillée et sur une plus longue période pour plusieurs raisons. Le tassement peut avoir un effet direct sur la croissance de la plante car il freine l'implantation et le développement des racines, ce qui limite par conséquent les rendements. Il peut diminuer la conductivité hydraulique qui favorise le ruissellement et l'érosion, et il peut avoir aussi des effets négatifs sur la fertilité du sol.

Conclusion

Au terme de ce travail expérimental ayant pour but d'étudier les effets de quatre classes de puissance de traction sur l'état structural du sol dans les petites exploitations maraîchères du Sahel tunisien, il est apparu que pour la technique de travail du sol utilisée, tous les engins ont permis d'atteindre pratiquement le même état structural du sol dans les profondeurs travaillées par l'ensemble des appareils. En effet, les résultats obtenus dans les deux sols, mettent en évidence un état structural meuble confirmé statistiquement par des effets hautement significatifs des différents traitements sur les variables mesurées sans différence entre les traitements eux-mêmes. Le labour avec la charrue à socs et versoirs ainsi que la reprise de labour au cultivateur rotatif animé par prise de force du tracteur sont traduits par un état poreux non compact avec un sol émietté en surface pour les quatre traitements. Ce qui met en évidence que l'ensemble des traitements a occasionné dans les couches travaillées un état structural similaire, malgré une différence au niveau de la vitesse de labour et de la forme des versoirs. Il en résulte que pour la technique de travail du sol adoptée, l'ensemble des puissances envisagées a offert les mêmes possibilités pour la préparation du sol ce qui favorise l'utilisation des petites puissances dans les exploitations maraîchères de taille réduite. Cependant, pour une meilleure conduite de ces petits équipements, plusieurs facteurs pourraient être pris en considération:

- un choix judicieux du moment d'intervention notamment pour l'opération de labour (état d'humidité du sol surtout), ce qui pourrait réduire davantage la résistance du sol et par suite l'effort de traction demandé;
- stabilité des motoculteurs au labour par un réglage adéquat de leur voie;
- meilleure adéquation entre la taille de l'outil et la puissance de l'engin, etc.

  En outre, il est nécessaire d'effectuer une étude technico-économique comparative entre différentes puissances de traction en travail du sol des exploitations maraîchères de taille réduite sur plusieurs années et qui pourrait renseigner davantage sur l'application de ce mode de traction dans ce secteur.

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Understorey Regeneration of *Lophira alata* as Affected by Seed Tree Size and Growing Conditions

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Keywords: Biomass- Deforestation- Morphology- Natural regeneration- Pioneer species- Seedlings

Summary

Demographic pressure and slash and burn practices are two factors which reduce the number of Lophira alata *plants in its natural range where it is more represented by young plants. The hypothesis that its understorey regeneration may be affected by seed tree size and growing conditions was investigated in the tropical moist forest in southern Cameroon using mature trees of various diameter classes for a sustainable management of the species. Biomass partitioning was also examined in regenerating seedlings growing in loading bays and forest understorey. Seedling density was highest when seed tree diameter at breast height (dbh) was 100 cm or more. A strong positive correlation was found between seed tree diameter dbh and crown size expressed as mean diameter of projected crown area, but crown size correlated much better with seedling density. Compared with their counterparts of the same height growing in loading bays in full sunlight but devoid of litter and topsoil, seedlings found in understorey exhibited lower root: shoot ratio, indicating that soil-derived resources were more limiting in loading bays than on undisturbed forest floor. Leaf weight per area (leaf dry weight/leaf area) (LWA) and leaf packing (leaf number/cm shoot height) were almost 2-fold greater in loading bays than in understorey. As seedlings seldom grew taller than 50 cm in the latter environment, it may be inferred that root: shoot ratio, LWA, and leaf packing can be used to assess the sustainability of growth and development of this pioneer species at the seedling stage.*

Résumé

Régénération de *Lophira alata* en sous-bois sous l'influence de la taille du semencier et des conditions de croissance

La pression démographique et l'agriculture itinérante sur brûlis sont deux facteurs qui réduisent le nombre de plants de Lophira alata *dans sa répartition naturelle où il est représenté par les jeunes plantules. L'hypothèse selon laquelle la régénération en sous-bois de* Lophira alata *pouvait être influencée par la taille des semenciers et les conditions de croissance était étudiée dans la forêt tropicale humide du sud Cameroun en considérant les grands arbres de différentes classes de diamètre pour un aménagement soutenu de cette essence. La répartition du feuillage était aussi examinée sur les jeunes plantules poussant en clairière et en sous-bois. La densité des plantules était élevée quand le diamètre à hauteur de poitrine des semenciers était de 100 cm ou plus. Une forte corrélation était trouvée entre le diamètre à hauteur de poitrine des semenciers et la dimension de la couronne comme diamètre moyen de la surface de projection de la couronne mais seulement, la dimension de la couronne était mieux correlée avec la densité des plantules. Comparées aux plantules de même hauteur poussant en clairière exposées au soleil mais dépourvues de la litière et du sol de surface, les plantules du sous-bois ont exhibé un bas ratio racine: pousse, indiquant que les ressources dérivées du sol étaient plus limitées en clairière qu'en surface du sol du sous-bois. Le poids des feuilles par unité de surface (Poids de feuille sèche/surface des feuilles) (PFS) et le pacquage des feuilles (nombre des feuilles/hauteur des pousses en cm) étaient presque deux fois plus grand en litière qu'en sous-bois. Comme les plantules du sous-bois ont difficilement dépassé 50 cm de haut, il peut être déduit que le ratio racine:pousse, PFS et le pacquage des feuilles peuvent être utilisés pour évaluer la croissance et le développement soutenu de cette essence pionnière en stade de plantules.*

Introduction

The tropical moist forests of Cameroon are complex, heterogeneous, and have stratified ecosystems with a mixture of plant species each requiring specific conditions for establishment, survival, and growth to maturity (2). Due to economic and population pressure, these forests are increasingly being exploited, either for commercial purposes or for subsistence farming. This has resulted in the degradation and rapid

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disappearance of important timber species of the country. Already, lack of forest cover in many parts of the country is not only causing acute timber shortage but also serious soil erosion and environmental degradation in general.

Commercial timber trees are essentially primary or late secondary species known to tolerate varying levels of shade during their establishment and growth habits. The apparent absence of juveniles from several species in the mature forests has been reported for African forests in particular. It has been also remarked that for several species which are dominant in the canopy, seedlings, saplings and treelets are virtually absent in the understorey (14). In the shaded understorey of a closed-canopy forest, survival is, among others, an important factor determining the abundance and distribution of tree species of rain forest prior to gap creation.

Two ecological species groups have been distinguished and defined (16) among tropical rain forest tree species: the pioneer and climax species (extremes of evolutionary specialisation). The climax species are able to germinate, establish and grow in the deep shade of a closed-canopy forest understorey, whilst the pioneer species only establish and grow in gaps in the forest canopy in which full sunlight penetrates to the forest floor for at least part of the day. This definition focuses on the early stages of a tree's life-cycle, that of germination and seedling establishment. In general spatial distribution of seeds is entirely determined by the distribution of reproducing adults and their seed dispersal strategy. After dispersal, environmental factors start having an impact on the germinating seeds. The spatial distribution of many of those, like light, proximity to sources of pathogens and herbivores and secondary dispersers is heterogeneous, which causes the original spatial distribution of the seeds to be modified (5). It is likely that after a number of years the surviving seedlings are distributed according to the occurrence of gaps in the area.

With the advent of logging for commercial uses, recovery of the forest following man-made disturbances may have become less certain, especially considering the extensive damage that is being inflicted on young trees, constituting future harvest generations. There is a fear that these rain forests will disappear as a result of the expansion of agriculture and of commercial logging (20). Opinions differ as to the relative weight of the various factors involved. Despite this, there is a widespread consensus that sustainable management is important in preventing further degradation and deforestation (17).

More attention has been devoted to studies on mature tropical trees than on seedlings demography (20). Moreover, experiments on early regeneration are limited to a number of species and largely focused on the neotropical lowland forest too. Seemingly, therefore, African forests are lagging behind in research efforts whose outcome could reveal important similarities and differences with those of the neotropics. In fact, Smith and Bariteau (15) stated that natural regeneration should be referred to as a result of many processes including flowering, fruiting, germination and post-germinative development.

There is a need, therefore, to design forest management systems for sustained *Lophira* production in the moist forest of Cameroon. Hence, the main objective of the present study is to establish trends in regeneration dynamic of *Lophira alata* (seedlings and sampling densities) in relation to the seed tree dbh and mean crown diameter. Since understorey conditions are known to be unfavourable to sustainable development of this pioneer species, we predicted that seedlings growing in low light (understorey) and high light (loading bays) environments would exhibit differences based on biotic and abiotic factors and morphological characteristics.

Material and methods

Site description

The study was carried out from April to December 1999 in the Tropenbos-Cameroon Programme (TCP) research area located in the evergreen moist tropical forest zone of southern Cameroon, between 2° 45' and 3° 15' N and 10° 15' and 11° E at about

Table 1
Location, elevation, rainfall, soil types, and soil characteristics of experimental areas

Locality	Ebimimbang	Ebom	Nyangong
Location	3°03'N, 10°28'E	3°05'N,10°41'E	2°58'N,10°45'E
Elevation (m.a.s.l)	100	440	550
Rainfall (mm)*	1707	2019	1780
Soil types	Ultisols	Ultisols, Oxisols	Oxisols
Clay (%)**	10-40	40-60	60-80
PH (water)	6.1	4.7	4.3
Carbon (%)	1.69	2.26	2.21
Nitrogen (%)	0.15	0.18	0.19
Available P in H_2O (µg/ml soil)	0.01	0.005	0.002

* Annual means of rainfall from 1995 to 1998
** Data derived from (26)

80 km east of Kribi. The site covers a total land area of about 200 000 hectares (18) and coincides to a large extent with former concessions of the Dutch logging company of WIJMA-Douala S.A.R.L (GWZ). The climate is humid tropical with average annual temperatures of about 25 °C and a mean annual precipitation of 2000 mm. Soils are moderately heavy clayey, generally strongly acid, deep and well drained, with low to medium organic matter content (Table 1). They are classified in the FAO system as xanthic ferralsol (18). The forest belongs to the Guineo-Congolian domain made up of dense humid evergreen forests dominated by Caesalpiniaceae. Much of the vegetation has been degraded by shifting cultivation and logging activities.

Study species

Lophira alata (Banks ex-Gaertn) is a commercial timber species that has been classified as a pioneer species (7), given its ability to germinate and develop only under gaps in the forest canopy or in twilight zone that are influenced by nearby gaps. *Lophira alata* (Ochnaceae) is a native large tree species, which provides highly valued timber and which is among the most frequently harvested tree species nationwide. It ranked fourth in total national export in 1998. Locally the most abundant timber, *Lophira* constituted 60% of extracted wood volume. The species has a strategy of mass flowering and fruiting in certain years while in other years it hardly produces seeds. Its seeds are bulging and elongated, weighing about 1.0 g. It was selected on the basis of its commercial value, abundance and choosen to cover the spectrum of regeneration strategies from pioneer to small gap specialist to understorey species (8). To some extent the present situation may be considered a competition in which the exploited commercial species has a large competitive disadvantage compared to others. A change in relative abundance of the species would certainly affect the future commercial value of the forest to a large extent.

Site selection and sampling

The present study is based on old secondary forest site (non-gap region) and canopy gap formed through loading bays. A gap was defined as a vertical opening in the forest extending through all foliage level to about 2 m of the crown projection limit (3).

In canopy gaps, seventy-five randomly selected felled-tree gaps, almost equally represented in number over 5 logged-over sites were determined using Runhle's definition (18). These gaps were randomly located in 5 spatially distinct logged-over sites. Preferred gaps were of the 700-1700 m^2 size range averaging 1225 m^2. The frequency distribution of the obtained gap size values showed the existence of very many small gaps and very few large ones as observed elsewhere by Whitmore (21). Based on mean gap size and range to all blocks, gap size classes were subdivided as follows: small (700-1000 m^2), medium (1000-1300 m^2), and large (1300-1700 m^2). Gap ages were provided by corresponding stump marks for up to 6 year-old logged-over forest beyond which one had to rely on interviews in order to establish time elapsed since exploitation for older gaps.

The experimental lay-out was a split-plot with major plots represented by logged-over forest blocks of different ages (1, 3, 6, 9, and 12 years) and minor plots by gap types (small, medium, and large) nested within forest blocks. In each block, 5 replicates of each gap type were retained for sampling survey. Thus 3 gap types x 5 replicates x 5 forest blocks= 75 gaps were systematically surveyed.

A main axis was positioned along the line linking the crown to the stump of the felled tree. In case a gap had been occasioned by felling two or more trees, the main gap axis was laid along the direction of the biggest tree. Five equidistant belt transects, each measuring 5 m wide were disposed perpendicularly on either side of this axis. Transect outlines were marked by pickets whose positions had been predetermined with the aid of a compass. Each transect was extended on both sides of the main axis into the adjacent relatively undisturbed forest by 10 m. For each gap, enumeration surveys was proceeded in every other plot (measuring 5 x 1m) within each transect. It consisted of identifying and recording seedlings (< 1m tall) and samplings (either > 1m tall or diameter at breast height (dbh) from 2-20 cm) according to size, transect location, and light condition.

In the old secondary forest sites (non-gap regions) forty-nine parent trees belonging to four diameter classes were randomly selected for their isolation from other mature trees of the same species, and for their distribution among diameter classes. Seedling measurements by cross callipering were carried out in 5 m^2 (5 m x 1 m) plots under each sampled seed tree. For each seed tree, two plots were laid along a north-south line and two were laid along an east-west line. The lines intersected at the bottom of the seed tree so that plots of the same line were located 1 m apart on either side of the stem.

Sample preparation and analytical methods

Twelve seedlings of about 50 cm high growing in full light (loading bays) and 12 others developing in low light (understorey) were selected for assessment of leaf morphology at this critical height. From each seedling, two leaf fragments of about 12 to 20 cm^2 were sampled of which one originated from an upper position in the crown (recent leaf) and the other from a lower position (old leaf). Following removal, leaf fragments were treated according to previously described methods (10). Briefly, they were oven-dried at 70 °C for 48 h, cooled in a desicator then weighed to the nearest 0.1 mg. Leaf weight per area (LWA) of

each fragment was calculated by dividing leaf dry weight with surface area.
For plant measurement, the number of leaves per seedling was counted and seedling height was measured with a rigid tape. Leaf packing was then obtained by dividing leaf number by individual seedling height, as defined by Boyce (1). Root and shoot dry weight were measured after careful removal of the entire seedling from soil, and each root system was washed free of soil in water prior to drying. Root and stem tissue were oven-dried following the same procedure as leaf fragments.

Data analysis
The effect of seed tree size on seedling density, and that of growing conditions on leaf and plant morphology were evaluated using one-way and multiple-way analyses of variance. All statistical analyses were performed using SYSTAT, Inc., Evanton, Il, (U.S.A) after appropriate transformation of seedling density, root:shoot ratio, leaf packing, and LWA. Post-hoc tests were used for mean separation if significance was indicated at $p< 0.05$.

Results and discussion

Seedling density
In the gap sites, seedling density varied significantly with gap age ($P< 0.0001$), gap type ($P< 0.030$), and light condition ($P< 0.030$). The highest value (0.55 stem/m^2) was recorded 1 year after gap creation. This was followed by a steep decline by year 6 (0.21 stem/m^2) after which it increased abruptly and attained 0.39 stem/m^2 at 9 years. A non significant decrease in seedling density was observed between years 9 and 12. This pattern of variation is similar to the one recorded for selection-felled gaps in a humid tropical rainforest in India (4). In that study, selection-felled gaps exhibited a tree seedling density of 7.2 stem/m^2 at age 1, 3.1 at age 5 and 6.9 at age 10. The decline in seedling densities observed between 1 and 6 years may be accounted for by the detrimental effect of competing vegetation on seedling development (herbs and shrubs) after gap formation. The sudden increase noticed after 6 years may be due either to the adverse effects of canopy closure on weed development or to competition among herb and shrub species.
Medium gaps exhibited a significantly higher seedling density (0.40 stems/m^2) compared with large and small-sized ones in which 0.33 and 0.32 stems/m^2 were recorded respectively (Table 3).
Large openings (loading bays) have been reported to exhibit lower seedling densities than treefall gaps, skidtrails and smaller openings in a study on forest regeneration after logging (7). This could be attributed to high light intensity favorable to herb and shrub development. On the other hand, the decline observed in small gaps may be associated with root competition between tree seedlings and surrounding forest. Elsewhere, a strikingly similar result has been obtained before. In an early experiment on Gunung Gede in Java (Indonesia), which apparently has never been repeated or extended, artificial small gaps of 0.1 ha in primary forest were soon colonized by young individuals of primary forest species. By contrast, in larger gaps of 0.2-0.3 ha these persistent individuals were suppressed by a lush vegetation of invading tree species (20).
In the forest understorey, small trees and shrubs (< 15 m maximum height) make up 38.4% of individuals, which indicate a good regeneration in forest understorey.

Table 2
Effect of seed tree size (dbh) on seedling density in an understory environments

Class number	Diameter (D) range (cm)	Number of sampled seed trees (replicates)	Seedling density within the projected crown area (stem number/m^2)
I	$50< D\leq 80$	13	0.24 ± 0.09a
II	$80< D\leq 110$	11	0.28 ± 0.08a
III	$110< D< 140$	11	1.72 ± 0.17b
IV	$D\geq 140$	14	2.25 ± 0.19c

∗ Densities followed by the same letter are not significantly different by post-hoc test ($p= 0.05$).

Table 3
Multi-way analysis of variance: means of juvenile population parameters with respect to gap size

	Gap type			
Parameters	Small	Medium	Large	P-value
Seedling density (stem/m^2)	0.32	0.40	0.33	0.03*
Sampling density (stem/m^2)	0.077	0.091	0.083	0.103 ns

Table 4
Correlation coefficients between seedling density, seed tree diameter at breast height, and mean diameter of projected crown area

	Diameter at breast height (cm)	Mean diameter (cm) of projected crown area
Seedling density	0.46 (P= 0.001)	0.56 (P< 0.0001)
Mean diameter of Projected crown area	0.89 (P< 0.0001)	1

The highest seedling density (2.25 seedlings/m^2) ($p < 0.0001$) has been recorded under parent trees > 140 cm dbh (Class IV). This density was significantly greater than those observed under class I and II seed trees respectively (Table 2).

These observations are consistent with the idea that seed production and dispersal range may be greater for very large trees compared with trees below the minimum girth (7). Contrary, in studying forest regeneration after logging, the author (7) have considered overmaturity to be absolutely detrimental to seed production in forest tree species. The fact that in the present study, a 42% increase in seedling density was observed between the third and fourth diameter classes suggests that the maturity of seed producers is an important factor for seedling density, since all seed trees and their progenies (seeds and seedlings) were exposed to similar climatic conditions. Alternatively, the lack of natural regeneration under some parent trees could be attributed to variation in understorey conditions affecting germination and seedling establishment. For a tree species failing to regenerate the key factors to be considered were the quantity of viable seeds produced, the frequency of seed production, light conditions for germination and establishment, and the ability of seedling, to grow on to saplings and poles (9).

Correlation analyses showed that there were significant correlations between seedling density, seed tree dbh, and mean diameter of projected crown area (Table 4).

Although seed tree dbh was strongly and positively correlated with crown diameter ($R= 0,89$) ($p< 0.0001$), the latter variable was found to be better correlated with seedling density ($R= 0,75$) ($p< 0.0001$) compared with the former ($R= 0.55$) ($p= 0.001$). The correlation coefficients found between seed tree characteristics and seedling density indicated that those parameters account only for a very small portion of the total variation in seedling regeneration. Other factors may be involved as well.

Seedlings growing in full sunlight exhibited a LWA (67.6 g/m^2) that was 76% greater than the value recorded for seedlings developing in the understorey environment (38.5 g/m^2) (Table 5).

These values fall within the range found by Oldeman (12) for leaves of the shade-intolerant species *Betula pendula* growing under different light levels (34.9 to 86.1g/m^2). In his study, LWA was observed to increase with increasing irradiance, both in pioneer and in non-pioneer species (*Lonicera xylosteum* and *Corylus avellana*), although the relative variability in LWA was smaller for *Betula pendula* than in the other two species. In our study, the pattern of variation in LWA of *Lophira alata* with respect to light intensity is quite similar to that observed in *Betula pendula*, described as a typical pioneer species. Since leaf position did not have any significant effect on LWA, the increased LWA in light conditions may be mainly associated with the stimulatory effect of light on leaf tissue production as pointed out by Oren *et al.* (13).

Leaf packing was 2 times larger in full light (0.63 leaf/cm shoot height) ($p< 0.0001$) than in the understorey (0.30 leaf/cm shoot height) (Table 5). Likewise, the root-shoot ratio exhibited by seedlings growing in light were higher compared with the ratio recorded in understorey. This may be an indication of poorer nutrient status of loading'bays (bare soil) compared with understorey. Root-shoot ratio increased with decreasing soil-derived resources such as water and nutrient supply has been reported (6). In *Gmelina arborea,* Ogbonnaya and Kinako (11) observed that root-shoot ratio declined with increasing amounts of high supplied nitrogen because this increase resulted

Table 5
Effect of growing environment on leaf and seedling morphology

Leaf and seedling characteristics	Growing environment	
	Understory	Loading bays
Leaf weight per area (LWA) (g dry weight/m^2)	38.5b	67.6a
Leaf packing (leaf number/cm shoot height)	0.30b	0.63a

* Within rows, means with different letters are significantly different at $p< 0.05$.

in more nitrogen transported to the shoots where it enhanced the utilization of carbohydrates for protein synthesis and growth.

Conclusion

This study has shown that the degree of natural regeneration of *Lophira alata* in the forest depends on several factors including the presence and size class distribution of parent trees. We also demonstrated that the concept of overmaturity in this species can be assessed using seed tree characteristics such as diameter at breast height and mean diameter of projected crown area. In studying tropical forest regeneration after logging, Hawthorne (7) has classified *Lophira alata* as a pioneer species, according to Whitmore (21) definition of pioneer and non-pioneer tree species. In the present study, we have found this species as seedlings (<1 m in height) and saplings (between 1 and 5 m in height) in loading bays, but only as seedlings under complete forest shade, which prompt us to consider it as a non-pioneer light demander. Seedlings growing in full light developed morphological traits that were different from those displayed by completely shaded ones. It appeared that medium gaps seem to be more suitable for regeneration processes and that *Lophira* does not have any particular preference as to gap size and light condition although it is poorly represented in the experimental plots. Since only the former plants could develop into saplings, further research should be focused on refining biochemical traits associated with such morphological differences, that could be used as efficient indicators for sustainable growth and development of *Lophira alata* in disturbed or undisturbed forest ecosystems.

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Land Suitability Assessment for Sugarcane Cultivation in "Herois de Caxito" (Angola)

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Keywords: Angola- Sugarcane- Land suitability- Irrigation

Summary

The suitability of the soils surrounding the sugarcane plantation at "Herois de Caxito" (7068 ha) is assessed. The main goal is to identify land suitability for the enlargement of the present plantation, using FAO land evaluation models (modified to suit Herois de Caxito conditions) and GIS. Calculations of the radiation-thermal production potential (RPP), land production potential (LPP), irrigation suitability index, and evaluation of the irrigation water quality are done. The water-limited production potential (WPP) is found equal to the RPP, because water needs were fully met under irrigation. Maps showing the spatial distribution of the LPP and the suitability for irrigation are generated. The matching of irrigation and fertility indices has shown that, about 40% of the soils with good fertility for sugarcane production present low suitability for irrigation, the main limitations being the very fine texture and the drainage. The available surface water at Herois de Caxito (Dande river) is of very good quality for irrigation of sugarcane.

Résumé

Evaluation de l'aptitude pour la culture de la canne à sucre à "Herois de Caxito" (Angola)

L'aptitude des sols aux alentours de la plantation de canne à sucre à "Herois de Caxito" (7068 ha) est évaluée dans le but principal d'augmenter la superficie de la plantation actuelle, utilisant des modèles d'évaluation des terres de la FAO (adaptés aux conditions de Herois de Caxito) et du SIG. La production potentielle radiation-thermique (RPP), la production potentielle de la terre (LPP) et l'indice d'aptitude pour l'irrigation furent calculés, tandis que la qualité de l'eau pour l'irrigation fut évaluée. La production potentielle tenant compte de la disponibilité en eau (WPP) est comparable à la RPP, les besoins en eau étant complètement satisfaits par l'irrigation. Des cartes reflétant la distribution spatiale de la LPP et l'aptitude pour irrigation sont générées par le logiciel SIG. La comparaison des indices d'irrigation et de fertilité a montré qu'environ 40% des sols ayant une bonne fertilité pour la production de la canne à sucre ne sont que peu aptes pour l'irrigation. Les principales limitations sont la texture très fine et le drainage insuffisant. L'eau de surface disponible à Herois de Caxito (rivière Dande) est d'une très bonne qualité pour l'irrigation de la canne à sucre.

Introduction

Sugarcane (*Saccharum officinarum* L.) is a C4 perennial crop with a metabolism leading to the accumulation of sucrose. The plant grows 2.5 to 4.25 metres tall (10). Higher yields are obtained with increasing incident solar radiation. Cane production is directly proportional to the water transpired (2). Therefore, good yields are obtained under adequate supply of water and sunshine in a climate which ensures sprouting of stem cuttings at mean daily temperatures of 32 to 38 °C, and which allows cane growth at mean daily temperatures of 22 to 30 °C (15). At maturation, the ratio of the difference between maximum and minimum temperatures to the mean temperature values should be above 0.5 for optimal conditions, while values below 0.35 are considered marginal. During ripening weather should be clear (high insolation), dry, cool with temperatures around 10-20 °C, as this stimulates the accumulation of sucrose (12). More than 2 000 hours of sunshine per year are required for a successful growth of sugarcane. When sunlight period is halved, sugarcane production is reduced by 50% (9). The rainfall is of capital importance in the sugarcane production areas. An effective rainfall of 1 500 mm, equivalent to a total of 2 255 mm during the growing period is required to attain good yields, otherwise irrigation is needed (8).
The "Herois de Caxito" sugarcane plantation is located in the region of Caxito (Figure 1) between 8° 30' to 8° 37' southern latitude and 13° 30' to 13° 45' eastern longitude, at about 50 km from Luanda (1).

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Figure 1: Location of Caxito .

A land evaluation study is presented for determination of both the land suitability for sugarcane cultivation (FAO-models) and for irrigation. As Angola is not self-supporting in sugar, extension of the sugar production is of great importance. Moreover, several plantations were destroyed during recent years. The methodology used in this paper is applicable to other parts of Angola, as well as in other countries, for land evaluation for sugarcane cultivation.

Materials and methods

Materials

Climatic data

The climate of Caxito, influenced by the cold current of Benguela, is semi-arid with a well-marked dry season. The maximum precipitation occurs during the months of March to April and November to December. A long dry season is noticed during the months of June to September (6). Climatic characteristics based on records of 20 years are given in table 1.

Soil data

The study area covers about 7 068 ha of fluvial lowlands, characterized by a temporary or permanent groundwater table, low content of soluble salts and sulphides, presence of illites and smectites, relatively good fertility and the development of a B-horizon in a few cases. A regional soil classification based on (i) dominant texture within 120 cm, (ii) drainage indicated by the intensity and deepness of redoximorphic features and, (iii) topographic position and duration of flooding as main keys, distinguishes 14 soil series (3) as shown in table 2.

According to WRB soil classification (5), the dominant soils are fluvisols and gleysols, with also important areas of vertisols and histosols. Soil classification and major chemical properties of the soil series are given in table 3. The CEC ranges from 25 to 70 cmol (+).kg^{-1}clay, the highest values being observed in the vertisols (3). Most soils have a slightly to neutral soil reaction (pH 6-7), apart from the histosols (pH 3-3.5) and those bordering the histosol area (pH 4-5). The

Table 1
Climatic characteristics of Caxito –Angola (6)

Station: Tentativa – Caxito* Latitude: 8° 33' S; longitude: 13° 40' E; altitude: 20 m asl

Months/ Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)													
Maximum	32.9	33.8	33.2	32.9	31.7	28.7	26.2	26.9	28.4	30.3	31.8	32.1	30.7
Minimum	21.9	22.1	22.3	22.6	21.4	18.4	17.2	17.9	20.	20.5	21.9	21.8	20.7
Average	27.4	28	27.8	27.8	26.5	23.6	21.7	22.4	24.2	25.4	26.9	27	25.7
Relative humidity (%)	77	76	79	82	81	80	83	84	81	80	79	78	80.0
Sunshine hours	212	205	197	189	221	196	156	142	148	151	178	200	2195
N/N **	0.54	0.59	0.53	0.53	0.61	0.57	0.43	0.39	0.41	0.41	0.45	0.53	0.50
Rainfall (mm)	27.5	56.8	154.3	185.7	40.2	0	0	1.1	1	8.7	54.3	40.1	568.8
Rainfall days	4	2	5	12	1	0	0	0	0	3	5	4	36.0
Eto (Penman method) (mm)	191	183	187	162	152	121	111	119	137	159	172	184	1878
Mean wind speed ($m.s^{-1}$)	5.7	6.3	6.2	5.6	5.5	5.4	5	4.8	5.4	6.6	6.4	5.7	5.7

* average data over period of 20 years ** actual insolation / theoretical possible insolation

Table 2
Soil series of the extension of the sugarcane plantation (3)

Drainage and inundation	Temporarily imperfectly drained	Imperfectly to poorly drained		
		Inundated per year		
Dominant texture under mineral soils Heavy clay	*No inundation*	*< than 2 months*	*2 to 4 months*	*> than 4 months*
	Buya	Ube	Quijanda	Sungue
Clay and sandy clay	Cume	Sassa	Ibendua	-
Sandy loam and loam	Dande	Caxito	-	-
Sand and sandy loam	Paranhos	Pinto	Icau	Tolola
Organic matter- hemic	-	-	-	Morima (permanent inundation)

Table 3
Soil classification (5) of and chemical properties of the soil series in Herois de Caxito

Series	Soil classification	ACEC $cmol(+).kg^{-1}$ soil	Base cations $cmol(+).kg^{-1}$ soil	pH	OC %	EC dS.cm	ESP %
Buya	Calcic vertisol	60-70	30-40	7-7.5	1.5-2	05-1.5	< 1
Ube	Eutric vertisol – Vertic cambisol	40-70	15-40	5-5.5	1.5-2	< 0.5	< 1
Quijanda	Humic gleysol	30-40	20-30	4-4.5	2-7	5-7	5-10
Sungue	Humic gleysol	40-50	30-50	4-5	2-6	1-2	1-3
Cume	Humic - Eutric fluvisol	50-70	25-35	6-7	1-2	< 0.5	< 1
Sassa	Gleyic fluvisol	30-40	20-30	5-7	1-2	< 0.5	0.5-2
Ibendua	Humic dystric gleysol	25-35	8-15	4-4.5	1-2.5	0.5-1	< 1
Dande	Arenic eutric fluvisol	35-40	4-6	6.5-7	0.5-1.5	< 0.5	< 1
Caxito	Gleyic humic fluvisol	40-60	15-20	6-7	1.5-4.5	< 0.5	< 1
Paranhos	Eutric fluvisol	60-70	20-30	6-6.5	1-2	< 0.5	< 1
Pinto	Eutric gleysol	60-70	5-10	5-5.5	1-1.5	< 0.5	1-2
Icau	Humic abruptic gleysol	30-40	5-10	4-4.5	2-4.5	1-1.5	2-4
Morima	Thionic histosol	-	15-50	3-3.5	> 20	10	-

latter, mostly humic gleysols, generally have a higher O.C content (2-7%) than the better drained fluvisols (1-2%). The heavy textured soils contain high amounts of exchangeable basic cations (15-50 cmol (+). kg^{-1} soil) compared to the sandy soils (series Pinto, Icau, Dande; < 10 cmol (+) basic cations. kg^{-1} soil). The exchangeable sodium percentage (ESP) is low in all soils. Also soil salinity (EC) is very low, apart for the organic soils (soil series Morima). The available water varies between 20 and 150 $mm.m^{-1}$ of soil with an infiltration rate which is texture dependent, ranging from 0.5 $mm.h^{-1}$ in the clay soils to 25 $mm.h^{-1}$ in the sandy soils (3).

Methods

Radiation-thermal Production Potential (RPP)
Sugarcane crop growth is simulated with the FAO-crop growth model. This model allows to estimate, from radiation and temperature data, the net biomass production (Bn) and yield of a high-yielding crop that is optimally supplied with water and nutrients and grown in the absence of pests and diseases (12). The RPP is calculated as the product of the economically useful part of the crop, in this case sugar (harvest index Hi), defined as a fraction of the net biomass of the crop (Bn), as follow: RPP= Bn x Hi.

Water-limited Production Potential (WPP)
WPP is defined as the reduction of RPP due to soil water deficit resulting in a decreased evapotranspiration (Eta < ETm) (7). Thus the WPP was quantified as follow:
WPP= RPP x [1-Ky x (1-ETa/ETm)]
where Ky: yield response factor;
ETa: actual evapotranspiration;
ETm: maximum evapotranspiration.
ETm refers to conditions when water is adequate for unrestricted growth and development. To determine ETa, the level of the available soil water must be considered. ETa equals ETm when available soil water to the crop is adequate. The response of yield to water supply is quantified through the yield response factor 'ky', which relates relative yield decrease to relative evapotranspiration deficit (1- ETa/ETm). It is evident that under optimal irrigation (Eta = Etm), WPP will equal RPP.

Land Production Potential (LPP)
The LPP is calculated from the water-limited production potential, a soil index (Sy) and a management index (My):
LPP= WPP x Sy x My
The soil index is based on the parameters with direct impact on the yield, such as the sum of basic exchangeable nutrients or pH, organic carbon, electric conductivity and exchangeable sodium percentage. The evaluation of those chemical soil parameters is based on the FAO approach for irrigated agriculture (4). These land characteristics of each soil unit are matched with the requirements of sugarcane using the parametric approach. This consists in the allocation of numerical ratings (R) from a maximum of 100 (optimal) to a minimum value (less optimal) for each characteristic (14). The soil index is then computed from the individual ratings using the square root method (11) as follow:

$Sy= Rmin \times (R1/100 \times R2/100 \times R3/100 \times \ldots)^{1/2}$
where Rmin: lowest rating attibuted;
R1, R2, R3 ….: ratings of the other chemical land characteristics (with the exception of the lowest rating).

For the determination of LPP, a high management has been considered (My= 0.8).

Evaluation for irrigation
The soils were evaluated for basin furrow irrigation by calculating an irrigation capability (11) index as follow:
Ci= A x B/100 x C/100 x D/100 x E/100 x F/100 x G/100
where Ci is the capability index and A, B, C, D, E, F and G are ratings for soil texture, soil depth, $CaCO_3$ status, gypsum status, soil salinity/ alkalinity, drainage and slope, respectively.
The capability classes were defined considering the capability indices as excellent (> 80), suitable (60-80), slightly suitable (45-60), almost suitable (30-45) and unsuitable (< 30).

Quality of irrigation water
The irrigation water was evaluated on salinity, sodicity and element toxicities according to the USDA diagram for classification of irrigation water (13). The chemical composition of the irrigation water is given in table 4.

Table 4
Chemical composition of the irrigation water in Herois de Caxito

Sample	A	B	C
pH	7.5	7.2	7.1
EC (µS/cm)	186	188	195
Cations		meq/l	
Na^+	0.126	0.107	0.116
K^+	0.075	0.035	0.082
Mg^{2+}	0.798	0.798	0.790
Ca^{2+}	1.267	1.262	1.307
Sum	2.266	2.242	2.295
Anions		meq/l	
Cl^-	0.023	0.023	0.056
SO_4^{2-}	0.159	0.229	0.157
NO_3^-	0.018	0.017	0.006
HCO_3^-	2.038	1.967	2.032
CO_3^{2-}	0.000	0.000	0.000
Sum	2.232	2.236	2.261
SAR	0.12	0.11	0.11
Boron (mg/l)	0.025	0.025	0.027

A: river dam; B: start of main irrigation channel; C: end of main irrigation channel

Results and discussion

Applying the FAO growing period concept it was found that planting in August, September and October is ideal for short cycle cane whereas for cane longer than 12 months January, February and March is the optimal planting period. In both cases the ripening will coincide with a period of relatively low temperatures and low relative humidity which are ideal for sucrose concentration. Cane grown in these conditions may yield a total net biomass production of 55.41×10^3 kg CH_2O/ha/day resulting in a RPP of 13.85 tonnes/ha/year (sugar) considering a harvest index of 0.25. The water-limited production potential (WPP) is found equal to the RPP, because water needs were fully met under irrigation.

Land Production Potential

Land suitability classification indicates the nature of constraints and allows attention to the land improvement activities and potential yields. Table 5 gives the suitability of the different soil series at Herois de Caxito in terms of land production potential. The results of the evaluation demonstrate that the only factor to be considered limiting is the pH. It was found that all other factors being equal, an increase in the amount of the sum of basic cations leads to an increase in LPP as the soil become less acid. Figure 2 shows the distribution of the LPP (tonnes sucrose.ha^{-1}) in the studied area. By using GIS tools (ArcInfo and ArcView) it was found that 2 050 ha, representing 40% of the surveyed area, yields the highest LPP class (8-12 tonnes.ha^{-1}), i.e. a value greater than the average yields at Herois de Caxito (7.8 tonnes.ha^{-1}). About 40% (an area with permanent inundation as main limitation) gives yields lower than 4 tonnes.ha^{-1}. Yields higher than those observed in the present plantation can be obtained by improving the infrastructure, traffic systems and farm size, and by improving the drainage systems and controlling the inundation and flooding.

Table 5

Evaluation of soil parameters and for sugarcane production and LPP in Herois de Caxito

Series	ACEC	Base cations	pH	OC	EC	ESP	Soil index	LPP tonnes.ha^{-1}
Buya	++	++	++	++	++	++	0.86	9.53
Ube	++	++	+	++	++	++	0.71	7.86
Quijanda	++	++	-	++	++	++	0.36	4.00
Sungue	++	++	-	++	++	++	0.39	4.32
Cume	++	++	++	++	++	++	0.96	10.65
Sassa	++	++	++	++	++	++	0.97	10.74
Ibendua	++	++	-	++	++	++	0.38	4.32
Dande	++	++	++	++	++	++	0.81	9.00
Caxito	++	++	++	++	++	++	0.96	10.5
Paranhos	++	++	++	++	++	++	0.96	10.5
Pinto	++	++	+	++	++	++	0.69	7.65
Icau	++	++	-	++	++	++	0.39	4.33
Morima	++	++	-	++	-	++	0.27	2.99

- : marginally suitable, rating 40-60; **+** : moderately suitable, rating 60-85; **++** : suitable, rating 85-100

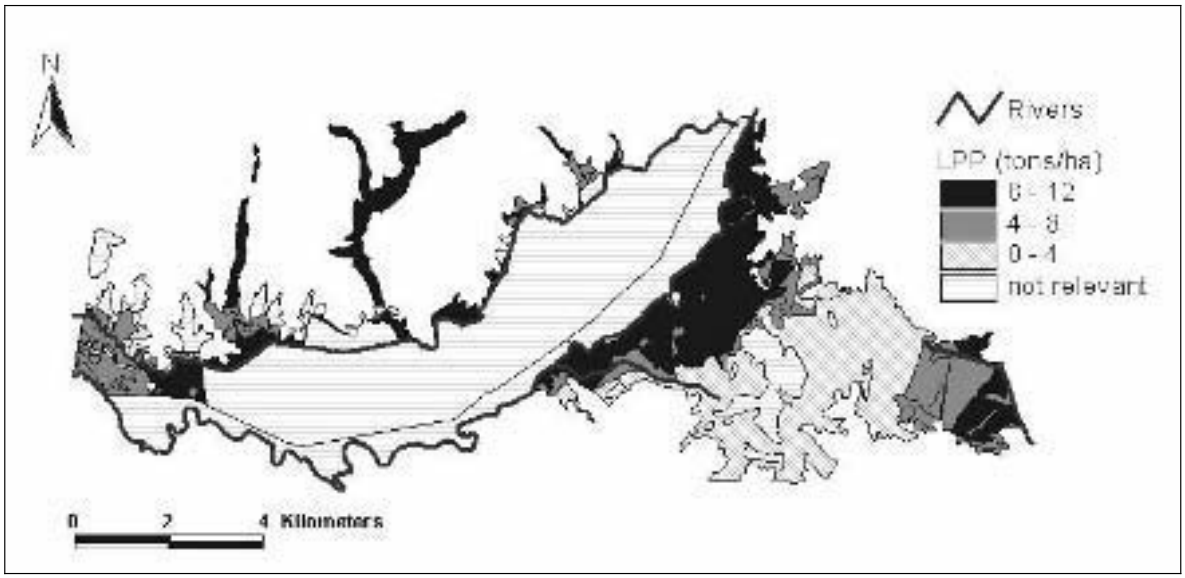

Figure 2: Distribution of LPP in Herois de Caxito.

Evaluation for irrigation

Surface furrow irrigation provides a mean for controlling and guiding water on steep, undulating and on very level land (16). The evaluation, presented in table 6 and figure 3, shows that in the study area 61% of the soil series presents drainage limitation. This is due to the high clay content of the A–C soil profiles in Caxito, totalling 92% in some horizons (3).

Values of both salinity and alkalinity are viable and do not constitute a limitation in the majority of the soil series. Exception constitutes the Morima series with high salinity that acts harmfully on the sugarcane growth.

Table 7 gives the areas of the different irrigation capability classes calculated by using ArcView tools. From this follows that out of 6 220 ha of mineral and organic soils surveyed, about 65% presents limitation ranging from moderate to slight and can be used for irrigation. Around 35% is unsuitable for irrigation and can be only irrigated if drainage operations are performed prior to cane plantation.

The irrigation water if of very good quality as expressed by its low salinity (EC) and sodium hazard. Also the boron concentration in the irrigation water, with values

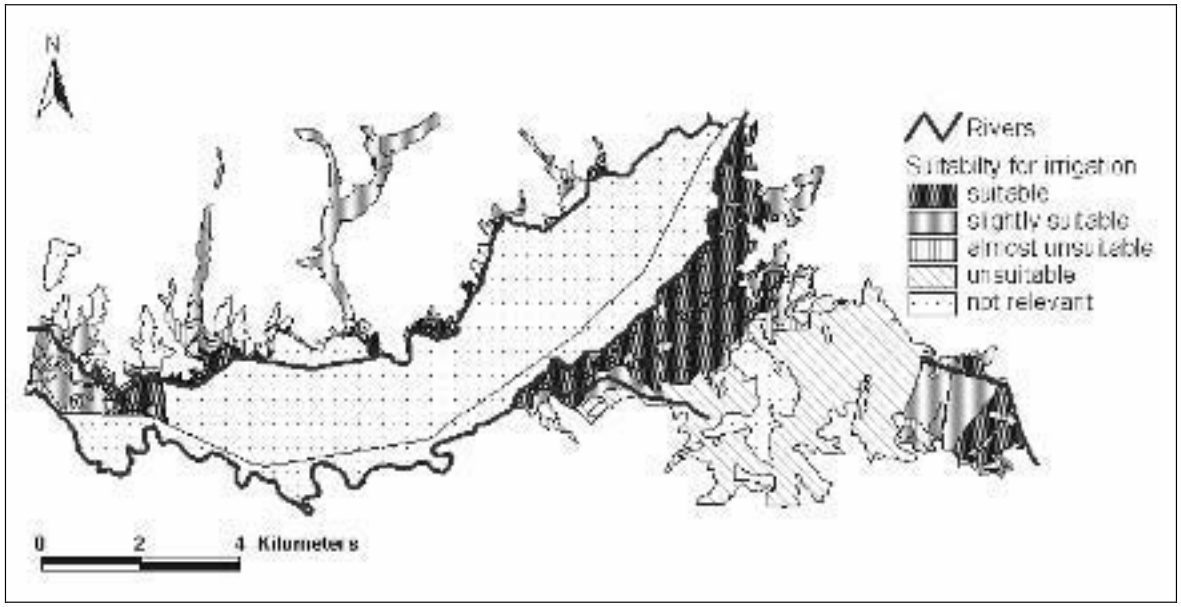

Figure 3: Irrigation capability classes in Herois de Caxito.

Table 6

Soil suitability for surface irrigation after flooding and artificial drainage control

Soil characte-ristics / Series	Topography (t)	Soil depth	Drainage /GWT depth saline,(w)	Soil physical condition (s)				Salinity and alkalinity (n)	Suitability for irrigation	
				Texture (0-1m)	Texture (1-2 m)	Carbonate	Gypsum		Rating (Ci)	Class and limitation
Buya	100	100	100	65	70	100	90	100	52	III, s
Ube	100	100	82	60	100	80	90	100	46	III, s
Quijanda	100	100	82	70	70	85	90	95	45	II, s, w
Sungue	100	100	70	80	70	80	90	100	44	III, s, w
Cume	75	100	100	80	100	80	90	100	57	III, t
Sassa	100	100	82	85	80	90	90	100	60	II, w
Ibendua	100	100	80	80	70	90	90	95	51	III, w, s
Dande	100	100	85	80	80	90	100	100	62	II, s
Caxito	100	100	85	100	80	90	100	100	70	II, s
Paranhos	100	100	100	70	60	90	100	100	48	III, s
Pinto	100	100	85	50	60	90	100	100	34	IV, s, w
Icau	100	100	85	50	60	90	100	100	34	IV, s, w
Morima	60	100	70	80	60	90	90	60	26	V, s, w, n

II: suitable; III: slightly suitable; IV: almost unsuitable; V: unsuitable; Ci: irrigation index

Table 7
Areas of irrigation capability classes in Herois de Caxito

Classes	Area (ha)	%
Moderately suitable (II)	2 534	40.7
Slightly suitable (III)	1 119	18.0
Almost unsuitable (IV)	369	5.9
Unsuitable (V)	2 198	35.4

clearly demonstrated in the series Buya, Cume, Sassa, Caxito, Paranhos, Quijanda and Ibendua.
The analysis of the soil fertility index and the irrigation index has demonstrated that the clayey texture and drainage are the main limiting factors in the majority of the surveyed soil units. About 40% of the soil units with good fertility for sugarcane production presents

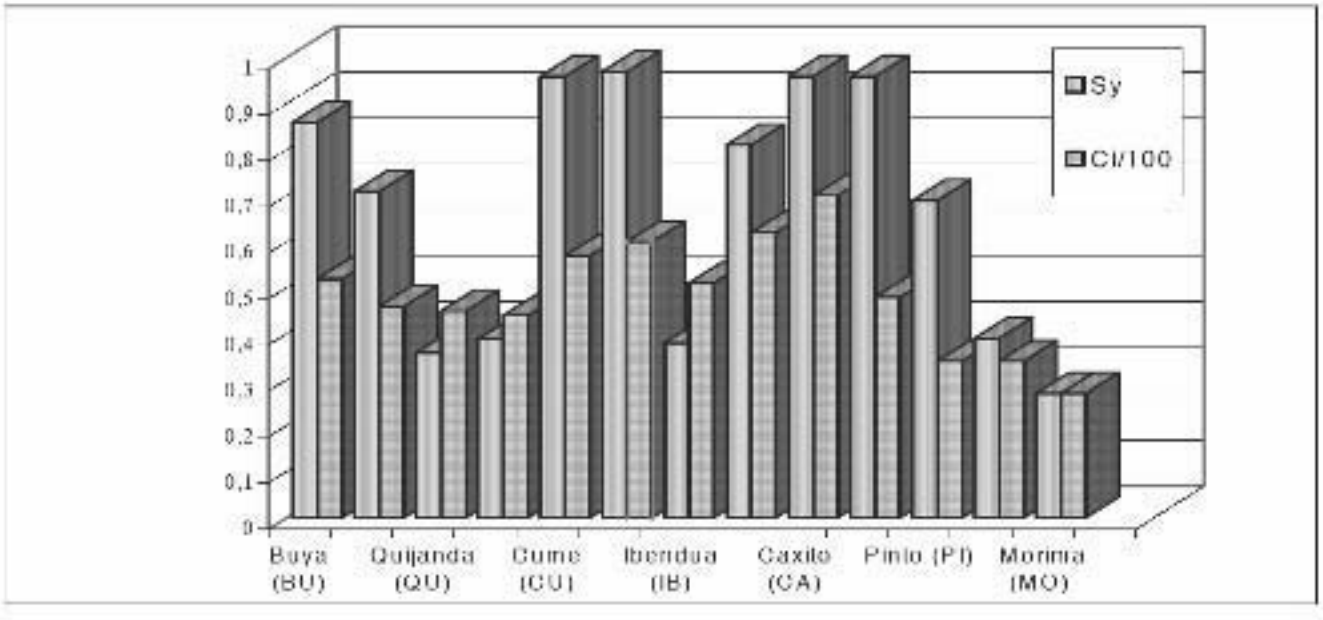

Figure 4: Combination of the soil index (Sy) and the irrigation capability index (Ci/100).

around 0.025 mg/l, does not constitute a constraint in the use of the water for irrigation of sugarcane.

Combination of the soil index and the irrigation capability index

The suitability for soils for cultivation and the suitability of soils for irrigation were combined in every soil unit to know whether a soil unit suitable for sugarcane cultivation is also suitable for irrigation. The results of the evaluation (Figure 4) indicate that soils with good fertility qualities present in many cases bad irrigable characteristics and vice versa, making the suitability for irrigation not ideal without reclamation. This is low suitability for irrigation. Dande and Caxito series are the best soils both for irrigation and sugarcane plantation and so 55% of the surveyed soils can be used directly for sugarcane plantation.

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AVIS

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Nous pensons ainsi, grâce à votre aide, pouvoir rendre un grand service à la communauté pour laquelle vous travaillez.

Merci.

BERICHT

Wij herrineren al onze lezers eraan, vooral diegenen in de ontwikkelingslanden ,
dat TROPICULTURA bestemd is voor ieder die werk verricht op het gebied van het platteland en dit in de meest ruime zin van het woord.

Daarom zou het nuttig zijn dat u ons de adressen zou geven van de Instellingen, Scholen, Faculteiten, Centra of Stations voor landbouwonderzoekvan het land of de streek waar U zich bevindt. Wij zouden ze kunnen abonneren, zo dit niet reeds gebeurd is.

Met uw hulp denken we dus een grote dienst te kunnen bewijzen aan de gemeenschap waarvoor u werkt.

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Prévalence de *Acidovorax avenae* subsp. *avenae,* agent des rayures bactériennes du riz dans les semences de base produites au Burkina Faso

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Résumé

Nous avons étudié, au DGISP (Danemark), l'incidence de Acidovorax avenae *subsp.* avenae *dans 9 échantillons de semences de base de* Oryza sativa *L. et un échantillon de semences d'une variété locale. La méthode de détection utilisée est le test des symptômes sur plantules élevées en boîtes de diapositives. Les 26 isolats obtenus des plantules infectées ont été identifiés sur la base de la morphologie des colonies, de la production de pigment fluorescent, des tests biochimiques et du pouvoir pathogène. Le système Biolog GN a permis de confirmer l'identification des isolats dont les indices de similarité avec* A. avenae *subsp.* avenae *varient de 0,51 à 0,9. Tous les 26 isolats réagissent positivement au test ELISA effectué avec l'antisérum dirigé contre* A. avenae *subsp.* avenae*. La bactérie est présente dans les échantillons de toutes les variétés à l'exception de celui de la variété locale. Des plantules issues des lots de semences infectées développent des symptômes typiques de la maladie des rayures brunes avec des taux d'infection allant de 4,7 à 20,1%. La prévalence de* A. avenae *subsp.* avenae *dans les semences de base nécessite qu'une stratégie de lutte efficiente soit développée en vue de réduire la propagation de l'agent bactérien dans d'autres zones rizicoles du Burkina Faso jusque-là indemnes.*

Summary

Prevalence of Bacterial Stripe Organism, *Acidovorax avenae* subsp. *avenae*, in Breeder Rice Seed Samples from Burkina Faso

Nine rice seed samples of improved and local varieties were tested at DGISP (Denmark) for the incidence of seed-borne bacterial stripe organism, Acidovorax avenae *subsp.* avenae*, using the cassette holder method. Twenty-six suspected bacterial colonies were identified by different methods including colony morphology, pigmentation, biochemical and pathogenicity tests. Using Biolog GN computer identification system, isolates were also identified as* A. avenae *subsp.* avenae *(sim 0.51 to 0.9). All the 26 isolates reacted positively in ELISA tests performed with antiserum against* A. avenae *subsp*. avenae*. The bacterium was detected in all the samples, except in that of the local variety, indicating that seeds of improved varieties are highly infected by this pathogen. Seedlings raised from infected seed samples showed typical bacterial stripe symptoms with infection rates ranging from 4.7 to 20.1%. Since such seeds are used for production of certified rice seed, it is important to develop an effective control strategy against this disease to reduce the propagation of the bacterial agent in other healthy regions of rice culture in Burkina Faso.*

Introduction

Le riz est la 4ème céréale cultivée au Burkina Faso en termes de superficie et de production. Bien qu'extrêmement importante pour l'économie nationale, la riziculture reste dans son ensemble peu développée. Elle est caractérisée par une variabilité inter-annuelle aussi bien en superficie emblavée qu'en production et en rendement. La production rizicole est confrontée à de nombreux problèmes phytosanitaires parmi lesquels les maladies occupent une place importante. De nombreuses maladies bactériennes ont été identifiées dans les pays producteurs de riz à travers le monde (4, 8, 13, 18). La maladie des rayures bactériennes, encore appelées rayures brunes, causée par *Acidovorax avenae* subsp*. avenae* (Manns) Willuns, Goor, Thielemans, Gills, Kerster, De Ley a été mise en évidence pour la première fois au Japon, à Taiwan et aux Philippines (2, 12). Elle peut attaquer le maïs, le petit mil, la canne à sucre et bien d'autres graminées (11). La maladie se manifeste sur les plantules de riz en pépinière par des rayures turgescentes qui prennent rapidement une couleur brune. Si l'infection est sévère, la plante demeure rabougrie ou meurt (8, 18). Les glumelles et l'endosperme subissent une décoloration et dans les cas extrêmes les grains pourrissent et ne se remplissent pas (18).

Bien qu'ayant fait l'objet de nombreux travaux à travers

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le monde, la maladie des rayures brunes n'est pas très étudiée en Afrique de l'ouest en général et au Burkina Faso en particulier. Des informations concernant l'incidence de *A. avenae* subsp. *avenae* sur le rendement et la qualité du riz n'y sont pas disponibles. La transmission de la bactérie de la semence à la plantule de riz et de la plante à la semence a été démontrée par Shakya *et al*. (15). Compte tenu des dégâts que peut causer cette maladie et de son mode de transmission, nous avons réalisé la présente étude en vue d'évaluer la prévalence de *A. avenae* subsp. *avenae* dans les semences de base de variétés de riz collectées dans la région ouest du Burkina Faso.

Matériels et méthodes

Echantillons de semences

Dix échantillons de semences de variétés de riz dont les caractéristiques sont inscrites dans le tableau 1 ont été analysés dans cette étude.

Neuf échantillons de semences de base proviennent du Programme Riz et Riziculture de l'INERA, Bobo-Dioulasso, Burkina Faso. Le dixième échantillon provient de la semence d'une variété locale obtenue auprès d'un producteur.

Souches bactériennes de référence

La souche de référence utilisée dans les tests biochimiques et biologiques est *Acidovorax avenae* subsp*. avenae* – Népal. Le témoin négatif utilisé pour le test ELISA est une souche de *Pseudomonas plantarii*. Ces souches ont été obtenues auprès de l'Institut du Gouvernement Danois de Pathologie des Semences (DGISP), Danemark.

Méthodes de détection de A. avenae *subsp*. avenae *dans les semences de riz*

L'échantillon de travail de 200 graines de riz est analysé pour apprécier le taux de graines décolorées et tachetées. Le test des symptômes des plantules en boîtes de diapositives (14) a été utilisé pour la détection de la bactérie. Deux morceaux de papier filtre rectangulaires de 4,5 cm² sont placés dans une fente sur deux de la boîte à diapositives. La boîte garnie de morceaux de papier filtre est placée dans un bac plastique contenant une solution azotée à 230 ppm d'urée. Après que les morceaux de papiers filtres aient été imbibés de la solution nutritive, quatre graines de riz sont déposées entre chaque double couche, à raison de 200 graines de riz par échantillon testé (soit deux boîtes à diapositives). Les bacs contenant les boîtes sont mis en incubation pendant 14 jours à 27-30 °C sous alternance de 12 heures d'obscurité et 12 heures de lumière blanche. Les bacs sont disposés sous plastique en vue de maintenir des conditions d'humidité (100%) favorables au développement de la maladie. Les symptômes provoqués par *A. avenae* subsp. *avenae* sont enregistrés à 14 jours après incubation et le nombre de plantules infectées par échantillon est évalué.

Méthodes d'isolement des bactéries

La méthode utilisée est celle décrite par Agarwal *et al.* (1). Quatre plantules manifestant les symptômes typiques de rayures brunes sur le coléoptile, sur les feuilles ou encore sur les gaines foliaires sont prélevées dans chaque échantillon pour l'isolement de *A. avenae* subsp. *avenae.* Des fragments d'organes de plantes prélevés dans les parties malades en incluant les parties saines sont placés sur une lame porte-objet dans des gouttes d'eau saline (0,85% de NaCl). Les fragments sont ensuite recouverts d'une lamelle et observés au microscope optique à des grossissements de 40-100 pour mettre en évidence les exsudats bactériens. Les échantillons présentant ces exsudats sont ensuite transférés dans quelques gouttes d'eau saline où ils sont trempés pendant 10-15 mn pour favoriser une sécrétion importante d'exsudats bactériens. Chaque suspension est étalée dans des

Tableau 1
Identité et origine des lots d'échantillons de semences des variétés de riz collectés en juillet 2000 dans la région ouest du Burkina Faso

Numéros des échantillons (DGISP)[a]	Variétés INERA	Types de riziculture	Localités	Types de semence
44734	FKR14	Irriguée/Bas-fond	Banfora	Base
44735	FKR 19	Irriguée/Bas-fond	Banfora	Base
44736	FKR 2	Irriguée/Bas-fond	Banfora	Base
44739	FKR 50	Irriguée/Bas-fond	Banfora	Base
44740	FKR 35	Pluviale	Farako-Bâ	Base
44741	FKR 33	Pluviale	Farako-Bâ	Base
44742	FKR 21	Pluviale	Farako-Bâ	Base
44744	FKR 16	Irriguée/Bas-fond	Niangoloko	Base
44746	FKR 28	Irriguée/Bas-fond	Banfora	Base
44747	ND	ND	Bobo-Dioulasso	Locale

[a] Echantillons répertoriés et déposés à l'Institut du Gouvernement Danois de Pathologie des Semences (DGISP), Danemark. ND: Non déterminé.

boîtes de Pétri contenant du milieu B de King (KB) et du milieu 'nutrient agar' (NA) de manière à obtenir des colonies individualisées. Les boîtes ainsi ensemencées sont mises à incuber en position renversée à 25-30 °C pendant 1-3 jours. Seules les colonies présentant les caractéristiques morphologiques semblables à celles de *A. avenae* subsp. *avenae* sont purifiées par des séries de transferts de colonies individualisées sur les milieux KB et NA pour les tests ultérieurs.

Méthodes d'identification des colonies bactériennes

Méthodes biochimiques et biologiques

Les isolats bactériens retenus pour chaque échantillon de semences ont été identifiés sur la base de la morphologie des colonies (taille, forme, couleur) et de la production de pigment sur le milieu KB (fluorescence sous lumière ultraviolette). Les isolats non-fluorescents sont retenus pour la réaction de Gram en utilisant le test de solubilité dans une solution aqueuse à 3% d'hydroxyde de potassium (7), les tests de l'oxydase de Kovac's (5, 6), de la réduction de nitrate (3), de l'hydrolyse de l'amidon (7), d'hypersensibilité sur des plantes de tabac âgées de deux mois et de pathogénie sur le riz (10). Les suspensions bactériennes titrées à environ 10^6-10^7 ufc/ml sont injectées dans les tiges des plantules de riz âgées de 21 jours. Les plantules inoculées sont ensuite incubées en conditions d'humidité saturante (100%) sous bâche plastique pendant 4-7 jours à 28 °C.

Le système Biolog GN (Biolog Inc., Hayward, CA computer identification system, Release 4.0) a été également utilisé sur quatre isolats provenant de quatre échantillons de semences pour confirmer la similarité avec la souche de référence *A. avenae* subsp. *avenae* - Népal disponible à l'Institut du Gouvernement Danois de Pathologie des Semences (DGISP).

Méthode sérologique

Pour confirmer l'identité des isolats bactériens retenus après les tests précédents, le test ELISA (Enzyme-Linked Immunosorbent Assay) a été effectué en utilisant un antisérum dirigé contre *A. avenae* subsp. *avenae* de la banque des antiséra du DGISP. Le témoin négatif est constitué d'une souche de *Pseudomonans plantarii* prélevée dans la collection de l'institut. Les isolats sont étalés sur le milieu KB et incubés à 30 °C pendant 24 heures. Les suspensions bactériennes préparées dans l'eau saline et titrées à 10^5-10^6 ufc/ml sont utilisées pour le test ELISA. Les suspensions de chaque isolat sont déposées dans deux puits à raison de 100 µL par puits de la plaque ELISA. Quatre puits sont utilisés pour la souche de référence *A. avenae* subsp. *avenae* - Népal et quatre autres puits pour le témoin négatif *P. plantarii*. Les antiséra et l'anticorps IgG anti-lapin conjugué à la phosphatase alcaline sont dilués à 1:1000 et 1:500, respectivement. Le substrat est constitué de p-nitrophenyl phosphate dilué dans un tampon diethanolamine (5 mg/10 ml). L'absorbance a été évaluée par un lecteur ELISA (Dynatech MR 5000) à 405 nm. La déviation standard a été calculée en utilisant les valeurs de l'absorbance du témoin négatif. Les isolats sont considérés comme étant identiques à *A. avenae* subsp. *avenae* quand leurs valeurs d'absorbance sont plus grandes que celle de la moyenne du témoin négatif augmentée de cinq fois la déviation standard (T).

Résultats

Valeur culturale des échantillons de semences

Les pourcentages des semences décolorées, de plantules manifestant des symptômes de rayures bactériennes et le taux de germination des semences des 10 échantillons analysés sont illustrés dans la figure 1.

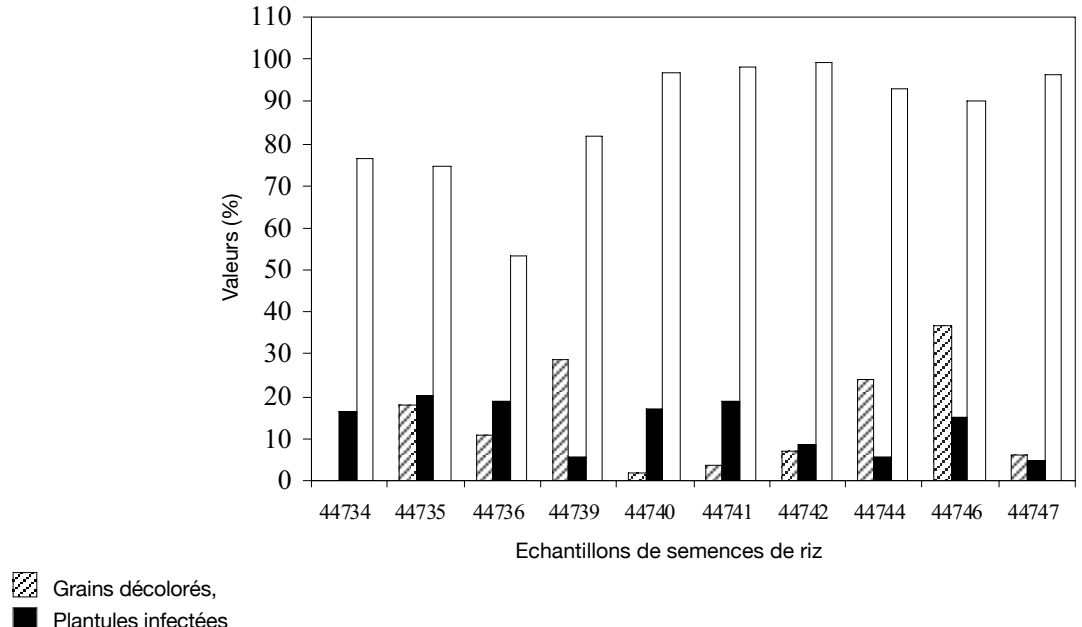

Figure 1: Valeur culturale de 10 échantillons de semences des variétés de riz collectés au Burkina Faso.

A l'exception de l'échantillon 44734 (FKR 14), tous les autres échantillons présentent des semences décolorées et tachetées à des taux variant de 2 à 37%. Les échantillons 44740 (FKR 35), 44741 (FKR 33), 44742 (FKR 21) et 44747 (variété locale) manifestent les plus faibles taux de décolorations et taches sur les semences. Les symptômes typiques comme les rayures brunes, les brunissements sur le coléoptile ou le jaunissement des feuilles sont observés dans tous les échantillons testés. Les pourcentages de plantules manifestant les symptômes de rayures bactériennes varient de 4,7% pour l'échantillon 44747 (variété locale) à 20,1% pour l'échantillon 44735 (FKR 19). En dehors des échantillons 44734 (FKR 14), 44735 (FKR 19) et 44736 (FKR 2) dont les taux de germination sont en dessous de 80%, les sept autres lots de semences présentent des taux variant de 81,5 à 99% correspondant aux variétés FKR 50 (44739) et FKR 21 (44742).

Caractérisation des souches

Des isolats bactériens n'ont pu être obtenus que sur 9 des 10 échantillons variétaux testés. Chaque isolat provient d'une plantule présentant des symptômes typiques de rayure brune. Des souches bactériennes ont été isolées de toutes les plantules présentant des symptômes typiques de rayure brune et provenant des échantillons 44734 (FKR 14), 44735 (FKR 19), 44744 (FKR 16) et 44746 (FKR 28). Aucun isolat n'a pu être obtenu de la variété locale (échantillon 44747). Un nombre variable d'isolats a été collecté dans les autres échantillons. Les isolats de *A. avenae* subsp. *avenae* présentent de petites colonies de couleur gris blanchâtre à blanches, translucides sur le milieu NA et non-fluorescentes sur le milieu KB sous lumière ultraviolette (données non présentées). Elles sont Gram négatif et réduisent le nitrate avec une réaction positive à l'oxydase (Tableau 2).

Tableau 2
Prévalence de *Acidovorax avenae* subsp. *avenae* dans les plantules de riz obtenues des semences naturellement infectées collectées au Burkina Faso

Isolats	Réaction de Gram[a]	Tests biochimiques[b]			Biolog[c] [I. S. (P.)]	RH/Tabac[d]	Pathogénie sur le riz	ELISA[e]
		Oxydase	Nitrate	Amidon				DO à 405 nm
A. a. avenae Nepal	-	+	+	-		+	+	0,64
44734-1	-	+	+	+	0,80 (92)	+	+	0,93
	-	+	+	+	NT	+	+	0,87
2	-	+	+	+	NT	+	+	0,77
3	-	+	+	+	NT	+	+	0,86
4								
44735-1	-	+	+	+	0,51 (62)	+	+	0,92
	-	+	+	+	NT	+	+	1,03
2	-	+	+	+	NT	+	+	0,93
3	-	+	+	+	NT	+	+	1,00
4								
44736-1	-	+	+	+	0,71 (95)	+	+	0,87
2	-	+	+	+	NT	+	+	0,34
44739-1	-	+	+	+	NT	+	+	0,58
	-	+	+	+	NT	+	+	0,62
2	-	+	+	+	NT	+	+	0,45
3								
44740-1	-	+	+	+	NT	+	+	0,73
44741-1	-	+	+	+	0,76 (98)	+	+	0,49
2	-	+	+	+	NT	+	+	0,48
44742-1	-	+	+	+	NT	+	+	0,58
2	-	+	+	+	NT	+	+	0,47
44744-1	-	+	+	+	NT	+	+	0,77
	-	+	+	+	NT	+	+	0,78
2	-	+	+	+	NT	+	+	0,66
3	-	+	+	+	NT	+	+	0,74
4	-	+	+	-	NT	+	+	0,68
44746-1	-	+	+	-	NT	+	+	0,47
2	-	+	+	-	NT	+	+	0,74
3	-	+	+	-	NT	+	+	0,63
4								

[a] Test de solubilité dans une solution aqueuse à 3% de KOH; [b] Oxydase de Kovac's, Réduction de nitrate, Hydrolyse de l'amidon; [c] Biolog GN version 4.0, I. S. (P.): Indice de similarité et probabilité, NT: non testé; [d] Réaction d'hypersensibilité sur le tabac; [e] Test ELISA avec T= 0,27 et la moyenne du témoin négatif (*Pseudomonas plantarii*)= 0,17; DO= Densité optique.

Le test d'hydrolyse de l'amidon a donné des résultats mitigés dans la mesure où sur les 26 isolats testés, quatre isolats (15%) provenant exclusivement de l'échantillon 44746 (FKR 28) réagissent négativement comme la souche de référence *A. avenae* subsp. *avenae* - Népal. Les 22 autres isolats (85%) hydrolysent l'amidon. Tous les isolats infiltrés dans les feuilles de tabac produisent au bout de 24 heures une réaction d'hypersensibilité caractérisée par une nécrose sèche brun clair. Après inoculation à des plantules de riz, tous les isolats ont provoqué des rayures bactériennes typiques, qui dans certains cas se manifestent par des brunissements des nervures principales des feuilles.
Les feuilles ainsi affectées jaunissent. L'identification suivant le système Biolog GN a permis de mettre en évidence une très grande similarité de la plupart des isolats analysés avec la souche de référence (Tableau 2). Les lectures de densité optique à 405 nm obtenues en utilisant le tampon du substrat comme la référence zéro et la souche de *P. plantarii* comme le témoin négatif, donnent des valeurs variant de 0,34 à 1,03 pour les isolats testés (Tableau 2). Le témoin négatif a une valeur DO= 0,17 alors que celle de la souche de référence *A. avenae* subsp. *avenae* - Népal est de 0,64. Tous les 26 isolats testés se sont révélés positifs au test ELISA puisque toutes les valeurs de densité optique sont supérieures à la valeur T= 0,27.

Discussion

Au Burkina Faso, des trois types de riziculture pratiqués, les types irrigué et de bas-fond sont les plus prédominants. Sur certains périmètres aménagés, au moins deux cycles de riz sont produits par an. Quel que soit le type de riziculture, la plupart des producteurs conservent une partie de la récolte de la campagne antérieure. L'agent responsable des rayures bactériennes peut dans ces conditions se maintenir pendant longtemps dans les semences de riz et en affecter le pouvoir germinatif; ce qui expliquerait les faibles taux de germination enregistrés dans les échantillons de semences de riz irrigué testés et dont certains présentent des taux élevés de décolorations et taches. La combinaison des effets des infections dues à *A. avenae* subsp. *avenae* et de ceux causés par certains champignons comme *Alternaria padwikii* et *Bipolaris oryzae* (données non publiées) serait à l'origine du faible taux de germination des semences (en dessous de 80%) des variétés FKR 14, FKR 19 et FKR 2. Les semences de riz certifiées devant être indemnes de toute infection de ces agents pathogènes, nos résultats établissent pour la première fois au Burkina Faso, que les semences de base produites par la recherche agricole ne sont pas indemnes de l'agent des rayures bactériennes. En effet, les plantules issues des semences de 9 variétés testées ont montré des symptômes typiques de rayures bactériennes. La maladie se manifeste par des rayures brunes ou lésions brunes sur le coléoptile, la gaine pouvant s'étendre à la nervure principale de la feuille. Occasionnellement, les feuilles ont présenté des jaunissements et certaines plantes infectées sont plus petites que les plantes normales. L'ensemble des tests biochimiques et biologiques appliqués aux isolats obtenus des différents échantillons a montré que l'agent des rayures bactériennes est présent au Burkina Faso. Le système Biolog GN et le test ELISA appliqués aux 22 souches réagissant positivement à l'hydrolyse de l'amidon confirment qu'elles sont identiques à *A. avenae* subsp. *avenae*. Nos résultats indiquent une certaine variabilité à l'intérieur des populations de *A. avenae* subsp. *avenae,* que des études ultérieures devraient contribuer à étayer. Des résultats similaires ont été obtenus au Népal et en Iran où différents sérovars de l'agent des rayures brunes du riz ont été mis en évidence (11). La bactérie est présente aussi bien sur les périmètres irrigués que dans les zones de bas-fond, en témoigne la typologie des variétés infectées. *A. avenae* subsp. *avenae* est également détectée sur le riz pluvial. Si Shakya *et al.* (16) montrent que la maladie des rayures brunes du riz est largement distribuée dans le monde, nous démontrons pour la première fois la prévalence de cette maladie au Burkina Faso (17). Elle affecte les plantules en pépinières aussi bien en riziculture pluviale qu'irriguée et une forte humidité favorise le développement de la maladie (9). La présence de la bactérie dans les semences de base de variétés de riz vulgarisées nécessite que des solutions idoines soient trouvées pour son contrôle. L'infection par cette bactérie peut avoir un effet persistant sur les rendements et la qualité des semences de riz produites au Burkina Faso. En effet, Shakya *et al*. (16) ont détecté la bactérie dans des semences conservées à 5 °C pendant 8 ans. Cette maladie pourrait alors compromettre à moyen ou à long terme la production rizicole d'autant plus que le Service National des Semences ne dispose pas de structures adéquates pour vérifier la qualité sanitaire des semences certifiées actuellement. Il apparaît urgent d'évaluer au champ l'incidence réelle de la maladie des rayures brunes, aussi bien en pépinières que sur les plaines rizicoles. Par ailleurs, des méthodes de lutte sont à développer pour limiter ou éviter la propagation de la maladie à travers les échanges de semences d'une région infestée vers d'autres régions qui seraient encore indemnes. Pour améliorer un tant soit peu la qualité sanitaire des semences de base de riz dans le schéma actuel de production, la thermothérapie à 65 °C pendant 6 jours comme le préconisent Zeigler et Alvarez (19) permettrait d'atténuer les effets néfastes de la maladie des rayures bactériennes.

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Analysis of Constraints to Agricultural Production in the Sudano Savanna Zone of Cameroon and Implication for Research Priority Setting

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Keywords: Diagnostic survey- Sudano savanna- Sudano sahelian zone- Cameroon- Constraint- Production systems- Sustainable production- Research priorities

Summary

A participatory rural appraisal (PRA) survey approach was used to identify the major constraints to agricultural production and to describe the major production systems in the sudano savanna and sudano sahelian zone of northern Cameroon. Relative emphasis was placed on the household level characterization to have a better understanding of the land use system, farmers' constraints to production and opportunities, so as to better target agricultural technologies and interventions in this vast agro-ecological zone. It was noted that, large variations exist in agriculture management practices between agro-ecological zones, among villages and households in terms of access to resources, such as labour, fertilizers, livestock, farm equipment, and land. Intensive and extensive farming practices might co-exist within the same village and households. The mains sources of vulnerability were identified. Results are used to set research priorities which will be directed towards the need of the majority of area's population; the improvement of sustainable food and feed crop production.

Résumé

Analyse des contraintes à la production agricole dans les zones de savane soudanienne du Cameroun et l'implication pour la prioritisation des thèmes de recherche

Une approche de diagnostic participative a été utilisée pour identifier les principales contraintes à la production agricole et caractériser les principaux systèmes de production dans les zones de savane soudanienne et sahélienne du nord Cameroun. L'accent a été mis sur la caractérisation au niveau du ménage pour mieux comprendre les systèmes d'utilisation des terres, les contraintes et les possibilités des paysans afin de mieux cibler les technologies et les interventions pour cette vaste zone agro-écologique. On a observé des grandes variations dans les pratiques de gestion agricole entre les zones agro-écologiques, les villages et les exploitants en terme d'accès aux ressources comme la main-d'œuvre, les engrais, le bétail, les équipements agricoles. Des pratiques de culture intensives et extensives peuvent co-exister au sein d'un même village et ménage. Les principales faiblesses ont été identifiées. Les résultats ont été utilisés pour prioritiser les thèmes de recherche qui devront répondre au besoin de la majorité des populations des zones concernées: une amélioration durable de la production agricole.

Introduction

Cameroon is situated on the west coast of Africa between latitudes 2^0 and 13^0 N and between longitude 8^0 and 16^0 E. It is characterized by a great climatic diversity ranging from the humid tropics near the coast where annual rainfall exceeds 3000 mm to the sahelian zone with 600-900 mm of precipitations, and a dry season of 9 to 10 months. Mountains and plateau areas affect both rainfall and temperature, breaking the regular succession of climatic zones from south to north. The potential for agricultural production is large and opportunities for increased agricultural development exist in the four main agro-ecological zones, each with its unique characteristics.

The Sudano-Savanna zone alone extends between latitude 7^0 30' and 13^0 N and longitude 9^0 to 15^0 and is characterized by a large eco-climatic diversity in terms of biophysical (climate, soils, hydrology,) and socio-economic (land, labors, resources, marketing and tenure practices) conditions. There are more than 60 ethnic groups in this region. The climate is of the type AW/BS in the Köppen classification (tropical humid with dry winter/semi-arid) (16). The rainfall pattern is unimodal with the peak in August. The rainy season lasts four months from June to September with two intermediate months of unreliable rainfall in May and October. Mean total annual rainfall is approximately

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750 mm and the length of the growing periods is 120 to 150 days with infrequent droughts. Annual temperatures range between 29 ^{0}C and 39 ^{0}C. The lowest mean temperatures occur between December and January, with the cold dusty harmattan winds. The major rainfed cereals are sorghum and millet; maize, groundnuts, cowpea, vegetables and rice are additional staple food crop; cotton is the predominant cash crop.

Cropping systems are based on sorghum and millet; but with increasing population densities and fertilizer prices, the quest for alternative, yet productive and sustainable production systems becomes more important. The key factor of production in any agricultural system is labor. It is the human investment, which transforms land and capital assets into consumable output. Different societies have fashioned different patterns of labor organization at different stages of their development. In northern Cameroon, the coexistence of Moslem and non-Moslem ethnic groups allows an analysis of several different patterns of organization. The land use systems and production strategies adopted by farmers depend on the interaction between biophysical and socio-economic resources available to them. A better understanding of environment in which these farmers operate and their constraints would help in sharpening the focus of research through adequate planning and characterization of agriculture environments and land uses; this will lead to the concentration of efforts on key commodities and promising areas of agricultural potentials.

The main objectives of this study were to identify constraints to production in the sudano savanna and sahelian zone of northern Cameroon and subsequently prioritize research and development themes.

Materials and methods

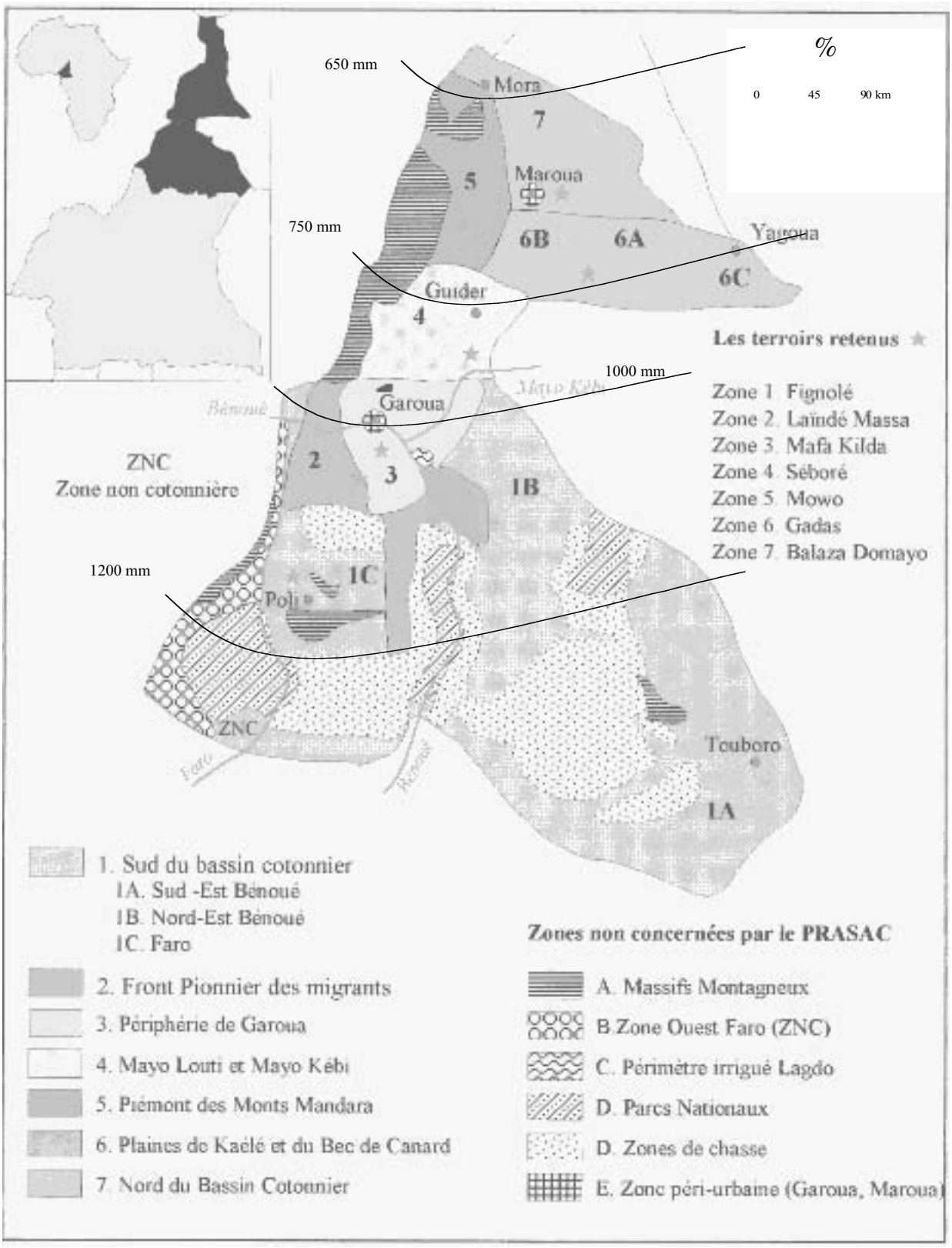
A research team of the Institute of Agricultural Research for Development (IRAD) conducted the research jointly with the Extension service of the Ministry of agriculture. The study area covered a total of seven villages selected from two distinct agro-ecological zones in the northern Cameroon. Four of the selected villages (Fignolé, Laindé, Mafa kilda, Séboré) were from the north province administrative region, representing the sudano savanna agro-ecological zone, and three villages (Mowo, Gadas, Balaza Domayo) from extreme-north province administrative region (Figure 1) representing the sudano sahelian zone. These villages were chosen to represent the agro-climatic and socio-economic diversity of the region.

Figure 1 provides the location of the selected villages and Table 1 the biophysical details. Others factors used in selection were the accessibility, annual rainfall and representations of main production systems. A total of 100 households were selected in the seven villages. Areas where dry season commercial gardening activities are known to be highly developed were avoided. Table 2 describes the basic characteristics of the two zones and each village. To collect information from the local farmer, several different methods were used sequentially. The study was initiated by conducting a Participatory Rural Appraisal (PRA) from October to December 2000. Activities of households were monitored. The second step was collection of information by means of single and group interviews to verify the information previously collected. Additional interviews with the household heads were held to determine their farming practices and resource endowments. In order to optimize the process, a series of pre-coded questionnaires was developed, modified from the Food and Agricultural Organization's Farm management data collection and Analysis computer package (5). The use of questionnaires provides a systematic, ordering way of obtaining precise statistical data from respondents. Information required included:

- Inventory of household members and livestock assets;
- Livestock management and utilization of range lands;
- Field characteristics and enumeration of area cropped per field;

Table 1
Location and selected biophysical details of the seven villages in northern Cameroon

Province	Ecological zone	Villages name	Village coordinates		Main soil type	Rainfall range (mm)
North	Sudano savanna	Fignolé	8°30'	13°10'	Lixisols/sandy Lixisols	1000-1500
		Laïndé	9°20'	13°19'	Sandy clay	1000-1200
		Mafa- Kilda	9°15'	13°28'	Lixisols Hydromorphic	900-1000
		Séboré	9°35'	13°60'	Lixisols Vertisols	800-1000 1000
Extreme north	Sudano sahelian	Mowo	10°10'	14°10'	Hydromorphic Vertisols	700-800
		Gadas	10°15'	14°25'	Sandy clay Vertisols	600-700
		Balaza – Domayo	10°45'	14°35'	Sandy clay	



Source: IRAD/PRASAC Méthodologie du diagnostic global au Cameroun (2000).

Figure 1: Location of the studied village in the northern Cameroon.

- Intercropping patterns and crop rotations;
- Land use practices and tenancy arrangement.

Farmers were also asked to provide information on: break down of labour stock, labour profile and utilization, animal traction used and fertilizer quantities distributed per field.

Information was collected not only from the head of the household but, also from each family member who cultivated his or her own field.

Table 2
Selected characteristics of the seven villages in the sudano savanna and sahelian zone of Cameroon

Agro-ecological zone	sudano savanna				sudano sahelian		
Region	Cotton belt	Pioneer	Garoua zone	Mayo louti and mayo kebi	Piedmont of mandara mountain	Plain of Kaélé, Bec de canard	Plains of diamaré, Mora zone
Villages	Fignolé	Laïndé	Mafa kilda	Séboré	Mowo	Gadas	Balaza Domayo
Population	800	680	900	1000	1350	1570	200
Density (Hab./km^2)	5-10	10-30	20-60	30-70	50-180	30-180	30-180
Total Household	160	150	170	170	180	240	45
Household selected	15	10	15	15	15	20	10
Working members/family	4	4	4	4	5	7	4
Farm size (ha)	2.5	2.9	3.1	4.0	2.5	1.6	2.2
Animal traction	8 POC	10 POC	55 POC	3 POC	40 POC	40 POC	3 POC
Fallow (years)	2 to 3	1	2	2 to 3	None	none	none
NPK (on crop)	Cotton, maize	Cotton, maize	Cotto, maize	Cotton, maize	Cotton	Cotton	Cotton
Manure (kg ha^{-1})	none	none	none	120	396	520	650
Cattle	130		140	400	300	300	200
Goat/sheep	560		400	300	1000	-	300
Donkey	13	11	10	-	100	15	20
Animal husbandry	Mbororo Transhumance Semi-sedentary	Mbororo Transhumance Semi-sedentary	Sedentary Transhumance	Sedentary Transhumance	Semi–sedentary	Sedentary	Semi-sedentary Transhumance

POC= Pairs of cattle used for plowing and transport

Results and discussion

Rainfall

The sudan-savanna zone of northern Cameroon may be subdivided into three sub-ecological zones. The sahelo-sudanian zone with rainfall less than 700 mm, the sudano-sahelian zone where the rainfall varied from 700 mm to 900 mm and the sudano-guinean zone where rainfall varies from 1000 mm to 1200 mm. The growing periods of the sudano-sahelian zone vary from 100 to 150 days while for the sahelo-sudanian zone it varies from 60 to 100 days. All zones are characterized by large inter-annual variability. Monthly variation is important since rainfall is usually limited to few months, i.e. June to October. Aridity prevails during the rest of the year and is most pronounced from November to April. The rainfall is variable and unreliable. As one moves north, the rains begin progressively later and end earlier. Rainfall variability, especially late starting and early cessation of rain often results in a shortened growing season. Effective moisture for plant growth is reduced by high evapotranspiration and runoff. The drought spells become more and more frequent. At the scale of agro-ecological zone, the mean annual rainfall during 1999 and 2000 cropping season varied between 1100 mm in sudano-savanna zone to 650 mm in the sudano-sahelian zone. According to Nicholson (9), the potential for development of these zones is limited not only by total rainfall, but also by other, less commonly considered characteristics of the area's rainfall such as spatial variability, intensities, infiltration and runoff.

Soils

Overtime, the various process of soils formation have given rise to important pedological heterogeneity of this part of Sudan savanna zone (Table 1). Based on a 1:100 000 soil map from ORSTOM (10) and translated to FAO classification, three major soil types maybe distinguished:

Vertisols: they are heavy textured soils having more than 30% clay at least to a depth of 50 cm, wide and deep cracks at some time of the year and a specific morphology characterized by one or more of the following three criteria: gilgai microrelief, intersecting slickensides, and wedge-shaped structural aggregates (2). They have low available water holding capacities because they may hold water and nutrients so tightly that they become unavailable to plants even though they have high total water holding capacities. The most extensive vertisols may be found between

the 600 and 900 mm isohyets. They cover 1 200 000 ha, that represents 12% of north Cameroon's land area and 2,5% of total country (3).
Lixisols: they are reddish brown and show the translocation of clay from the surface horizon to the sub soil horizons. The structure is massive with sandy clay loam texture. A common feature of these soils is low organic matter content; cation exchange capacity (CEC), and low nutrient content, especially N and P.
Hydromorphic soils are found in pockets in all zones in the northern Cameroon. These soils have fluctuating water tables and occur in small valley bottoms and flood plains. They are sandy loam or loamy clay. Farmers recognized these three types of soil.
Others factors that may influence soil physical properties in the region include the very high intensity of rainfall and its erosive power. Rains are very strong and aggressive and cause intense erosion, which lead to significant runoff as well as prolonged condition of superficial soil water logging. Farmers maintain soil fertility through application of inorganic fertilizers, mixed cropping practices and animal manure. The quantities are, however insufficient to meet crop requirements. Land degradation through overgrazing and also degradation through overgrazing and also deforestation is common in most parts of the region.

Land use right and production patterns
Crop production increases in the region have primarily come from increases in the cultivated area. Land use comprises cereal-based cropping, cotton-based cropping and ruminant-based livestock activities with considerable variability between agro-ecological zones (Table 1). Averaged over ecological zones, farm sizes decreases as one moves from the sudano savanna to sudano sahelian zone. Agricultural land falls into two discrete categories: rainy season fields and dry season fields. In the less crowded villages, farmers' rainy season fields are usually located around the compound. Cotton, the region's primary cash crop, is grown in large blocks subdivided into plots of 0.25 ha. SODECOTON (Société pour le Développement du Coton au Cameroun) the largest industrial force in the region, which organizes all phases of cotton production and marketing has organized the block system in order to standardize plot sizes and facilitate the use of animal traction and chemical inputs. In principle, the sites of the blocks are rotated each year to allow villages to contribute land to common. Very little land if any is left to fallow on a regular basis.
The cultivation of dry season sorghum crop commonly called "Muskwari" is a unique feature of northern Cameroon agricultural systems. Seedlings are taken from their rainy season nursery beds one month after planting and transplanted into vertisol, which are heavy clay soils, known as "Karal" fields. These "Karé" (plural of Karal) are normally completely flooded during the rainy season, and completely unworkable. As the rains taper off, these heavy clay soils are prepared for transplanting of dry season sorghum seedlings. The moisture absorbed by these swollen vertisols from May to September plus the cup of water added at transplanting time will sustain the sorghum (Muskwari) plant for five next months without a single additional drop of water. Dry season sorghum is recognized to be one of the preferred grains for consumption by the majority of the region's population and has grown in importance, particularly because cotton cultivation sometimes competes with sorghum for land and labor during the rainy season. As the demand for dry season sorghum increases, so does the demand for heavy clay soils (Karé). A farmer's field can be much further away from his house. Because of the great competition for vertisols, they figure more prominently in the land rental market, than do rainy season food grain or cotton fields.
In all villages studied, tenure over land is not always secure. All lands belong to the village chief. He distributes control of land to his deputies (Djooros). They in turn oversee the allocation of usufructuary rights to farming families. Land is neither formally rented nor sold, but farmers in need of extra land can borrow field from a neighboring household or from a village chief to use during the growing season. The usufructuary rights to land are effective only during the cropping season. In the dry season, the itinerant livestock herders are free to search for forage and crops residues on all fields that are not enclosed. According to Azarya (1) the 1963 land tenure legislation reinforced the traditional right to land ownership by collective units, even though they are not actually cultivated by those units. This practice is still in force today. Land use is intense and holding are very small. Average cultivated area per household is just about one ha, but more that 50 percent of holdings are smaller than one ha.
Farmers use all their land to grow crops, and there is virtually no grazing land available for livestock during the rainy season. Most fertile lands have already been put under cultivation. To increase or maintain production levels, farmers have extended cultivation into more marginal lands. The growing land constraint in the area of higher population density has caused a breakdown of the traditional fallows system used for maintaining soil fertility. The shortening of fallow cycles without adequate replenishment of soil nutrients through the use of organic and inorganic inputs have caused cereal yields to decline. Increased cultivation on bush fields and the reduction of the fallow period have implications for sustainable long-term production. In addition the growing land constraint in the area of higher population density suggests that extensification of agricultural practices will no longer be feasible solution to increase agricultural production, but that intensification of agricultural production should be sought.

Cropping systems
Cropping systems in the two zones are mainly based on sorghum, cotton, and maize (Table 3).

Table 3
Cropping systems in the seven villages in the sudano savanna and sahelian zone of northern Cameroon

Agro-ecological zone	sudano savanna zone				sudano sahelian zone		
Villages	Fignolé	Laïndé	Mafa kilda	Séboré	Mowo	Gadas	Balaza domayo
Types							
Sole crops							
Sorghum	3	2	3	4	14	15	12
Cotton	8	9	6	8	10	10	8
Maize	10	8	6	6	4	-	1
Groundnut	6	7	9	9	3	4	4
Cowpea	2	1	1	2	6	5	10
Muskwari	0	0	0	1	9	10	8
Sub-total	29	27	25	30	46	44	43
2-Crops mixture							
Sorghum/groundnut	-	-	6	11	7	5	8
Sorghum/cowpea	0	-	1	-	5	8	8
Cotton/groundnut	12	9	10	10	9	8	7
Millet/cowpea	0	0	0	-	0	2	0
Cotton/maize	12	3	9	14	-	0	0
Cotton/sorghum	4	5	9	-	9	10	12
Cotton/cowpea	9	8	6	8	11	9	9
Sub-total	37	25	41	43	41	42	44
3-crops mixture							
Cotton/maize/grndt	12	12	9	10	-	0	-
Cotton/sorgh/grndt	7	10	8	4	4	1	2
Cotton/sorgh/veget	-	6	1	-	1	-	-
Maize/cotton/veget	9	8	9	8	-	-	0
Sorgh/grndt/cotton	-	3	5	4	1	-	2
Sorgh/cowp/cotton	2	0	2	-	-	-	1
Sorgh/grndt/cowp	-	5	-	-	1	-	2
Sub-total	30	44	34	26	7	1	7
Others	3	4	-	1	6	13	6
Total	100	100	100	100	100	100	100

Sorgh= sorghum; Cowp= cowpea; grndt= groundnut; veget= vegetable

On the south-north axis, the importance of maize decreases and that of sorghum increases, while cotton remains the major cash crop regardless of geographical position. A typical rotation involves cotton and sorghum; groundnuts may enter into this succession on lighter soils. Although continuous cultivation of some fields for up to twenty years or more has been reported, fallows last up to three years depending on location and scarcity of land. In the region, major food crops are sorghum, maize, groundnuts and cowpea. Minor crops include sesame, vegetables, Bambara-nuts grown in a variety of intercrop. Sole crops are predominant in the sudano savanna zone were the use of herbicide for weed control is important; but variability in surface cultivated at both provinces and villages is considerable. Small – scale farmers produce the bulk of total output in the region, the size of farm holding varies from 1 to 3 ha (Table 2).

In low rainfall zones that is in the sudano sahelian zone, the most important cropping systems is the two-crop system: cotton/maize; cotton/sorghum; cotton/cowpea; sorghum/groundnut; sorghum/cowpea and millet/cowpea (Table 3) on sandy clay and hydromorphic soils. On heavy textured soils (vertisols), the most frequent cropping system is muskwari/muskwari. Other important enterprises specific to some location include: muskwari/cotton/sorghum and cotton/sorghum/muskwari.

The three-crop system and others patterns are most common in the sudano savanna zone (Table 3) with higher rainfall, more fertile lixisols and low population density; these included: cotton/maize/groundnut or

cotton/sorghum/groundnut; cotton/sorghum/vegetables; maize/cotton/vegetables; sorghum/groundnut/cotton; sorghum/cowpea/cotton; sorghum /groundnut/cowpea. The dry season sorghum (muskwari) where it is being cultivated does not enter in any rotation. Flat plowing of fields is the most common practice of land preparation after field have been cleared and burned.
Farmers were asked about the source of their crop seed and the factors influencing their choice of varieties. It was revealed that farmers stored rainy season sorghum, dry season sorghum (muswkari), maize, and cowpea seeds from their previous harvest or bought seeds on local markets. Groundnut seeds are more commonly bought on the market than those of the other crops. Cottonseeds are provided by the industry (SODECOTON).
The varieties of sorghum, maize and cowpea are chosen for their yield of grain as well as for by-product depending on the specific needs of the farmer. Livestock keeping farmer will chose a variety yielding high amounts of by-product, thereby integrating fodder production with grain production. Other criteria used in the choice are availability of seeds or length of the growing period. In any case, food self-sufficiency and risk avoidance for the farm families are among the principal objectives. A mixture of several sorghum varieties may be planted in the same field to extend the harvesting period and minimize risk of failure. The species, varieties and mixtures of crops grown on particular soils depended on how farmers rate the crop production potentials of the soils. The main source of vulnerability is drought, declining soil fertility, weeds (striga) leading to crop failure.
Because of poor distribution systems and high cost, farmers seldom apply chemical fertilizer on food crops. Farmers look for alternatives to fallow to maintain soil fertility, as extensive techniques of soil fertility maintenance become inadequate to boost crop production. Farmers prepare their manure in the compounds on the basis of droppings from ruminants and crop residues. Because the quantity of manure produced by farmers is usually insufficient to cover the whole farm in any given years, it is only applied to specific spots in the field with each field receiving manure in average every two to three years. However, nutrient transfer from the rangeland to the cropland through farmyard manure application or corralled animals is an important strategy for maintaining soil fertility. To better deal with the scarce manure, farmers take into account the slope of the field to minimize run-off and the risk of “crop burning” on newly manured plot in case of low rainfall in the early growing period. In year of abundant rainfall, spot that has received manure will produce high yield, whereas in years of little or poorly distributed rainfall plots which has received less manure will still produce minimal yields. According to the farmers, the second year of intensively manured spots results in better crop yields without risk of burning. Hence, such difference in soil fertility on one single field would help to reduce risk of crop losses and equalize yield variations. Brouwer et *al*., (4) reported similar use of micro-variability for millet planting as a risk aversion strategy in Niger and argued that farmers aim for reliable but not maximum yields even in years of poor rainfall.

Labor force
Labor is the most limiting factor in resource – poor farming systems. The amount of land a family can cultivate is constrained by the amount of labor available to it. Any expansion of production must come either from an increase in the amount of available labor including hired labor or from an increase in labor productivity through technological innovation. The use of animal traction for land preparation is the most common technological advance encouraged by development agencies and adopted by farmers. It is widely practiced in the sudano savanna zone where land availability is important. This practice reduces human labor input and alleviates drudgery. Family members provide the bulk of farms labors. Small-scale agriculture in the sudano sahelian zone is highly labor intensive because farms sizes are smaller and all the farm operations are done manually.
General knowledge holds that there are different patterns of labor organization by ethnicity in northern Cameroon. Thus non-foulbé household rely to a greater extent on family labor and community labor. They do not resort to hired labor. Between the foulbé and non-foulbé, a market exits for hired labor. Generally, labors are hired for cotton and muskwari cultivation and the only outside labor input for rainy season sorghum is hired for harvesting of grain. Labor requirement vary considerably in the course of the year. The agricultural calendar year starts in May with clearing and carry the manure to the fields. The onset of rains and subsequent sowing is between June to early July. During these periods labor use is important.

Animal husbandry
Livestock constitutes an important component of agricultural production systems in the region. Serving as a store of wealth and a source of cash for the purchase of seasonal inputs in agricultural activity. That is, pastoralism and mixed-crop livestock farming are at the two ends of a continuum of livestock production systems found in the region (Table 2). The main species are cattle, goat, sheep and donkey. These animals are kept on-farm for ploughing, manure and farm transport. Animals are grazed extensively by family members or entrusted to Mbororo herders. The mixed farmers keep 2 to 5 heads of cattle and 5 to 10 sheep, while Mbororo pastoralists keep 20 to 50 cattle and 20 to 50 sheep and goats. Women tend to keep smaller ruminant such as sheep or goats. In the

highly populated mountains regions, cattle and small ruminants are stall-fed during the rainy season. This labor-intensive activity appears to be an ecologically well-adapted means of raising animals in the face of land scarcity and also complements intensive crop production in the mountains (11).

Livestock production in pastoral systems of sudano savanna zone is based on periodic movements of cattle in search for pastures and water (Table 2). However, pastoralist change their production strategies in accordance with their perception of environmental conditions, which may require occasional movements of short duration or seasonal transhumance lasting several months (6, 15). During the rainy season, the most used practice consists of moving animals into drier areas of the arid zone to take advantage of the flush of high quality forage produced by annual grasses. During the dry season, pastoralists attempt to access enough water, crop residue and forages to maintain the productive capacity of their herds (12). Within each season they take advantage of the patches of pasture that produce more forage either due to higher soil moisture or fertility (14). This traditional transhuman production system appears to be in a state of transition and is becoming increasingly difficult to sustain. The problem is not simply of too many animals relative to available grazing areas. Long periods of below average rainfall, recurrent severe droughts and animal health problems have decreased pastoralists' herds. In addition, in many parts of the region, farmers have taken over the best grazing lands and converted them into cropland. This process has been accompanied by the increasing cultivation of valley bottoms, which has restricted pastoralists movement and prevented them from using these areas as trekking routes or pasture during the dry season. This phenomenon is common in all semi-arid regions of West Africa (17). The net effect has been a reduction in total pasture area and seasonal inaccessibility to remaining pastures due to diminution caused by cropping. Farmers-herders' conflicts increase as access paths to local (transhumance) pastures are obstructed. In densely populated zones such as piedmont of mont mandara, plain of Diamaré and plain of Kaélé, livestock and crop systems have become more integrated and cropping intensity as well as labor input increase with population density. Small ruminant increase whereas cattle decline. Livestock feeding becomes more labor intensive because of the scarcity or complete loss of natural range. Crop residue, cut grass and browse are gathered to feed livestock kept in confinement. The mains source of vulnerability are feed and water availability, especially during the dry season, leading to animal health problems and the distress sale of assets.

Mixed crop-livestock production systems in the sudano sahelian zone are growing in importance as population pressure rises and demand for arable land increases. There is however evidence which indicates that irrespective of the extent of integration of crop and livestock production, many of the direct benefits of closer integration are small (7, 13). The notable benefits in improved soil quality and fertility, as a result of manuring and the use of animal traction may not always result in large increases in crop yields due to low output response of available crop varieties and the inadequate quantities of manure applied. This implies that along with closer crop-livestock interactions, new technology development involving breeding adapted high yielding varieties, increase soil fertility under sustainable input conditions and improvement in feed production are needed to raise overall agricultural productivity.

Future research need

Within this ecological zone, crop combinations and rotations vary widely in response to local conditions. The complex cropping strategies of traditional systems contribute to their stability, diversity, as well as their productivity. It is probably not possible to substitute simplistic production packages. Therefore, the objective should be to improve components within the system, which includes better varieties, agronomic practices and develop strategies to maintain high soil fertilities. In the drought prone zone, a key priority will be to reduce the likelihood of crop failure through improved land husbandry and water harvesting; plus utilization of more efficient crop combinations involving drought tolerant cultivars, and early maturing varieties.

The effects of each cropping system on soil productivity and cultural operations such as weed control need to be better understood. Similarly, understanding factors that affect crop-water balance, such as plant type, plant density, soil moisture and soils preparation techniques are essential. The resource-use patterns of sorghum/cotton/leguminous sole and intercropping systems are yet to be adequately studied. Understanding the of cropping patterns on soil fertility and water-use efficiency, particularly those that have an impact on moisture loss due to soil evaporation will be important when developing strategies to improve and stabilize crop productivity in the region. Of equal importance is the development of integrated control methods for *striga* and other weed. In the livestock sub-sector, research on animal productivity should focus on feeding strategies, the utilization of crop residues and by-products, the utilization of locally-adapted breeds and the control of epizootics diseases. Forest regeneration is necessary for sustainable fuel wood supplies.

Conclusion

This study was carried out in seven villages located in the north and extreme north province of Cameroon using the rural appraisal survey on the basis of the

following aspect: crop and livestock husbandry, land, labor and climatic conditions. It is recognized that all aspect of variability could not be captured, but with this survey, constraints and opportunities were better identified. It may be observed that, in general high population growth and large number of rainfall deficit years have encouraged extensification of arable farming and heightened the competition between grazing and cropping systems. The unpredictability of the rainfall patterns makes the timing of plow-planting absolutely critical. Moreover, the cultivation of marginal lands and changes in farming systems (e.g. no or shorter fallows) have rendered farmers more vulnerable to climatic risk. In this contest, expansion of cultivated areas to marginal and fragile environments may no longer be a feasible solution to increase agricultural production; therefore the intensification of practiced agronomy should be in order. In most areas, land allocation to agricultural production is hindered by lack of exclusive use rights and land tenure insecurity. Common property or access to large land area is desirable in this case, since it can reduce production losses in poor rainfalls years.

It is in light of these developments that technologies are urgently required which fit in with the land-use systems of resource-poor farmers and which do not destroy the natural resource base. Increase in food crop, feed production and quality are needed not only to improve human nutrition and livestock production in the region but also to provide the needed energy for economic growth and poverty alleviation. The integration of grain and forage legumes can serve an important role in sustaining the production of crop and livestock in the region. To this end, mixed crop-livestock systems can be seen as offering a solution to the crisis of pastoralism and extensive cropping in the region specifically and generally in all the semi-arid region of the west Africa (8).

The multiple problems identified will not be solved without stronger and more stable government commitment to research. The National Agricultural Research program and extension services must find ways of increasing adoption where existing technology has shown promise, while developing new models where it has failed. These goals are essential and involve not only direct support, but also policy decision that recognize that technological change is a dynamic process endogenous to the economy, and that successful adoption is not simply a function of research and extension, but is highly correlated with policy and the effective development of the overall institutional framework.

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The Resistance of Farmers' rice Varieties to Rice Yellow Mottle Virus (RYMV) at Badeggi, Nigeria

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Keywords: Resistance- Farmers- Rice- Varieties- Rice Yellow Mottle Virus- Nigeria

Summary

Forty-eight farmers' rice varieties and 12 improved and released varieties were screened in the screenhouse at the National Cereals Research Institute (NCRI) Badeggi, Nigeria by mechanical sap inoculation for their resistance to Rice Yellow Mottle Virus (RYMV). The rice varieties were categorized into 4 groups: highly susceptible, moderately susceptible, moderately resistant and resistant, based on standard evaluation scale (SES) for rice. Back-inoculation tests to a highly susceptible variety, Bouake 189 and enzyme linked immunosorbent assay (ELISA) showed that none of the varieties was immune to RYMV. The highly susceptible varieties displayed conspicuous yellow, mottle and stunting symptoms of RYMV. Many varieties were highly susceptible to RYMV and elicited high virus titre. Most of these farmers' varieties are either highly susceptible or moderately susceptible to RYMV.

Résumé

La résistance des variétés traditionnelles de riz aux virus de la panachure jaune de riz (RYMV) à Badeggi, Nigeria

Quarante-huit variétés traditionnelles de riz et douze variétés améliorées de riz vulgarisées, ont été criblées dans la serre de l'Institut national de recherche des céréales (INRC) à Badeggi au Nigeria par inoculation mécanique de la sève pour leur résistance aux virus de la panachure jaune du riz (RYMV). Les variétés de riz testées ont été classées par catégorie dans 4 groupes: très sensible, modérément sensible, modérément résistant et résistant, sur base de l'échelle standard d'évaluation (ESE) pour le riz. La rétroinoculan sur une variété très sensible, Bouaké 189, et le test ELISA ont montré qu'aucune des variétés testées n'était immune au RYMV. Les variétés très sensibles ont présenté des symptômes typiques de la panachure jaune (jaunissement et rabougrissement). Plusieurs de ces variétés très sensibles au RYMV ont également montré un taux élevé de virus. La plupart des variétés de ces fermiers sont très sensibles ou modérément sensibles au RYMV.

Introduction

The *Oryza* species *O. glaberrima* Steud., *O. sativa* L., *O. longistaminata* Chev. and Roehr, *O. barthii* Chev. and *O. punctata* Kotsky and Steud are found in west African rice ecology (21). *O. glaberrima* is said to be indigenous to west Africa (24) and has been in cultivation for the past 3500 years (16, 23). *O. sativa* was introduced into west Africa in about 1890 (12, 30). Another report had it that *O. sativa* was first brought to Madagascar from Indonesia and then to east and west Africa in the 1950s (22).

Rice Yellow Mottle Virus (RYMV) was first noticed in November 1966 along the shores of the Kavirondo Gulf of Lake Victoria, Kenya where the disease had probably been present for a number of years on grass hosts (10). It was noticed in west Africa in 1975 (25) and was subsequently detected in Nigeria in the 1980s (26). The disease is widespread in Africa including Nigeria (3, 5).

RYMV is transmitted by mechanical contact and inoculation of sap (1, 2, 10). The virus is also transmitted by beetles and insects with chewing and biting mouthparts (2, 3, 10). It belongs to the sobemovirus group (17, 27) and is very stable and highly infectious to rice (14). The virus causes a severe disease of rice in most rice growing countries in Africa and its adjourning islands (3). Yield loss ranges from 25 to 100% depending on the date and time of infection as well as the genotype (9).

It has been documented that RYMV is indigenous to Africa (15) and it came to the limelight with the introduction of exotic rice varieties from southeast Asia coupled with intensification of cropping practices without dry season gaps (29). The area originally affected in Kenya was part of a new irrigation project which had led to an increase in rice cultivation due to the availability of water for sequential planting throughout the year (10, 29). It was under similar conditions that RYMV was reported on rice in west Africa in 1975 (25). This situation as well as lack of extensive adaptive testing of the exotic rice varieties in their new environments, led to the disruption of apparent equilibrium established between host local

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rice and RYMV (13). Much traditional African rice such as *O. glaberrima* has been found to have higher level of resistance to RYMV than *O. sativa* (7, 23).
Many improved rice varieties have been released to farmers by National Cereals Research Institute (NCRI) in Nigeria (16). However, the constant cultivation of supposed landraces with local names alongside some new introductions released to or held on by the farmers during on-farm trials has thrown a doubt as to true identity of these landraces. It has also been noticed that most farmers named varieties after either the person or organization that introduced them (6). It is generally believed that local landraces should be more tolerant to stresses than newly introduced exotic varieties (7, 23) because they have co-evolved and became adapted to the environments (29).
The objective of this study is to evaluate the resistance levels of farmers' rice varieties collected from farmers' rice fields in some states in central zone of Nigeria.

Materials and methods

The source of improved and local rice varieties

The varieties with local names were collected from farmers' fields at harvest time while some released improved varieties were obtained from the Genetic Resources Unit of Rice Division, National Cereals Research Institute (NCRI) Badeggi.

The source and maintenance of RYMV isolate

The virus isolate was obtained from infected rice plants in a farmer's field at Edozhigi near Bida, Niger state, and was maintained on Bouake 189, a highly susceptible rice variety, in the screenhouse at Badeggi by serial sap inoculations at the seedlings stages. The virus was designated as "Edozhigi RYMV strain".

Preparation of virus extracts and inoculation procedure

For serial sap inoculations, virus extracts were prepared from virus infected leaves of rice plants. Infected leaves were ground in an electric blender (6 g leaf-tissue/100 ml of distilled water i.e 6% w/v). The virus extracts were finger rubbed on test rice varieties previously dusted with carborundum (600 mesh) to allow virus penetration into leaf tissues. In order to avoid possible escapes from infection, all plants were re-inoculated twice at 2-day intervals as described by Thottappilly and Rossel (28). Twenty-five seedlings of each test variety were first inoculated at 45 days after seeding (DAS) in the screenhouse at Badeggi. Thirty cm diameter plastic pots were filled with 2 kg Fadama topsoil, and three pots were used for each treatment. The seedlings were thinned to five plants per pot. About 3.4 g of NPK (25-10-10) fertilizer was dispensed in each pot at seedling stage when they were 5 weeks old. Some improved rice varieties with known levels of resistance to RYMV (4, 8, 28) were included in the test to serve as reference checks (See footnote on table 2).

Scoring for RYMV

The Standard Evaluation Scale (SES) of 1-9 (18) for RYMV was used to rate the entries at 80 days after planting (DAP). The rating was based on height reduction, mottle and yellow symptoms of infected leaves where 1-3 represents green leaves with sparse dots or streaks and 5 represents green leaves or pale green leaves with mottling. A score of 7 represents pale yellow or yellow leaves whereas 9 represents yellow or orange leaves and some plants dead.

Back-inoculation test

The back-inoculation on Bouake 189, a highly susceptible variety, was carried out at 35 days after inoculation (80 DAP). Sap from leaves of infected plants of every test entry extracted in distilled water as described previously was inoculated to five carborundum dusted 25 days old seedlings of Bouake 189. The leaves were dusted with carborundum prior to inoculation to aid virus penetration into leaf tissues. The back-inoculation tests were rated by ELISA (13, 20).

Enzyme linked immunosorbent assay (ELISA) procedure

ELISA of leaf samples was carried out to evaluate and determine the virus titre in the inoculated rice plant (28). The indirect triple antibody sandwich (TAS) ELISA as described by Koenig and Paul (20) and modified by Virology Unit International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria was followed. The wells of ELISA plates were coated with 100 ul/well of polyclonal antibodies raised in rabbits against RYMV at $^{1}/_{500}$ dilution in coating buffer (1.5 g sodium carbonate, 2.93 g sodium bicarbonate, 0.20 g sodium azide dissolved in 900 ml H_20 and adjusted to pH 9.6 with HCl to make up to 1 litre) and incubated at 37 °C for 2 hours. The plates were then washed three times with phosphate buffered saline-Tween (PBS-T) (8.0 g sodium chloride, 0.2 g monobasic potassium phosphate, 1.15 g dibasic sodium phosphate, 0.2 g potassium chloride, 0.2 g sodium azide dissolved in 900 ml H_20 and adjusted to pH 7.4 with HCl to make up to 1 litre + 0.5 ml Tween 20 per litre) and tapped dry. The sites on the well where antibodies were not adsorbed were blocked with 200 ul of 5% w/v solution of non-fat milk (Marvel, UK) dissolved in distilled water and incubated at 37 °C for one hour. The plates were inverted and allowed to drain. Then 100 ul of sap macerated from 1 g leaf in 10 ml PBS-T + 2% w/v polyvinyl pyrollidone (PVP) were put in each well and left overnight in the refrigerator at 4 °C. The plates were again washed three times with PBS-T and 100 ul of monoclonal antibody (Mab) reared against RYMV at a working dilution of 1:1000 diluted in PBS-T was added to each well of the plates and incubated at 37 °C for 2 hours. The plates were washed further three times with PBS-T. Then 100 ul of goat anti-mouse IgG alkaline phosphotase diluted in conjugate buffer was added per well and incubated at 37 °C for 2 hours. It was

further washed three times with PBS-T and 200 ul of 1 mg/ml of p.nitrophenyl phosphate substrate tablets dissolved in substrate buffer (97 ml diethanolamine 600 ml H_20, 0.2 g sodium azide adjusted to pH 9.6 with HCl and make up to 1 liter with H_20) was added to each well. The plates were incubated at 37 °C and the colour change in the substrate quantified at A405 nm with a DYNEX MR ELISA micro-reader after 1 hour. Absorbance values (A405 nm) were accepted as positive when the reading was greater or equal to twice the mean absorbance of the non-infected control rice sample.

Table 1
Morphological characteristics, visual scores and ELISA values of some farmers and researchers' varieties

S/No	Varietal names	Location/ Village	States	Agronomic Characteristics			RYMV score	ELISA Values (A405 nm)
				Days to 50% Flow.	Plant height (cm)	Pan/m ^{2}		
1	Tomawawagi	Gubata	Niger	89	102	260	7(MS)	1.19
2	Ebangichi	Badeggi		88	89	250	9(HS)	1.61
3	Saganuwangi	Kanko		93	91	200	9(HS)	1.96
4	Tomako	Kusotachin		102	97	240	9(HS)	1.84
5	Ladanci	Doko		89	101	165	7(MS)	1.48
6	Ebangichi	Kusotachin		86	88	220	7(MS)	1.92
7	Nasara	Bidakowangi		65	105	205	5(MR)	0.72
8	Gyanako	Kusotachin		113	105	225	5(MR)	0.87
9	Ebangichi	Gbadafu		103	127	275	7(MS)	1.51
10	Toma	Doko		89	98	325	9(HS)	2.16
11	Egwazawunkpa	Doko		86	103	225	9(HS)	1.25
12	Finiko	Gbadafu		98	113	315	7(MS)	1.70
13	Philippines	New Bussa		85	87	200	9(HS)	1.84
14	Danmale	New Bussa		89	70	310	5(HS)	1.83
15	Gargaza	New Bussa		82	87	195	7(MS)	1.49
16	Mass	Dwarfu		106	103	215	7(MS)	1.77
17	Ebangichi	Edozhigi		83	88	205	7(MS)	1.69
18	Jufangi	Kanko		82	68	185	9(HS)	1.97
19	Faro-Sipi	Gbadafu		96	98	220	9(HS)	1.83
20	Somazhigi	Doko		86	102	285	5(MR)	1.28
21	Gabaci	Gbadafu		82	138	160	5(MR)	0.83
22	Dokoci	Doko		97	104	190	5(MR)	0.59
23	Manbeci	Kanbari		107	119	210	3(R)	0.35
24	Shankuyagi	Kusotachin		86	119	190	7(MS)	1.22
25	Ndawodzufanci	Sheshi Audu		89	116	145	9(HS)	1.90
26	Bokuchi	Doko		75	122	150	7(MS)	1.62
27	Gyanako	Chanchaga		105	124	200	9(HS)	1.68
28	Shagari	Gubata		75	122	220	7(MS)	1.44
29	Ebangichi	Kanko		82	113	190	5(MR)	0.83
30	Bisalane Yakolo	Chanchaga		103	78	270	2(R)	0.26
31	Eyewawagi	Kusotachin		100	117	180	2(R)	0.31
32	Nnakashi Kpanti	Dwarfu		114	118	195	2(R)	0.29
33	Mambechi	Edozhigi		82	117	140	2(R)	0.26
34	Ndacelegbo	Dwarfu		101	134	180	2(R)	0.37
35	Dubbu 1	Ndabissan		86	104	190	2(R)	0.35
36	Faran Kaura	Birnin Kebbi	Kebbi	98	134	205	3(R)	0.30
37	Akpuruka	Ndabissan	Niger	100	88	275	7(MS)	1.66
38	Jarankaura	Birnin Kebbi	Kebbi	79	106	150	5(MR)	1.17
39	Ndabisangi	Ndabissan	Niger	98	97	125	7(MS)	1.66
40	Kpuruga	Gaza		75	98	170	5(MR)	1.14
41	Danboto	Birnin Kebbi		82	88	165	5(MR)	0.74
42	Gbagudu	Tufa		107	123	270	9(HS)	1.90
43	Pasankunya	Tufa		76	122	285	2(R)	0.28
44	Janiri	Birnin Kebbi	Kebbi	105	137	175	7(MS)	1.55
45	Manbekochi	Ndabissan	Niger	82	102	250	7(MS)	1.55
46	Bubanfari	Birnin Kebbi	Kebbi	98	83	235	5(MR)	1.43
47	Ebangichi	Gadza	Niger	82	90	270	5(MR)	0.36
48	Dubu 2	Ndabissan		101	93	155	5(MR)	1.50
49	Nasarawa 1	Lafia	Nasarawa	96	88	190	7(MS)	1.95
50	Ndachele	Ndabissan	Niger	107	131	140	2(R)	0.30
51	Maiada	Birnin Kebbi	Kebbi	103	132	175	5(MR)	0.51
52	FARO 44	NCRI, Badeggi	Niger	92	96	228	9(HS)	1.83
53	LAC 23			93	118	100	2(R)	0.31
54	Suakoko 8			115	119	245	2(R)	0.28
55	FARO 52 (WITA 4)			97	102	175	7(MS)	1.61
56	FARO 27			99	98	288	5(MR)	1.48

HS= Highly Susceptible, MS= Moderately Susceptible, MR= Moderately resistant, R= Resistant, According to IRRI (1996)
ELISA= Enzyme linked immunosorbent Assay. Numbers 1 - 51 are varieties with local names while numbers 52 - 56 are varieties with researchers names.

Results and discussion

Some of the agronomic characteristics, RYMV score and ELISA values of the test varieties are presented in table 1. It indicated high diversity in days to fifty percent flowering, ranging from early to very late maturing. Many entries are dwarf to intermediate (70 to 120 cm) in height while few exhibited tall height (about 130 cm). The number of panicles per square meter ranged from 100 to 325. It was significant to note that all the tested cultivated rice varieties harbored the virus and none was immune although many of these varieties are cultivated widely in northern part of Nigeria (5), hence the spread of RYMV.

The results of the screening showed that 13 varieties were highly susceptible, 17 moderately susceptible, 14 moderately resistant and 12 resistant to the virus (Table 2). The highly susceptible varieties displayed conspicuous yellow, mottle and stunting symptoms of RYMV. Other varieties in this group exhibited stunted growth and eventually died. The local landraces exhibited similar symptoms of RYMV to those exhibited by the improved varieties such as Bouake 189, IR5, and FARO 44 (Sipi 692033) classified in the same group. As mentioned by Thottappilly and Rossel (28), the ELISA result corresponded with the visual rating based on SES scale. The varieties that showed conspicuous yellow mottle symptoms in the highly susceptible group contained high virus titre. Some varieties in moderately resistant group such as Nasara, Somazhigi, Ebangichi (Kanko), Dubu 1 and Dubu 2 however contained high virus titre in ELISA yet they exhibited mild and less conspicuous visual symptoms.

It was found that many farmers' varieties had similar agronomic characteristics and groupings to the improved released varieties (Tables 1 and 2). It is possible that most of these varieties with local names are not actually landraces but improved and released varieties which have lost their identity over time through the deliberate re-naming of such varieties by farmers. It is also possible that the farmers' variety called "Philippines" might have been a lowland indica introduced from southeast Asia. The indica

Table 2
Resistance levels of farmers' varieties with local names to Rice Yellow Mottle Virus (RYMV) as determined by visual evaluation scale, ELISA and back-tests in the screenhouse at Badeggi, Niger State, Nigeria

Groupings of varieties into categories	Reaction rating (SES) [1]	ELISA (A405 nm)	Back-test inoculation test[2]
Highly susceptible (HS)			
Toma, Faro-Sipi, Ndawodzufanchi, Ebangichi (Badeggi), Philippines, Gyanako (Chanchaga), Danmale, Egwazawunkpa, Saganuwangi, Tomako, Bouake 189, IR5, FARO 44 (Sipi 692033)	9 (HS)	+++	+++
Moderately susceptible (MS)			
Tomawowagi, Landaci, Ebangichi (Kusotachin), Ebangichi (Gbadafu), Ebangichi (Edozhigi), Finiko, Gargaza, Mass, Shankuyagi, Bokuchi, Akpuruka, Ndabisangi, Janiri, Manbekochi, Nasarawa1, FARO 52, FARO 29 (BG90-2)	7 (MS)	+++	+++
Moderately Resistant (MR)			
Nasara, Gyanako (Kusotachin), Somazhigi, Gabaci, Dokoci, Ebangichi (Kanko), Kpuruga, Danboto, Bubanfari, Ebangichi (Gadza), Dubu 2, FARO 27, FARO 40, Suakoko 8	5 (MR)	++	+++
Resistant (R)			
Manbechi (Kanbari), BisalaneYakolo, Eyewawagi, Dubbu1, Maiada (Birnin Kebbi), Nnakashi kpanti, Manbeci (Edozhigi), Ndacelegbo, Faran Kaura (Birnin Kebbi), Ndachele, Moroberekan, LAC23	1-3 (R)	+	+++

[1]IRRI(1996) Standard Evaluation Scale (SES) for rice
[2]Back-inoculation test to a Highly Susceptible rice variety, Bouake 189
ELISA= Enzyme linked immunosorbent assay
Researchers' varieties used as checks in different groupings: Highly Susceptible (HS)= Bouake 189, IR5, FARO 44 (Sipi 692033); Moderately Susceptible (MS)= FARO 52, FARO 29 (BG90-2); Moderately Resistant (MR)= FARO 27, FARO 40, Suakoko 8; Resistant (R)= Moroberekan, LAC 23.

type varieties are highly susceptible to RYMV (3, 4, 9). Therefore, further classification of these varieties with local names should be made to ascertain their real identity so that they could be used as donors for breeding for resistance to RYMV in Nigeria.

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La multiplication végétative du goyavier (*Psidium guayava* L.) sous climat soudano sahélien du nord Cameroun

A. Hammasselbé*

Keywords: Guyava- Sahelian climate- Grafting- Layering

Résumé

*Le goyavier (*Psidium guajava *L.) est une plante fruitière particulièrement adaptée au climat du nord Cameroun. Après trois années de sélection massale dans l'antenne fruitière de Kismatari, la diffusion en milieu paysan du matériel végétal sélectionné était limitée par le manque des techniques de multiplication adaptées aux conditions agro-climatiques de cette station. Les résultats préliminaires des essais de multiplication végétative ont montré que le greffage et le marcottage aérien ne sont pas praticables dans les conditions rencontrées à la station fruitière de Kismatari. Le marcottage terrien est dans ce cas la technique de multiplication végétative à promouvoir pour la production massive du matériel végétal homogène pour satisfaire les besoins de la recherche et ceux du développement.*

Summary

Vegetative Propagation of *Guyava Psidium* L. Guavaya under Sudano Sahelian Climate in the North Cameroon

*Goyava (*Psidium guajava *L.) is a fruit tree, which is well suited to the climate of north Cameroon. After three years of mass selection at Kismatari fruit tree research station, release into farmers' fields of the high yielding selected plant material was not possible due to lake of multiplication techniques adapted to the agro-climatic conditions of this fruit tree station. Preliminary results of vegetative propagation trials showed that grafting and aerial layering are not practicable at Kismatari station. Terrestrial layering is the most adapted multiplication technique for a massive production of homogeneous plant material to meet research and farmers' needs.*

Introduction

L'intérêt que revêt la multiplication végétative est évident dès que l'on désire multiplier rapidement et avec certitude un sujet d'élite présentant de hautes potentialités de rendement et d'autres caractéristiques susceptibles d'augmenter la rentabilité de la culture fruitière (1).

Sous climat soudano sahélien, la réussite au greffage et au marcottage dépend des espèces végétales, des conditions du milieu de production des plants et de la technicité disponible; le faible taux d'humidité de l'air dû à des fortes chaleurs a handicapé le bouturage des arbres fruitiers (4). Le greffage et le marcottage qui sont possibles ont été expérimentés sur les goyaviers de la collection provisoire de l'antenne de Kismatari en vue de choisir et mettre au point des techniques de production du matériel végétal homogène et de haut potentiel génétique pour satisfaire les besoins de la recherche (mise en place d'une collection définitive de goyaviers) et ceux du développement (diffusion massive du matériel végétal de haute qualité).

Matériel et méthodes

Un essai «mode de greffage» et un test de marcottage du goyavier ont été réalisés en 1992 dans l'Antenne fruitière de Kismatari (9° 19´ N, 13° 28´ E), 180 m d'altitude, située à 12 km de l'est de la ville de Garoua.

L'essai «mode de greffage» comptait deux facteurs étudiés: types de greffe (G) et modes de repiquage des porte-greffe (R)

Le facteur types de greffe comptait 5 traitements:

G_1= greffe en écusson en T
G_2= greffe en écusson en ⊥ (T inversé)
G_3= greffe en écusson boisé
G_4= greffe en placage à un œil
G_5= greffe en fente en tête

Combinés factoriellement avec deux modes de repiquage des porte-greffe:

R_1= Repiquage en pots
R_2= Repiquage en terre

Donnant 10 traitements suivants: G_1R_1, G_1R_2, G_2R_1, G_2R_2, G_3R_1, G_3R_2, G_4R_1, G_4R_2, G_5R_1, G_5R_2.

Le test de marcottage comptait 2 traitements:

M_1= marcottage terrien
M_2= marcottage aérien

Les clones qui servaient de porte-greffe pour l'essai «mode de greffage» ont été choisis en fonction des résultats des tests de germination et de la disponibilité des semences récoltées dans la collection provisoire de goyaviers de Kismatari. Les clones retenus étaient: A_9, A_{16}, D_6, F_6, F_{29}, K_{19}, L_2, L_{28} . Le semis des porte-greffes a lieu en février, le repiquage en juillet suivi du greffage en août. La ligature était faite à l'aide du raphia. La déligature des greffes réussies étaient effectuée 2 semaines après le greffage. Pour les greffes

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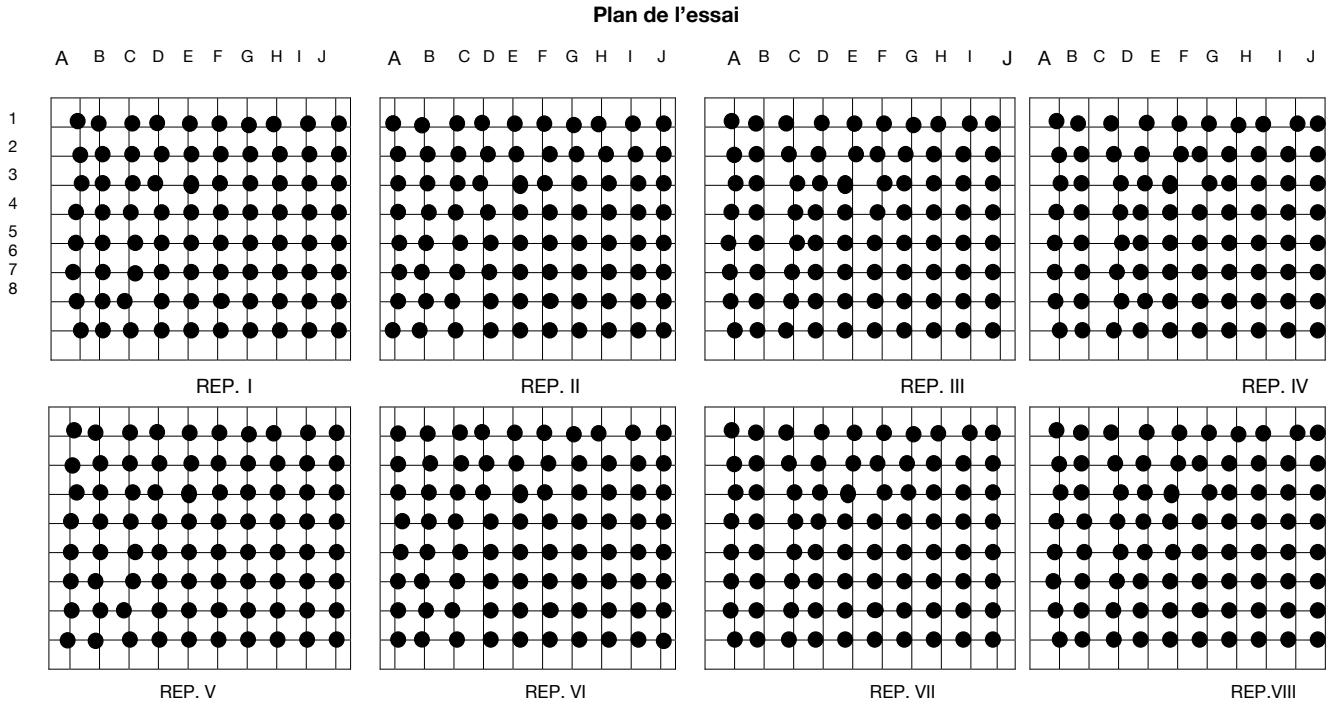

Les chiffres 1, 2, 3, 4, 5, 6, 7 et 8 représentent les lignes de variétés de porte-greffes réparties par tirage au hasard.
A_1, B_1, C_1…. J_1 représentent les 10 traitements répartis par tirage aléatoire.

en écusson, le rabattage partiel et le rabattage définitif étaient réalisés respectivement 2 semaines et 1 mois après le greffage. L'irrigation par aspersion était faite deux fois par jour en saison sèche et une fois par jour en saison des pluies pendant une heure. Le débit journalier était de 64 m^3/ha.
Les plants étaient fertilisés avec un mélange de scories (16-8) et de l'engrais complet pour coton (15-20-15) à la dose de 250 kg/ha (5 g/plant). La parcelle élémentaire était constituée de 8 lignes de 10 plants chacune. On a effectué 10 greffes par variété de porte greffe et 8 greffes par traitement par parcelle soit au total 64 greffes par bloc (voir le plan ci-plus haut).

Les dimensions de la parcelle élémentaire étaient de 6 m x 3 m. Les plants étaient repiqués à 25 cm entre les plants et 75 cm d'interligne soit 50 000 plants/ha. Le dispositif expérimental était le Factoriel (5 x 2) à 8 répétitions en blocs de Fisher.
Le marcottage terrien a été effectué sur 10 clones de goyaviers (A_{12}, B_{24}, B_{27}, D_{25}, E_{26}, G_{35}, J_{27}, J_{30}, K_{19} et L_{18}) en phase végétative ayant des rameaux de 5 à 8 mm de diamètre, pas trop vieux ni trop sèveux. Sur ces rameaux, on avait supprimé les feuilles sur 15 cm et coupé puis enlevé l'écorce sur 5 cm de longueur. Dans de petits sillons de 25 x 10 x 15 cm creusés au sol et préalablement remplis du fumier de ferme bien décomposé, on avait enterré les parties écorchées des rameaux. Ces rameaux étaient maintenus au sol par des fourches et des piquets. L'arrosage était fait une fois par jour à l'aide d'un arrosoir de 15 litres d'eau soit 5 l/m^2; le sevrage avait lieu 2 mois après la mise en terre. On avait réalisé 80 marcottes terriennes.

Le marcottage aérien était effectué sur 8 clones de goyaviers (E_{26}, G_{35}, J_{10}, J_{22}, J_{27}, J_{30}, K_{19} et L_{18}). Les critères de choix des rameaux, leur préparation, ainsi que le substrat de marcottage étaient identiques à ceux du marcottage terrien. Des sachets en polyéthylène suffisamment transparents pour permettre de contrôler l'enracinement étaient utilisés pour emballer le substrat préalablement bien mouillé; le sevrage avait lieu 2 mois après le marcottage. On avait réalisé 70 marcottes aériennes.
Les observations étaient faites uniquement sur le nombre total de greffes réussies à 2 semaines, 1 mois et 2 mois après le greffage et le nombre total de marcottes réussies à 2 mois après le marcottage. L'analyse de la variance (ANOVA) a été faite uniquement pour le nombre de greffes réussies au moyen du logiciel MSTAT (7) et la séparation des moyennes à l'aide du Test de Duncan (2)

Résultats et discussion

Essai mode de greffage

Les tableaux 1 et 2 présentent respectivement les résultats par traitement et les taux de réussite au greffage.

Le taux moyen de réussite au greffage des plants repiqués en terre (46% ± 17) est significativement ($P< 0,05$) supérieur à celui des plants repiqués en pots (26% ± 23). En effet, selon Hammaselbé, le repiquage en pots est une méthode classique de production des plants qui présente l'avantage d'une bonne économie de l'eau d'irrigation, d'une meilleure homogénéité de croissance des porte-greffes et d'une gestion plus

Tableau 1
Résultats moyens et taux de greffes réussies en relation avec les différents traitements

Traitements	Nombre de greffes réussies			Taux de réussite au greffage (%)			Effectif de départ
	Après 2 semaines	Après 1 mois	Après 2 mois	Après 2 semaines	Après 1 mois	Après 2 mois	
$G_1 R_1$	4	13	24	6,2	20,3	37,5	64 plants
$G_1 R_2$	2	12	27	3,1	18,7	42,2	64 plants
$G_2 R_1$	3	8	10	4,7	12,5	15,6	64 plants
$G_2 R_2$	5	11	45	7,8	17,2	70,3	64 plants
$G_3 R_1$	8	12	41	12,5	18,7	64,1	64 plants
$G_3 R_2$	5	5	39	7,8	7,8	60,1	64 plants
$G_4 R_1$	2	2	2	3,1	3,1	3,1	64 plants
$G_4 R_2$	0	5	17	0	7,8	26,6	64 plants
$G_5 R_1$	0	1	5	0	1,6	7,8	64 plants
$G_5 R_2$	1	7	20	1,6	10,9	31,3	64 plants
Moyenne	3,0	7,6	23,0				64 plants

Tableau 2
Résultats moyens et taux de réussite de greffe par facteur étudié (après 2 mois)

Mode de repiquage	Type de greffe					Taux de réussite	Ecart type
	G_1	G_2	G_3	G_4	G_5		
En pot (R_1)	37,5	15,6	54,1	3,1	7,8	25,6%	22,6
En terre (R_2)	42,2	70,3	60,1	26,6	31,3	46,1%	16,6
Taux de réussite	39,9	43	62,1	14,9	19,6	35,8%	

rationnelle de la pépinière (4). Mais, selon Sizaret, il a l'inconvénient d'un mauvais développement des plants qui sont plus susceptibles au stress hydrique que les plants repiqués en terre (9).

Dans l'ensemble, les taux de réussite au greffage sont faibles (0–70%) dans les conditions agro-climatiques de Kismatari. L'analyse de la variance des taux de réussite au greffage (Tableau 3) montre que deux semaines après le greffage, période classique d'observation des greffes, l'effet de différents types de greffes n'est pas significatif (P≤ 0,05) et le coefficient de variation est très élevé (194,5%).

Par contre, les différences entre les types de greffes deviennent significatives (P≤ 0,05) et la précision de l'essai meilleure (C.V.= 30%) 1 ou 2 mois après le greffage; en effet, c'est à partir de 1 mois après le greffage que le maximum des greffons demeurés verts émettent des pousses végétatives attestant la réussite de la greffe.

Un mois après le greffage, la greffe en écusson en T (G_1) qui a donné 19,5% de taux de réussite est significativement (P≤ 0,05) supérieure aux greffes en placage à un œil (G_4) et en fente en tête (G_5). Deux mois après le greffage, le taux de réussite finale de la greffe en écusson boisé (G_3) (62%) est significativement plus élevé que les taux de réussite des autres types de greffe. La quantité du bois du greffon serait à l'origine de la réussite de cette technique de multiplication; en effet, de toutes les greffes réalisées, la greffe en écusson boisé est le seul traitement où le greffon est prélevé avec une masse importante de bois; celui-ci protégerait le greffon du dessèchement qui est un facteur défavorable à la réussite de la greffe.

Le plus faible taux de réussite à 2 mois après le greffage (14,9%) a été obtenu avec la greffe en placage à un œil (G_4). Ces résultats sont contraires à ceux que Lyannas (6) a obtenus à la Guadeloupe où ce type de greffe a donné un excellent taux de réussite (95%).

Dans l'antenne fruitière de Kismatari, Hamasselbé (4) a obtenu 95% de taux de réussite avec la greffe en écusson en T des plants d'agrumes. Ces résultats confirment ceux de Sizaret (9) qui étaient de 98% de taux de réussite chez la même espèce fruitière mais Sizaret observe que cette technique de multiplication particulièrement adaptée aux agrumes a donné un faible taux de réussite chez le goyavier (27%). Ces résultats peuvent être expliqués par l'épaisseur du parenchyme qui est plus importante chez les agrumes; celle-ci permettrait une meilleure soudure de l'assise cambiale et des vaisseaux libéro-ligneux du greffon et du porte-greffe chez les agrumes, facteur essentiel à la réussite au greffage.

Le test de marcottage

Les résultats des essais de marcottage sont présentés dans le tableau 4.

Tableau 3
Analyse de la variance des taux de réussite au greffage

a) - 2 semaines après le greffage

Source de variation	dl	SC	CM	Fcal	Ftab. (5%)
Traitement	4	18,5	4,62	$0,54^{ns}$	5,91
Bloc	7	19,6	6,53	$0,76^{ns}$	8,74
Erreur	12	102,5	8,54		
Total	23	41			

C.V.= 194,5%

b) - 1 mois après le greffage

Source de variation	dl	SC	CM	Fcal	Ftab. (5%)
Traitement	4	777,3	194,32	$11,18^{*}$	5,91
Bloc	7	101,2	33,73	$1,94^{ns}$	8,74
Erreur	12	208,3	17,36		
Total	23	1086,8			

C.V.= 34%
Test de Duncan (P= 5%):

$G_{4=\ 5,5}{}^{c}$
$G_{5=\ 6,3}{}^{bc}$
$G_{3=\ 13,3}{}^{ab}$
$G_{2=\ 14,9}{}^{ab}$
$G_{1=\ 19,5}{}^{a}$

c) - 2 mois après le greffage

Source de variation	dl	SC	CM	Fcal	Ftab (5%)
Traitement	4	608	152	$11,04^{*}$	5,90
Bloc	7	111,4	37,13	$2,69^{ns}$	8,74
Erreur	12	165,6	13,8		
Total	23	885			

C.V.= 32%
Test de Duncan (P= 5%):

$G_{4=\ 14,9}{}^{d}$
$G_{5=\ 19,6}{}^{cd}$
$G_{1=\ 39,9}{}^{bc}$
$G_{2=\ 43}{}^{ab}$
$G_{=\ 62,1}{}^{a}$

Tableau 4
Résultats des essais et taux de réussite au marcottage

Clones	Types de marcottage					
	Terrien			Aérien		
	Nombre de marcottes réalisées	Nombre de marcottes réussies	Taux de réussite (%)	Nombre de marcotte	Nombre de marcottes réussies	Taux de réussite (%)
A_{12}	6	1	16,6	0	-	0
B_{24}	6	3	50	0	-	0
B_{27}	6	2	33,3	0	-	0
D_{25}	8	2	25	0	-	0
E_{26}	8	4	50	8	0	0
G_{35}	8	4	50	6	2	33,3
J_{10}	0	0	-	10	1	10
J_{22}	0	0	-	10	2	20
J_{27}	10	5	50	10	3	30
J_{30}	10	10	100	10	3	30
K_{19}	8	6	75	6	1	16,5
L_{18}	10	9	90	10	0	0
Total	80	46	57,5%	70	12	17%

Le taux de réussite au marcottage terrien est de l'ordre de 58%, mais des variations importantes sont observées selon les clones; les clones J_{30} (100%), L_{18} (90%) et K_{19} (75%) ont donné d'excellents taux de réussite au marcottage terrien. Les taux de réussite au marcottage aérien sont très faibles (0-33%). Les faibles taux de réussite au marcottage aérien seraient imputables au manque d'arrosage du substrat; en effet, on a observé dans le temps un dessèchement du substrat de certaines marcottes dû probablement aux températures élevées de l'air et/ou à une mauvaise étanchéité des points d'attache des sachets en polyéthylène ainsi que le signale Sizaret (9).

Conclusion

Ces résultats préliminaires ont montré que plusieurs techniques de greffage et le marcottage aérien qui ont donné de faibles taux de réussite ne sont pas praticables techniquement pour la production massive des plants de goyavier dans les conditions agroclimatiques de l'antenne fruitière de Kismatari. Mais en cas de nécessité absolue, on peut recourir à la greffe en écusson boisé qui a donné un taux de réussite de 62% pour la production en quantités très limitées, du matériel végétal pour satisfaire les besoins de la recherche par exemple, pour les clones de goyavier A_{12}, D_{25}, B_{27} ayant une mauvaise reprise au marcottage.

Le marcottage terrien qui a donné d'excellents résultats avec deux clones de goyave de transformation ou d'industrie* (J_{30} et L_{18}) et un clone de goyave de bouche ou de table* (K_{19}) serait la technique de multiplication végétative du goyavier à promouvoir à la station fruitière de Kismatari. Ces résultats gagneraient à être confirmés et/ou testés dans d'autres conditions agroclimatiques pour identifier des techniques de multiplication végétative adaptées à la production des plants de goyavier de haut potentiel génétique.

Nota Bene

*goyave de bouche ou de table: goyave de poids $\geq$ 100 gr, de goût sucré; les clones retenus sont: A_{12}, B_{24}, B_{27}, D_{25}, E_{26} G_{35} et K_{19}.

*goyave de transformation ou d'industrie: goyave de poids $\leq$ 100 gr, de goût acidulé, de couleur rose; les clones retenus sont: J_{10}, J_{22}, J_{27}, J_{30} et L_{18}.

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Comparative Studies of Nitrogen Fixing Potential of *Desmodium ramissisimon* and *Vigna unquiculata* for Soil Fertility Management

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Keywords: Soil Fixing Legumes- Nitrogen Potentials- Nodulation- Soil Management

Summary

The occurrence of large numbers of legume species in the tropics with potentials for nitrogen fixation could be exploited to supply nitrogen, if they can be integrated into the farming system. The N_2 – fixing potential of a native herbaceous leguminous species namely, Desmodium ramissisimon *(Dm) and grain legume,* Vigna unquiculata *(Cp) were studied in the green house and field, on three types of soil.*
In both situations, nodulation was influenced by the soil type. Nsukka soil, which had sandy texture, highest level of available phosphorus among the soils investigated in the study and moderate level of other plant nutrients (Mg and K) enhanced nodulation, which supported N-fixation. Soil type also influenced the quantity of N accumulated by each species, but had no effect on nitrogen concentration in the different plant parts. Desmodium ramissisimon *had higher nodule weight and accumulated more nitrogen and fixed more N_2 than* Vigna unquiculata *in the three soils. The mean nodule dry weights were in the ranges of 61.6-239.2 mg/plant for Dm in the three soils as compared to the range 3.2-31.4 mg/plant for Cp. Symbiotic dependence of DM varied with soil type ranging from 63.62% in Adani soil to 88% in Nkpologu soil, whereas Cp had the least symbiotic dependence value. These trends were confirmed in the field thereby indicating that* Desmodium ramissisimon *had greater N_2-potential than the cultivated legume studied.*

Résumé

Etudes comparatives de la capacité de fixation de l'azote par *Desmodium ramissisimon* et *Vigna unquiculata* pour la gestion de la fertilité du sol

L'existence d'un grand nombre d'espèces de légumineuses qui présentent une bonne capacité de fixation de l'azote atmosphérique, dans les tropiques peut être exploitée pour remplacer l'utilisation d'engrais azotés, s'il est possible d'intégrer ces légumineuses dans les systèmes de production agricole. Des essais ont été réalisés en serre et au champ sur trois types de sol afin de comparer la capacité de fixation de l'azote de deux légumineuses: une plante de couverture, Desmodium ramissisimon *(Dm), et une plante principalement cultivée pour ses graines comestibles,* Vigna unquiculata *(Cp). Dans les deux cas, le type de sol a eu un effet significatif sur la formation des nodules. Pour le sol de Nsukka, caractérisé par la texture sableuse, une haute teneur en phosphore disponible comparativement aux autres sols étudiés, une teneur moyenne en autres éléments (Mg et K), la formation de nodules a connu une augmentation significative et a permis une fixation importante d'azote. Le type du sol a également influencé la quantité d'azote accumulée d'une manière significative pour chaque espèce mais sans toutefois montrer de différence significative sur sa concentration dans différentes parties de la plante. Pour les trois types de sol,* Desmodium ramissisimon *avait un poids élevé en nodules et fixait une quantité plus importante d'N_2 par rapport à* Vigna unquiculata*. Dans les trois types de sols, les poids secs moyens des nodules se situaient entre 61,6-239,2 mg/plante pour Dm et entre 3,2-31,4 mg/plante pour Cp. Quant à la dépendance symbiotique de Dm, elle variait de 63,62% dans les sols d'Adani à 88% dans les sols de Nkpologou tandis que cette dépendance était la plus faible pour Cp. Ces tendances ont été confirmées lors des essais réalisés en champ montrant que* Desmodium ramissisimon *avait une capacité plus élevée de fixation de N_2 comparativement à la légumineuse à graines étudiée.*

Introduction

Nitrogen required by plants is commonly obtained from either mineralization of native nitrogen in the soil, from the application of fertilizers or through nitrogen fixation by both leguminous plants and non-symbiotic

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nitrogen fixers (16). Legumes have been used to enhance soil fertility because of their ability to fix atmospheric nitrogen through symbiotic association with Rhizobia. Of all known biological systems that fix atmospheric nitrogen, a *Rhizobium* symbiosis is the most elaborate and efficient (10). It contributes the greatest quantity of nitrogen to the ecosystem and therefore, influences crop production more than any other nitrogen fixing system. A *Rhizobium* symbiosis contributes up to 20% of the annual total of fixed nitrogen by all biological systems (13). The *Rhizobium* symbiosis has, therefore, been more intensely studied than all other biological nitrogen fixing systems because of its singular importance in the nitrogen balance of ecosystems.

Industrial sources of nitrogen are expensive. Most farmers in developing countries cannot easily afford using fertilizers because of their cost. Hence, nitrogen importance in farming systems of the technologically less developed countries of the tropics. Moreover, the use of nitrogenous fertilizers has posed some problems such as pollution of fresh waters in developed countries. Apart from direct use of elemental nitrogen gradual release of nitrogen from residues enables more efficient use of nitrogen by subsequent non-legume crop (3).

Legumes occur through out the world but the largest numbers of genera and species are found in the tropics. Members of the three subfamily *Papillinoideceae* have the highest (93%) nodulating species followed by *Minosoideae* (87%) and *Caesalpinoidecaeae* with only 23% nodulating species. Ironically, it is also in the tropics that the greatest demand for nitrogen occurs due to weather and soil factors, which combine to make nitrogen availability very short-lived. Although tropical agriculture incorporates many leguminous species, the full potential of these species as sources of cheap nitrogen has not been intensely exploited. In traditional farming systems of the tropics, bush fallows are relied upon to recycle nutrients and restore soil fertility and soil organic matter, which are lost during several cycles of cropping without fertilizer application.

Natural bush regrowth often contains a high proportion of leguminous species, which contributes to the restoration of soil fertility. Little is known, however, about the quantities of nitrogen contributed by the legumes to the nitrogen economy of these fallows. Proper utilization of legumes in agriculture requires fairly detailed knowledge of the quantities of nitrogen fixed by the plants under different conditions. Managed or planted fallows can dramatically reduce the length of cultivation cycle and provide an intermediary practice between shifting cultivation and continuous cultivation. For instance, fallow under Kudzu (*Pueraria phaseoloides*) a nitrogen fixing creeper for 1-2 years, has the same restorative effect as 25 years of forest fallows (*14*). There are good indicators that selection of herbaceous fallow legumes with high dry matter yield, nitrogen fixing potential and moderate decomposition rate, can reduce the duration of fallow drastically. This will be to the advantage of the peasant farmers where increasing population density exerts pressure on the use of land with the consequent need to decrease the fallow period.

Justification for choosing *D. ramississimon* and *V. unquiculata* for the study.

A survey of the distribution of herbaceous legumes in fallow lands of the derived savanna conducted by Ezedinma *et al.* (6), showed that *Desmodium* and *Vigna* genera were found at all the invistigated sites, whereas abrus was found at only two sites.

Based on this premise, it was decided that species belonging to *Desmodium* and *Vigna* genera should be chosen. *Desmodium ramississiman* is a representative of species with forage qualities which is quite available in the experimental area. Nodulation of *Desmodium* is profilic and the amount of N_2 fixed quite considerable amounting to 320–360 kg N/ha/yr. As *Vigna unquiculata* occurred in all the sites studied, it was interesting to have a more accurate idea of its possible contribution to the nitrogen supply in local soils. Therefore, the nitrogen- fixing potential of wild and cultivated legume species were evaluated with a view to using them in planted fallow.

Materials and methods

Two separate experiments were conducted, namely a green house experiment using three soil types and two-legume species and a field experiment conducted during the rainy season using the same legume species as in the green house experiment. A preliminary screening to select the wild legume species used was conducted before the start of the experiments and selection of the wild legume species was based on the following observed criteria:

(a) The general growth habit of the plant, that is whether erect, spreading or climbing.
(b) Relative growth rate.
(c) Ability to nodulate without inoculation.
(d) Amount and viability of available seeds. The legume species considered in the preliminary screening were *Abrus canescens, Vigna micranta.*

The main characteristics of the two species finaly chosen are as follows:

(1) *Desmodum ramississimon* (G. Don). This plant has spreading growth habit, high seed viability, good establishment, comparatively high dry matter yield, and abundant and well-distributed nodules along the whole root system including adventitious roots. It is annual with indeterminate growth, flowering and fruiting continuous with first flowers appearing at 8 weeks.

Vigna unquiculata. This plant has spreading growth habit, high viability of seeds, good establishment, good dry matter yield and nodules are found on main

root and its branches. It is an annual with interminate growth habit, flowering and fruiting are continuous for a fairly short period with first flowers appearing at 6 weeks.

The green house study

The legume species used were given the following designations, *Vigna unquiculata* (CP) *Desmodium ramisissimon* (DM). The three soils (15 cm soil depth) used were Nsukka soil collected from the Faculty of Agriculture farm, University of Nigeria, Nsukka, the other soils were collected from Nkpologu and Adani. The characteristics of the soils are as shown in table 1. Although from the results of the particles size analysis the Adani soil was classified as loam, it has very poor physical properties (poor water infiltration and high puddling capacity). This was probably because the silt and clay fractions accounted for 62% of the weight of the soil. The soil, therefore, behaved more like a clay soil.

Table 1

Characteristics of the three soils used in the green house study and the field experiment

Soils	PH		Exchangeable Cations				Available		Particle size Analysis			Textural Class
	KCl	H_20	Organic C	total N	Ca	Mg	K	P	Sand	Silt	Clay	
			– % —		mg/kg	mg/kg ——		ppm		%—		
Nsukka	4.16	4.65	0.51	0.056	210.00	55.00	17.50	5.00	90	6	4	Sand
Nkpologu	4.05	4.76	0.57	0.043	100.00	25.00	20.00	4.00	84	4	12	Loamy sand
Adani	4.20	4.43	0.39	0.063	325.00	225.00	32.50	2.00	38	48	14	Loam
Field Block 1	4.31	4.86	0.87	0.071	162.00	21.00	15.41	10.00	72	8	20	Sandy clay loam
Field Block 11	4.05	4.80	0.87	0.074	168.00	23.00	16.06	5.50	72	8	20	Sandy clay loam
Field Block 111	4.08	4.68	1.1	0.084	156.00	240.00	15.82	8.00	72	8	20	Sandy clay loam
Field Block IV	4.06	4.76	1.02	0.081	181.00	21.00	18.03	8.00	68	6	26	Sandy clay loam

The treatment combinations of the species and the three soils in this experiment were as follows:

CPNS = CP + Nsukka
CPNK = CP + Nkpologu
CPAD = CP + Adani
DMNS = DM + Nsukka
DMNk = DM + Nkpologu
DMAD = DM+ Adani
Control = CO (no crop).

The experimental design was a randomized complete block with three replications and five harvest periods from the three locations.

The three soils were air-dried in the green house and crushed to pass through a 2 mm sieve. Four kilograms of each soil were weighed into 28 cm diameter non-perforated black polythene bags. Three bags without any crops growing in them were included to serve as controls and to correct for any N that may be introduced in the water used to grow the plants and possible activities of free-living N_2 fixers. The legume seeds were scarified in concentrated H_2SO_4 for one week and left to sprout in petri-dishes. After sprouting, they were transplanted at the rate of five seedlings per bag and later thinned to two per bag at two weeks after transplanting. The grain legume seeds were planted unscarified into the bags at the rate of five seeds per bag on the same day the wild legume seeds were scarified. One week after seedling emergence, the plants were thinned down to two plants per bag.

Harvesting

The first harvest was taken at 4 weeks for cowpea and all subsequent harvests were taken at 2 weeks interval till the last harvest at 16 weeks. At each harvest the following observations were carried out.

i. Inspection of nodules for the presence of leghemglobin (pink coloration).
ii. Separation of nodules from roots and enumeration.
iii. Complete excavation of roots from the soil and separation of each plant into leaves, stems, roots and fruits.
iv. Collection of soil sample from each bag for N determination.

The separated plant materials and nodules were properly bagged, labeled and dried to a constant weight at 65 °C (using a forced draft oven) and weighed. The samples were ground with a stainless steel mill, and stored in polythene bags for N determination.

Analytical procedure

Soil

The particle size analysis was done using (1) hydrometer method, while soil pH was measured in a suspension with a soil/water and soil/0.1N KCl ratio of 1:2.5 using a Beckman pH- meter. Soil total N, Organic matter, available P and exchangeable P were determined by the Kjeldahl method, nitrogen determinations for the soil were done using the microkjeldahl method. Carbon determination was by the Walkley and Black (17) method, Bray's method (II),

Bray and Kurtz (2) and flame photometry, respectively. Calcium and magnesium were determined by atomic absorption spectrophotometry.

Plant materials
All the plant components collected at harvest were analysed for total N using the regular microkjeldahl procedure.

Determination of the amount of N fixed symbiotically
The amount of apparent N fixed was estimated using the following equation:
N accretion= Total N in the system at harvest – (seed N+ initial soil N+N change in soil control) (9). Where Total N in the system is equivalent to: soil N + plant N (N in leaves, stems, root nodules and fruits). The N content is the N percentage of the component multiplied by the dry weight. For the wild legume species, *Desmodium* seed weight was so small (0.002/g) that N from this source was negligible. There was no need to correct for this N source.

Statistical analysis
All data were analysed using the analysis of variance (8, 15). All values were compared using Fisher's least significant difference at 5% levels of probability.

The field experiment
The field experiment was conducted during parts of rainy season of 1989 (May -October) at a site in the University of Nigeria Nsukka farm that had not been cropped for four years, the characteristics of the soil were as given in table 1 and the soil was very low in N. The same legume species used in the green house study were grown.

Field layout
The field experiment was laid out in a randomized complete block design with four blocks. Each block (22.75 m x 8.25 m) composed of five plots each measuring (9.55 m x 7.60 m) and each having one of the species used. The blocks were separated by a distance of 1.5 m and plots within the block by 1 m. Each plot had 6 rows of plants sown at a spacing of 75 cm between and within row. Scarified seeds of the wild legume species were planted out in seed boxes and the seedlings transplanted at 2 weeks of age. The grain legume seeds were planted on the same day the wild legume seeds were planted, weeding was done at intervals of two weeks.

Harvesting
The first harvest was taken at 4 weeks for cowpea and all subsequent harvests were taken at intervals of 2 weeks till the end of the fifth harvest period at 12 weeks after transplanting.
For *Desmodium*, the first harvest was at 12 weeks due to delay in plant establishment and nodule initiation. The experimental design was a randomized complete block with three replications. There were (7) treatments as follows:

So	Soil alone (Control)
So + Cpl	Soil + *V. unquiculata* leaves
So + Cps	Soil + *V. unquiculata* stems
So + Cpr	Soil + *V. unquiculata* roots
So + cpl	Soil + *V. unquiculata* leaves
So + Dml	Soil + *D. ramississimon* leaves
So + Dms	Soil + *D. ramississimon* stems
So + Dmr	Soil + *D. ramississimon* roots

Results and discussion

Green house experiment
Nitrogen fixation and some parameters for assessing its efficiency.
(1) Nodule weight and number
Table 2 shows the mean dry weights (mg/plant) of nodules of CP and DM. At each harvest period, nodules were visually inspected for the presence of legbemoglobin. Most of the nodules had pink coloration (an indication of effectiveness), which decreased with increasing nodule age. In all the

Table 2
Mean dry matter of legumes as well as number of nodules as influence by plant age

Treatment	Dry matter yield					Nodule number/plant
	Leaf	Stem	Root	Nodule	Total legumes	
					Components	
	———	g/plant	———		mg/plant	g/plant
CPNS	3.71	2.18	1.27	200.80	7.16	45.11
CPNK	1.54	1.05	0.67	86.00	3.26	26.06
CPAD	1.70	0.78	0.45	46.00	2.93	31.39
DMNS	6.21	7.06	2.53	239.20	15.80	391.95
DMNK	2.71	3.16	1.53	86.68	7.40	244.80
DMAD	2.26	2.49	0.86	61.60	5.61	103.11
FLSD (0.05) (CP and Dm)	0.79	0.53	0.30	0.80	2.61	0.14

legume species, soil type affected nodule weight.
Nodulation was highest in Nsukka soil and for each species, not significantly different between Nkpologu and Adani. Nodule numbers and weight per plant for CP recorded in this experiment fall within the ranges observed by Eaglsham *et al.* (4). *Desmodium* had higher nodule weight in all the three soils although the magnitude of the difference depended on soil condition. High performance of DM is likely to be due to superior genetic potential to nodulate.
The highest number of nodules was observed in Nsukka soil and least in Adani soil. Nodule weight is a very important parameter that contributes to nitrogen fixation. In a study conducted by Miller *et al.* (11) using three cowpea genotypes, nodule weight was the major factor contributing to N_2 fixation activity in both green house and field experiments while number was important mainly through correlation with nodule weight.
Figure 1 shows the pattern of nodules mass accumulation of cultivated and wild legumes respectively.

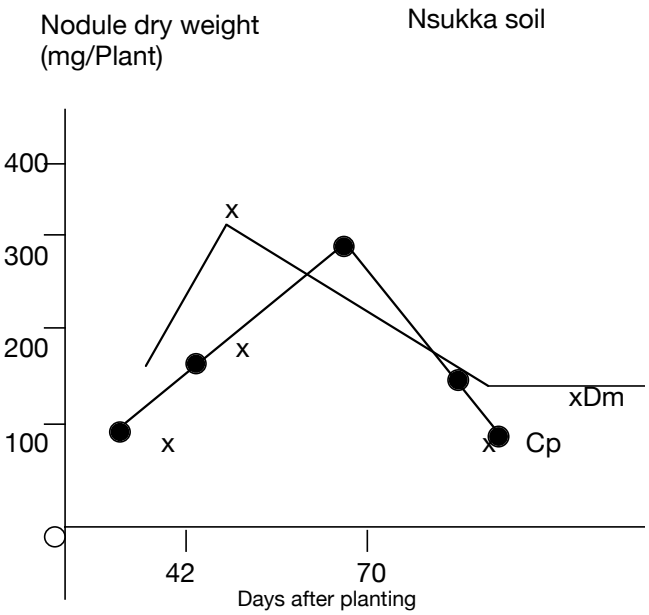

Figure 1: Green house experiment, nodule mass with time for cowpea and Desmodium in three different soils.

In Nsukka soil, all the legume species had clearly defined peaks of nodule weight after which there were marked declines. Cowpea reached its peak at 56 DAP in Nsukka soil and at 70 DAP in Nkpologu and Adani soils. *Desmodium* reached its own peak at 84 DAP in Nsukka and Nkpologu with no clear peak in Adani. Maximum nodulation occurred in CP after flowering.

Time of peaking of nodule number in CP, was influenced by soil type. Nodule population pattern was more variable within species than nodule mass, thus suggesting that numbers may be more sensitive than weight indifferent soil conditions.

Nitrogen fixation
Table 3 shows the mean values of symbiotically fixed N_2 (mg/plant) in the legume species. Soil type influenced the amount of N_2 fixed by each species.

Table 3
Mean values of symbiotically fixed N_2 in the green house as influenced by plant age

Soils	Legume Species	
	Cp mg/plant	DM
Nsukka	108.62	173.74
Nkpologu	37.56	91.98
Adani	23.34	56.15

F-LSD 0.05 (CP and Dm)= 0.32

All the species fixed maximum N_2 in Nsukka soil. There were no significant differences in amount of N_2 fixed in Nkpologu and Adani by CP while DM fixed significantly more N_2 in all the three soils. For example in Nsukka soil, DM fixed 173.7 mg N_2/plant and CP 108.62 mg N_2/plant. The superiority was also manifested in the other two soils. The amount of N_2 fixed by leguminous plant varies considerably among species and is influenced by several factors.
However, when a legume consistently shows higher levels of N_2–fixation under different growing conditions, it might be concluded that it has superior N_2 fixation potential. Among the several factors that determine the quantity of N_2 fixed by a legume plant, dry matter yield is very important (5, 7, 12, 18). Therefore, most of the unfavourable factors retarding plant yield

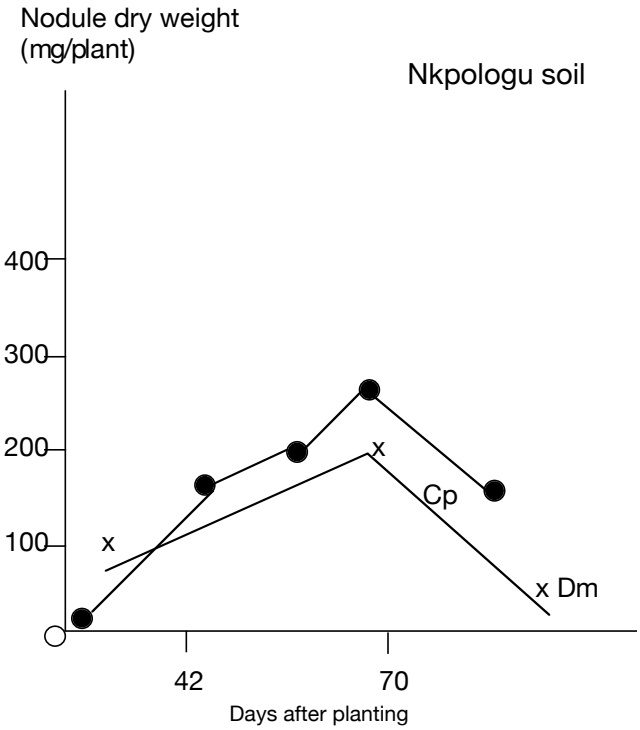

Figure 2: Green house experiment, nodule mass with time for cowpea and Desmodium in three different soils.

invariably also reduced N_2 fixation. The rate of N_2–fixation was strongly influenced by plant age and soil type but the pattern varied with species although it was sigmoidal. The highest level of N_2 fixation was attained after flowering as shown in figure 3.

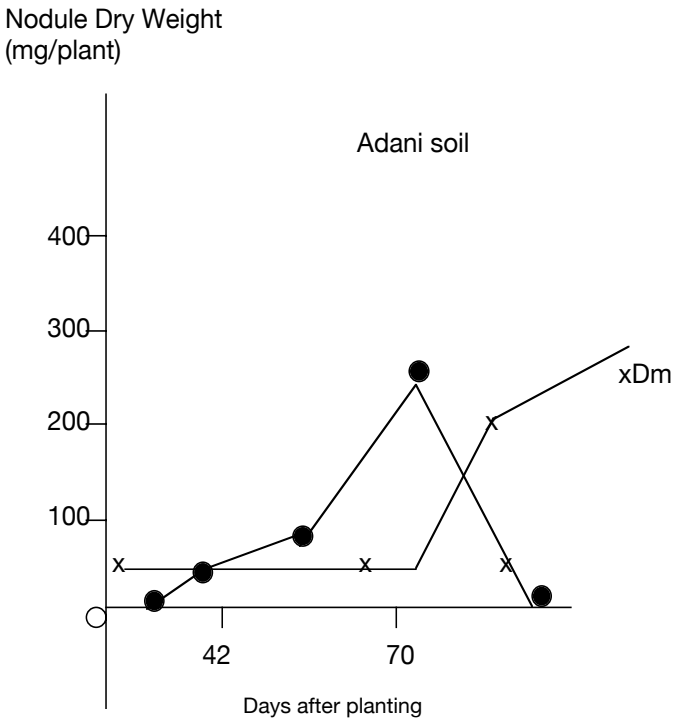

Figure 3: Green house experiment, nodule mass with time for cowpea and Desmodium in three different soils.

Field experiment

Some parameters of assessing N_2–fixation

Number and weight of nodules

Table 4 shows the dry weight of nodules (g/plant) of the legume species *Desmodium* had significantly the highest mass of nodules (8.50 g/plant), while CP had 1.51 g/plant. In the green house experiment, DM also had higher nodule mass than CP in each of the three soils.

From the green house results of this study and the work of Whiteman (19) the amount of N_2 fixed is a function of nodule mass and since DM had the highest nodule mass, it meant that DM had the greatest genetic potential for fixing N_2. *Desmodium* had the unique ability to form nodules on adventitious roots and stolons and this characteristic contributed significantly to the very high nodule mass.

The green house nodule yields represented only 8.0 and 2.81 percent of the yields of the field grown CP and DM, respectively. The very low value of nodule yield in the green house of only 2.8% of field value for DM could be due to the stress imposed by restricted soil volume, DM grown in the polythene bags formed only very little adventitious roots and stolons on which nodules would form since the spreading branches did not come into much contact with soil while in table 4, *Desmodium* produced the highest numbers of nodules, which differed significantly from CP.

Conclusion

The results of the green house and field experiments suggest strongly that *Desmodium* had greater N_2-fixing potential than CP. *Desmodium* fixed greater amount of N_2, had higher nodule weight.

There is very strong evidence that the wild legume species, *Desmodium ramississimon* has higher N_2–fixing potential than CP, therefore this wild legume species should be better adapted for building up the N–status of the soil than CP- grain legume studied.

In addition, the spreading growth habit (forms very good ground cover), unique ability to nodulate on adventitious roots and stolons, long vegetative growth period all combine to make *Desmodium* a good species to be incorporated into our farming systems as a fallow legume species.

Table 4

Mean dry matter yield of legumes as well as number of nodules for plant as a function of plant age (field)

Legume Species	Leaf	Stem	Root	Nodul	Fruit	Total components	Number of nodules per plant
			g/plant				
Cowpea	86.89	79.81	18.25	1.51	51.39	237.89	521.67
Desmodium	109.01	136.9	321.60	8.50	0.00	276.04	562.78
FLSD (0.05)	NS*	NS*	0.58	2.76	0.10	NS*	0.17

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Adoption of Improved Fish Preservation Technologies in Northwestern Nigeria

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Keywords: Fish preservation technologies- Adoption levels- Northwestern Nigeria

Summary

A study was conducted to determine the status of awareness and adoption of disseminated improved post-harvest fisheries technologies among fish processors in the northwestern zone of Nigeria using structured questionnaire to obtain information from fish processors and secondary data collected from the Agricultural Development Projects (ADPs) and some Research Institutes in the selected states. A multi-stage sampling technique was adopted in the selection of four states in the zone (Kaduna, Kano, Katsina and Kebbi). Data was analyzed using descriptive statistics and Pearson's correlation. The variables were tested at 5% level of significance.

Results of data analysis showed that about 66% of respondents were in the economically active age group of 21-40 years and the mean age was 32 years. About 89% were males; 83.7% had only koranic education, while 28.7% had between 6-10 years processing experience and equally 28.7% had over 20 years processing experience. The mean year of experience was 17.5 years. Only about 43.1% of respondents were aware of improved fish smoking kilns disseminated in the zone, with about 32% adopting one kiln or the other. Improved smoking kilns disseminated include Chokor, Altona, Burkinabe, and Watanabe. Major constraints to adoption of improved fish processing and preservation technologies in the zone include scarcity of improved kilns, high cost of kilns when available, difficult technical features of the kilns and insufficient awareness creation by the ADPs. Results of Pearson's correlation analysis on socio-economic factors influencing adoption showed that year of experience (r, 0.02), extension contacts (r, 0.03), access to credit (r, 0.01) and "contact farmers status" (r, 0.00) were significant (P≠ 0.05) in positively influencing the adoption of Chokor oven. Burkinabe kiln's adoption was significantly (P≠ 0.05) and positively influenced by age (r, 0.04), acquisition cost (r, 0.02) and access to credit (r, 0.02). Altona kiln's adoption on the other hand was significantly (P≠ 0.05) and positively (r, 0.00) influenced by the educational achievement of processors.

The study concluded that concerted policies by government geared towards post-harvest loss

Résumé

Adoption de technologies améliorées de conservation des poissons dans le nord-ouest du Nigeria

Une étude a été entreprise pour déterminer le statut de conscience et l'adoption des technologies après la diffusion de techniques améliorées de conservation des poissons parmi les transformateurs dans la zone du nord-ouest du Nigeria. Un questionnaire structuré a été utilisé pour obtenir l'information des transformateurs de poissons, des projets de développement agricole (ADPs) et de quelques instituts de recherche dans les états choisis. Une technique d'échantillonnage à plusieurs étages a été adoptée dans quatre états de la zone (Kaduna, Kano, Katsina et Kebbi). L'analyse des données s'est faite en utilisant des statistiques descriptives et la corrélation de Pearson. Les variables ont été testées au niveau 5%.

Les résultats de l'analyse de données ont montré que environ 66% des répondants étaient dans la catégorie d'âge économiquement active de 21-40 ans et l'âge moyen était de 32 ans. Environ 89% étaient des hommes; 83,7% ont seulement l'éducation coranique; 28,7% ont entre 6-10 ans d'expérience et également 28,7% ont une expérience de 20 ans. La durée moyenne d'expérience était 17,5 ans. Seulement environ 43,1% de répondants étaient au courant de la diffusion des fours améliorés dans la zone, avec environ 32% adoptant un four ou l'autre. Les fours améliorés disséminés comprenaient Chokor, Altona, Burkinabe, et Watanabe. Les contraintes principales à l'adoption des fours améliorés sont la pénurie des fours améliorés, le coût élevé des fours si disponibles, la difficulté des dispositifs techniques et l'insuffisante conscientisation par l'ADPs. Les résultats de l'analyse de la corrélation de Pearson sur les facteurs socio-économiques influençant l'adoption ont montré que l'expérience (r, 0,02,), la vulgarisation (r, 0,03), l'accès au crédit (r, 0,01) et le statut de fermiers de contact (r, 0,00) étaient significatifs (P≠ 0,05) en influençant franchement l'adoption du four Chokor. L'adoption du four Burkinabe était de manière significative (P≠ 0,05) et franchement influencée par l'âge (r, 0,04), le coût d'acquisition (r, 0,02) et l'accès au crédit

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reduction in fisheries must aim at making the designing of improved kiln appropriate to the clienteles' needs so as to increase fish protein supply in the zone and improve the production level, income level, and standard of living of fish processors.

(r, 0,02). L'adoption du four Altona, d'autre part, était de manière significative (P≠ 0,05) et positivement (r, 0,00) influencée par la formation accomplie des transformateurs.
L'étude a conclu que les politiques concertées par le gouvernement orientées vers la réduction après la moisson des pertes de poissons capturés doivent viser à rendre disponible des fours améliorés appropriés aux besoins des clientèles afin d'augmenter l'offre de protéine de poisson dans la zone et d'améliorer le niveau de production, le niveau de revenu, et le niveau de la vie des commerçants de poissons.

Introduction

Post-harvest losses in fish products are a major bane of the Nigerian fish industry especially at the artisanal level. Whereas artisanal fisheries is responsible for over 60% of total domestic production annually, the magnitude of losses in this sector has been estimated at 30-50% of total catches (7, 11, 14). This range of figure is alarming when one considers the fact that Nigeria presently meets only 60% of her total fish need and spends scarce foreign exchange in importing frozen and canned fish to supplement the deficit. The artisanal fisheries of Nigeria are endemic to these post-harvest losses. Apart from the subsistence operation in catching fish, in most cases bacterial infection set in on the fish flesh as a result of injuries sustained in the traps and nets – open wound, and stress from struggling accelerating the deterioration of fish. The time interval between catching and preparation for preservation further aggregates the problem. The commonest methods and practices for traditional processing and preservation of fish products include smoke-drying, sun-drying and fermentation.
Successive governments in Nigeria over the years recognized the need to reduce the extent of losses to the barest minimum. Knowing the limitations of traditional preservation equipments and the inadequacy of other methods used in processing and preservations, Research Institutes were funded to generate and package technologies to tackle the problems. Improved technologies were developed and disseminated on some aspects of post-harvest fish handling. Grass root extension delivery was also carried out by the ADPs to disseminate such technologies. It is therefore significant to evaluate the levels of awareness and adoption of the technologies by fish processors in the zone. This will enhance recommendations and policy formulations in attempts to reduce post-harvest losses of fish products. The broad objectives of the study were to study the personal characteristics of the respondents, identify the improved fish curing technologies available in the zone, identify possible constraints to adoption and determine the factors influencing the adoption.

Methodology

The study was conducted in 4 states (Kaduna, Kano, Katsina and Kebbi) out of the seven states that make up the north-west agro-ecological zone of Nigeria. Primary data were collected from fish processors using structured questionnaires. A total of 3 ADP zones in each of the 4 states were purposively selected. One Local Government Area (LGA) of intensive fishing activities was randomly selected from each

Table 1
Distribution of respondents by personal characteristics

Characteristics	Distribution	
	Frequency	Percentage (%)
Age (years)		
< 20	15	4.8
21 - 30	79	25.2
31 - 40	129	41.2
41 - 50	40	12.8
51 - 60	38	12.1
> 60	12	3.8
Mean= 32		
Sex		
Male	278	88.8
Female	35	11.2
Educational qualification		
None	16	5.1
Koranic	262	83.7
Primary	31	9.9
Secondary	3	0.9
Post secondary	1	0.3
Experience (years)		
1 - 5	48	15.3
6 - 10	90	28.7
11 - 15	51	16.3
16 - 20	31	9.9
> 20	90	28.7
Mean= 17.5		

of the zone. Between 25 to 30 questionnaires were administered in each LGA. The overall total number of questionnaires usefully completed, retrieved and used for analysis was 313 i.e. 76 (Kaduna) 92 (Kano) 70 (Katsina) and 75 (Kebbi).
Secondary data were obtained from the records of the ADPs and some Research Institutes. Data were collected between April and July 1999. Both descriptive statistical tools (frequencies and percentages) and Pearson's correlation (16) were used in the data analysis.

Results and discussion

Personal characteristics of respondents
Table 1 shows that the ages of respondents across the zone range from less than 20 years to over 60 years.

About 66% of the respondents were between 21-40 years, 24.9% were between 41-60 years, 4.8% were below 20 years, and only 3.9% were above 60 years. The main age was 32 years. Comparable works on women fish processors in Ghana (3) showed that active age of respondents (fish processors) were between 21-40 years. 88.8% of the respondents were males while only 11.2% were females. The result is in agreement with studies by various authors (1, 4, 5) in which they reported that males dominated the fish post-harvest enterprises in northern Nigeria. This was due to religious and cultural limitations imposed on majority of women that restrict their roles purely to confines within household. About 84% of fish processors in the zone acquired only koranic education, indicating that majority were illiterates. Educational level have significant roles to play in influencing the adoption decision of respondents as more enlightened and educated people tend to be more dynamic in response to technological innovations and changes (2). From the total sample of fish processors interviewed, 28.7% had between 6-10 years experience in the business. The same percentage was reflected for those with over 20 year's experience. The mean year of experience was 17.5 years. The number of years of experience of a fish processor could be an important factor in predicting adoption behavior.

Awareness and adoption of improved kilns and pre-processing recommendations
Limitations imposed on traditional fish smoking kilns necessitated the need to either improve on their technical design and efficiency or introduce new kilns that are not common to artisans. Traditional kilns are labour intensive, have long smoking duration, risky to operate with small holding capacity. In attempts to reduce the high post-harvest losses, research agencies introduced improved kilns and some recommendations on fish handlings. The ADPs in the zone were able to disseminate information on such technologies. Figure 1 shows the levels of awareness and adoption of the four improved smoking kilns spread across the zone among fish processors.
These improved fish preservation technologies, for which adoption levels of respondents were measured, include Altona, Watanabe, Burkinable and Chokor smoking kilns (17).

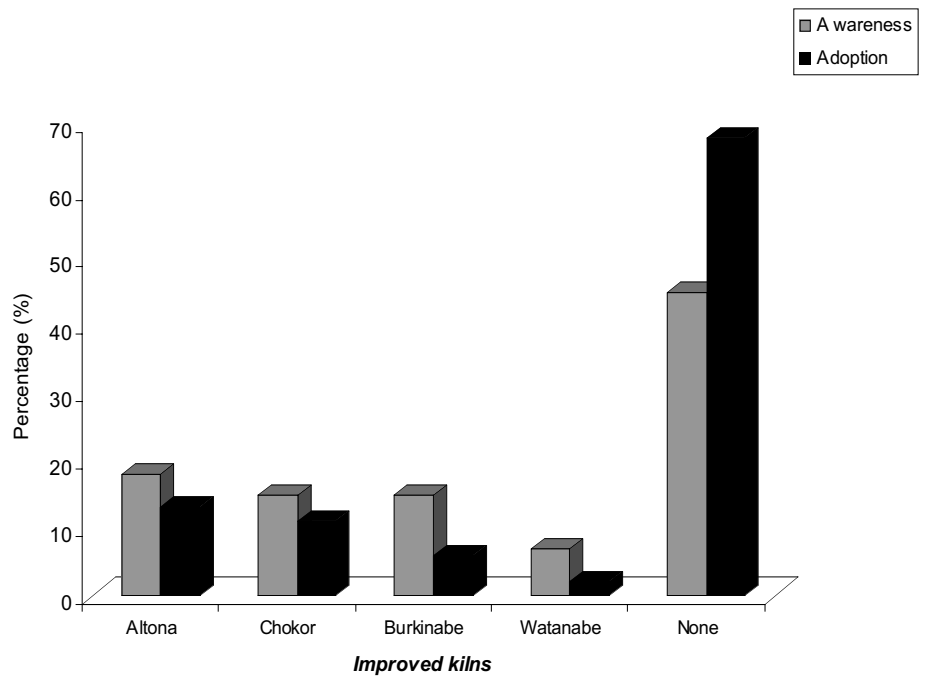

Figure 1: Distribution of Respondents by Awareness and Adoption levels of Improved fishsmoking kilns in the zone.

Table 2
Distribution of respondents by awareness and adoption levels of disseminated pre-processing handling practices

Practices / Problems	Awareness level		Adoption level	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Handling Practices				
Gilling/beheading	170	54.3	117	37.4
Scaling	235	75.1	165	52.7
Splitting	115	36.7	82	26.2
Gutting/Evisceration	190	60.7	185	59.1
Washing	190	60.7	154	49.2
Salting/Brining	165	52.7	131	41.8
Cutting into chunks	189	60.4	149	47.6
Partial decomposition	105	33.5	83	26.5

Altona kiln is an improved smoking kiln made of cement blocks with the dimensions of 1.5 x 1.25 x 3.65 m. The top is sealed with a slab of concrete perforated at the centre to form a chimney. Three wire mesh trays are located impart, below which is the hearth. A metal steel door flushes over the smoking chamber and the fireplace. Smoking is carried out by burning wood in the hearth.

Watanabe kiln is a modified Altona kiln connected to a fire-box by an asbestos pipe 0.5 m long and 0.35 m in diameter. The fire box has dimensions of 0.8 x 0.5 x 1.0 m. Fish is smoked by burning wood in the fire box and the smoke passes through the tunnel into the smoking chamber. During smoking, the door of kiln must be closed to conserve heat and smoke in the smoking chamber.

Burkinabe smoking kiln is constructed in the form of a box with variable dimension. Five sheets of corrugated iron sheet nailed to plank frames covering the sides of the kiln. Fish is placed on wire mesh trays in the kiln while smoke is supplied by burning wood from a full drum length which is cut open to serve as the smoking chamber at the base of the kiln.

Chokor oven is a kiln originated from Ghana in Chokor village from where it derived its name and it is an improvement over the traditional smoking kiln. It is typically rectangular in shape and has a mud, cement or brick wall of internal dimensions of 0.7 x 0.7x 0.7 m. The top of the wall must be flat to enable the wooden-framed trays to rest snugly against them. It has two chambers with each having a centrally placed stoke hole of 38 cm high and 38 cm wide.

Awareness levels were Altona (18%), Chokor (15%), Burkinabe (15%) and Watanabe (7%). Only a total of 34% of respondents had adopted one kiln or the other. These include Altona (13%), Chokor (11%), Burkinabe (6%) and Watanabe (2%). Non-adopters of any of the kilns were in the larger majority (68%). Pre-handling practices are actions taken upon the fish to prepare them for smoking, sun-drying or alternatively to promote the quality of products and by implication their appeal to consumers. Adoption of pre-processing handling technologies would increase the quality of products, monetary value of products and their shelf life. Disseminated technologies include gilling, scaling, splitting, gutting, washing, salting, cutting into chunks and partial decomposition etc. In table 2, about 54% of processors in the zone were aware of the practice of gilling/beheading to allow blood flow out of the fish; this is practiced for large fish and in case of processors that fry fish-all sizes. However, only about 37% adopted it. Scaling involves the removal of fish scales to improve product consumption.

About 53% of processors in the zone adopted this practice as against about 75% awareness level. These were mostly fresh fish and fried fish vendors. Splitting, gutting, washing, salting of products, cutting into chunks and partial decomposition had about 37%, 61%, 61%, 53%, 60% and 34% awareness levels respectively with adoption levels at about 26%, 59%, 49%, 42%, 48% and 27% in that order.

Constraints to adoption of improved technologies

Reasons advanced for poor adoption of the (improved) kilns by the respondents include high cost of kilns (29.7%), scarcity of kilns (30.3%), difficult technical features of the kilns (21.7%), operational difficulties (27.1%), lack of clear relative advantages over traditional kilns (11.5%) and insufficient awareness creation (44.7%) (Table 3).

For the pre-processing recommendations, the major problems of processors in adopting them were additional cost input (35.8%) extra time input (19.8%) inconvenience due to swamps of flies and oviposition (34.8%) and untidy environment created (44.7%).

Table 3
Distribution of respondents by constraints encountered in the adoption of disseminated technologies

Constraints	Distribution	
	Frequency	Percentage (%)
Improved Kilns		
1. High cost	93	29.7
2. Scarcity of kilns	95	30.3
3. Difficult technical features	68	21.7
4. Operational difficulties	68	21.7
5. No relative advantage	36	11.5
6. In sufficient awareness creation	140	44.7
Pre-processing recommendations		
1. Additional cost input	112	35.8
2. Extra time input	62	19.8
3. Inconvenience of operation	109	34.8
4. Untidy environment creation	140	44.7

Adoption of post- processing fish quality improvement recommendations

The study probed into specific recommendations that EAs taught the fish processors to enhance the quality of fish products. Targeted technologies were degutting, salting, drying/smoking, packaging and quick processing. Figure 2 shows that only 15.3% of processors were aware of gutting recommendation with only 14.1% adopting; 12.5% were aware of recommendation on salting as against 5.4% adoption.

Hard smoke-drying was recommended to increase the shelf-life of fish with 26.5% of respondents aware and equal proportion adopting. About 16.1% of respondents were aware of packaging technology and only 15.9% adopted. Immediate processing of fresh fish as a recommendation to reduce the activities of microbes had 20.7% awareness and 18.8% adoption. A larger majority (41.8%) of respondents were unaware of any recommendation on quality improvement. The low awareness and adoption levels of disseminated fish smoking kilns and processing recommendations indicate the poor state of technology dissemination by the ADPs in the zone. The economic down-turn in the country has affected most government agencies (including the ADPs) in performing their job schedules.

Factors affecting fish processing technologies adoption

Technologies adoption is always influenced by certain factors. Generally in agriculture, favourable factors of production recommendations' adoption include profitability, compatibility and viability of such technologies (among others). In this study, certain socio-economic factors of respondents (variables) were tested on the adoption of improved fish smoking kilns (Chokor, Burkinabe, and Altona) disseminated in the zone. Watanabe kiln was excluded in the analysis because it had the least levels of awareness (7%) and adoption (2%) as a result of the constraint listed in table 3. Results of the Pearson's correlation analysis are presented in table 4.

The variable was tested at 5% significant level. For all significant variables, the correlation co-efficients '*r*' were very weak ($r < 0.4$), showing weak positive correlation with the dependent variables (adoption of the kilns). Adoption of Chokor oven was significantly related ($P \neq 0.05$) to the processors years of experience ($P \neq 0.05$, r, 0.02), extension contact ($P \neq 0.05$, r, 0.03), access to

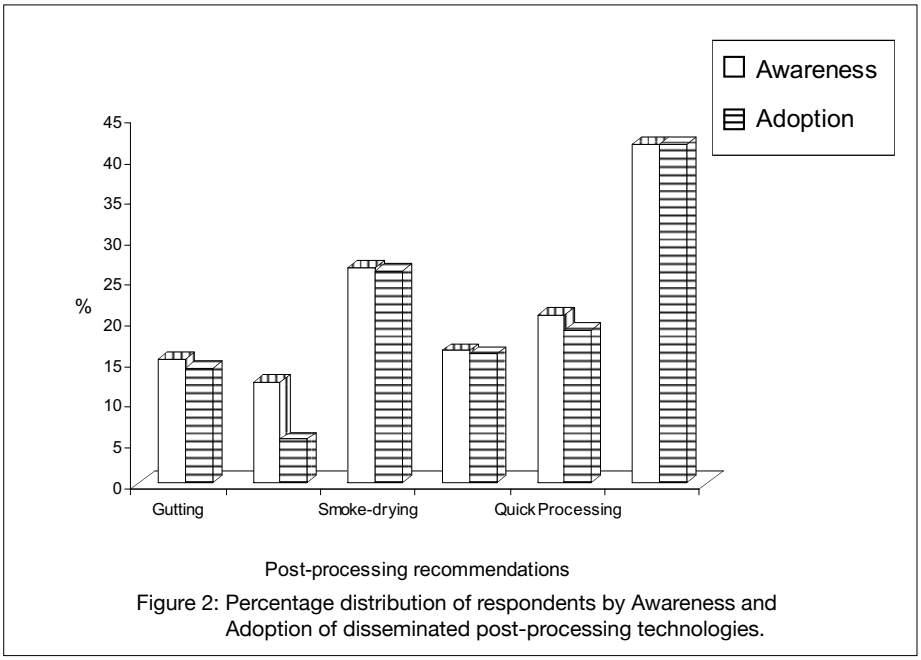

Figure 2: Percentage distribution of respondents by Awareness and Adoption of disseminated post-processing technologies.

credit (P≠ 0.05; r, 0.01), and contact farmers' status (P≠ 0.05; r, 0.00). The implication of the significantly related years of experience of processors to adoption of Chokor kiln is that the more experienced a processor is the more likely the tendency to adopt Chokor kiln. The significant correlation of extension contacts to adoption of Chokor kiln indicate that with more visits and demonstration on construction and operation of the kiln, there is the likelihood that awareness and adoption levels would be increased among processors. Baryeh *et al.* (3) in a study on women fish processors in Ghana discovered that extension contacts was significantly related to the adoption of post-harvest fisheries technologies. Although one of the advantages of Chokor kilns is that of relatively low cost of construction, a processors access to credit would strongly influence the acquisition and usage of the kiln. Olayide *et al*. (13) viewed credit inadequacy as a major constraint to adoption of agricultural technologies. The significant positive correlation of Chokor kilns adoption with contact farmer's status of a processor was the *a priori* expectation since such farmers receive more visits from extension agents and are often the first beneficiaries of introduced innovations.

The adoption of Burkinabe kiln was influenced by age of processors (P≠ 0.01; r, 0.04), the acquisition cost (P≠ 0.05; r, 0.02) and access to credit (P≠ 0.05; r, 0.01). For Burkinabe kiln, the significant positive correlation of age with adoption indicates that older processors might be inclined to adopt this kiln, due to a long period of awareness of its introduction. Vabi and Williams (15) had shown high adoption of agricultural technologies at middle ages, although Feder *et al.* (8) also indicated that in some instances, younger ages were associated with adoption of innovations. The significant positive correlation of acquisition cost and access to credit on adoption of Burkinabe, indicate that subsistence processors may not be able to acquire the technology without access to credit from formal and informal sources.

Altona kiln adoption was significantly and positively related to educational attainment (P≠ 0.05; r, 0.00). The kiln is a bit complex in construction and operation and this would need a knowledgeable and enlighten clientele to operate it. Some studies (2, 9) have found positive relationships between education and adoption of innovations.

Generally it can be asserted that age of clienteles, their years of experience in fish processing business, their educational level, access to credit, construction cost, extension contact and "contact farmers" status of processors would influence the adoption of fish processing technologies in the zone. This lends credence to results of studies by various authors (6, 10, 12) that certain personal characteristics of farmers, income level, cost and effectiveness of an extension approach greatly influence technology adoption.

Conclusion and recommendations

The northwestern zone of Nigeria is endowed with abundant inland fisheries resources.

Despite this fact, some constraints, which are multi-dimensional in nature, operate to hinder the realization of its full potentials in meeting the fish protein needs of the populace in the zone in particular and Nigeria in general. The institutional constraint is manifested in the poor awareness creation on improved technologies by the ADPs that could reduce post-harvest losses to the barest minimum. The operational constraints on the part of the processors are the lack of access to credit to transform them form subsistence operators to large-scale processors. On the part of Research Institutes and Extension Agencies there is a constraint of appropriateness (in terms of cost, technical features, availability and simplicity) of introduced smoking kilns and other recommendations. Constraints and problems should not be obstacles in attempts to reduce fish post-harvest losses, increase fish products availability to consumers and improve the income and living standard of fish processors in the zone. The objectives of government along these direction can only be achieved through concerted efforts to transform the operations and elevate the operators of the artisanal fisheries of the zone.

Table 4
Results of Pearson's correlation analysis of some socio-economic characteristics of respondents and adoption of improved fish smoking techniques

Independent variable / Dependent variable	Age	Sex	Education	Experience	Acquisition cost	Access to credit	Membership of cooperative	Extension contact	Contact farmer status	Kilns' availability
Adoption of Chokor	0.504	0.881	0.989	0.022*	0.171	0.006*	0.210	0.030*	0.003*	0.412
Adoption of Burkinabe	0.039*	0.620	0.8021	0.215	0.021*	0.010*	0.927	0.316	0.875	0.511
Adoption of Altona	0.709	0.620	0.005*	0.795	0.464	0.152	0.333	0.817	0.802	0.308

* Significant at 1% (P≤ 0.05)

The following are recommended measures to achieve these goals;

i. Research Institutes should ensure that improved fish smoking kilns developed are appropriate to fish processors operating environment. Indices of appropriateness are simplicity in operation, low and affordable cost, availability of the kilns and clear relative advantage over traditional kilns.

ii. Awareness levels for the smoking kilns were generally low. The ADPs being the grass-root extension agencies should create more awareness on post-harvest fisheries technologies. Extension strategies such as field days, agricultural shows, method demonstration and result demonstration are avenues for creating awareness on such technologies. Also the farm broadcast of ADPs on radio and television should include enlightenment on improved smoking kilns and other recommendations in attempts to meet government objectives of increased income to fish processors and reduction of post-harvest losses.

iii. Access to credit is an important facilitator in transforming small-scale operators to large-scale producers. Most fish processors in the zone have been operating under an economic environment that made them subsistent and sub-servient. The Agricultural Credit Guarantee Scheme of the Central Bank of Nigeria (administered by the Nigerian Agricultural Cooperative and Rural Development Bank and Commercial Banks) should pay more attention to granting credit to artisanal fisheries operators (including processors) under minimal conditions to encourage their access to credit and ensure that money loaned out are used for the purpose meant for.

iv. Fish processors should be formed into cooperatives to solve the problems of collateral when seeking loans from formal financial institutions. Cooperative operations certainly have overwhelming advantages over individual subsistence practices (educational enlightenment of members, enhancing their operational securities and offering assistances to members).

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LES ACTIONS DE LA DGCD — DE ACTIVITEITEN VAN DE DGOS

DGCD'S ACTIVITIES — LAS ACTIVIDADES DEL DGCD

Dans le domaine de la coopération universitaire, la Direction Générale de la Coopération au Développement (DGCD) finance directement des actions via le Conseil Interuniversitaire de la Communauté française de Belgique (CIUF) et le Vlaamse Interuniversitaire Raad (VLIR). Ces actions concernent principalement l'appui institutionnel à des Universités des pays en développement et la réalisation de projets plus ciblés sur le terrain dont le but final est d'améliorer les conditions de vie des populations de ces régions. Nous présentons dans ce numéro deux actions réalisées grâce au support du CIUF aux Philippines et au Maroc.

Pour une gestion participative des ressources naturelles de la forêt aux Philippines: validation des informations indigènes par imagerie satellitaire*

«We believe that sustainable development without sustainable communities is impossible».
V.O. Ramos, Ancien Secrétaire du Département Environnement et Ressources naturelles, Gouvernement des Philippines.

Contexte

Le projet s'inscrit dans le contexte de la déforestation sauvage des zones tropicales. Il est né en réponse à la demande exprimée par les populations indigènes de la Pantaron Range, chaîne montagneuse sur l'île de Mindanao au sud des Philippines.

La Pantaron Range couvre un peu plus d'un million d'hectares et constitue un des derniers blocs de forêt primaire et secondaire sur l'île de Mindanao. Deux tiers de ses bassins versants sont considérés comme érodés à 45%. On estime à 6000 le nombre de familles indigènes vivant de et dans ses hautes terres. La sécurité alimentaire de plus de cinq millions de personnes est liée aux bassins versants de ses deux rivières principales.

Demande exprimée

Les communautés forestières locales demandent une aide technique pour transcrire leurs droits, pratiques et visions dans un langage compréhensible par le gouvernement afin de promouvoir un dialogue réel au sein de l'Ancestral Domain Management Plan (ADMP).

Objectif du projet

Le projet vise à faciliter le dialogue communautés/gouvernement sur une base technique commune, en vue de l'intégration des connaissances des indigènes aux pratiques d'exploitation des zones forestières pour une gestion durable des ressources naturelles de la forêt.

Concrètement, il est proposé d'objectiver la connaissance du territoire, que les communautés indigènes expriment sous forme de «Community Maps» (cartes perceptives) grâce à une interprétation avancée d'images d'observation de la terre (Landsat, Spot et Ikonos).

Partenariat

L'intégration des informations fournies par les indigènes et par les données du gouvernement au Système d'Information Géographique (SIG) des chercheurs locaux est le fruit d'une étroite collaboration scientifique entre:

- MILA (département des sciences du MILieu et de l'Aménagement du territoire- agronomie, UCL, Belgique): pour la partie géoréférence des images et calcul des indices forestiers (15 chercheurs),
- GEOSATEL (laboratoire de GEOmétrie Appliquée à la TELédétection - géographie + mathématiques, FUNDP, Belgique): pour la classification fine de l'affectation du sol de la Pantaron Range sur base des images satellitaires (5 chercheurs),
- ESSC (institute of Environmental Sciences for Social Change, ateneo de Manila university campus, Philippines): pour la coordination du travail de terrain, l'intégration SIG des données et le dialogue permanent avec les instances politiques compétentes en aménagement du territoire (40 chercheurs).

*Ce projet a fait l'objet d'une publication parue dans l'Echosud[3], Bulletin trimestriel de la Commission Universitaire pour le Développement (CUD), mai 2004 pp. 6-7.

Déroulement du projet

Les partenaires attribuent notamment la réussite du projet à :
- la grande qualité scientifique et morale du partenaire local,
- l'insertion parfaite du travail dans le projet global à long terme du partenaire local,
- l'acquisition judicieuse de l'équipement de soutien à la recherche,
- la flexibilité budgétaire de la CUD.

Ils regrettent cependant le manque de disponibilité et de stabilité du personnel scientifique dans les laboratoires belges vu que, n'étant pas rémunérés par la CUD, ceux-ci doivent respecter les bailleurs de fonds qui permettent leur maintien en poste.

Résultats

Après 3 années de partenariat réussi (2000-2003), le projet a permis:

* techniquement:
- la formation de 2 chercheurs qualifiés en imagerie satellitaire au sein d'ESSC,
- le transfert des algorithmes de classifications utiles au contexte tropical,
- l'intégration des techniques de pré-traitement et de traitement d'images au sein des logiciels d'ESSC,
- la production d'une classification fine de la couverture forestière de la Pantaron Range,
- l'intégration des images classées dans les informations des communautés et du gouvernement.

* au niveau des communautés cibles:
- une intensification du dialogue communautés / gouvernement à travers la validation des Community Maps et l'introduction de celles-ci dans la base de données gouvernementales,
- une objectivation des informations indigènes en vue de leur prise en compte par le gouvernement,
- un accroissement de la motivation des indigènes pour une gestion durable de la forêt,
- une insertion des femmes dans le tracé des Community Maps,
- une réduction de la marginalisation des communautés indigènes par l'accroissement de leur autonomie de gestion.

* au niveau des partenaires:
- une augmentation de l'expertise de chacun par le croisement des connaissances complémentaires et des synergies réussies,
- une diffusion des connaissances acquises aux différents laboratoires d'ESSC,
- un partage des compétences avec les milieux gouvernementaux locaux,
- la consolidation du partenariat scientifique dans une atmosphère de sincère amitié, gage de durabilité.

En fin de projet, une conférence scientifique a réuni aux Philippines 31 participants regroupant 7 universités, 3 gouvernements locaux, 4 organisations non gouvernementales et 3 représentants des Communautés indigènes autour du thème «Remote Sensing and GIS in the Environment: Facilitating Management». Elle a considérablement consolidé et élargi le partenariat.

Conclusion

Réalisé sur une base scientifique solide, ce projet est radicalement socio-économique et participatif. Ayant intégré tout au long de son cheminement le politique, le scientifique et les communautés, il est considéré comme un projet pilote pour toute la forêt philippine, en tant qu'aide à la gestion durable des bassins versants, de l'équilibre des sols et de la forêt. Il est en cours de diffusion au sein de l'Asian Forest Network.

Ce projet est fondamentalement engagé dans la promotion d'une démocratie respectueuse des droits de tous et de l'environnement. Reste alors à mettre le décideur politique au défi de transcrire les informations produites en actions concrètes.

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Projet PIP
Appui Scientifique à la formation, la recherche et le développement en matière de qualité, d'hygiène et de sécurité alimentaires au Maroc*

Promoteur belge:
Sonia Collin, Professeur à l'Université catholique de Louvain
Promoteur marocain:
Amina Bouseta, Professeur à la Faculté des Sciences Dhar El Mahraz, Université Sidi Mohamed Ben Abdellah, Fès

Le développement de l'agriculture au Maroc a constitué depuis l'indépendance un choix stratégique et l'une des priorités nationales car il conditionne la croissance du pays. La contribution à la garantie de la sécurité alimentaire et l'intégration de l'agriculture au marché national et international compte parmi les orientations de la politique agricole.
Quant au secteur agro-alimentaire, il compte 1663 entreprises, ce qui représente 24% de l'ensemble des unités industrielles au Maroc avec une production de l'ordre de 51,4 milliards de dirhams. Ces industries sont actuellement en pleine mutation, elles doivent répondre aux nouvelles contraintes réglementaires dans un contexte de compétition de plus en plus difficile. De plus, la prise de conscience grandissante de la notion de qualité et sécurité sanitaire des aliments pousse les industriels marocains à améliorer sans cesse leurs procédés technologiques et la gestion de la qualité des denrées qu'ils commercialisent, objectifs qui ne peuvent être réalisés que par un personnel qualifié.
Pour contribuer à cette politique agricole et répondre aux besoins des industriels, notre devoir est d'assurer une formation universitaire qualifiante et ciblée.
Dans ce contexte, le projet d'une durée de 4 ans vise à renforcer à la Faculté des Sciences Dhar El Mahraz de Fès la formation universitaire et la recherche en matière de qualité, d'hygiène et de sécurité alimentaires.
Le projet a démarré le 15 septembre 2001 et les différentes actions prévues dans le programme des trois premières années ont été réalisées dans les meilleures conditions.

Acquisition du matériel scientifique de pointe

Dès la première année, l'équipement du laboratoire a été mis en place pour assurer la formation, la recherche et l'analyse des denrées alimentaires. Du matériel lourd de laboratoire a été installé (Chromatographe en phase gazeuse «CPG» et chromatographe en phase liquide haute performance «HPLC»). Ces deux appareils sont toujours opérationnels et ont permis de réaliser de nombreuses analyses aussi bien pour les travaux des thèses de doctorat et des mémoires de DESS prévus par le projet que dans la cadre de la coopération universitaire (stages des étudiants ou membres d'autres institutions).

Formation

Afin de contribuer à la valorisation des denrées alimentaires et la mise à niveau de l'industrie alimentaire marocaine, notre équipe a réuni dans le cadre du projet l'expérience industrielle et universitaire pour former des spécialistes de la gestion et contrôle qualité qui pourrait s'insérer facilement dans la vie active.
En effet, nous avons élaboré une formation de troisième cycle: UFR de Biochimie Appliquée et Sciences Alimentaires «DESS en qualité et sécurité alimentaire» qui a été accrédité en 2002. Parallèlement à ce DESS, une formation doctorale a été ouverte à la Faculté des Sciences Dhar El Mahraz de Fès (UFR de Biochimie Appliquée et Sciences Alimentaires: Doctorat en Biochimie Appliquée, Nutrition et Sécurité Alimentaire). Le programme d'enseignement et les axes de recherches des deux UFR ont été conçus en étroite collaboration avec les partenaires universitaires belges.
L'implication, dans l'UFR de DESS, d'intervenants internationaux compétents en la matière et l'association du secteur socio-économique sont des atouts pour la réussite et la qualité de cette formation. A ceci s'ajoute le grand intérêt que portent les étudiants à cette formation où 182 candidats (marocains et étrangers) ont postulé en 2002-2003 parmi lesquels 14 ont été recruté pour suivre ce programme. De même, en 2003 sur 145 candidats 16 suivent cette formation. Nous entamons actuellement la troisième année de la formation où une troisième promotion a été sélectionnée. Les deux premières années se sont distinguées par une grande motivation aussi bien des enseignants que des étudiants et ont créé un dynamisme national et international qui a permis le

*Ce projet a fait l'objet d'une publication parue dans l'Echosud[5], Bulletin trimestriel de la Commission Universitaire pour le Développement (CUD), décembre 2004 pp. 8-9.

renforcement de la coopération scientifique entre les différentes institutions partenaires de l'UFR. D'autre part, les stages réalisés, par les étudiants de DESS durant les deux premières années, dans les entreprises agro-alimentaires installées dans plusieurs villes du Maroc (Fès, Meknès, Casa, Marrakech, Agadir, Rabat, …) ont permis d'une part de contribuer au rayonnement scientifique et pédagogique de l'institution locale et d'autre part de consolider et de créer une nouvelle forme de partenariat entre la FSDM et certaines industries marocaines, coopération facilitée par l'expérience acquise par le partenaire belge (UCL) dans ce domaine. C'est ainsi que certains travaux réalisés par les stagiaires ont permis d'ores et déjà d'apporter quelques éléments de réponses aux problèmes quotidiens que vivent les entreprises marocaines.
Deux mémoires de DESS ont été réalisés en Belgique (Laboratoire de Brasserie et des Industries alimentaires) grâce à des bourses de stage attribuées dans le cadre du projet.

A côté de la formation DESS, trois thèses de doctorats ont été réalisées et sont actuellement en cours de rédaction. Des bourses de stages en Belgique ont également permis à ces doctorants, d'acquérir de nouvelles techniques et d'enrichir leurs connaissances. Les résultats de recherche se sont concrétisés par plusieurs communications orales et affichées ainsi que par des publications dans des journaux scientifiques spécialisés.
Par ailleurs, les missions d'enseignement effectuées par les experts belges au Maroc et les stages en Belgique ont permis à l'équipe locale de renforcer et d'acquérir de nouvelles compétences en agro-alimentaire et ont facilité le transfert de nouvelles techniques. Ces échanges ont également contribué au renforcement de la coopération scientifique entre l'institution locale, l'UCL et certaines entreprises agro-alimentaires favorisant ainsi l'ouverture de l'université locale sur son environnement socio-économique.

Résultats scientifiques
Outre son rôle évident dans la formation de lauréats qualifiés, le renforcement de la coopération universitaire et des compétences, le projet a permis également d'obtenir des résultats scientifiques importants parmi lesquels on peut citer:

**** Mycotoxines & champignons producteurs***

- L'isolement et l'identification des moisissures contaminant certaines denrées marocaines (céréales, raisins, olives) ont été réalisées sur de nombreux lots. Parmi les 150 souches qui ont été testées pour leur capacité à élaborer des mycotoxines, certaines se sont révélées productrices d'ochratoxine A. Cette mycotoxine est connue pour ses propriétés néphrotoxiques, carcinogènes, tératogèniques et immunotoxiques.

- L'influence de la température, l'activité de l'eau et le temps d'incubation sur le développement de certaines moisissures toxinogènes et l'élaboration de mycotoxines a été étudiée. Les résultats ont montré que le taux de croissance et la production de la toxine dépendent de l'interaction entre les différents paramètres. Une bonne maîtrise de cette interaction permettra de déterminer les conditions optimales à la préservation de la qualité sanitaire des denrées.

- Les mycotoxines sont des substances très stables et ne sont pas détruites lors des traitements technologiques. De plus, de nombreux métabolites toxiques différents peuvent être produits par un même isolat et nécessitent pour leur analyse des méthodes parfois très différentes. Dans ce contexte et pour maîtriser le risque sanitaire lié aux mycotoxines, deux études ont été menées en parallèle: la mise en évidence de composés volatils marqueurs de mycotoxines et la recherche des procédés de détoxication. Les résultats ont montré que certains composés volatils peuvent être exploités comme indicateurs de déoxynivalénol (mycotoxine produite par le genre *Fusarium*). D'autre part, l'association de traitements physiques et chimiques permettent une dégradation partielle de certaines mycotoxines.

**** Qualité organoleptique des aliments***
L'étude des arômes est effectuée en utilisant les techniques d'extraction adaptées pour chaque aliment, des techniques physico-chimiques (GC/FID, GC/Sniffing, GC/MS « réalisée à l'UCL ») et des analyses sensorielles. Dans un premier temps, une grande partie de nos travaux a été consacrée à l'extraction et l'identification de composés odorants qui contribuent significativement à l'arôme de l'aliment (GC/Sniffing). L'évolution de ces arômes au cours des procédés technologiques a également été étudiée dans le cas de l'olive.
Par ailleurs, une étude réalisée le cadre de mémoires de DESS a permis de mettre en évidence d'une part les sources de contamination et de détérioration de la qualité des olives et d'autre part l'influence des conditions de stockage sur leur composition aromatique.

BIBLIOGRAPHIE BOEKBESPREKING

BIBLIOGRAPHY BIBLIOGRAFIA

Veterinary institutions in the developing world: current status and future needs (Les institutions vétérinaires dans le monde en développement : situation actuelle et besoins futurs).

Cees de Haan (ed) OIE

Rev. sci. tech. Off. Int. Epiz., **23** (1) 401 pages, Format 21 x 29,7 cm, ISBN 92-9044-605-6. ISSN 0253-1933
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Ce volumineux numéro spécial de la revue scientifique de l'Organisation Mondiale pour la Santé Animale (OIE) est coordonné par Cees de Haan qui fut longtemps actif dans ce domaine pour la Banque Mondiale. Le document passe en revue les récents développements concernant la prestation de services de santé animale dans les pays en développement, suite aux changements survenus au cours des dernières décennies.

L'impact des réductions budgétaires, l'évolution du partage des responsabilités entre les prestataires des services gouvernementaux et ceux du secteur privé, la mondialisation des échanges et les modifications des systèmes d'élevage concourent à transformer totalement le paysage dans lequel les prestations de services vétérinaires doivent avoir lieu et poussent les acteurs à s'adapter.

Le document est un bilan des expériences en la matière. Les articles sont rédigés en anglais, en français ou en espagnol. Des résumés dans les autres langues que celle de l'article sont ajoutés à chaque article.

On trouve tout d'abord un chapitre sur les rôles du secteur privé et du secteur public. Les arguments économiques sous-jacents sont évoqués et des outils de nouvelle économie institutionnelle sont présentés qui permettent de mieux approcher la problématique. Le mandat sanitaire et la problèmatique du contrôle des maladies contagieuses sont évoqués dans deux autres articles.

Le chapitre suivant traite de la problématique des normes internationales à introduire suite à la globalisation des échanges. Le troisième chapitre s'attarde sur le problème délicat du partage des tâches entre les différents niveaux de prestations de services. Quelles sont les tâches qui peuvent être confiées à un professionnel, un para-professionnel ou un auxilaire? Comment articuler leurs rôles respectifs? Des exemples d'expériences de terrain avec des para-professionnels sont présentés. Le rôle des guérisseurs traditionnels n'est pas négligé.

Le cinquième chapitre présente des études ciblées pour l'Afghanistan, la République Populaire de Chine, les pays de l'ancienne URSS, la Jamaïque, le Kenya et le Sénégal.

Le document contient, ensuite, une évaluation donnée des forces et des faiblesses des systèmes vétérinaires actuels dans les pays en développement. Pour finir, trois articles traitent des implications pour le futur, notamment en matière d'organisation, de recherche et d'enseignement.

Ce document très complet est à conseiller à tous ceux qui suivent avec intérêt l'évolution du secteur de l'élevage et le rôle du vétérinaire dans ce contexte. L'avenir dépend d'actions concertées et d'une vision globale de la problématique du contrôle des maladies animales et des maladies transmissibles par l'animal à l'homme. Ceci doit permettre, dans un contexte d'échanges commerciaux de plus en plus mondiaux de garantir l'intégrité du cheptel et de préserver la qualité des produits d'origine animale mis à la disposition des populations dans le monde.

Dr. E. Thys

Juin 2004.

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Concept of editors and objectives of TROPICULTURA

Agri-Overseas is an association created in order to establish common-interest professional relationships between people working on overseas rural development. It publishes the scientific and information publication « Tropicultura » which covers rural problems in developing countries. This publication is published every three months with the aid of the «Directorate- General for Development Cooperation (D.G.D.C.), Federal Public Service Foreign Affairs, Foreign Trade and Development Cooperation Belgium», and the «Région Bruxelles - Capitale».

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All references should be cited in the text with numbers in parentheses. For more than two references, numbers should follow in ascending order. References will be given in alphabetical order of author’s name and in chronological order for a given author. They will be continuously numbered beginning with the number 1.

For Journal publications, references will include author names preceded by forename initials, year of publication, complete title of the publication in the original language, name of the Journal, underlined volume number, number of the first and last page separated by a hyphen.
Example: Poste G., 1972, Mechanisms of virus induced cell fusion. Int. Rev. Cytol. 33, 157 – 222.
For monographs, the following elements are essential: author name followed by forename initials, year of publication, complete title of the publication, editor name, place of edition, first and last page of mentioned chapter, total number of pages in the publication. Conference proceedings are to have the same format as monographs; plus , they should mention if possible the place and date of the conference and the scientific editor(s).
Example : Korbach M.M. & Ziger R.S., 1972, Heterozygotes detection in Tay-Sachs disease a prototype community screening program for the prevention of recessive genetic disorders pp 613 – 632, *in* :, B.W. Volks & S.M. Aronson (Editors), Sphingolipids and allied disorders, Plenum, New-York, 205 p.

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