ISSN - 0771 - 3312

TROPICULTURA

2002 Vol. 20 N° 4
Trimestriel (octobre – novembre – décembre)
Driemaandelijks (oktober – november – december)
Se publica por ano (octubre – noviembre – diciembre)

Brochette de larves palmistes de *Rhynchophorus* sp. (Col., Curculionidae) extraites des troncs décomposés des palmiers *Caryota Cumingii* Lodd. – Pascal Lays

Editeur responsable / Verantwoordelijke uitgever:
J. Vercruysse
Square du Bastion 1A Bolwerksquare
1050 Bruxelles / Brussel

Avec les soutiens de
la Direction Générale de la Coopération Internationale (DGCI),
Ministère des Affaires étrangères,
Coopération belge internationale (www.dgci.be),
et la Région Bruxelles Capitale

Met de steunen van
Directie Generaal Internationale Samenwerking (DGIS),
Ministerie van Buitenlandse Zaken,
Belgische Internationale Samenwerking (www.dgis.be),
en van het Brusselse Gewest

BUREAU DE DEPOT - AFGIFTEKANTOOR
BRUXELLES X / BRUSSEL X

SOMMAIRE / INHOUD / SUMARIO

ARTICLES ORIGINAUX OORSPRONKELIJKE ARTIKELS

ORIGINAL ARTICLES ARTICULOS ORIGINALES

Développement végétatif et potentiel de rendement chez le manioc

Segnou*

Keywords: Cassava– Vegetative growth– Dry storage root yield– Dry matter content

Résumé

La transformation du manioc en produits dérivés nécessite l'utilisation des clones ayant un haut potentiel de rendement et une teneur en matière sèche élevée. Cette étude analyse l'évolution de la taille, du nombre de feuilles, de la surface foliaire, du poids sec des racines tubéreuses et leur teneur en matière sèche au cours du cycle végétatif. Quatre clones améliorés de manioc (8017, 8034, 8061 et 820516) et un clone local (témoin) sont utilisés comme matériel de plantation. Les observations sont faites 1, 2, 4, 6, 9 et 12 mois après la plantation.

Les résultats obtenus montrent que: (i) il n'y a aucune différence significative entre la taille du clone local et celle de deux clones améliorés (8034 et 820516) 12 mois après la plantation; (ii) aucune différence significative n'est aussi notée au niveau du nombre de feuilles; (iii) la surface foliaire du clone local est significativement plus petite que celle des clones améliorés, ainsi que le poids sec des tubercules. La différence de rendement en racines tubéreuses fraîches et leur teneur en matière sèche résulteraient du volume de la masse foliaire du clone, l'interception de la lumière solaire, son activité photosynthétique et sa vitesse de translocation des réserves nutritives des feuilles aux racines tubéreuses au cours du cycle végétatif.

Summary

Vegetative Growth and Yield Potential in Cassava

Cassava processing into derived products implies using clones with high yield potential and high dry matter content. This study analyses the evolution in plant height, number of leaves, leaf area, dry weight of the storage roots and their dry matter content during the vegetative cycle. Four improved cassava clones (8017, 8034, 8061, and 820516) and a local clone (control) were used as planting material. Observations were made 1, 2, 4, 6, 9, and 12 months after planting.

The results obtained show that: (i) there is no significant difference between the height of the local clone and that of two improved clones (8034 and 820516) 12 months after planting; (ii) no significant difference was also noted in the number of leaves; (iii) leaf area in the local clone is significantly smaller than in the improved clones as well as the dry weight of the storage roots. The difference in fresh storage root yields and their dry matter content could result from the volume of leaf canopy, their interception of solar radiation, the canopy photosynthetic activity and the speed of translocation of nutrients from the leaves to the storage roots during the vegetative cycle.

Introduction

Le manioc (*Manihot esculenta* Crantz) est une plante pérenne appartenant à la famille des Euphorbiacées. Il est cultivé essentiellement pour ses racines tubéreuses qui sont une importante source calorique, et à un degré moindre, pour ses feuilles riches en protéines et en vitamines (7). Le manioc garantit en outre la sécurité alimentaire aux petits paysans pratiquant une agriculture de subsistance. A cause de sa production efficace et peu coûteuse d'énergie alimentaire, sa disponibilité à toutes les périodes de l'année, sa tolérance aux conditions extrêmes de stress pédo-climatiques et son adaptation aux systèmes culturaux et alimentaire, le manioc joue un rôle important dans les efforts d'allègement de la crise alimentaire et de la pauvreté en Afrique subsaharienne.

Les racines tubéreuses de manioc se prêtent à une large gamme de procédés de transformation, aboutissant à des sous-produits alimentaires variés. L'objectif principal du producteur est d'approvisionner régulièrement et en quantité suffisante l'unité de transformation en racines tubéreuses de manioc. Un accent particulier est donc mis sur l'utilisation des clones de manioc ayant un haut potentiel de rendement en tubercules frais par unité de temps, lesquels possèdent à leur tour une haute teneur en matière sèche.

Cette étude analyse l'évolution de certains paramètres du développement végétatif qui déterminent le rendement en racines tubéreuses fraîches et leur teneur en matière sèche, en particulier l'évolution de la taille des plants, du nombre de feuilles et de la surface foliaire des

* Institut de la Recherche Agricole pour le Développement (IRAD), Programme plantes à tubercules, BP 13 Njombé, Cameroun.

Reçu le 21.11.00 et accepté pour publication le 07.06.02.

plants de manioc, le poids sec des racines tubéreuses et leur teneur en matière sèche au cours du temps.

Matériel et méthodes

L'expérience a été réalisée dans le champ expérimental de Muyuka (80 m d'altitude; sol sablo-limoneux; température annuelle moyenne: 28 °C; pluviométrie annuelle moyenne: 2000 mm) de l'Institut de la Recherche Agricole pour le Développement (IRAD) à Njombé (Cameroun). Quatre clones améliorés de manioc (8017, 8034, 8061 et 820516) et un clone local (témoin) ont été utilisés comme matériel végétal de plantation. L'essai a été mis en place selon un dispositif factoriel «*Split plot*» en quatre répétitions comportant chacune cinq parcelles constituées de 13 billons de 7 m de long et distants d'un mètre l'un de l'autre. A la plantation, des boutures de 20-25 cm de long sont insérées obliquement (45°) sur les billons, à l'écartement de 1 m x 1 m (densité de plantation de 10.000 plants/hectare). Chaque parcelle est subdivisée en six sous-parcelles de 3 billons chacune, correspondant aux stades de la croissance végétative auxquels les plants sont récoltés pour observations, à 1, 2, 4, 6, 9 et 12 mois après la plantation.

A chaque période d'observation, 5 plants sont considérés dans une sous-parcelle préalablement choisie au hasard dans chaque parcelle. Le billon central est utilisé comme parcelle utile, les 2 billons périphériques limitant l'effet de bordure.

Au champ, la taille des plants (cm) est mesurée à l'aide d'une règle en bois graduée de 3 m de long, dans chaque parcelle utile. Ensuite ces plants sont prélevés: le prélèvement est effectué de façon à ne pas perturber les parties aériennes ou souterraines des plants.

Au laboratoire, les feuilles de chaque plant sont détachées et on note leur nombre. Après ce comptage, 10 feuilles sont choisies au hasard dans chaque lot et leur surface foliaire (cm^2) est déterminée automatiquement à l'aide d'un appareil portatif «*leaf area meter*» de marque *Delta*-T. Ensuite les racines tubéreuses sont détachées des tiges et on détermine leur poids frais (g) à l'aide d'une balance automatique *Sartorius*. Des échantillons de 100 g de racines tubéreuses (parties médianes) sont prélevés sur chaque clone et fragmentés en vue de faciliter leur dessèchement. Ces échantillons sont placés dans une étuve électrique, séchés à 70 °C pendant 48 heures, puis le poids sec est déterminé. Le test multiple de Duncan est utilisé pour comparer les moyennes.

Résultats et discussions

Les mensurations faites montrent que jusqu'à 2 mois après la plantation, il n'y a pas de différence significative entre la taille des plants de manioc, tant chez les clones améliorés que chez le clone local. Au-delà de ce stade de croissance, le clone amélioré 820516 croît plus vite en hauteur que tous les autres. Il est seul à avoir une taille moyenne au-dessus de 1 m, 4 mois après la plantation. A six mois, il est toujours le plus haut (175,5 cm), suivi par 2 autres clones améliorés, 8017 (146,9 cm) et 8061 (142,2 cm). A ce stade de la croissance végétative, le clone amélioré 8017 et le clone local (témoin) ont

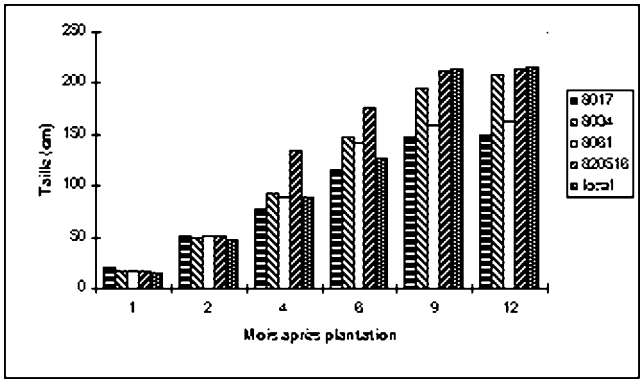


Figure 1: Taille (cm) des plants de manioc au cours du cycle végétatif.

les tailles les plus basses (114,7 cm et 126,5 cm respectivement). Au-delà de cette période, le clone local s'allonge plus rapidement en hauteur et rattrape le clone 820516; 9 mois après la plantation (Figure 1). A douze mois, il n'y a pas de différence significative entre la taille des deux clones améliorés 8034 (208,9 cm) et 820516 (232,9 cm) et le clone local (216,1 cm), les deux autres clones améliorés 8017 et 8061 ayant approximativement 150 cm de taille chacun.

Un mois après la plantation, il n'y a pas de différence significative entre le nombre de feuilles du clone local et de tous les 4 clones améliorés. A deux mois, le clone amélioré 8017 présente le nombre de feuilles le plus élevé (52 feuilles) et le clone 820516 n'en possède que la moitié (25 feuilles). Quatre mois après la plantation, il y a équilibre au niveau du nombre de feuilles chez tous les clones de manioc. Cet équilibre est rompu 6 mois après la plantation, le nombre de feuilles des clones améliorés étant significativement supérieur à celui du clone local (Figure 2). Au-delà de ce stade de la croissance végétative et ce jusqu'à la récolte (12 mois après la plantation), la vitesse d'émission foliaire du clone local augmente rapidement, à tel point qu'il n'y a plus de différence significative entre le nombre de feuilles chez tous les clones de manioc.

De 1 à 6 mois après la plantation, la surface foliaire des clones améliorés de manioc est significativement supérieure à celle du clone local (Figure 3). Le clone 820516 possède la surface foliaire la plus élevée (280,1 cm^2), 6 mois après la plantation et le clone local présente la plus faible surface foliaire (163,3 cm^2). A neuf mois, il n'existe plus de différence significative entre la surface foliaire du clone local (85,0 $cm^{2)}$ et celle des clones améliorés 820516 (85,9 cm^2) et 8017 (79,6 cm^2). Les

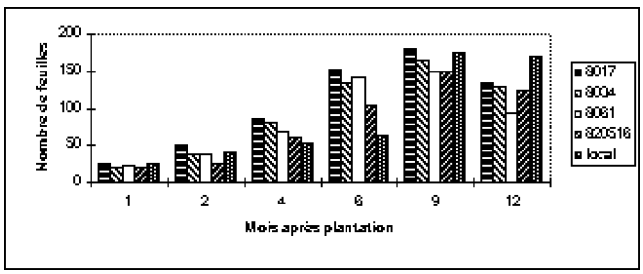


Figure 2: Nombre de feuilles des plants de manioc au cours du cycle végétatif.

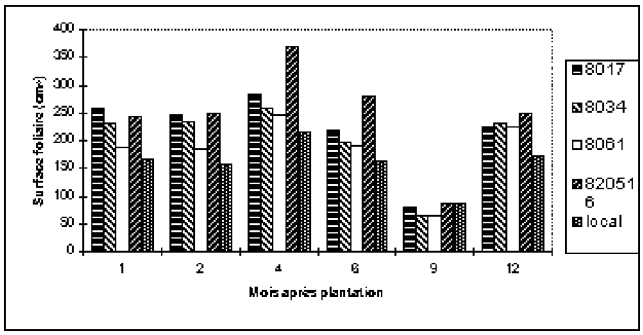


Figure 3: Surface foliaire (cm^2) des plants de manioc au cours du cycle végétatif.

valeurs réduites de la surface foliaire à ce stade de développement s'expliquent par le fait que tous les clones de manioc ont laissé chuter leurs feuilles les plus larges, produisant en compensation des feuilles de taille réduite: c'est un mécanisme de résistance au stress dû à la sécheresse qui a sévi dans la localité au cours de l'expérimentation (5, 8). A la récolte, 12 mois après la plantation, il y a reprise de la végétation avec le retour des pluies et la surface foliaire des clones améliorés est à nouveau significativement supérieure à celle du clone local.

Les observations faites un mois après la plantation montrent qu'il n'y a pas de différence significative au niveau du rendement en racines tubéreuses sèches chez tous les clones. Le clone 8017 possède néanmoins le rendement le plus élevé (0,8 g/plant), et le clone local le rendement le plus faible (0,1 g/plant). A deux mois, il y a croissance rapide du poids sec des racines tubéreuses chez tous les clones; le cultivar 8034 a augmenté 40 fois le poids sec de ses racines tubéreuses, le clone 8017 et le témoin, 34 fois chacun. La teneur en matière sèche des racines tubéreuses, à ces stades de développement, est sensiblement la même (18% et 21% chez le clone 8017 à 1 et 2 mois après la plantation, respectivement). Après 4 mois, le rendement du clone local (22,3 g/plant) est significativement inférieur à celui des clones améliorés (Figure 4). Le clone 8017, avec un rendement de 12,2 t/ha; 9 mois après la plantation, a le poids sec de racines tubéreuses le plus élevé; 2,5 fois celui du clone local (5,0 t/ha). La teneur des racines tubéreuses en matière sèche est plus élevée chez tous les clones 9 mois après la plantation (jusqu'à 42% chez 8034). Cette forte concentration en matière sèche est liée à la saison sèche qui a sévi dans la localité d'expérimentation à ce stade de la croissance végétative (1, 5). La baisse de concentration en matière sèche dans les racines tubéreuses à la récolte, 12 mois après la plantation est due au retour de la saison des pluies: dans un sol plus humide, les racines se gorgent plus facilement d'eau. Le temps idéal de récolte des clones améliorés de manioc est de 10-12 mois après la plantation: cette période correspond au stade végétatif auquel les racines tubéreuses ont: (i) le poids frais et (ii) la concentration en matière sèche les plus élevés (6). Elles constituent ainsi une matière première idéale pour la transformation en sous-produits alimentaires dérivés du manioc: gari, farine, amidon,...etc (3, 4). Lorsque les racines tubéreuses sont laissées sur pied au-delà de ce délai, l'engorgement en eau et la concentration en amidon provoquent des éclatements dans le sol. Les fissures qui résultent de ces éclatements sont des portes d'entrée aux microorganismes responsables des pourritures, avec perte significative de la matière première aussi bien qualitativement que quantitativement.

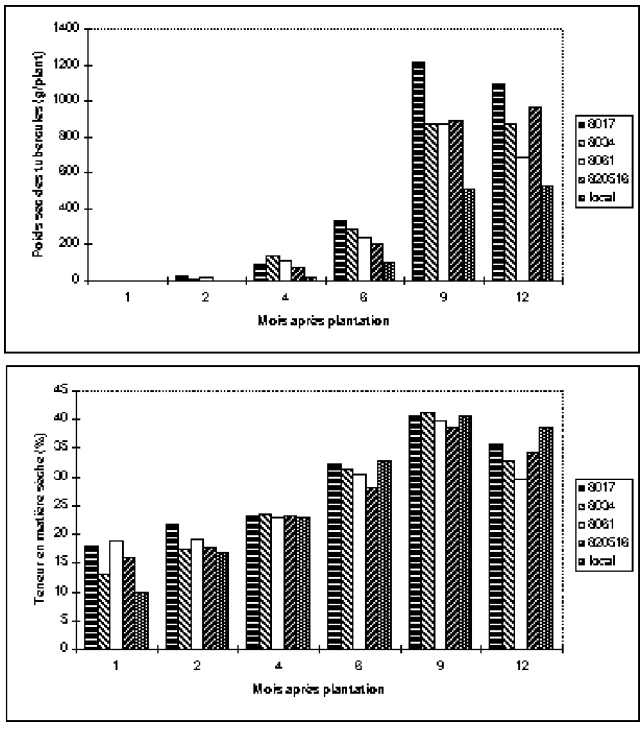


Figure 4: Poids sec (g/plant) et pourcentage de la matière sèche des racines tubéreuses de manioc au cours du cycle végétatif.

Conclusions et suggestions

Au vu des résultats obtenus, il se dégage que le développement végétatif d'un plant de manioc peut être subdivisé en deux grandes phases: (i) de la plantation jusqu'à l'âge de 4 mois, qui correspond à la phase d'initiation de la canopée et des racines tubéreuses, (ii) de 4 mois jusqu'à la récolte, 10-12 mois après la plantation, qui correspond à la mise en place effective du couvert végétal et à l'accumulation progressive des réserves nutritives dans les racines tubéreuses. Les clones de manioc utilisés dans cette expérimentation diffèrent aux points de vue morphologique et physiologique; mais considérant leur développement végétatif, ils se comportent relativement selon cette subdivision: la différence de rendement en racines tubéreuses fraîches à la récolte et leur concentration en matière sèche résulteraient du volume de la masse foliaire (nombre de feuilles, surface foliaire) que le clone est capable de développer, de l'interception de la lumière solaire par cette masse foliaire, de son activité photosynthétique et de la vitesse de translocation des réserves nutritives depuis les feuilles jusqu'aux racines tubéreuses (2, 8).

Il est recommandé de cibler la récolte des clones améliorés de manioc à 10-12 mois après la plantation, période qui correspond au pic du développement du poids frais et de l'accumulation de la matière sèche dans les racines tubéreuses. Il serait ainsi possible d'appro-

visionner une unité de transformation du manioc en matière première de qualité, régulièrement et en quantité suffisante pendant toute l'année.

Remerciements

L'auteur remercie l'Institut de la Recherche Agricole pour le Développement (IRAD) du Cameroun pour le financement de ces travaux de recherche.

Références bibliographiques

1. Adeyeye S.O., Dixon A.G.O., Asiedu R. & Hahn S.K.,1989, Assessment of dry-matter content in cassava. pp 111-112 *in*: M.O. Akoroda and B. Arene (Editors), Tropical Root Crops: Promotion of Root Crop-Based Industries. Proceedings of the fourth triennial symposium of the International Society for Tropical Root Crops-Africa Branch- held in Kinshasa, Zaïre, 5-8 December 1989.

2. Cock J.H., 1976, Characteristics of high yielding cassava varieties. Experimental Agriculture, 12, 135-143.

3. Kogbe J.O.S., Omidiji M.O., Akinlosotu T.A., Omueti O. & Osikanlu Y.O.K., 1989, Evaluation of local and improved cassava cultivars for desirable characteristics in South-Western Nigeria: evaluation for yield and related components. Journal of Root Crops, 15, 71-77.

4. Ntawuruhunga P., Ojulong H., & Dixon A. G. O., 1995, Genetic variability among cassava genotypes and its growth performance over time. pp 242-248 *in*: M.O.Akoroda & I.J. Ekanayake (Editors), Root Crops and Poverty alleviation. Proceedings of the sixth triennial symposium of the International Society for Tropical Root Crops-Africa Branch- held in Lilongwe, Malawi, 22-28 October 1995.

5. Osiru D.S.O., Hahn S.K.,& Osonubi O., 1989, Varietal response to drought stress in cassava. pp 97-102 *in*: M.O. Akoroda and B. Arene (Editors), Tropical Root Crops: Promotion of Root Crop-Based Industries. Proceedings of the fourth triennial symposium of the International Society for Tropical Root Crops-Africa Branch- held in Kinshasa, Zaïre, 5-8 December 1989.

6. Osiru D.S.O. & Hahn S.K., 1995. Dry matter production and partitioning in cassava (*Manihot esculenta*) intercropped with maize or groundnut. pp 76 *in*: M.O. Akoroda and I.J. Ekanayake (Editors), Root Crops and Poverty Alleviation. Proceedings of the sixth triennial symposium of the International Society for Tropical Root Crops-Africa Branch- held in Lilongwe, Malawi, 22-28 October 1995.

7. Oyenuga V.A., 1968, Nigeria's food and feeding-stuffs: their chemistry and nutritive value. Ibadan University Press. pp 6-35.

8. Veltkamp I.J., 1985, Physiological causes of yield variation in cassava (*Manihot esculenta* Crantz). Agricultural University Wageningen Papers 85-6, pp 87-92.

Segnou, Camerounais, Ir. agronome, Ms. Sc., Chercheur (Grade de Chargé de Recherche) à l'IRAD, Station de Njombé, BP 13, Njombé, Cameroun.

AVIS

Nous rappelons à tous nos lecteurs, particulièrement ceux résidant dans les pays en voie de développement, que TROPICULTURA est destiné à tous ceux qui œuvrent dans le domaine rural pris au sens large.

Pour cette raison, il serait utile que vous nous fassiez connaître des Institutions, Ecoles, Facultés, Centres ou Stations de recherche en agriculture du pays ou de la région où vous vous trouvez. Nous pourrions les abonner si ce n'est déjà fait.

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.

Dank U.

Ingestion volontaire et digestibilité apparente d'une ration à base de la farine de graines de *Mucuna pruriens* var. *utilis* complétée de fourrages chez les lapins

A.B. Aboh**, M. Olaafa*, G.S.O. Dossou-Gbété*, A.D. Dossa* & N. Djagoun*

Keywords: Mucuna grain flour– Forage crops– Digestibility– Weight-gain– Rabbit– Benin

Résumé

La farine de graines de Mucuna pruriens *var.* utilis *(mucuna) détoxiquées est valorisée comme source de protéines végétales dans la ration alimentaire de base de quinze lapins en croissance, répartis en cinq lots de trois. Chaque lapin a reçu quotidiennement une quantité fixe de la ration de base (soit 130,5 g de MS), mais comme aliment unique (RP) pour le lot témoin; plus 40,5 g de MS de fourrage de* Panicum maximum *et 60 g de MS de l'une des quatre légumineuses expérimentales de* Aeschynomene histrix *(RH),* Mucuna pruriens *(RFM),* Stylosanthes scabra *Secca (RS) et* Tridax procumbens *(RT) pour les autres lots.*

L'expérimentation conduite au Bénin a duré 26 jours, décomposés en 19 jours d'adaptabilité aux rations alimentaires et 7 jours de collecte des données. Les ingestions alimentaires volontaires quotidiennes étaient de l'ordre de 28 à 42 g MS/kg de poids vif (PV) pour la ration de base et de 10,5 à 18 g de MS/kg PV pour le Panicum maximum*. Les consommations des fourrages verts de* Aeschynomene histrix, Mucuna pruriens*,* Stylosanthes scabra *étaient supérieures à celle de* Tridax procumbens *(P< 0,01). L'apport de fourrages verts à la ration alimentaire de base a accru l'ingestion totale d'aliment par jour qui est de l'ordre de 67 à 89 g de MS/kg PV et 26 à 39 g MS/jour pour la production de crottes. La consommation d'eau chez les lapins soumis à la ration alimentaire RP est plus élevée. Les rations alimentaires RFM mais aussi RS et RH ont été très digestes avec des taux en matière sèche de 70%, 61% et 54%. Elles ont induit des gains de poids élevés de 30-22 g/jour.*

Summary

Volontary Ingestion and Apparent Digestibility of a Ration Based on *Mucuna pruriens* var. *utilis* Seeds Flour Completed with Forage on Rabbits

Mucuna pruriens *var.* utilis *(mucuna) detoxified seeds flour is used as a vegetable protein source, in a basal diet of fifteen growing rabbits divided in five groups of tree. Each rabbit received per day a fixed quantity of basal diet (130.5 g DM), but as only feed (RP) for control group; plus 40.5 g DM of* Panicum maximum *forage and, 60 g DM of one of the four experimental legumes of* Aeschynomene histrix *(RH),* Mucuna pruriens *(RFM),* Stylosanthes scabra *Secca (RS) and* Tridax procumbens *(RT) for the others groups. The experiment conducted in Benin has lasted 26 days, split in 19 days for diet adaptability and 7 days for data collection. Voluntary daily feed intake varied from 28 to 42 g/kg of dry mater (DM) of live weight (LW) for basal diet and from 10.5 to 18 g DM/kg of LW for* Panicum maximum*. Green forage consumption of* Aeschynomene histrix*,* Mucuna pruriens *and* Stylosanthes scabra *were higher compared to the one of* Tridax procumbens *(P< 0.01). The supply of green forage to basal diet has increased the total daily feed intake that is about 67 to 89 g DM/kg of LW and 26 to 39 g DM/day for dung production. Water intake is higher for rabbit fed with RP diet. Feed resource RFM but also RS and RH have been digestible with 70%, 61% and 54% DM. They gave high weight gain of 30-22 g/day.*

Introduction

Le développement de la production intensive de lapins dans les zones périurbaines du Bénin a entraîné un accroissement important des demandes d'aliments composés équilibrés en nutriments, notamment en matières azotées totales (MAT). L'une des conséquences de ce développement a été l'accroissement de la pression sur les sources de protéines conventionnelles comme les farines de soja et de poisson dont les prix ne cessent d'augmenter. L'alternative d'utiliser les graines de légumineuses telles que *Mucuna pruriens* et *Canavalia ensiformis,* comme sources potentielles de protéines non conventionnelles dans l'alimentation des animaux monogastriques, a été alors suggérée pour réduire le coût de production (12). Au Bénin, la légumineuse *Mucuna pruriens* var. *utilis* (mucuna) est cultivée comme

* Unité de Recherches Zootechnique et Vétérinaire, Institut National des Recherches Agricoles du Bénin. 01 BP 884 Cotonou Bénin. E- mail: inrabdg4@bow.intnet.bj
** Adresse de contact
Reçu le 14.02.01 et accepté pour publication le 19.08.02.

plante de couverture par les paysans pour améliorer la fertilité du sol, lutter contre les mauvaises herbes et alimenter les animaux (1, 16, 17, 19). Ainsi, d'énormes quantités de graines riches en MAT sont produites dans les exploitations agricoles. Malheureusement, elles sont toxiques en raison de leur teneur élevée en des facteurs anti-nutritionnels dont le plus important est la L-dopa (13, 14, 15). Des traitements physico-chimiques de détoxication des graines ont été mis au point. Ils permettent de réduire le taux de L-dopa et d'autres facteurs anti-nutritionnels à un seuil inoffensif aussi bien pour l'homme que pour les animaux (3, 6). Il a été par ailleurs, recommandé d'utiliser la farine des graines détoxiquées dans une combinaison avec celle des céréales (8).

Les informations sur l'ingestion et la digestibilité de la ration à base de farine de graines de mucuna chez les lapins sont peu fournies (5).

Les pratiques alimentaires cunicoles dans les fermes consistent à complémenter la ration alimentaire avec des fourrages locaux. Les fourrages des plantes cultivées telles que *Aeschynomene histrix*, *Mucuna pruriens*, *Stylosanthes scabra* Secca et *Panicum maximum* C_1, ne sont pas utilisés dans l'alimentation des lapins; bien qu'ils disposent de potentiels nutritionnels élevés. L'objectif de l'étude est de déterminer l'ingestion volontaire, la digestibilité apparente, la production de crottes chez les lapins en croissance nourris avec une ration alimentaire contenant la farine de graines de mucuna et les fourrages verts des plantes cultivées.

Matériel et méthode

Composition des rations alimentaires

Les graines de mucuna ont subi au préalable, un traitement physico-chimique permettant la réduction de la L-dopa de 50%. Elles ont été concassées à sec, dépelliculées, trempées pendant 24 heures, bouillies pendant 30 mn, retrempées pendant 24 heures et séchées (6). La farine des graines de mucuna a été mélangée à d'autres ingrédients pour fabriquer la ration de base des lapins, mais comme aliment unique (RP) pour le lot témoin (Tableau 1). Cette ration alimentaire de base, associée aux fourrages verts de *Panicum maximum*, complémentée avec une des quatre légumineuses ou astéracée expérimentales *Aeschynomene histrix* (RH), *Mucuna pruriens* var. *utilis* (RFM), *Stylosanthes scabra* Secca (RS) et *Tridax procumbens* (RT) ont constitué les autres rations alimentaires expérimentales. L'utilisation de fourrage de *Panicum maximum* est une pratique courante dans les exploitations cunicoles, ce qui justifie son inclusion comme ration de base dans l'essai. Les légumineuses et *Panicum maximum* utilisés pour l'essai sont des plantes exotiques adaptées à plusieurs zones agro-écologiques du Bénin, mais de plus en plus cultivées dans les exploitations agricoles. L'astéracée, *Tridax procumbens* ou herbe à lapin est par contre, une espèce locale qui pousse spontanément dans les champs et exploitée par les agro-éleveurs pour alimenter les lapins en milieu rural. Les compositions chimiques des fourrages et ration de base sont présentées dans le tableau 2.

Tableau 1

Composition centésimale de la ration de base

Ingrédients alimentaires	Poids (%)
Farine des graines de mucuna	12,5
Maïs	25,0
Tourteau d'arachide	12,5
Tourteau de palmiste	10,0
Son de blé	36,5
Coquille d'huître	2,8
Complément minéral vitaminé	0,2
Sel de cuisine	0,5

Alimentation des lapins

Quinze lapereaux sevrés, âgés de 35 à 55 jours, de poids vif moyen de 533 ± 44 g au début de la période d'adaptation alimentaire et de 1056,7 ± 125,3 g au démarrage de l'essai, ont été répartis en cinq lots homogènes de trois lapins sur la base de leur poids vif et de leur âge. Ils ont été disposés dans des cages individuelles de digestibilité de 0,25 m^2 de surface et de 0,45 m de hauteur. Chaque lot d'animaux a été affecté au hasard à l'une des cinq rations alimentaires. Il a été distribué quotidiennement à chaque lapin des quantités fixes d'aliment, soit 130,5 g de MS de ration de base, mais aliment unique pour le lot témoin; plus

Tableau 2

Teneur moyenne en matière sèche (MS), en matière minérale (MM) et en matière azotée totale (MAT) et cellulose brute des fourrages et de la ration alimentaire de base

Ingrédients alimentaires	MS (%)	MM (%)	MAT (%)	Cellulose brut (%)
Panicum maximum C_1	29,00	9,86	5,34	39,65
Feuilles de mucuna	28,00	3,83	23,16	28,75
Stylosanthes scabra Secca	41,00	4,84	12,96	40,59
Aeschynomene histrix	34,00	4,36	13,02	33,30
Tridax procumbens	15,00	6,22	9,02	27,90
Ration alimentaire de base	87,00	16,02	19,26	7,91

40,5 g de MS de *Panicum maximum* et 60 g de MS de l'une des quatre légumineuses ou astéracée expérimentales (*Mucuna pruriens* var. *utilis, Aeschynomene histrix, Stylosanthes scabra Secca, Tridax procumbens*). Une quantité de 500 ml d'eau est distribuée quotidiennement à chaque lapin. Les différents types de fourrages verts ont été distribués séparément et simultanément aux lapins. L'étude a duré 26 jours décomposés en une période de 19 jours d'adaptation aux rations alimentaires et 7 jours de collecte des données. Les lapins ont été pesés au début et à la fin de l'essai. Les aliments proposés et refusés, ainsi que les crottes ont été enregistrées par animal et par jour afin de déterminer l'ingestion et la digestibilité apparente.

Analyse de laboratoire

Des échantillons d'aliments proposés, refusés et de crottes ont été prélevés quotidiennement et séchés à l'étuve à 80 °C pendant 48 h pour déterminer la matière sèche. Ils ont été ensuite broyés à l'aide d'un moulin à rotor muni d'un tamis de 1 mm de diamètre. La matière minérale a été déterminée par incinération et le dosage de l'azote a été fait par la méthode Kjeldhal (4). L'azote dosé a été multiplié par 6,25 pour calculer la matière azotée totale (MAT). La cellulose a été déterminée par la méthode de Van Soest (18).

Analyse statistique

Les données ont été analysées en utilisant la procédure du modèle général d'analyse de variance du logiciel GENSTAT (9).

Résultats

Ingestion d'aliments

L'ingestion volontaire aussi bien du *Panicum maximum* que de la ration de base ne présentait pas de différence significative (P> 0,05) quelles que soient les rations alimentaires. Cependant, la consommation des légumineuses par les lapins était plus élevée que celle de l'astéracée (*Tridax procumbens*). Par ailleurs, la consommation *d'Aeschynomene histrix* par les lapins était supérieure (P< 0,01) à celle des autres légumineuses (Tableau 3). L'ingestion totale par les lapins des rations alimentaires contenant des fourrages des légumineuses était significativement plus élevée (P< 0,01) comparée à celle contenant la plante d'astéracée (Tableau 3).

L'introduction des fourrages dans la ration a accru la consommation totale d'aliments par jour (P< 0,01). Les lapins ont ingéré au moins 50% de fourrages par rapport à leur ingestion totale quotidienne. Cette proportion de fourrages consommés est plus élevée dans le cas des rations alimentaires RH et RFM. Quant à la consommation d'eau, elle était plus importante (P< 0,05) chez les lapins nourris exclusivement à la ration de base.

Digestibilité apparente de matière sèche (MS), de matière organique (MO), production de crottes et développement pondéral

L'apport des fourrages à la ration de base a amélioré la digestibilité apparente de MS et de MO chez les lapins. Mais, ces digestibilités apparentes de MS et MO étaient significativement élevées (P< 0,05) pour la ration RFM comparée aux autres rations contenant des fourrages (Tableau 4). L'apport des fourrages en complément à la ration alimentaire de base a accru la production de crottes qui était plus importante (P< 0,01) chez les lapins aux rations RH et RS (Tableau 4).

Toutes les rations (composées ou non de fourrages) avaient entraîné une augmentation de poids vif corporel. Celle-ci était significativement importante (P< 0,05) chez les lapins nourris avec les rations contenant les fourrages des légumineuses à savoir RFM mais aussi RH et RS (Tableau 4).

Discussion

Les teneurs en MAT de la ration de base et des fourrages sont similaires à celles obtenues par d'autres auteurs (2, 7, 13). La teneur en cellulose brute de la ration de base est faible. L'ingestion de cette ration

Tableau 3

Variations des consommations journalières d'aliments, d'eau et du ratio d'ingestion fourrage/ration de base chez les lapins

	Rations alimentaires						
Consommation	RFM	RH	RS	RT	RP	SED	CV%
Panicum maximum (g MS/kg PV)	13,0	11,1	10,5	17,8	–	NS	25,7
Légumineuses (g MS/kg PV)	37,5	47,4	32,6	17,5	–	5,0	18,2
Ration de base (g MS/kg PV)	37,1	27,8	42,0	31,9	35,8	NS	15,7
Ingestion totale (g MS/kg PV)	87,7	86,3	85,1	67,2	35,8	9,7	16,4
Ratio fourrages/Ration de base (%)	57,19	68,05	50,49	51,23	–	–	–
Eau (ml/jour)	56,3	51	86,3	45,0	123,7	20,14	34,00

Nombre de lapins= 3/ration alimentaire;

NS: Non Significatif

Tableau 4

Variation des taux de digestibilités apparentes de MS, de MO, de production de crottes et de développement pondéral

Rations	Digestibilité		Crottes		Gain de poids vif (g/semaine)
	MS (%)	MO (%)	g MS/jour	g MO/jour	
RFM	70,5	68,94	26,3	24,7	208
RH	58,4	55,69	39,1	36,4	167
RS	61,2	56,85	37,9	35,6	158
RT	54,2	51,76	29,2	26,2	75
RP	49,8	42,5	8,1	7,6	67
SED	5,89	4,74	3,61	3,7	43,9
CV (%)	11,2	12,6	15,7	17,4	29,9

Nombre de lapins= 3/ration.

farineuse est trop faible (moins de 50% par rapport aux autres aliments) en comparaison avec des granulés. Cette faible consommation de la ration alimentaire RP serait due à la forme de présentation farineuse. En effet, le lapin supporte très mal les poussières inévitablement présentes dans les farines parce qu'elles perturbent le fonctionnement normal de ses voies respiratoires (11).

L'addition à la ration alimentaire de base des fourrages du *Panicum maximum* et de légumineuse n'a pas diminué l'ingestion alimentaire quotidienne de la ration de base mais au contraire a induit une augmentation de l'ingestion totale; et par conséquent, le gain de poids substantiel. Toutefois, l'ingestion totale de la ration RT est faible à cause de la faible consommation de *Tridax procumbens*, indication probable d'une faible palatabilité. Les gains de poids obtenus en associant le *Panicum maximum* et les légumineuses à la ration alimentaire de base sont comparables à ceux d'un granulé équilibré (10, 11). Les rations alimentaires RFM mais aussi RH et RS ont été très digestes avec des performances pondérales intéressantes. Ces digestibilités témoignent de l'utilisation judicieuse de ces rations alimentaires par les lapins. Le taux de digestibilité apparente de matière sèche obtenue avec la ration RFM est comparable à ceux enregistrés au Nigeria, soit 66-75% en utilisant la farine de soja comme source principale de protéines (3). Par ailleurs, la mauvaise utilisation de la ration RP serait liée à sa faible teneur en fibres. En effet, les travaux ont montré qu'un minimum de 9 à 10% de cellulose brute indigestible est nécessaire aux lapins pour leur assurer un fonctionnement digestif normal. Chez les lapins en croissance, une teneur de 13 à 14% de fibres apparaît comme suffisante en alimentation pratique (11). Le taux élevé de digestibilité de la ration RP chez les lapins du lot témoin serait dû à la faible ingestion alimentaire.

Pour pouvoir digérer la ration alimentaire, la consommation d'eau a été proportionnellement au taux de MS contenue dans les rations alimentaires. Ainsi, plus le taux de MS est élevé plus les lapins ont consommé de l'eau. Cette alimentation en eau est faible chez les lapins soumis aux rations alimentaires RT, RH, RFM ainsi que RS à cause de la teneur en eau contenue dans les légumineuses et *Panicum maximum*.

Conclusion

Une farine à base de graines de mucuna associée avec des fourrages de *Panicum maximum* et de légumineuses locales notamment la ration RFM mais aussi RH et RS (mais pas RT) donnent une ration assez digestible ainsi que des performances de croissance élevées, même comparables avec des granulés équilibrés.

Remerciements

Les auteurs remercient sincèrement Dr. Ir. G.A. Mensah et Dr. S.C. Dossa pour leur appuis scientifique et technique puis leurs critiques constructives lors de la réalisation de cette étude.

Références bibliographiques

1. Aklamavo M. & Mensah G.A., 1997, Quelques aspects de l'utilisation du mucuna en milieu rural en République du Bénin. Bulletin de la Recherche Agronomique, N° 19, PP 34-46. INRAB, Bénin.

2. Akpona A.S., Dossa C.S., Mensah G.A., Dossa A.D. & Fatoke M., 1998, Chemical evaluation of velvet bean seeds: Qualities as a vegetable protein source. Proceedings of the Vth Animal conference: Bioscience and food security 4, 409-415 ISSN 1019-7702. Ed CMF Mbofung, F.X. ETOA, P.F. Moundipa, J. Ngogan.

3. Anugwa F.O.I., Adesua M. & Ikurior S.A., 1998, Proceeding: Silver Anniversary, WASAP inaugural conference March 21-26, 1998. 610-611 Paper N° 308.

4. AOAC, 1990, Official Methods of Analysis. Association of Official Agricultural Chemist (AOAC), 15th Edition, Washington, DC, USA. P 66-89

5. Attidéhou S., 1998, Utilisation de farine de graines de *Mucuna pruriens* dans l'alimentation des lapins: Effets sur la croissance. Mémoire de fin de cycle pour le DIT UNB/CPU-Bénin. P 50

6. Dossa C.S., Mensah G.A., Dossa A.D. & Adoun C., 1999, Influence de divers traitements physico-chimiques de graines de *Mucuna pruriens* sur leur composition chimique en nutriments. Tropicultura, 1998-1999, **16-17** (3) p141-146.

7. Ehouinsou M. & Aboh B.A., 1998, Adaptabilité de *Aeschynomene histrix* à la production fourragère dans les savanes du Nord Bénin. Bulletin de Recherche Agronomique N°22, pp. 31-42 INRAB-Bénin.

8. Flores M., 1993, La utilizacion del Frijol Abono Como Alimento Humano. Informe Technico N° 8: 1-4 CIDICCO / Honduras.

9. Genstat, 1999, An introduction for Genstat. 2nd ed. Statistics Department, IACR-Rothansted, Harpenden, Herts ALJQ, UK.

10. King J.O.L., 1974, The effects of pelleting rations with or without an antibiotic on the growth rate of rabbits vet rec. 94, 586-588.

11. Lebas F., Coudet P., de Rochambeau H. & Thébault R.G., 1996, Le lapin: Elevage et Pathologie. Collection FAO: Production et santé animales N° 19 p29, Rome.

12. Leon A., Angulo I., Picard M., Carré B., Derouet L. & Harscoat J. P., 1989, Proximate and amino acid composition of seeds of *Canavalia ensiformis*. Toxicity of the kernel fraction for chicks Ann. Zootech. 38, 209-218, Elsevier/INRA.

13. Lorenzetti F., MacIsaac S., Arnason J.T., Awang D.V.C. & Buckles D., 1998, The phytochemistry, toxicology and food potential of velvet bean (*Mucuna adans* spp., Fabaceae). Cover Crops in West Africa: Contributing to sustainable Agriculture. IDRC/IITA/SG 2000 67-84.

14. Mary R.J. & Janardhanan K., 2000, Etude sur la composition chimique et les facteurs anti- nutritionnels de 3 lots de semences issus du germoplasme de *Mucuna pruriens* (L.) DC. Bulletin d'information du CIEPCA N° 5 Av. 2000 p5.

15. Ravindra V. & Ravindra G., 1988, Nutritional and antinutrionnal characteristics of *Mucuna* (*Mucuna utilis*) bean seeds. J. Sci. Agric. 46, 71-79.

16. Spore, 1995, Les agriculteurs béninois améliorent la fertilité des sols. Spore 57, 11. CTA.

176. Spore, 1996, Le mucuna, une plante fourragère bientôt vivrière. Spore 63, 7. CTA.

18. Van Soest P.J., 1982, Nutritional Ecology of the ruminants and Books, Corvallis, O R, 374 pp

19. Versteeg M.N. & Koudokpon V., 1990, Contribution du mucuna à la lutte contre imperata au Sud du Bénin. Bulletin RESPAU N°7, pp. 7-8.

A.B. Aboh, Béninois, Zootechnicien, Unité de Recherche Zootechnique et Vétérinaire (URZV) de l'Institut National des Recherches Agricoles du Bénin (INRAB), Assistant de recherche.

M. Olaafa, Béninois, Collège Polytechnique Universitaire de l'Université Nationale du Bénin – Option laboratoire de recherche et enseignement – Attaché de recherche.

G. Dossou-Gbété, Béninois, Diplôme d'ingénieur des Travaux d'élevage- Spécialité en Production Animale Tropicale, Assistant de recherche dans la division Santé Animale (LRZVH/INRAB/MAEP).

A.D. Dossa, Béninois, Assistant de Recherche à l'Unité de Recherche Zootechnique et Vétérinaire (URZV) de l'Institut National des Recherches Agricoles du Bénin (INRAB) du Ministère du Développement Rural (MDR).

N. Djagoun, Béninois, Diplômé de capacité en droit et science économique et politique, Technicien de recherche en agriculture, Chargé de la production de lapin à l'Unité de Recherches Zootchnique et Vétérinaire, précisément à la valorisation des sous-produits dans l'alimentation des lapins.

TROPICULTURA, 2002, **20**, 4, 170-175

Traditional Underground Grain Storage in Clay Soils in Sudan Improved by Recent Innovations

A.T. Abdalla*, C.J. Stigter**#, N.I. Bakhiet***, M.C. Gough****, H.A. Mohamed*, A.E. Mohammed* & M.A. Ahmed***

Keywords: Clay soils– Grain storage– Pit grain storage– Sorghum grain– Underground grain storage– Sudan

Summary

In the central clay plain of the Sudan, traditional subsistence farmers and small farmers that also produce for local markets want to keep the region near food self-sufficiency. They combine annual production of sorghum with underground pit storage of part of the harvest. With increasing climate variability this food security is coming more and more under pressure. Farmers recently experimented with pit innovations that would allow storage for more than one season. These innovations were quantified and further improvements were suggested. It was found that in the most abundantly occurring cracking clay soils, wide shallow pits, using thick chaff linings, with wider above ground soil caps, are most suitable for longer term storage.

Résumé

Amélioration du système traditionnel de stockage souterrain des céréales dans les sols argileux au Soudan

Les agriculteurs de la région argileuse centrale du Soudan pratiquent une agriculture d'autosubsistance tout en vendant une partie de leur récolte. Pour la conservation des céréales, une méthode traditionnelle basée sur un stockage dans des fossés souterrains est pratiquée. Cette technique ne permet cependant pas une conservation de plus d'une saison suite aux variations des conditions climatiques. Une nouvelle méthode a été initiée, quantifiée et améliorée. Elle consiste à creuser des fossés larges, peu profonds, garnis de pailles hachées et couverts par une couche épaisse de terre. Cette technique prometteuse garantit une conservation de longue durée même dans les sols argileux, très sensibles aux fissures qui sont abondants dans la région.

Introduction

The Sudanese government has been advised that increasing climate variability caused longer sequences of dry as well as wet years (1, 15, 17). Subsistence farmers in marginal areas such as central Sudan, but also those producing for themselves as well as for local markets, depend on rainfed production and traditional storage to the next harvest. Improving storage for longer duration at the village level is thought to be part of the solution to this change of climate (2, 14). The storage systems in use are warehouses and underground pits, so called matmuras (12). Small farmers use small size pits, from 2 to 10 tonnes, as a food security store. Medium and big farmers use pits up till more than 50 tonnes as alternative banks for gaining credit early next season (5, 6). The government even uses very big pits of up to 300 tonnes as strategic food reserves against famine.

For long term storage, warehouses are subject to high infestation by store pests (10, 11). Darling (8) already wrote that pit storage was so successful that modern technology sought to extend its scope rather than supersede it. Main underground pit advantages are high efficiency of protection against insects, mites, fire and theft as well as low construction and operational costs (1, 5, 6). However, main disadvantages are (a) increasing moisture content (mc) of the grain with time of storage, that leads to mould damage, lower grain quality and reduction of viability and some nutritional value (4); (b) operational difficulties such as manual work for filling and emptying the pits and (c) rain water damage occurring to the pit cap and its immediate environment (1, 9).

The main scientific issue of underground storage is that the mc of the grain in pits is observed to increase, by water ingress. Diminishment of moisture transfer must therefore be the main goal of modification of pit design. Abundant research has shown that the unsafe mc of sorghum grain is above 13.5% (e.g. 2, 3, 7, 13). Below this value also long term storage has been shown to preserve the grain in good condition.

To increase the period of safe storage, farmers started to experiment with innovations of shallower but wider

* and *** University of Gezira, P.O. Box 20, Wad Medani, Sudan (*Dept. of Environmental Sciences & Natural Resources; ***Dept. of Agricultural Economics).

** Department of Environmental Sciences, Wageningen University, Duivendaal 2, 6701 AP Wageningen, Netherlands (#corresponding author); ****40 Cherry Orchard, Chestfield, Whitstable, CT5 3NH, Kent, UK.

Received on 01.03.01. and accepted for publication on 09.09.02.

pits (about 0.5 m deep) and lining of pits with chaff. Shallower pits have the advantage of less wall surface for entering cracks and drier bottoms if cracks are covered at the surface. Chaff should form a barrier against diffusion of water vapour from the walls and the bottom. Originally, chaff was only used as a cover on top of the grain, but now it was also applied at the bottom and sides of the pits, with the hope to keep the grain drier for a longer time (1, 6). Other linings were also tried (1).

The research reviewed wanted to quantify and this way scientifically better understand the consequences of such innovative measures and of other improvements that could be made (1 – 4). Participation of farmers was sought for use of their expertise, for improved understanding of their needs and for better dissemination and extension of the results (5, 6, 15). The research combined physics of water (vapour) contents and transports, and of the influence of temperature and its gradients, with chemistry and biology of grain with respect to quality (viability, nutritional values, toxins) and damage in storage due to moulds and insect pests (1, 13). The research is an example of increasing use of agrometeorology/-climatology for protection and improvement of agricultural production in developing countries (14, 16), where they also have a traditional base (15, 17). The latter is also exemplified by this research.

Materials and methods

Three villages with different types of soil were selected in Jebel Muoya area (3): Fangoga el Jabal (cracking clay soil), Awlad Mahala (non-cracking clay soil) and Kumur el Nair (sandy soil), hereafter referred to as villages A, B and C respectively. Data collection was done through: (i) a survey and a pilot questionnaire in the study area; (ii) contact with farmers, concerned government officials, research institutions, NGOs and local extension personnel; (iii) a main questionnaire for about 10% of the households in the three villages, to investigate how they value the underground pit storage; (iv) field experiments for investigating, through monitoring, pit mc, temperature (T) and carbon dioxide (CO_2) with regard to the influences of types of lining, depth of the pits and treatment of the surface around the pit; (v) laboratory determinations of grain quality aspects (4).

Experimental work ran for three years, from January 1993 to January 1996, on land also used by local farmers for underground storage. In the course of time small pits with different dimensions (diameter, depth) and capacity (2-4 tonnes) were investigated. They were unlined, lined with a mixture of mud/dung/straw (abandoned after two years) and lined with chaff, on which attempts by farmers for improved storage existed.

The pits were remotely monitored continuously by solar powered data loggers using well calibrated thermistors for T and by reethorpe moisture sensors for mc on vital places throughout the grain (1 – 4). Most of these were at or near the surfaces most liable to grain damage due to moisture ingress. Occasionally CO_2

Table 1

Review of pits as used in three soils (first year) and additionally (add.) in soil A (village A) for two more years. Soil A (in village A): Cracking clay (black cotton) soil, Soil B (in village B): non-cracking clays (Azaza soil), Soil C (in village C): highly sandy soil. Deepest pits were used in the first year, shallowest pits in the third year

1st year of experiments	2nd year (add.)	3rd year (add.)
Pit A, village B, Ml	Pit I, Unl, rs	Pit W, Unl, wc
Pit B, village B, Un l	Pit II, Unl, wc	Pit X, Unl
Pit C, village B, Ch	Pit III, Ch	Pit Y, Ch
Pit D, village B, Un l	Pit IV, Unl	Pit Z, Ch, wc
Pit E, village B, Ml	Pit V, Ml	Pit W1, Unl, wc
Pit F, village B, Ch	Pit VI, Ch	Pit X1, Unl
Pit G, village B, Un l	Pit VII, Ml	Pit Y1, Ch
Pit H, village B, Ml	Pit VIII, Unl	Pit Z1, Ch, wc
Pit I, village B, Ch	Pit IX, Unl, wc	[W1, X1, Y1, Z1 = ns]
Pit J, village C, Unl, ns	Pit X, Unl, rs	
Pit K, village C, Ch	Pit XI, Unl, rs	
Pit L, village C, Ml	Pit XII, Ch	
Pit M, village C, Un l	Pit XIII, Ml	
Pit N, village C, Ch, ns	Pit XIV, Unl	
Pit O, village C, Ml, ns	Pit XV, Unl, ns, wc	
Pit P, village A, Unl		
Pit Q, village A, Ml		
Pit R, village A, Ch		
Pit S, village A, Ml		
Pit T, village A, Unl		
Pit U, village A, Ch		

Ch= chaff; Ml= Mixed lining; Unl= unlined; ns= no sensors; rs= roughened surface; wc = widened surface cap

concentration was measured in some of the unlined pits. Visual and other tests (mould [aflatoxin], caking, colour, smell, taste, and grain viability) were carried out by experienced farmers and/or the authors when opening pits at the end of the experiments.

The first year pits had 1.5 m diameter and 1.5 m depth, distributed in the villages as six pits in village A, nine pits in village B and six pits in village C. In the second year, fifteen new shallower pits (all in village A) were 1.6 m in diameter and 1.0 m in depth. Nine pits had the same three linings as in the first year. To improve closing off of cracks, six of the pits received surface treatments such as roughening of the surface around the pit with different methods or covering that surface with soil as extended pit cap of different widths. In the third year, eight new still shallower pits were added (all in village A), with 3.5 m diameter and 0.5 m depth, four of them with the improved surface treatments. All pits are detailed in table 1. We exemplify here with only some representative pits. Additional scientific, technical and socio-economic details may be found in papers that already appeared on this research (1 – 6).

Results and discussion

1.Grain temperatures and moisture contents

Temperatures and moisture contents in underground stored bulk grain may be understood the same way as temperatures of soil and soil moisture contents below field capacity. Both are porous media in which thermal conductivity goes mainly through contact points and water diffusion goes through the pores. Contrary to bulk stored grain in silos and warehouses, convection currents do not play a role (18). A representative example of temperature patterns, here for a 1 m deep chaff lined pit (III), is given in table 2. Position [1] was in the middle of the pit at the bottom, position [2] at the north side at half depth, position [5] was in the centre of the grain and position [8] near the top. Ts started around 30 °C and increased during the first 100 to 135 days, reaching everywhere maxima between May and July close to or over 40 °C. Highest maximum Ts were usually reached in the first year of storage for the top (earliest) and the centre. Considerable cooling in the course of the season was only obtained near the top of the grain. Such high Ts contribute to protection against insects, which can't survive such conditions (2).

Table 3 indicates that the mc took 200 days of storage (dos) or more to reach the unsafe level of 13.5% in the middle of the pit at the bottom (position [1]) in the chaff lined pits (R and U), while it took only about 50 dos to reach that value in the unlined pits (P and T). This was at the same, almost always worst behaving bottom position for first year pits in village A. The chaff apparently had a delaying effect on moisture transport. At the north side at half depth (position [2]), the difference in moisture transport rates (215 to 355 days to reach 13.5% mc for chaff linings against 35 to 160 days for unlined conditions) was also clear for those same pits.

Table 2

Temperature at different positions (pos) in pit III (village A, depth of 1 m), with chaff lining, for two years

dos/pos	1	2	5	8
07	31.2	31.0	31.1	32.2
42	34.0	34.5	35.7	37.8
72	36.4	35.6	41.4	42.2
103	37.2	38.5	41.6	41.2
115	38.4	39.6	42.7	40.8
134	38.8	39.9	42.2	41.2
171	38.1	36.9	40.9	39.7
203	37.7	36.7	40.5	37.6
237	37.4	38.0	40.0	38.0
265	37.4	37.3	39.8	37.7
302	35.8	37.5	38.3	34.1
377	36.1	38.8	39.0	38.4
421	37.3	40.3	39.5	38.9
468	37.6	39.7	39.7	38.4
508	37.1	39.4	39.4	36.8
554	36.3	39.7	40.2	37.6
607	37.0	40.9	39.8	39.5
641	37.1	40.6	39.7	38.3
673	37.5	40.1	39.9	37.2

March 2, 1994, is day of storage (dos) 07; December 23, 1994, is dos 302; December 29, 1995, is dos 673.

Table 3

Round off duration, in days of storage (dos), before the moisture content (mc) reaches 13.5% at positions (pos) [1], [2], [5] & [8] in the unlined (ul) and chaff lined (ch) pits in villages A, B and C

pit	lining	dos\pos	1	2	5	8
R	ch	358	200	215	nr	nr
U	ch	1029	240	355	820	nr
III	ch	673	115	470	nr	440
VI	ch	673	345	520	nr	540
XII	ch	320	135	nr	nr	nd
Y	ch	319	200	205	nr	nr
Z	ch	319	nr	nr	nr	nr
C(B)	ch	345	250	275	nr	nr
I(B)	ch	345	250	nr	nr	nr
F(B)	ch	1003	345	425	780	nr
K(C)	ch	1049	250	250	600	nr
P	ul	358	040	160	nr	nr
T	ul	1020	055	035	695	190
IV	ul	673	095	205	nr	nr
VIII	ul	320	060	190	nr	nr
XIV	ul	673	095	205	nr	nr
X	ul	319	080	200	nr	nr
W	ul	319	145	nr	nr	nr
D(B)	ul	345	245	275	nr	nr
G(B)	ul	345	275	nr	nr	nr
B(B)	ul	696	035	075	615	nr
M(C)	ul	705	100	115	nr	nr

nr= never reached 13.5%; nd= no data.

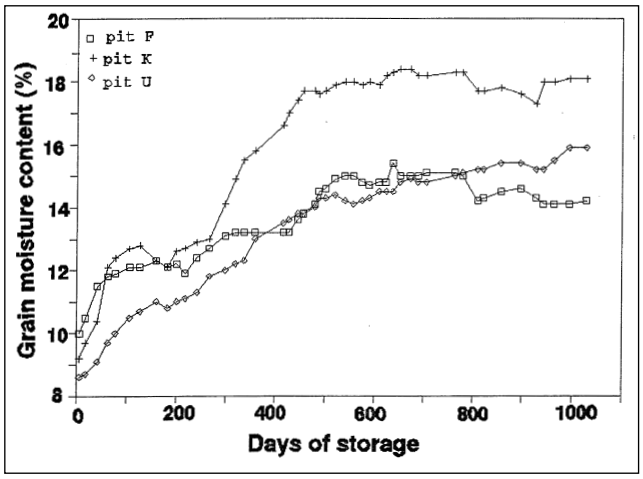


Figure 1: Moisture content (mc) at position [2], north side at half depth, in first year 1.5 m deep pits F (village B, non-cracking clay), K (village C, sandy soil), U (village A, cracking clay soil), all chaff lined and kept for more than 1000 days of storage. Pit F is superior.

Figure 1 shows a comparison for this position [2] between the chaff lined pits kept for more than 1000 dos in the three soil types compared. Pit K (sandy soil in village C) behaved poorly because of high moisture transport in these soils. The others were relatively similar, reaching 13.5% in these deep pits almost simultaneously after about 450 days, which is already much longer than the present storage times. Pit U, in the cracking clay soil of village A, ended at a somewhat higher (unsafe) moisture content than pit F in the non-cracking clay of village B. The final disparity between the last two pits occurred only in the third year of storage. This can only be due to the presence of soil cracks, that come into existence during the dry season, and that get filled with water in the rainy season. Unfortunately non-cracking clays are relatively rare and most grain must therefore be stored in cracking clays.

The already less deep second year pits of table 3 show also again the delaying effect of moisture diffusion through the chaff layers in the pits III, VI & XII

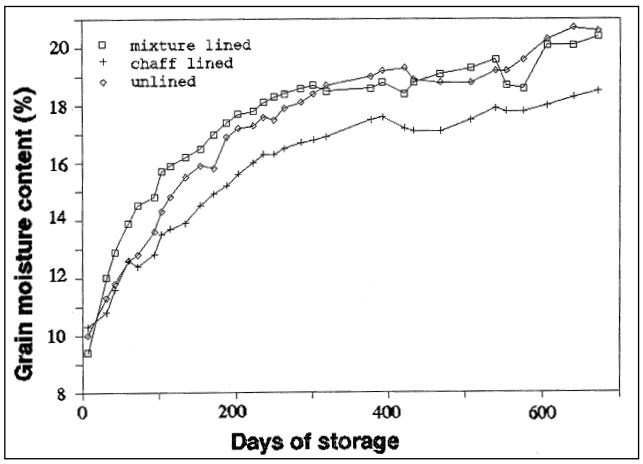


Figure 2: Moisture content (mc) at position [1], middle of the pit at the bottom, in three 1m deep differently lined pits from the second year in village A, kept for more than 600 days of storage. Unlined pit IV and mixture lined pit XIII behave worse than chaff lined pit III.

compared to the unlined pits VI, VIII & XIV at both, positions [1] and [2]. Comparing, for position [1], the three different linings of these pits kept for two years in the cracking clay soil, figure 2 shows the same. However, figure 2 also demonstrates that this delaying effect comes into being only slowly, because of the smaller amounts of chaff used in this second year. The unsafe level of 13.5% is reached much earlier than for the chaff lined pit U of figure 1 in the same cracking clay soil.

This effect is again built up faster in figure 3, in the example of shallow wide capped pit Z, where abundant chaff was applied and sorghum remained in very good quality over nearly 350 days. With respect to these third year chaff lined pits (Y, Z), unfortunately Y, that did not have a widened surface cap, suffered from a crack that opened at one side, making some water seeping into the stored sorghum. Pit Z, with an improved wide cap (50 cm high and for 1 m beyond the rim all around), was far out superior because none of the positions reached the hazardous limit of 13.5% during the first year (4). As for the unlined pits it was clear that even pit W, with improved wide cap, was superior to pit X with ordinary cap, but the chaff of pit Z made an additional very positive difference. The data for these pits in table 3 show of course the same effects for positions [1] and [2]. The wide caps indeed close off cracks that have their opening at quite some distance but still end up in the walls of the pits.

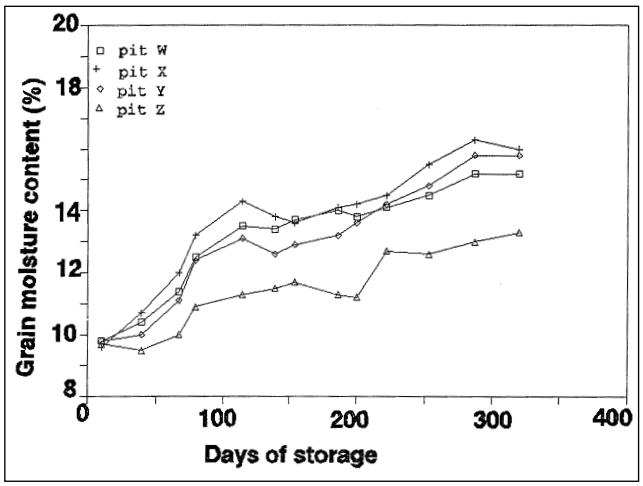


Figure 3: Moisture content (mc) at position [1], middle of the pit at the bottom, in the 0.5 m deep pits of the third year in village A: unlined, with (W) and without (X) improved wide cap, and chaff lined, with (Z) and without (Y) improved wide cap, kept for more than 300 days. Pit Z is clearly superior.

At position [5], the centre of the grain, the delaying effect of the chaff is again shown in the long term storage pits (U and T) in table 3. There were also pits without sensors, which were only analysed by observation at opening (see under 2. below). They confirmed the above results. The unique continuous monitoring of moisture contents and temperatures made it possible to show the superiority and the effectiveness of the innovative measures already designed by some farmers and of the additional improvements introduced by the research.

2. Visual observations

The visual observations, upon opening of all the pits, showed that the sorghum quality from the chaff lined pits was much better than that from the other two types of pit linings in all the villages for the different types of soils. However, the sorghum from village B (non cracking clays, which are least abundantly occurring) was better than in the other two villages (3). Mould damage was particularly noticed at the bottom and sides of the unlined and mixture lined pits. In village C (sandy soil) there was a top layer of moulded sorghum that was not good even as animal feed. Farmers exclude such soils for underground grain storage wherever possible or only use it till the next rainy season starts.

It was also found from the first and second year experiments that the top sorghum in the most abundantly found cracking clay soil was only affected by slight *Tribolium* sp and *Cryptolestes* sp insects attack. The quality of the top sorghum was better than that at the bottom and the chaff lined pits had better quality sorghum in terms of colour, smell, taste and viability, expressed as germination percentage (4). The sorghum quality from the surface treated pits was better in the case of the improved wide cap.

3. Farmers' opinions

From the questionnaire it followed that 90% of the farmers use pits as the only means of storage. Most of the farmers (85%) use pits as precaution against hunger, fire and theft. About 80% thought there is no need for lining material, mainly due to the short storage periods generally in use, 11% thought chaff is appropriate and 9% said cement might be suitable. Good preservation of the sorghum is the best property of the pit for 40% of the farmers, 36% said it is a cheap way of storage and 24% mentioned both. Another very important factor is that 84% of the farmers use no chemicals at all with pits, while 16% said they use some chemicals in powder form. About half the farmers said that in unlined shallow pits sorghum will be still good enough for emergency consumption after two years, nearly 20% think this is only one year and 30% claim a potential of three years or even longer if cracks can be avoided, so in the most suitable soil (3). All the farmers believe that insect damage ranks low in order of importance.

General conclusions from the study

Rainwater seeping through cracks and moisture diffusion through the pores were confirmed to be the most important deterioration factors in underground grain storage. The innovative attempt by farmers to delay moisture movement by lining the pit walls and bottom with chaff showed satisfactory results when monitoring temperature and mc. The use of large amounts of chaff was important. This may be understood from its function as a resistance against water vapour diffusion. The innovative use of shallow wider pits also clearly improved storage conditions. The mc of the sorghum was generally less than in the deeper pits. Also the research innovation of using high wider caps to close the catchment area of the cracks proved effective.

The longer term underground storage of grain in such improved pits is a viable system in dryland farming areas for fighting famine, maintaining food security. It also is an alternative banking systems for farmers producing beyond subsistence, particularly with the observed increasing variability in annual production and the longer sequences of dry and wet years experienced. These developments are a good example of the beneficial use of climate information in agricultural production by low income farmers assisted by contemporary science and research technology.

Acknowledgements

This study was made under the Traditional Techniques of Microclimate Improvement (TTMI) Project, core funded by the Directorate General of International Cooperation (DGIS) of the Ministry of Foreign Affairs, The Netherlands, at four African Universities and coordinated at Wageningen University, The Netherlands.

Samenvatting

Traditionele ondergrondse graanoslag in kleigrond in Sudan werd met recente innovaties verbeterd

Traditionele boeren in de centrale klei vlakte van Sudan die alleen voor eigen voorziening verbouwen en kleine boeren die daarnaast ook voor lokale markten produceren willen hun gebied zo goed mogelijk zelvoorzienend houden met hun jaarlijkse sorghum produktie en ondergrondse kuilopslag van een deel van de oogst. Met de toenemende klimaatvariabiliteit komt deze voedselveiligheid echter steeds meer in gevaar. Boeren namen recentelijk proeven met innovaties om de doeltreffendheid van de opslag te verbeteren naar meer dan een seizoen. Deze innovaties werden in ons onderzoek in cijfers uitgedrukt en verdere verbeteringen werden voorkomende scheurende kleigronden in dit gebied brede ondiepe kuilen die overvloedig met kaf gevoerd worden en bovengronds een wijdere bedekking hebben, geschikt zijn voor langduriger opslag.

Literature

1. Abdalla A.T., 1998, An evaluation of the durability of sorghum grain in traditional and modified underground storage pits in Central Sudan. Ph.D.-thesis, Department of Environmental Sciences and Natural Resources, University of Gezira, Wad Medani, Sudan, 420 pp.
2. Abdalla A.T., Stigter C.J., Mohamed H.A., Mohammed A.E. & Gough M.C., 2001, Effects of wall linings on moisture ingress into traditional grain storage pits. Int. J. Biometeorol. 45, 75-80.
2. Abdalla A.T., Ali K.H., Stigter C.J., Adam I.A., Mohamed H.A., Mohammed A.E. & Gough M.C., 2002, Impact of soil types on sorghum grain stored in underground pits in Central Sudan. Agric. Engn. J. 11, 219–229.
3. Abdalla A.T., Stigter C.J., Gough M.C., Mohamed H.A. & Mohammed A.E., 2002, Underground grain storage in cracking clay needs shallow pits, chaff linings and wide caps. Trop. Sc. 42, 57–65.
4. Bakheit N.I., 1997, Some economic aspects of traditional underground grain storage pits (matmura) in Sennar State, Sudan. M.Sc.-thesis, Department of Agricultural Economics, University of Gezira, Wad Medani, Sudan, 75 pp.
5. Nageeb Ibrahim Bakheit, Kees Stigter & Ahmed el-Tayeb Abdalla, 2001, Jebel Muoya: underground storage of sorghum as a banking alternative in the Blue Nile area of Sudan. Low Ext. Input Sust. Agric. (ILEIA Newsl.) **17**(1), 13.
6. Bodholt O. & Diop A., 1987, Construction and operation of small solid-wall bins. FAO Agricultural Services Bulletin, 69, FAO, Rome, 20 pp.
7. Darling H., 1954, The storage of food grain in the Sudan. Memoires of the Research Division, No. 37, Ministry of Agriculture, Khartoum, 74 pp.
8. El Daw A., 1984, The storage of food grains in the Sudan with special reference to sorghum. Diplomarbeit, Technishe Universität Berlin, 115 pp.
10. FAO, 1991, Improvement of storage and pest management procedures for food security. The Sudan Project Findings and Recommendations. FAO, Rome, 57 pp.
11. Hall D.W., 1970, Handling and storage of food grains in tropical and subtropical areas. FAO Agricultural Development Paper No. 90, FAO, Rome, 111 pp.
12. ISNAR, 1988, The agricultural technology management in the Sudan. Arab Organization for Agricultural Development, Khartoum, 95 pp.
13. Smith C.V. & Gough M.C., 1990, Meteorology and grain storage. Technical note No 101, WMO - No 234, TP. 133 (Rev), WMO, Geneva, 82 pp.
14. Stigter K., 2001, Operational agrometeorology in Africa and Asia: Lessons for sustainable agriculture. Proceedings International Conference on Agricultural Science and Technology (ICAST), Session 2: Sustainable Agriculture (1), Part III: Land, Water and Nutrient Management, Beijing, China, pp. 276-280.
15. Stigter C.J., 2002, Climate and Agricultural Production. A. Introduction to Indonesian Conditions. B. Seminar 1: Applying climate information for decision making in agricultural production. C. Seminar 2: Adaptation options in agricultural production to climate related extreme events. Seminar in Agrometeorology. Faculty of Agriculture, Sam Ratulangi University, Manado, Indonesia, July, 40 pp.
16. Stigter C.J., Sivakumar M.V.K. & Rijks D.A., 2000, Agrometeorology in the 21st Century: Workshop Summary and Recommendations on Needs and Perspectives. *In*: M.V.K. Sivakumar, C.J. Stigter & D.A. Rijks (eds.), Agrometeorology in the 21st Century - Needs and Perspectives. Agric. For. Meteorol., 103: 209-227.
17. Stigter C.J., Zheng Dawei, Onyewotu L.O.Z. & Mei Xurong, 2003. Using traditional methods and indigenous technologies for coping with climate variability. Invited paper for presentation at the International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change, Ljubljana, Slovenia, October 2002. Submitted for publication in Climate Change.
18. Uiso C.B.S., Gough M.C. & Stigter C.J., 1990. Detection, causes and consequences of convection currents in bulk stored grain. *A synopsis*. Neth. J. Agric. Sc. 38, 195-199.

A.T. Abdalla, Sudanese, M.Sc. (Environm. Sc.), Ph.D. (Agric. Sc.), Associate Professor, Department of Environmental Sciences and Natural Resources, Deputy Academic Dean, University of Gezira, Wad Medani, Sudan.

C.J. Stigter, Dutch, Drs. Exp. Phys., Dr. Agric. Sc., Visiting Professor in Africa and Asia for Wageningen University, Netherlands; Immediate Past President Commission for Agricultural Meteorology (1991-1999), World Meteorological Organization, Geneva, Switserland.

N.I. Bakheit, Sudanese, M.Sc. (Agric. Econ.), Lecturer, University of Sennar, Abu Naama, Sudan.

M.C. Gough, British, Ph.D., former Principal Research Scientist, Natural Resources Institute (UK), private consultant, Chestfield, UK.

H.A. Mohamed, Sudanese, Ph.D. (Agric. Sc.), Professor, Dean Faculty of Agriculture, University of Gezira, Wad Medani, Sudan.

A.E. Mohammed, Sudanese, Ph.D. (Environm. Sc.), Professor, Deputy Vice Chancellor, University of Gezira, Wad Medani, Sudan.

M.A. Ahmed, Sudanese, Ph.D. (Agric. Econ.), Professor and Head of Department, University of Gezira, Wad Medani, Sudan.

Bio-Economic Evaluation of the Performance of Rabbits Raised Under Two Different Housing Systems

Peace U. Mobolaji-Bukola**, E.A. Allison-Oguru*, N.A. Berepubo** & B.M. Oruwari**

Keywords: Bio-economics- Rabbits- Housing systems

Summary

This study was conducted to evaluate the bio-economic performance of rabbits raised under two different housing systems: conventional hutch with cage system as control (A) and the non-conventional floor housing system (B). Thirty six adult rabbits of medium size breed category of both sexes aged 5-6 months comprising Chinchilla (20), New Zealand White (10), Dutch (6) were used in the study which lasted 24 weeks. Fifteen does and 3 bucks were each randomly but equally assigned to both housing systems. Data on individual and group treatments were analysed with a one-way analysis of variance and students' t-test, employed in testing differences between the means. A benefit-cost analysis was used to evaluate the relative cost effectiveness of each housing option. Results obtained showed that rabbits raised on floor performed better (6 kittens) < 0.05 biologically than those reared in hutched (3 kittens). For example, significant final weights (1.9 kg) and weight gains (0.4 kg) were observed in rabbits reared on floor as against those in hutch 1.6 kg and 0.09 kg). From an economic viewpoint, rabbits raised on floor contributed higher positive income (₦ 58.2) per unit of meat produced than rabbits reared in hutch or cage. Rate of return on investment in the former was estimated at about 50%. The floor housing system which is the cheaper, more productive and cost-effective is therefore recommended for farmers who are lacking the fundamental factors of production namely land and particularly capital as observed in the study location or environment.

Résumé

Evaluation bio-économique de la performance des lapins sous logement conventionnel et non-conventionnel dans des conditions humides et tropicales

Cette étude a été réalisée afin de comparer deux systèmes de logement sur la performance bio-économique de l'élevage des lapins. Ces systèmes étaient le témoin (logement traditionnel en clapier) et le traitement (logement non conventionnel en étages). Trente-six lapins adultes de race mi-lourde (20 de Chinchilla, 10 de New Zealand White et 6 de Dutch) ont été utilisés et l'essai a duré 24 semaines. Quinze femelles et trois mâles âgés entre 5 et 6 mois ont été randomisés et répartis respectivement entre le témoin (A) et le traitement (B).

Les données individuelles ainsi que celles des groupes de traitements ont été analysées par l'analyse de la variance à un critère et la différence entre les moyennes a été comparée par le test t- de Student. Les résultats obtenus montrent que le traitement (B) a une meilleure performance biologique comparativement au témoin (A). Les moyennes des poids des lapins adultes et le gain de poids étaient respectivement de 1,98 kg et de 0,35 kg pour le traitement (B) alors que ceux du témoin (A) étaient faibles, respectivement de 1,65 kg et de 0,90 kg. Au point de vue économique, les lapins élevés en étages ont généré un revenu plus élevé comparativement au témoin et représentait 58,18 ₦ par unité de viande produite. Quant au revenu d'investissement, il a été estimé à environ 50%. En conclusion, le système de logement en étage, comme le démontre cette étude, est moins cher, plus productif et à coût faible. Il est donc recommandable aux fermiers à faibles revenus.

Introduction

Protein intake in the diet of the average Nigerian both in terms of quality and quantity is widely acknowledge to be inadequate. For example, 35 g out of the required minimum of 65-72 g of reference protein in the diet of the average Nigerian should be obtained from meat products; but regrettably, only 8.4 g out of the 53.8 g of protein consumed per head per day in Nigeria comes from animal sources (2, 7, 10). The remedy to the perceived protein deficiency situation in the country calls for increased supply of animal protein products such as beef, pork, mutton, chevon, milk, poultry, lago meat, etc. (3).

Hitherto, Government's animal production programmes had tended to emphasise increased supply

Faculty of Agriculture, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria
*Department of Agricultural Economics and Extension, **Department of Animal Science.

Received on 13.08.01 and accepted for publication on the 23.08.02.

of conventional livestock products such as beef, pork, mutton and chevon as well as poultry. However, the undue emphasis on these conventional animal products notwithstanding, the animal production subsector of the Nigerian economy has not been able to meet the minimum protein requirements of the teeming population. If the target of food for all by the year 2010 is to be met, there is the need to consider all available options including the promotion of non-conventional micro-livestocks such as rabbit. Rabbits are very prolific, producing at least 4-5 litters per year with litter sizes of 6-8 kitten. They have a short gestation period of 30-32 days and do not compete with man for grains since they could rely solely or largely on fibre rich forages and kitchen wastes to satisfy their basic nutritional requirements (1, 5, 9).

In view of the foregoing advantages, farmers in Nigeria are being encouraged to produce rabbits as a way of meeting the minimum protein needs of their families as well as boosting animal protein supply in the country. Currently, rabbit production in Nigeria is carried out mainly in hutches. This production technology is reported to have deterred prospective rabbit farmers because of its high cost. Besides, field reports by farmers using the hutch system have indicated considerable mortality among their rabbit colonies even when feeding seems to be optimum (5). This study was therefore designed to evaluate the relative bioeconomic performance of rabbits raised under the non-conventional semi natural floor system against the conventional hutch system.

Material and methods

1. Physical weather conditions, animals and treatment

The study was done in a University environment with a coastal setting in the southern most part of Nigeria and located within the typical tropical rain forest belt. The environment is hot and humid with mean daily maximum and minimum temperatures of 21-33 °C and 20-23 °C respectively. Although a relatively photostable climate with 12 hours of diurnal light all year round, the high cloud cover tends to diminish the sunshine hours to as low as 1.5 hour (sometimes) to 6 hours daily. Precipitation is quite high (1,700-4,500 mm annually) with correspondingly high relative humidity of 50-90%, depending on the season of the year. There are two seasons (rainy and dry), and in some years the rains fall every month of the year. Unlike some part of Nigeria, the dry season is usually short (3 months or less).

Thirty-six 5-6 months-old adult rabbits of different sexes comprising medium breed rabbits, namely Chinchilla (20), New Zealand White (10) and Dutch (6) were used in the experiment for this study. The animals were equally but randomly assigned to two groups, A (control) and B (treatment) of 18 animals each (comprising 3 males and 15 females). There were six animals per replicate and three replicates per treatment.

Group A comprising 18 rabbits which served as the control were housed in conventional hutches housed in a building with concrete floor. The hutches were designed to allow enough ventilation (half wall and the rest were covered with wire mesh of 1.27 cm). The rabbits were housed one per compartment in a two-tier conventional hutch of six compartments, made up of wire mesh and metal frame, with litter pans placed under each cage. Mesh or grid openings were large enough to allow faecal pellets to drop through readily, yet small enough to provide comfort and prevent their feet from becoming entangled. The grid of the wire mesh for the floor was 15 mm while the mesh size was 1.27 cm x 2.54 cm. The cage dimensions were 1.2 m x 0.6 m x 0.6 m for length, height and width, respectively. The legs of the hutches were 1.0 m above the ground. A total of four hutches were used. Three hutches were used to house the replicates while the remaining one was used to house the weaners. The bucks were housed separately except when needed for mating the does and this was done conventionally (4).

Group B comprising 18 rabbits which served as treatment were housed in a hut with a floor area of 5 m x 4 m for the length and width, respectively. They were placed on deep litter non-concrete floor to encourage burrowing. Wood shavings were used as the deep litter material and the depth of the litter was 12.70 cm. The floor area was divided into three with wire mesh wooden frames dug into the ground to accommodate each replicate of six animals. The floor space per rabbit was 1 m^2.

All the experimental animals were tagged, allowed one-month pre-conditioning period, and medicated against common diseases like coccidiosis and mange. They were administered prophylactic coccidiostat (Ampro-vitracycline) via drinking water at the rate of one teaspoon into 4 litres of water. They were also dipped with cinatic powder (one sachet) into 9 litres of water and bleached with palm oil mixed with fresh citrus leaves as a treatment against mange. Standard sanitary regimes such as daily washing of feeders, drinkers, trays and disinfecting the pens were maintained in both housing systems. All the animals were subjected to similar management/husbandry conditions of feeding and hygiene except the housing system. The animals were fed 50 g of poultry growers mash and forage *ad libitum* such as *Panicum maximum* (grass); *Centrosema pubescens* and *Calopogonium mucunoides* (legumes). The experiment lasted for 24 weeks, after the does had been bred according to standard procedures of taking the females at a time to the males (bucks) (1, 11).

2. Statistical design/analytical techniques

The experiment was a completely randomised design. Data collected on individual and group treatment include growth rate (initial body weight, final body weight, food intake, body weight gain, and feed efficiency), mortality, physical and service inputs used and costs, and market value of a kilogram of lago meat in the study area. On the basis of these data, a cost-benefit analysis was undertaken for each housing system. The mean values of rabbit meat obtained from each housing system were estimated and a student

t-test employed to test for differences between the means as outlined by Snedecor and Cochran (13).

Results and discussion

1. Production parameters

The productive performances of rabbits raised under the two different housing systems are presented in table 1. Whereas there was no significant difference (P> 0.05) in average initial weights of rabbits reared under the two housing systems, a significant difference (P< 0.05) in final weight in favour of the floor system (1.98 ± 0.18 kg) over those in the hutches (cages) 1.65 ± 0.13 kg) was observed. Average weight gain and feed efficiency were also significantly higher (P< 0.05) in the floor system than in the hutch system. However, there was no significant difference (P< 0.05) in their average feed intake, although higher for treatment B.

Table 1

Effect of housing system on productive performance of rabbits

Production Parameter	Treatment A Hutch or Cage	Treatment B (Floor)
Average initial weight (kg)	1.6[a] ± 0.1	1.6 ± 0.1
Average final weight (kg)	1.7[a] ± 0.1	2.0[b] ± 0.2
Average weight gain (kg)	0.1[a] ± 1.2	0.4[b] ± 0.2
Average feed intake (kg)	77.5[a] ± 13.6	83.5[a] ± 1.8
Mean litter size	3.4[a] ± 0.8	6.1[b] ± 1.3
Mean litter weight (g)	40.1[a] ± 3.1	48.8[b] ± 3.7
Average weaning weight (g)	429.6[a] ± 48.0	536.9[b] ± 84.0
Total number weaned / doe/litter	2.3[a] ± 0.9	5.8[b]
Mortality (%)	34.2[a] ± 0.9	6.0[b] ± 0.7
Mortality of young	27[a]	7[b]

[a], [b] means within the same row with the same superscript denote not significantly different (P< 0.05).

The growth rate of the young for the first 56 days from day old to weaning was evaluated and the results are presented in table 2. The observed differences in treatment means with regards to weekly weight gain were statistically significant (P< 0.05) with treatment B being superior to A at 14-28 days and 28-42 days. The observed differences in treatment means on weekly weight gain were not statistically (P< 0.05) significant at 0-14 days and 42-56 days. However, treatment B showed overall numerically superior mean values.

Litter size was nearly twice as high (P< 0.05) when housed on floor (3.4 and 6.1 respectively). The number of weaned kits as well as the weights were significantly higher for treatment B. Mortality was high in caged rabbits among both the adults and young, and was significantly lower among the group on the floor.

Table 2

Average weekly weight gains of experimental kits for the first 56 days

Production Parameter	Treatment A	Treatment B
Mean litter weight (g)	40.1 ± 3.0	48.8 ± 3.8
Weight gain at 0-14 days (g)	75.8 ± 26.3	78.1 ± 16.3
Average daily Wt gain (g/d)	5.4	5.6
Cumulative Wt gain (g)	155.9 ± 28.2	126.9 ± 17.4
Weight gain at 14-28 days (g)	94.8 ± 20.6	143.8 ± 37.3
Average daily Wt gain (g/d)	6.8	10.3
Cumulative Wt gain (g)	210.7 ± 57.1	270.7 ± 83.6
Wt gain at 28-42 days (g)	109.9 ± 18.5	145.7 ± 32.1
Average daily wt gain (g/d)	7.8	10.4
Cumulative weight gain (g)	320.6 ± 75.4	416.4 ± 62.8
Wt gain at 42-56 days (g)	109.5 ± 26	120.7 ± 32.4
Average daily wt gain (g/d)	7.8	8.6
Cumulative wt gain (g)	429.6 ± 48.0	536.9 ± 84.0
Average daily body Wt gain for first 56 days (g/d)	7.0	9.0
Mean daily Wt gain		8.0

[a], [b] means within the same row with the same superscript are not significantly different (P> 0.05).

From the biological viewpoint, the results shown in tables 1 and 2 indicate that with the same level of concentrate feed and forages as well as the same standard breeding procedures (1, 4), higher significant average final weights and weight gains were recorded in the rabbits raised on floor viz. 1.98 kg and 0.36 kg as against 1.65 kg and 0.09 kg in those reared in hutches respectively. This might be due to what Fielding (6) explained as the "instinctive wisdom" of the rabbit which helps it to select good balanced diet which the floor system enables the young to increase its feed by eating fibrous litter material from the floor to balance its fibre requirements. This observation is consistent with those of Slade and Hintz (12), Ndor (8) and Timibitei (14) who had earlier remarked not only increased feed intake and feed efficiency but also increased litter size among rabbits reared on the floor. This observation is quite fascinating in this study as the littersize was not only doubled but also mortality which is the bane of rabbit farming in Nigeria was found to be considerably reduced among those reared on the floor.

A number of explanations can be adduced for the observations noted in tables 1 and 2; for instance, poultry mash is better suited for rabbits which can supplement their diets with the litter material as in treatment B. Secondly, higher heat load or stress could be anticipated for the caged rabbits. Finally, the breeding system which consisted in monitoring "latent" heat signs in the does (female rabbits) and then introducing them in the male hutches for mating after observed heat/oestrus signs (4) made some of the results on these parameters rather tentative. This fact did not however invalidate the more essential points in the tables as the breeding results were found to be much better and the weight gain of the young was considerably (P< 0.05) higher.

2. Bio-economic performance parameters

Building on the biological production parameters given in tables 1 and 2, a cost-benefit (or cost-return) analysis was conducted in order to ascertain the relative cost-effectiveness of the two production technologies. In doing this, the inputs employed in each production option were quantified and valued at their purchase price or opportunity cost. The resulting output, measured in average final weight of young produced, was also valued at the prevailing market price. The difference between these two quantities gave us a measure of the income contribution per kilogram of lago-meat produced. The resulting figures from these analyses are given in table 3.

Table 3

Cost-return analysis of the performance of kitten reared under two housing systems (Unit= ₦)

	Item	Treatment A	Treatment B
A.	**Fixed cost**		
	Depreciation:		
*	Cages	35	0
*	Feeders/drinkers, etc.	2	2
*	Rent on housing	2	2
	Total fixed costs	39	4
B.	**Operating costs**		
*	Feed	25	25
*	Animal health care	47	23
*	Labour	60	44
*	Transport	20	9
*	Miscellaneous	40	14
	Total operating costs	192	115
	Total production costs	231	119
C.	**Value of production**		
*	Total weight gain (g)	429.6[a]	536.9[b]
*	Unit value of meat (₦/g)	0.33	0.33
*	**Value of production**	141.78	177.18
D.	**Estimated income**	(89.22)	58.18
E.	**Benefit - cost ratio**	0.61	1.5

[a], [b] means within the same row with the same superscript are not significantly different (P< 0.05). Figure in parenthesis is a negative figure.

The results in table 3 indicate that from an economic viewpoint, rabbits raised on floor contribute higher positive income per unit of meat produced. Income contribution per unit of meat produced under the cage system was observed to be negative. This implies that returns are inadequate to defray the costs associated with production under this system. This is understandable given the higher cost of cages, the stress suffered by the young rabbits raised under this system, the higher costs incident on the greater attention accorded the young, and the high mortality rate recorded under this system. Because of the greater attention accorded the young rabbits raised under the hutch system, higher costs are incurred in labour input and in the provision of health care services. This coupled with the low feed efficiency, weight gain, and litter size discourages cost-effectiveness in this system of housing.

Consequently, for every ₦ 100.00 worth of production inputs employed in rabbit production under the hutch system, only ₦ 61.00 was realised as revenue. Thus for every ₦ 100.00 costs incurred, a loss of about ₦ 39.00 resulted. Conversely, every ₦ 100.00 worth of production inputs employed in rabbit production under the floor system, about ₦ 150.00 was realised as revenue. Thus for every ₦ 100.00 costs incurred, a profit margin of ₦ 50.00 resulted. This gives a rate of return on capital investment of about 50%.

Conclusion

This study has shown that both from the biological and economic viewpoints, rabbits raised under the floor or deep litter housing system perform significant better than those raised in the conventional cage (hutch) system. Performance indicators considered in this study include feed conversion efficiency, growth rate, litter size, mortality as well as income per unit weight of meat produced. For example, significant average final weight and weight gains were observed in rabbits raised on floor (1.98 kg and 0.36 kg) as against those in cage or hutch (1.65 and 0.09 kg), respectively. Similarly, from an economic viewpoint, rabbits raised on floor contribute higher positive income per unit of meat produced. Between the two production technologies, therefore, the floor housing system is the cheaper and more productive biologically and economically. This technology is therefore more cost-effective and appropriate for resource poor farmers as we find in the area of study. It should therefore be further replicated, revalidated, and packaged for dissemination to farmers in the area.

Literature

1. Aduku A.O. & Olukosi J.O.,1990, Rabbit Management in the Tropics. Living Book Series, GU Publications: Abuja, FCT.
2. Allison-Oguru E.A., 1992, Econometric analysis of aggregate demand for fish in Nigeria 1980-1987, Delta Agriculturist. 1(1), 1-10.
3. Allison-Oguru E.A., 1998, Empirical analysis of aggregate demand for meat in port Harcourt Metropolis, 1980-1989, Delta Agriculturist. **5**(1), 1-10.
4. Berepubo N.A., Nodu M.B., Monsi A. & Amadi E.N.,1993, Reproductive response of prepubertal female rabbits to male presence and/or to photoperiod. World Rabbit Sci. **1**(2), 83-87.
5. Berepubo N.A. & Baa B.B., 1995, Growth rate of rabbit weanlings fed sweet potato leaves supplemented with varying proportions of poultry Growers Mash Journal of Innovations in Life Sciences. (2), 70-75.
6. Fielding D., 1991, Rabbit: In Tropical Agriculture Series. CTA/Macmillan Education Ltd., London.

7. Mba A.U., 1983, Meat production in Nigeria: Problems and prospects. In: Nutrition and food policy in Nigeria, National Institute for Policy and Strategic Studies, Jos.
8. Ndor L., 1995, Performance evaluation of rabbits reared under hutch versus floor system of production. PGD Research Project, Department of Animal Science, RSUST, Port Harcourt.
9. Osuji, P.U. 1999, Performance evaluation of rabbits raised under two different housing systems. Unpublished MSc. Thesis, Department of Animal Science, RSUST, Port Harcourt.
10. Oyenuga V.A., 1987, Fundamental strategy for livestock production in Nigeria. Journal of Animal Production. **14**(1), 20-25.
11. Sese B.T. & Berepubo N.A. 1996, Growth response and organ weights of young rabbits fed graded levels of dietary raw soybean in the host humid tropics. World Rabbit Science. **4**(1), 15-18.
12. Slade C.M. & Hintz H.F., 1969, Comparison of digestion in horse, rabbit and Guinea pig pories, J. Anim. Sc. 28, 842-843.
13. Snedecor G.W. & Cochran W.G., 1978, Statistical methods, 6th Ed. The Iowa State University Press, Iowa.
14. Timibitei K.O., 1998, Performance evaluation of rabbits reared on the floor or deep litter. BSc. Anim. Sc. Thesis, RSUST, Port Harcourt.

Peace U. Mobolaji-Bukola, Nigerian, Master's Degree, Faculty of Agriculture, **Department of Animal Science, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.

E.A. Allison-Oguru, Nigerian, Doctoral Degree Candidate, Agri-economist and Consultant in agri-business, management and development economics, Faculty of Agriculture, Department of Agricultural Economics and Extension, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria

N.A. Berepubo, Nigerian, Research and Consultant in minilivestock production including rabbits, snails and grasscutter, University teaching/research, Faculty of Agriculture, Department of Animal Science, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.

B.M. Oruwari, Nigerian, Head of Department of Animal Science and Professor of Animal Nutrition and Management, Faculty of Agriculture, Department of Animal Science, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.

A Survey of the Insect Pests and Farmers' Practices in the Cropping of Tomato in Nigeria

V.C. Umeh*, Felicia O. Kuku *, E.I. Nwanguma *, Oyeboade S. Adebayo* & A.A. Manga**

Keywords: Tomato– *Aphis gossypii*– *Helicoverpa armige*– *Zonocerus variegatus*– Pathogens– Nigeria

Summary

A survey of some tomato producing areas of Nigeria indicated that the major insects attacking tomato included the fruit borer Helicoverpa armigera *Hübner, the grasshopper* Zonocerus variegatus *L., the whitefly* Bemisia tabacci *Gennadius, and various species of aphids, mostly* Aphis gossypii *Glover. Interviews conducted to assess farmers' practices which contribute to insect damage showed that inappropriate application of insecticides and the use of wrong dosages may have contributed to insect control failures. Intercropping tomato with crops such as cereals tubers and other vegetables reduced infestation in some areas. However, most farmers' practices did not affect insect pest abundance. Insect populations and percentages of infestation were, in most cases, found to be significantly higher in Oyo state (in the rain forest agro-ecological zone) than in other surveyed states located in the savannah agro-ecological zones.*

Résumé

Enquête sur les insectes nuisibles et sur les techniques culturales de la tomate au Nigeria

Une enquête effectuée dans des zones productrices de la tomate au Nigeria a indiqué que parmi les insectes ravageurs de cette plante figurent les rongeurs de fruits Helicoverpa armigera *Hübner, les sauterelles* Zonocerus variegatus *L., les mouches blanches* Bemissia tabacci *Genadius ainsi que diverses espèces de pucerons dont la plupart est* Aphis gossypii *Glover. Les enquêtes réalisées chez les fermiers ont montré que certaines mauvaises techniques culturales sont à la base des dégâts causés par les insectes. Il s'agit d'une application inappropriée d'insecticides ainsi qu'un mauvais dosage d'insecticide. Il a été constaté que l'infestation était réduite dans des champs où la tomate était associée avec les céréales, les tubercules ou avec d'autres légumes. Néanmoins, la plupart des techniques culturales n'avaient pas de rapport avec l'effectif d'insectes nuisibles. Cette étude montre que les populations d'insectes ainsi que les pourcentages d'infestations sont significativement plus élevés dans l'état d'Oya (zone forestière) par rapport aux autres états situés dans les zones savanières.*

Introduction

Tomato, *Lycopersicon lycopersicon* L. Kast (= *Lycopersicon esculentum* Mill.) is a fruit vegetable consumed extensively in Nigeria. Its production spreads all over the country. However, the major producing areas lie between latitudes 7.5 °N and 13 °N, and within a temperature range of 25 – 34 °C (11). The areas include most states in northern Nigeria such as Bauchi, Benue, Borno, Kaduna, Kano, Plateau, Sokoto, and some southern states which include Delta, Kwara and Oyo (3). Tomato production in Nigeria has been facing many biotic and environmental constraints. Prominent among such constraints are pests and diseases which reduce yields and the quality of marketable fruits. In the tropics, particularly in Nigeria, many insect pests are associated directly with tomato damage and yield losses while some others are most important as vectors of diseases (1, 6, 8, 10).

A survey was therefore conducted by the National Horticultural Research Institute in some major producing areas to assess the state of the art in tomato production with a view to identifying production problems related to insect pests that require research attention.

The findings presented in this report are those on insect pests of economic importance to tomato. The survey had the objective of (i) identifying, through questionnaires, technologies applied by farmers and their cultural practices which influence insect spread and damage, and; (ii) identify through field sampling major tomato insect pests and their spread.

Material and methods

The survey was conducted in 120 tomato farms located in five major producing states of Bauchi (now

* National Horticultural Research Institute, P. M. B. 5432, Jericho Reservation Area, Idi-Ishin, Ibadan, Nigeria.

** National Horticultural Research Institute, Kano Sub-Station, P. M. B. 3390, Kano State, Nigeria.

Received on 11.12.00 and accepted for publication on 26.08.02.

split into Bauchi and Gombe states), Kaduna, Kano, Oyo and Plateau in the 1995 cropping season (Figure 1).

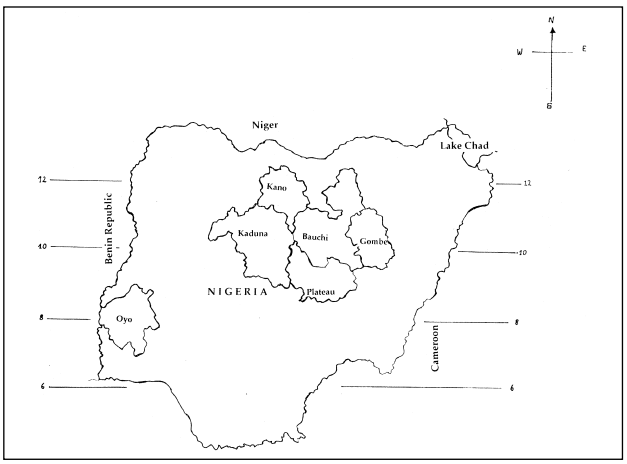


Figure 1: Map of Nigeria showing the surveyed states.

The choice of the states, zones and localities (consisting of villages) visited was based on the following: (a) relative importance of tomato in the crops grown in the state, (b) its level of production and (c) agro-climatic zone. Oyo state is in the rain forest belt with its northern part in the southern Guinea savannah agro-ecological zone. The average annual rainfall of the latter is 2000 mm, and tomato cultivation is rain-fed or with residual moisture. Parts of Plateau state consist of rocky terrain (plateau) with high elevation, and has lowest temperature records in Nigeria (often< 24 °C) during the dry season, with an average annual rainfall of about 1200 mm. Beside Kano state which is in the Sudan savannah zone with an average annual rainfall of 800 mm, Bauchi and Kaduna states are in the northern Guinea savannah zones and receive about 1100 mm mean annual rainfall. Apart from Oyo state where tomato is grown in the rainy season, cultivation in the other states is at the onset of the dry season with residual moisture or irrigation. Insect pests were sampled in farmers' plots between June and July in Oyo state, and in December in the other states using a stratified random sampling methods. A total of 40 plants were sampled from fields less than 1500 m^2, while 80 samples were taken from those = 2500 m^2. Observations were made *in situ* on the leaves, fruits and stems for insect damage. Since the farmers did not allow the removal of apparently healthy plants, only the roots of dead plants were observed for insect damage. Insects samples were identified in the field and in the laboratory at the National Horticultural Research Institute. Farmers owning the sampled farms were interviewed on the cultural practices that were likely to influence insect damage. The practices include: the cropping systems practised, method of land preparation, maintenance of bush fallow system and pest control methods. Percentages of plants damaged by insects per farm were grouped and rated 0 - 6 at an interval of 15% damage, with 6 being the highest level, and correlated with relevant quantifiable survey variables such as the number of years a farm was kept under fallow, the number of times a farm was treated against pests per cropping season, the number of intercropping species found in the field. T-test analyses were used to compare insect pest populations between states. Parameters assessed through questionnaires were expressed in percentages of responses obtained.

Results

Farmers' responses on farm cultural practices and observations from field sampling

The major occupation of the 120 interviewed farmers was farming. Only about 30% were involved in some off-farm activities to supplement income generated from farming. Majority of the farmers derived more than 50% of their income from tomato production. While the farmers' cultivated tomato plots ranged between 0.2 and 6 ha in the areas surveyed, only about 40% of the farmers cultivated more than 1 ha of land at a time. Farmers preferred to rotate tomato with other crops such as cereals, tubers and other vegetables but seldom practise bush fallow system due to the scarcity of cultivable land. Only 25% of farmers in the surveyed areas practised bush fallow system which they claimed had no effect on insect infestation. Land clearing prior to tillage consisted of slashing and burning, clearing and leaving the residues to decay *in situ*, or by direct burning of vegetation without cutting or using tractor to plough the land. Farmers did not experience any effects on insect pest damage by these methods of clearing. Crops intercropped or relayed with tomato include lettuce *Lactuca sativa* L., cabbage *Brassica oleracea* L., pea *Pisum sativum* L., carrot *Daucus carota* L., onion *Allium cepa* L. and peppers *Capsicum* spp. in the northern states, while in Oyo state in the south, the crops are okra *Albelmoschus esculentus* (L.) Moench, peppers, amaranths *Amaranthus* spp., *Celosia* spp., *Corchorus* spp., maize *Zea mays* L., cassava *Manihot esculenta* Crantz and yam *Dioscorea rotundata* Poir (Table 1).

Multiple cropping was observed in 60% of the surveyed farms. However, 42% of the farmers who intercropped tomato in Oyo state affirmed that they sometimes practise monocropping. More than 50% of farmers in Bauchi, Kaduna and Plateau states practised multiple cropping, while 90% monocropped tomato in Kano. Responses from 55% and 65% of farmers in Oyo and Kaduna states respectively indicated that intercropping reduce pest damage on tomato. Farmers from other states do not share this view. The varieties of tomato planted by the farmers vary considerably across localities (Table 1) depending on adaptability to local conditions. The percentages of insect attack reported by farmers varied across the states (Table 1). Ninety percent of the farmers reported higher insect attack at plant maturity compared to early growth stages of tomato. Majority (76%) of these farmers initiated various methods of control against insect pests. Among these farmers, 41% controlled insect pests by applying synthetic

Table 1

Farmers' responses to questionnaires, and field observations on tomato insect pests in major producing areas of Nigeria

States and Local Government Areas (LGA)	Varieties cultivated in the LGA	*Crops interplanted with tomato	*Predominant insect pests	Plants attacked (mean %)	Control methods in the LGA
Bauchi state		Pepper, onion, lettuce, carrot,	Aphids, *Helicoverpa*		
Deba	2, 7, 9, 10, 11, 12, 13	cabagge	*armigera,*	21	CH, NC
Durun	2, 7, 9, 10, 11, 12, 13, 14		white flies	13	CH
Ningi	2, 7, 9, 10, 11, 12, 13, 14			46	CH, CC
Kaduna state		Pepper, onion, carrot, cabagge	Aphids, *H. armigera*		
	2, 7, 9, 10, 11			62	CH, CC
Birnin	2, 7, 9, 10, 11			26	CC, NC
Gwari	2, 7, 8, 9, 10, 11			36	CC, NC
Kaura	2, 7, 8, 9, 10, 11, 12, 13			48	CH, CC
Ikara					
Zango Kattaf					
Kano state		Onion, carrot, pepper,	Aphids, *H. armigera*		
Kura	2, 8, 9, 10	cabbage		20	CH, NC,
Dambatta	2, 7, 8, 9, 10, 11			29	CH
Wudil	2, 8, 11			36	CH, CC
Plateau state		Lettuce, pepper,	Aphids, *H. armigera*		
	2, 7, 8, 9, 10, 11, 12	cabbage,		12	CH, CC, NC
Jos South	10, 11, 12	green pea		37	CH, NC
Birnin Ladi	2, 10, 11, 12			8	NC
Mangu	2			18	CC, NC
Panshin	2			27	CH
Wase	2			40	CH
Keffi					
Oyo state		Okra, pepper, amaranths,	Aphids, grasshoppers,		
Ifedapo	1, 2	*Celosia* spp.,	crickets,	41	CH, NC
Orelope	1, 3	*Corchorus* spp.,	leaf miners,	43	CH, CC
Irepo	1, 3	maize,	white flies,	42	CH, CC
Orire	1, 3, 4	cassava, yam	*H. armigera*,	38	NC
Kajola	1, 2, 3, 4		*Spodoptera*	49	CH, CC, NC
Ogo-Oluwa	3, 4, 5		*littoralis*	65	CH
Surulele	1, 4			32	CC
Ido	3, 4, 5			10	CH
Ibarapa	1, 6			36	CC, NC

1= Ibadan local; 2= Roma; 3= Alara; 4= Omowere; 5= Omoko; 6= Ojutonsoro; 7= Tandino; 8= Harvester; 9= UTC; 10= UC; 11= Ronita; 12= Dansiria; 13= Rukuta; 14= Sawunkura; CH= Chemical control; CC= Cultural control; NC= No control; *Field observations.

pesticides, 8.4% used cultural methods such as roguing and application of wood ash, while 50% applied both synthetic pesticides and cultural control. The insecticides used namely gamma-BHC, DDT etc., were inappropriate or applied at wrong dosages for the identified pests. Of the interviewed farmers 77% did not obtain any satisfactory results from their control methods while others could not discern whether their control methods were successful. The major insect pests observed during field sampling included the grasshopper *Zonocerus variegatus* (defoliators), the tomato fruit borer *Helicoverpa armigera*, white fly *Bemissia tabacci*, aphids *A. gossypii* (most occurring) and *Myzus persica* Sulzer. The white flies and aphids are most important as vectors of viral diseases. The incidence of mole crickets *Gryllotalpa* spp., which severed tomato plants at the base, was sporadic and limited to Oyo and plateau states. The occurrence of the leaf miner *Liriomyza trifolii* Burgess which made serpentine tunnels on leaves was mostly limited to Oyo state.

White fly mean population per plant varied from one to two in Oyo and Bauchi states. No occurrences were recorded in other states. A significantly higher mean population of Z. *variegatus* per plant was observed in Oyo state compared to Bauchi, Kaduna and Kano states (t= 3.5; df= 38; P< 0.001) (Table 2) which had approximately the same mean population (Figure 2).

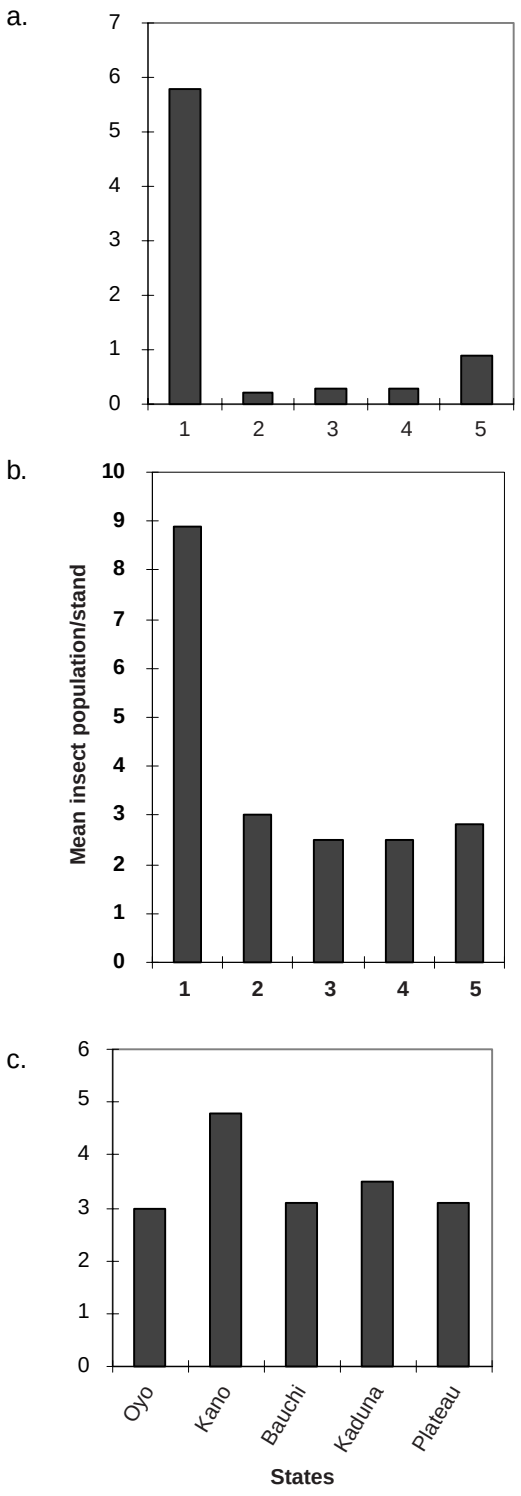


Figure 2: Population of insect pests in field tomato in five producing states of Nigeria. (a) *Zonocerus variegatus* (b) *Helicoverpa armigera* (c) *Aphis gossypii*.

Similar significantly higher population of Z. *variegatus* was observed in Oyo compared to plateau (t= 2.08; df= 38; P< 0.05). *Zonocerus variegatus* populations were not significantly different (P> 0.05) between Bauchi, Kaduna, Kano and Plateau states. The mean populations of aphids *A. gossypii* per plant ranged from 3.0 to 4.8, with no significant differences between the states. Fruit infestation by the fruit borer *H. armigera* was predominant. *Spodoptera littoralis* (a defoliator) was only observed in about 8% of the total samples. The mean population of *H. armigera* per plant was significantly higher (P< 0.01; df= 38) in Oyo state (8.9) compared to 2.5 in Bauchi, 3.0 in Kaduna and Kano and 2.8 in Plateau with t= 2.67, 2.56 and 2.62 respectively (Table 2).

Table 2

T-test analyses for differences between the populations of major tomato pests in the surveyed states in Nigeria

Insect species	t-test values (other states compared with Oyo)$^{\gamma}$			
	Kano	Bauchi	Plateau	Kaduna
Zonocerus variegatus	3.5***	3.5***	2.08*	3.5***
Aphis gossypii	NS	NS	NS	NS
Helicoverpa armigera	2.5**	2.67**	2.62**	2.67**

* P< 0.05; ** P< 0.01; *** P< 0.001; NS= Not significant; $^{\gamma}$Degree of freedom (df)= 38

The mean percentages of plants infested by *Z. variegatus* and by the tomato fruit borers per farm were higher in Oyo state compared to the mean values in other states with only fruit borer infestation in Oyo being significantly (P< 0.01) higher (Figure 3).

The percentage infestation of tomato by aphids was significantly lower in Oyo compared to Bauchi, Kaduna, Kano and Plateau states. There were no significant differences between the percentages of infested tomato in these four states. Relatively higher mean percentage (12%) infestation of tomato by leaf miners was recorded in Oyo state compared to other states where infestation was very low or non-existent. Pathogens which may have contributed to tomato stand and yield losses in the survey included *Fusarium*, *Alternaria*, *Stemphylum* and *Erwinia* species, while the parasitic nematodes included *Meloidogyne* and *Practylenchus* species. Viral diseases such as tobacco mosaic virus, cucumber mosaic virus and tomato leaf curl virus were also identified on tomato.

Relationship between some farmers' cultural practices and insect damage on tomato

Regression analyses showed that most of the farmers' cultural practices such as the number of years a field

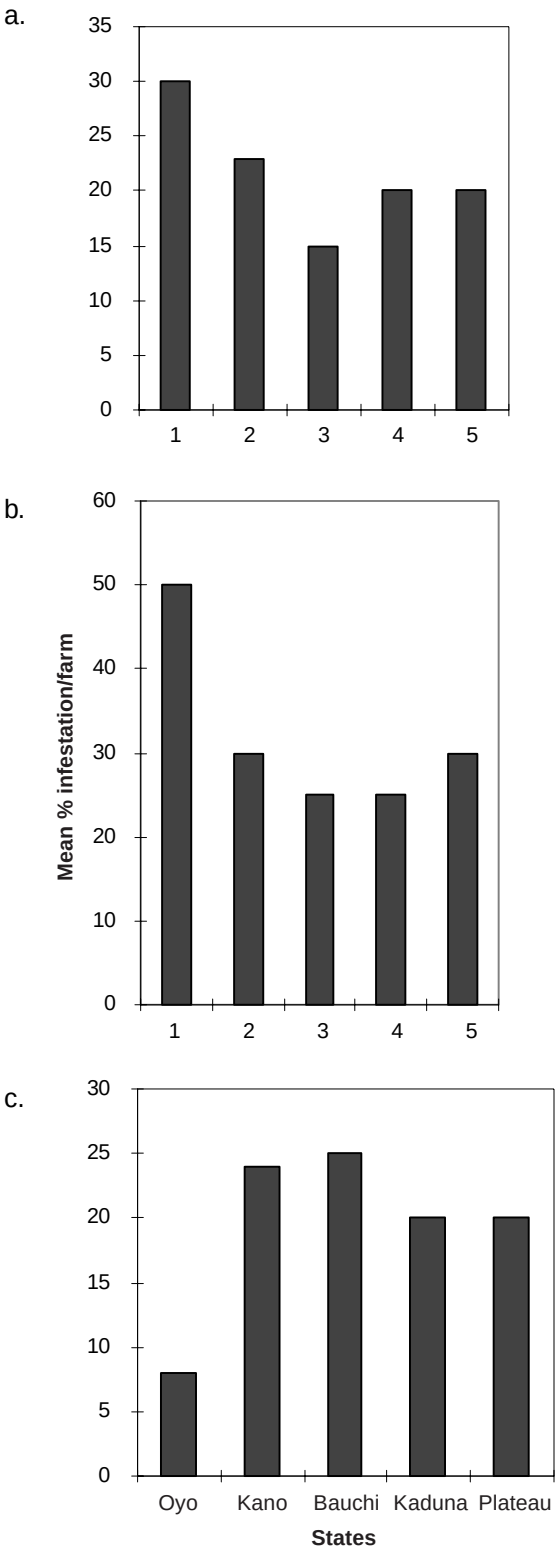


Figure 3: Percentage of tomato plants infested by insect pests in five producing states of Nigeria. (a) *Zonocerus variegatus* (b) *Helicoverpa armigera* (c) *Aphis gossypii.*

was kept fallow or given treatments against pests did not influence the level of insect damage. Only observations made in farms in Oyo and Kaduna states were used to assess the effect of the number of plant species intercropped with tomato on insect damage because both monocropping and intercropping involving various plant species were practised in these two states. The levels of damaged tomato significantly decreased with increase in the number of plant species in the intercrop in Oyo ($r= -0.731$; $P< 0.03$; $df= 19$) and Kaduna ($r= -0.637$; $P< 0.002$; $df= 19$).

Discussions

In Oyo and Kaduna states where intercropping tomato with other crops is predominantly practised, majority of farmers reported that the practice has advantages to reduce insect pests. Our regression analyses showed that there was a significant decrease in tomato infestation with increase in the number of plant species intercropped with tomato ($r= -0.731$). This advantage may have been derived from the companion crops acting as barrier or camouflage against insects, or masking the host's attractants thereby distorting the orientation and host seeking behaviour of the insect pests (4, 5, 7, 9). Farmers responses indicated that the methods of land preparation for tomato did not influence insect infestation. Similarly, regression analyses of damage versus some farmers' cultural practices also showed no influence on insect pest damage. The higher pest infestation at plant maturity indicated by the farmers may be associated with the period of attack of the insects most familiar to them; an example is the fruit boring *H. armigera* that is quite known to them as being most damaging at fruit formation than at early vegetative stage. Farmers' insecticide applications did not reduce pest problems as insecticides and dosages appropriate for the control of the identified insects were seldom utilised. Furthermore, cultural practices such as staking that reduce diseases and fruit borer damage (10) were not applied by the farmers. The higher incidence of insect pests in Oyo state in the south may be attributed to its relatively higher humidity (due to the rainy season) which supports the multiplication of pests and diseases, and vegetation diversity associated with humid zones (including various off-season alternative hosts of the pests' developmental stages) compared to the other states located in the savannah agro-ecology. These favourable conditions may have contributed to the increased population of insects such as *Zonocerus variegatus*, *Helicoverpa armigera* and the leaf miner *L. trifolii* in Oyo state. The survey showed that tomato production is likely to be less prone to insect pest attack in the northern than the southern parts of Nigeria probably due to periods of cultivation. Therefore to increase tomato production in southern Nigeria, research efforts should be geared towards the development of high-yielding and pest/disease resistant varieties adapted to the southern agro-ecological zones as well as promoting the cultivation of dry season tomato. Extension methods should be improved to ensure adoption of new agricultural technologies by farmers in the entire country. Since, it has been reported that despite the technologies already transferred to farmers on tomato production, signifi-

cant shortfalls are still experienced (2). The survey also showed that intercropping tomato with other plant species as practised by farmers reduced insect pest damage. This emphasises the need to develop integrated pest management strategies that should include some desirable farmers' practices in order for them to be acceptable to small holders.

Acknowledgement

We thank Prof. M. F. Ivbijaro and Dr. A. A. Kintomo for reviewing the manuscript. This survey was part of a preliminary study on the development of practices for the improvement of tomato production in Nigeria under the National Agricultural Research Project (NARP) sponsored by the World Bank.

Literature

1. Anonymous, 1986, Advances in fruit and vegetable research at NIHORT (1976 - 1986), NIHORT Press Ibadan, Nigeria 62 pp.
2. Babatola J.O., 1981, Root-knot nematode problems of horticultural crops in Nigeria *in*: Proc. ISHS VIth African Horticultural Symposium, 19-25 July 1981, Ibadan, Nigeria
3. Denton O. A. & Swarup V., 1983, Tomato cultivation and its potential in Nigeria. Acta Horticulturae, 123, 257-263
4. Hasse V. & Litsinger J. A., 1981, The influence of vegetation diversity on host finding and larval survivorship of the Asian corn borer, *Ostrinia furnacalis*. IRRI Saturday Seminar, Entomology Dept. International Rice Reseach Institute (IRRI). Los Bãnos, Laguna Phillipines.
5. Litsinger J.A. & Moody K., 1978, Integrated pest management in multiple cropping systems. Papendick R. I. & P. A. Sanchez (Eds). P. 253-316. Proceedings of a symposium held in Knoxiville, Tenessee, Tenessee Special Puplication No. 22. America Society of Agronomy, Madison, Wisconsin.
6. Messiaen C., 1992, The tropical vegetable garden. Principles for improvement and increased production, with applications to the rain vegetable types. Macmillan Press Ltd. London and Basingstoke 514 pp.
7. Perrin R. M., 1977, Pest management in multiple cropping systems. Agro Ecosystem, 3, 93-118
8. Tindall H.D., 1983, Vegetables in the tropics. Macmillan Press Ltd., London, Basingstoke 553 pp.
9. Umeh V.C. & Ahonsi S., 2000, The increasing importance of the leaf miner *Liriomyza trifolii* Burgess (Diptera: Agromizidae) on tomato in South western Nigeria, and the difficulties of its control with a vegetable insecticide Karate. Proceedings of the 18th Annual Conference of the Horticultural Society of Nigeria, 28 May- 1 June 2000, Institute for Agricultural Research, Ahmadu Bello University Zaria, Nigeria (in the press).
10. Umeh V.C. & Oyedun O., 1995, Effects of spacing, staking and insecticide applications on the abundance of tomato fruit worms *Spodoptera* and *Helicoverpa* species and on infection by *Alternaria* sp. Proceeding 10th Annual Conference of the Horticultural Society of Nigeria, 12 - 15 March 1995, Kwara state ADP, Nigeria.
11. Villareal R.I., 1980, Tomato in the tropics. Wesview Press Bouwer, Colorado U.S.A

V.C. Umeh, Nigerian, Ph.D., Entomologist with the Crop Protection Division, National Horticultural Research Institute (NIHORT), P.M.B. 5432, Ibadan, Nigeria.

Felicia O. Kuku, Nigerian, Ph.D., Pathologist with the Crop Protection Division, NIHORT, P.M.B. 5432, Ibadan, Nigeria.

E.I. Nwanguma, Nigerian, Ph.D., Nematologist with the Crop Protection Division, NIHORT, P.M.B. 5432, Ibadan, Nigeria.

O.S. Adebayo, Nigerian, M.Sc., Pathologist with the Crop Protection Division, NIHORT, P.M.B. 5432, Ibadan, Nigeria.

A.A. Manga, Nigerian, M.Sc., Agronomist with NIHORT, Kano Sub-Station P.M.B. 3390, Kano, Nigeria.

The Production Performance of Broiler Birds as Affected by the Replacement of Fish Meal by Maggot Meal in the Starter and Finisher Diets

A.Téguia[1], M. Mpoame[2] & J.A. Okourou Mba[1]

Keywords: Maggot meal- Fish meal- Broiler chickens- Performance

Summary

The effect of replacing fish meal with maggot meal in the starter and grower-finisher diets on the production performances of broiler chickens was studied. For both the starter and the grower-finisher periods, total weight gain in the control group receiving exclusively fish meal was significantly (P< 0.05) lower than that of birds receiving the diet containing the largest amount of maggot meal. No significant difference (P> 0.05) was detected among treatment groups for feed conversion ratio for both the starter and grower-finisher periods. No significant difference was detected among treatment groups for either hot carcass yield or proportion of different parts of the carcass, although increasing the amount of maggot meal in the diet tended to increased proportion of liver and gizzard. Although no significant difference was recorded among treatment groups for the feed cost for the production of one kg of live weight, there was a 4 to 16% reduction in cost of production as compared to the control group for both the starter and the grower-finisher periods. It was concluded that from the technical and economic point of view, maggot meal could replace fish meal, but that the earlier should be analysed for toxicity before it could be widely used for broiler chicken feeding.

Résumé

Effet de la substitution de la farine de poisson par de la farine d'asticot dans les rations démarrage et finition sur les performances de production des poulets de chair

L'effet de substitution de la farine de poisson par de la farine d'asticot dans les aliments démarrage et finition sur les performances de production des poulets de chair a été étudié. Aussi bien au démarrage qu'en finition, le gain de poids des oiseaux du lot témoin nourri exclusivement à la farine de poisson a été significativement (P< 0,05) moins élevé que celui de ceux recevant de la farine d'asticot. Pendant les deux périodes de production, aucune différence significative (P> 0,05) n'a été détectée entre les différents lots pour l'indice de consommation. Bien que le foie et le gésier avaient tendance à grossir avec des taux croissants de farine d'asticot, il n'y avait aucune différence significative entre les différents lots pour le rendement carcasse et la proportion des différentes parties. L'utilisation de la farine d'asticot a permis de réduire le coût de production du poulet même si aucune différence significative n'existait entre les lots pour le coût alimentaire de production d'un kg de poulet. Du point de vue technique et économique, la farine d'asticot pourrait remplacer celle de poisson dans les aliments de poulets de chair. Il est cependant nécessaire d'analyser la farine d'asticot pour la détermination de facteurs anti-nutritionnels avant que son utilisation à grande échelle ne soit envisagée.

Introduction

The development of poultry industry in developing countries in general and Africa south of Sahara in particular has been very rapid during the past two decades. Although rural poultry continues to supply about 60% of the consumption in some countries (2), the importance of broiler meat from modern farms is increasing very rapidly. However, the major constraint of the young industry is feeding that represents up to 60-70% of costs of production (12). Adopting an intensive poultry production supposes the used of protein sources of high biological value such as meat meal, fish meal and soybean meal that are usually imported. Due to the economic crisis affecting developing countries in general and Africa in particular, it becomes more advisable to envisage the utilisation of non conventional sources of protein, not suitable for human consumption but that are widely available (6). This could save some of the limited hard currencies for other development priorities. Such sources of protein have successfully been used (4, 6).

[1] Faculty of Agriculture and Agricultural Sciences, University of Dschang, Cameroon.

[2] Faculty of Sciences , University of Dschang, Cameroon.

Received on 24.04.01. and accepted for publication on 27.08.02.

In rural Africa, maggots have always constituted part of the daily diet of scavenging poultry. In modern poultry production farms, manure disposal is increasingly becoming a serious environmental problem and it is not uncommon to see huge amount of manure stocked in open air and readily invaded by flies. Chicken manure has been found to be a good environment for the development of common flies (11). While solving an environmental problem, the production of maggots could provide an excellent source of animal proteins for local poultry farms. The crude protein content of maggots is high (7) and comparable to that of fish meal. Reports were made that maggots were being produced in Ghana (12) and Burkina Faso (5) for the feeding of birds. However, the product there was fed fresh. For intensive farming, if maggots are to be used as a source of proteins for poultry, they would be more interesting in a dry form.

The objective of this study was therefore, to evaluate the nutritive value of maggots and analyse the effect of maggot meal on the production performances of broiler chickens.

Material and methods

The study took place in the experimental farm of the University of Dschang. Dschang is located in the Western Highlands of Cameroon at an altitude of 1450 m. The climate is characterised by a long rainy season running from mid March to mid November and a short dry season from mid November to mid March. The mean daily temperature varies from 16 to 27 °C and a relative humidity from 40 to 100% depending to the season.

Animals

One hundred and sixty unsexed day old Arbor Acres broiler chicks were used. For the brooding period, the birds were randomly distributed into 16 groups of 10 and raised on litter under similar environmental and management conditions. For the grower-finisher period, the birds were housed in pairs in Californian type cages. The chicks were immunised against Newcastle disease, infectious bronchitis, and Gumboro disease. Coccidiostatics were distributed three consecutive days per week as from 15 to 30 days of age. The birds received vitamins every 15 days and were dewormed at 30 days before they were transferred into cages.

Feeding

Maggots were collected fresh from a commercial layer farm. They were thoroughly washed using tap water and dried on aluminium sheets set 1.5 m above wood flame. After about 1.5 hour, the maggots were completely dry and were then milled and added to the experimental diets. The cost of production of maggot meal was estimated at FCFA 434/kg as compared to FCFA 550/kg for fish meal (1 euro = FCFA 657.56)

Samples of maggot meal were analysed for crude protein, crude fibre and phosphorus (3), dry matter (105 °C for 24 h) and ash (500 °C over night).

For the brooding period, 0 (control diet), 5 (S1), 10 (S2) or 15% (S3) of the fish meal were replaced by maggot meal. Each of the 4 experimental diets was given to 4 groups of 10 chicks. At the end of the brooding period, all the birds fed on each starter diet were randomly distributed into the three groups corresponding to the three experimental grower-finisher diets where 0 (control diet), 50 (F1) or 100% (F2) of the fish meal were replaced by maggot meal with 25 replicates per treatment. The composition and determined analysis of experimental diets are given in table 1 for the starter period and table 2 for the grower-finisher period.

Table 1

Composition and determined analysis of starter broiler chicks diets containing maggot meal (g.kg^{-1})

	Control diet	S1	S2	S3
Composition				
Maize	625.000	625.000	625.000	625.000
Soybean meal	120.000	120.000	120.000	120.000
Cotton seed cake	100.000	100.000	100.000	100.000
Fish meal	45.000	42.750	40.500	38.250
Maggot meal	0.000	2.250	4.500	6.750
Vitamin/Mineral premix[a]	100.000	100.000	100.000	100.000
NaCl	10.000	10.000	10.000	10.000
Determined analysis				
Dry matter	896.000	903.110	920.230	915.300
Crude protein	207.810	213.230	208.400	211.000
Crude fibre	40.520	40.731	40.861	41.010
Ash	24.620	34.620	34.010	34.310
M.E*	2725.9	2726.7	2727.4	2728.2

[a] Vitamin/Mineral premix composition (g.kg^{-1}): dry matter (920), protein (520), fat (35), ash (350), Ca (92.6), P (35.2) lysine (30.5), methionine (24.1) methionine + cystine (28.9), vitamin A (15 x 10^6 IU/100 kg), Vitamin D (3 x 10^6 IU/100 kg), vitamin E (35000 mg/100 kg), vitamin (mg.kg^{-1}) K3 (26), B1 (26), B2 (66), B3 (193), B6 (20) B10 (0.26), folic acid (19), choline (21), biotine (0.2), trace mineral (mg.kg^{-1}) Fe (1600) Cu (200), Zn (1320), Mg (800), Se (3.3).

* Calculated metabolizable energy (Kcal.kg^{-1})

Data collection statistical analysis

During the seven-week experimental period, weekly live body weight and weekly feed consumption were collected. The weekly weight gain and feed efficiency ratio were then calculated. At the end of the production period, 4 broiler birds from each of the three treatments including 2 males and 2 females were processed for carcass analysis (9). For the economic evaluation of diets, the feed cost of producing 1 kg of live weight was calculated by multiplying the feed conversion ratio by the cost of 1 kg of diet.

Data were analysed using a completely randomised design. The least significant difference test was used for mean separation in case of significant difference (13).

Table 2

Composition and determined analysis of grower-finisher broiler diets containing maggot meal (g.kg^{-1})

	Control diet	F1	F2
Composition			
Maize	560.0	560.0	560.0
Wheat middlings	200.0	200.0	200.0
Soybean meal	70.0	70.0	70.0
Cotton seed cake	40.0	40.0	40.0
Fish meal	20.0	10.0	00.0
Maggot meal	00.0	10.0	20.0
Vitamin/mineral premix[a]	100.0	100.0	100.0
NaCl	10.0	10.0	10.0
Determined analysis			
Dry matter	896.2	886.5	892.9
Crude protein	187.1	188.2	187.4
Crude fibre	43.6	44.3	44.2
Ash	76.2	74.6	75.3
M.E*	2574.9	2578.3	2581.7

[a] Vitamin/Mineral premix composition (g.kg^{-1}): dry matter (920), protein (520), fat (35), ash (350), Ca (92.6), P (35.2) lysine (30.5), methionine (24.1) methionine + cystine (28.9), vitamin A (15 x 10^6 IU/100 kg), Vitamin D (3 x 10^6 IU/100 kg), vitamin E (35000 mg/100 kg), vitamin (mg.kg^{-1}) K3 (26), B1 (26), B2 (66), B3 (193), B6 (20) B10 (0.26), folic acid (19), choline (21), biotine (0.2), trace mineral (mg.kg^{-1}) Fe (1600) Cu (200), Zn (1320), Mg (800), Se (3.3).

* Calculated metabolizable energy (Kcal.kg^{-1})

Table 3

Chemical composition of maggot meal (% DM)

Chemical characteristic	% DM
Dry matter	93.50
Crude protein	61.25
Ash	19.12
Crude fibre	3.58
Phosphorus	5.21
M.E*	3060.6

* calculated according to Sibbald (1980) quoted by INRA (1989)

Results

The chemical composition of maggot meal is summarised in table 3. Crude fibre content and total ash are comparable to those of fish meal (9). However, fish meal has lower crude fibre and total phosphorus content (7). Metabolisable energy content of maggot meal is higher than that of fish meal.

Weight gain

From day old to four-weeks of age, the lowest weight gain was recorded with the control group of chicks, while the birds fed with the S3 diet obtained the highest (Table 4). Except for week 2, using maggot meal always yielded higher weight gain as compared to the control (Figure 1). Statistical analysis showed that the treatment effect was significant (P< 0.05).Total weight gain in the S3 group was significantly higher than that of the control group, but not significantly different from the S1 group of birds. However, no significant difference was found between the control group and the S2 group of birds and between S1 and S2 broiler chicks for total weight gain during the starter period.

During the grower-finisher period, weight gain ranged from 1062.2 ± 59.9 g for the control group, to 1209.4 ± 73.3 g for the birds fed with the diet in which all the fish meal was replaced with maggot meal (F2). Except for the F0 group of birds, the increase in weight gain was linear (Figure 2)

Statistical analysis revealed that there was no significant difference among the birds fed with maggot meal (F1 and F2), while those fed the F2 recorded significantly (P< 0.05) higher weight gain as compared to the control. There was however, no significant difference between the birds on the control diet and those fed the F1 diet.

Feed consumption

Feed consumption during the starter period varied from 1356.50 ± 106.12 g for the birds fed with the control diet to 1456.58 ± 110.16 g for those fed with the S3 (Table 4). The broiler birds fed with the S3 diet consumed significantly (P< 0.05) more feed than those fed with the control or the S2 diets. No significant difference was however recorded among the control, the S1 and the S2 groups for feed consumption. Replacing 5%

Table 4

Weight gain (g), feed consumption (g), feed conversion ratio and feed cost of production of one kg live weight (FCFA)* of broiler chicks fed with maggot meal from day old to 4 weeks of age

Diet	Weight gain ± SEM	Feed consumption ± SEM	Feed conversion ± SEM	Feed cost for the production of 1kg of live weight
Control	678.25 ± 96.46^{c}	1356.50 ± 106.12^{b}	2.00 ± 0.19^{a}	419.54^{a}
S1	795.38 ± 125.28^{ab}	1415.77 ± 102.60^{ab}	1.78 ± 0.37^{a}	371.49^{a}
S2	717.50 ± 107.50^{bc}	1377.60 ± 98.78^{b}	1.92 ± 0.20^{a}	401.06^{a}
S3	837.12 ± 138.87^{a}	1456.58 ± 110.16^{a}	1.74 ± 0.07^{a}	363.26^{a}

[abc] A treatment is not significantly different (P> 0.05) from the control group when means of both groups carry the same letter.

* 1 euro= 657.56 FCFA.

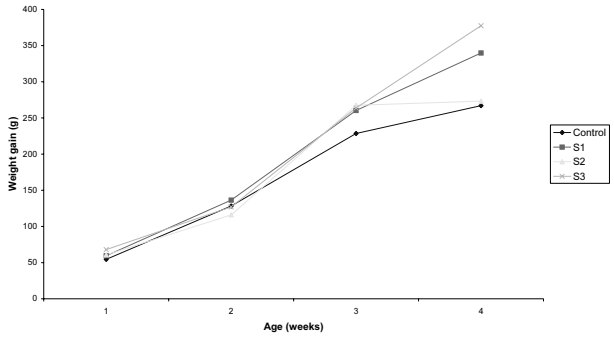


Figure 1: Weight gain of broiler chicks fed with maggot meal from day old to 4 weeks of age

	1	2	3	4
Control	54.5	128.25	228.5	267
S1	59.5	136.38	260.25	339.75
S2	60.75	116	267.5	273.25
S3	68	127	263.75	377,5

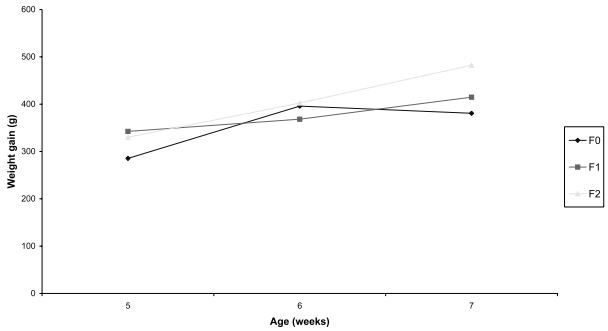


Figure 2: Weight gain (g) of broiler chickens fed with maggot meal during the grower-finisher period

	5	6	7
F0	285.47	395.94	380.78
F1	342.50	368.29	414.84
F2	330.15	402.50	482.35

(S1) or 15% (S3) of the fish meal with maggot meal did not significantly (P> 0.05) affect feed consumption.

For the last three weeks of production (Table 5), feed consumption was lower in the group of birds fed with the diet containing only maggot meal (F2) and higher in the F1 group of birds fed with the diet containing equal amount of both fish meal and maggot meal. There was no significant difference (P> 0.05) between the control birds and those fed on the F2 diet in which 100% of the fish meal was replaced with maggot meal. Feed consumption in the group of birds fed with the diet containing equal amounts of fish and maggot meals was significantly (P< 0.05) higher than that of the other two groups.

Feed conversion efficiency

Feed conversion was 1.74 ± 0.07 for the S3 group of birds and 2.00 ± 0.19 for the control group during the starter period (Table 4). From table 5, it appears that

Table 5

Weight gain (g), feed consumption (g), feed conversion ratio and feed cost for the production of one kg of live weight (FCFA)* of broiler chicks fed with maggot meal from 30 to 49 days of age

Diet	Weight gain ± SEM	Feed consumption ± SEM	Feed conversion ± SEM	Feed cost for the production of 1 kg of live weight
Control	1062.19 ± 59.88^{b}	2718.59 ± 202.46^{b}	2.63 ± 0.30^{a}	458.01^{a}
F1	1125.63 ± 36.66^{ab}	2972.81 ± 249.09^{a}	2.65 ± 0.39^{a}	457.87^{a}
F2	1209.38 ± 73.28^{a}	2668.28 ± 241.50^{b}	2.23 ± 0.28^{a}	383.80^{a}

^{abc} A treatment is not significantly different (P> 0.05) from the control group when means of both groups carry the same letter.

* 1 euro= 657.56 FCFA.

Table 6

Carcass yield and proportion of different parts of the carcasses (%) of 49 days old broiler chicken birds fed with diet containing maggot meal

Diet	Hot carcass yield	Heart	Liver	Gizzard	Legs	Abdominal fat
	As a percentage of live weight					
Control	64.23^{a}	0.45^{a}	1.75^{a}	1.80^{a}	4.38^{a}	1.35^{a}
F1	63.62^{a}	0.43^{a}	1.80^{a}	1.86^{a}	4.97^{a}	0.88^{a}
F2	64.90^{a}	0.48^{a}	1.83^{a}	2.15^{a}	5.43^{a}	0.81^{a}

^{a} Percentages carrying the same letter in the same column are not significantly different (P> 0.05).

during the grower-finisher period, the F1 group of birds recorded a feed conversion ratio of 2.65 ± 0.39 while the F2 group of birds had 2.23 ± 0.28. For both the starter and grower-finisher periods, no significant difference (P> 0.05) was recorded among groups of birds for feed conversion ratio.

Carcass quality

Data on carcass yield and proportion of different parts of the carcass are summarised in table 6. Carcass yield varied from 63.92% for the control group to 64.9% for the F2 birds. Percent legs, percent gizzard and percent liver increased from the control group to the F2 group. There was a decreased in the proportion of abdominal fat with increased amounts of maggot meal in the diet. There was however, no significant difference (P> 0.05) among treatment groups for carcass yield and proportion of heart, gizzard, liver, legs and abdominal fat.

Feed cost for the production of one kilogram of live broiler chicken weight

The feed cost for the production of one kg of live broiler chick varied from FCFA 363 for the group of birds fed with the S3 diet to FCFA 419 for the birds under the control diet (Table 4). During the grower-finisher period, the feed cost for the production of one kg of live broiler decreased from FCFA 458 for the birds under the F0 diet to FCFA 383 for those fed on the F2 diet (Table 5). However, there was no significant difference (P> 0.05) among treatment groups either during the starter or the grower-finisher periods for the feed cost for the production of one kg of live broiler chicken weight.

Discussion

Weight gain for both the starter and the grower-finisher periods have been significantly higher for the group of birds fed with the feed containing the highest amount of maggot meal as compared with the control group. In general, adding maggot meal to the diet resulted to a higher weight gain as compared with the control (Figures 1 and 2), although the difference between the control birds and some diets containing maggot meal was not significant. Weight gain of all birds used in this experiment either for the starter or grower-finisher periods was lower than suggested for Arbor Acres broiler birds, 1069 g and 1408 g from day old to 4 weeks and from 5 to 7 weeks respectively. This difference in weight gain could be related to the quality of feed but also to the environment as this birds are initially selected for temperate regions.

During the starter period, feed consumption has been significantly higher for the birds fed with the diet containing the largest amount of maggot meal as compared with the control group, however, no difference was detected between the later and the two other groups for feed consumption. The grower-finisher ration was significantly more consumed by birds on F1 diet as compared to the control and F2 groups. No clear treatment effect was detected. Also, in general, all birds used in this experiment consumed less feed than suggested for Arbor Acres broiler birds. This could be related to the relatively low energy to protein ratios recorded for the diets used in this experiment that were between 128 and 131 for the starter diets and around 137 for the grower-finisher diets as compared to values between 138 and 145 and between 157 and 190 as suggested (10) respectively for starter and grower-finisher diets.

Although no significant difference was detected among treatment groups for feed conversion either for the starter or the grower-finisher, a better feed utilisation was observed for birds fed with feeds containing maggot meal, particularly during the 4 first weeks of life. However, all birds used in this experiment recorded poorer feed efficiency than suggested by the breeder except for the F2 group of birds fed with the feed containing exclusively maggot meal in replacement of fish meal in the grower-finisher diet. With the control group also giving lower performance, the poor feed utilisation could not be totally attributed to the introduction of maggot meal in the diet. This could rather be related to the quality of the feed used, particularly to the lower energy concentration as previously noticed (8) for poultry diets in the tropics.

The carcass yield and proportion of heart were in the range previously suggested (9) 63.92% and 0.43% respectively, however, proportions of legs and gizzard were higher than the suggested 4.0% and 1.15% respectively. All the birds in this experiment recorded lower proportion of abdominal fat than the 2.0% suggested (9). While the inclusion of increased amount of maggot meal resulted in a proportional increase in the percent legs, liver and gizzard, the proportion of abdominal fat decreased with increased amount of maggot meal in the grower-finisher diet. An increase in the proportion of the gizzard and liver could be an indication of a more intensive activity of these organs and a possible toxicity of maggot meal, although no clinical sign of toxicity was observed in birds fed with maggot meal. The relative decrease in the abdominal fat deposit with increased amount of maggot meal could be due to the better utilisation of feed containing maggot meal.

Although no significant difference was detected among treatment groups for the feed cost for the production of 1 kg of live weight, there was a net decrease in cost ranging from 4.4% to 13.4% and from 0.03% to 16.2% as compared to the control group respectively for the starter and the grower-finisher periods. The reduction in cost of feeding in treatment groups as compared to the controls is probably related to the lowest cost of maggot meal as compared to fish meal, but also to better utilisation of feed particularly in groups fed with the highest amount of maggot meal both during starter and grower-finisher periods. The difference between the control group and the one fed with maggot meal could be of prime practical importance as this could mean a sensible reduction in the cost of production, particularly in large production units.

Conclusion

The replacement of fish meal with maggot meal in broiler chicken starter and grower finisher diet resulted in higher weight gain as compared to control diets. Carcass yield was comparable for birds fed with control diets and those containing maggot meal. From the technical point of view, the substitution was a success.

Under commercial conditions, using maggot meal could also be justified by a reduction in cost of feeding broiler chicken to market weight.

However, with the increased size of gizzard and liver, it is advisable that maggot meal should be analysed for toxicity before it could be widely used for broiler chicken feeding.

Literature

1. Agbédé G., Nguekam & Mpoame M., 1994, Essai d'utilisation de la farine de vers de terre *Eudrilus eugeniae* dans l'alimentation des poulets de chair en finition. Tropicultura, **12**(1), 3-5
2. Agbédé G.B., Téguia A. & Manjeli, Y., 1995, Enquête sur l'élevage traditionnel des volailles au Cameroun. Tropicultura, **13**(1), 22-24
3. AOAC, 1980, Official Methods of Analysis of the Official Analytical Chemist. 13th Edition. Association of Official Analytical Chemist, Washington, DC
4. Barcelo P.M., 1988, Production and utilisation of earthworms as feeds for broilers in the Philippines. Tropicultura, **6**(1), 21-24.
5. Cicogna M., 1992, First International Seminar on Farming of Invertebrates and Other Minilivestocks. Tropicultura, **10**(4), 155-159
6. Hardouin, J., 1986, Mini-élevage et sources méconnues de protéines animales. Annales de Gembloux, 92, 153-162.
7. Hardouin, J., 1992, Termites and maggots use as feed. In EEC-GXII/CTA/IFS (ed): Proceedings of the Seminar on Invertebrates Farming, The Philippines, P. 163.
8. Institut Nationale de la Recherche Agronomique, 1989, L'alimentation des animaux monogastriques. 2e Edition. Paris, France, pp 282.
9. Jourdain R., 1980, L'aviculture en milieu tropical. Edition Sté Jourdain, Boissy le Chatel, France, pp 148.
10. Leeson S. & Summers J.D., 1997, Commercial Poultry Nutrition. 2nd Edition. University Books, Guelph, Ontario (Canada), pp 350.
11. Nguemfo, E.L., 2000, Essai de production d'asticots dans les fientes de poule et dans la bouse de vache. Mémoire de maîtrise, Faculté de Science, Université de Dschang.
12. Smith A.J., 1992, L'élevage de la volaille (deuxième volume). Collection " Le Technicien d'Agriculture Tropicale". ACCT/CTA/Ed. Maisonneuve et Larose, Paris, 151p.
13. Steel R.G.D. & Torrie J.H., 1980, Principles and Procedures of Statistics. 2nd Edition, McGraw-Hill, New York, 633 pp.

A.Téguia, Cameroonian, M.Sc., Animal Scientist, Senior lecturer, Department of Animal Science, Faculty of Agronomy and Agricultural Sciences, University of Dschang, P.O.B; 70 Dschang, Cameroon.

M. Mpoame, Cameroonian, Ph.D., Zoologist, Associate professor, Faculty of Science, University of Dschang, Cameroon.

J.A. Okourou Mba, Cameroonian, Agricultural engineer, Department of Animal Science, Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon.

La théiculture au Burundi: Diagnostic d'une filière en mutation

T. Nkunzimana[1] , A. Thonon[2] & P.-F. Ndimira[3]

Keywords: Subsector– Tea– Liberalization– Burundi

Résumé

L'analyse des statistiques montre que le thé a représenté environ 9% de la valeur ajoutée créée par l'ensemble des cultures de rente. Sur la même période, la part de cette culture dans le produit intérieur brut aux prix du marché a été d'environ 0,4%. De 1990 à 1999, le thé a représenté en moyenne 13% des recettes annuelles d'exportation du Burundi.

Il s'agit donc d'un produit particulièrement important pour le pays et pour sa population.

Cependant, la filière présente une série de problèmes d'ordre technico-économique que cet article voudrait mettre en exergue. A titre d'exemple, nous pouvons citer le dépassement des capacités installées dans les usines, le vieillissement des équipements, l'irrégularité dans la qualité du produit, la non-maîtrise des coûts et l'augmentation du service de dettes due à la détérioration du taux de change.

Des ébauches de solutions sont proposées en vue de faire face à ces différentes contraintes avant de passer à la libéralisation.

Summary

Tea Subsector in Burundi: Diagnosis of a Subsector in Transformation

The statistical analysis shows that the tea has represented 9% of the added value created by all the cash crops. During the same period, the share of the tea in gross domestic product at market prices has been approximately 0.4%. From 1990 to 1999, the tea has represented in average 13% of the annual exports revenues.

It is a particularly significant product for the country and its population.

However, the tea subsector presents a series of problems of a technical and economic nature that this article would like to point up. As an example, we can quote the going beyond of installed capacities in the factories, the aging of the equipment, the irregularity in the quality of the product, the non control of the costs and the increase in the service of debts due to the deterioration of the exchange rate.

Some recommendations are proposed in order to face these various constraints, before passing to liberalization.

Introduction

Le théier a été introduit à la station de recherches agronomiques de Gisozi au Burundi en 1931. Ce n'est qu'en 1963, trente-deux années plus tard, que la théiculture fut diffusée en dehors de cette station expérimentale.

Le théier exige des sols acides et des terroirs convenablement arrosés. Au Burundi, ces conditions sont réunies dans les régions naturelles du Mugamba et du Mumirwa, plus précisément sur les flancs Est et Ouest de la crête Zaïre-Nil. La filière théicole s'est développée grâce à des moyens financiers très importants. Toutefois, suite à la crise socio-économique que traverse le Burundi depuis 1993, les moyens pour faire fonctionner la filière sont limités. Sa volonté est réelle de libéraliser la filière en vue de la rendre plus efficace. D'autre part, l'Etat burundais, principal acteur, se trouve actuellement sans moyens suffisants pour assurer la gestion et le développement de la filière.

Trente-huit ans après l'introduction du théier et face à cette réforme en vue, il s'avère opportun d'analyser les enjeux et les perspectives de la filière théicole au Burundi.

Les statistiques utilisées dans cette analyse sont extraites des rapports techniques de l'Office du Thé du Burundi (OTB), des rapports techniques de la Banque de la République du Burundi (BRB) et d'autres travaux d'expertise qui ont été effectués sur la filière «thé» au Burundi.

1 Université Catholique de Louvain, Faculté d'ingénierie biologique, agronomique et environnementale, Place Croix du sud 2/15, B-1348 Louvain-la-Neuve.

2 Université Catholique de Louvain, Faculté d'ingénierie biologique, agronomique et environnementale, Place Croix du sud 2/15, B-1348 Louvain-la-Neuve (Professeur à l'Université Catholique de Louvain, Belgique).

3 Compagnie de Financement pour le Développement (COFIDE) B.P. 139, NgozI-Burundi.

Reçu le 04.07.02 et accepté pour publication le 30.08.02.

Office du Thé du Burundi (OTB): organisation et rôle dans la filière

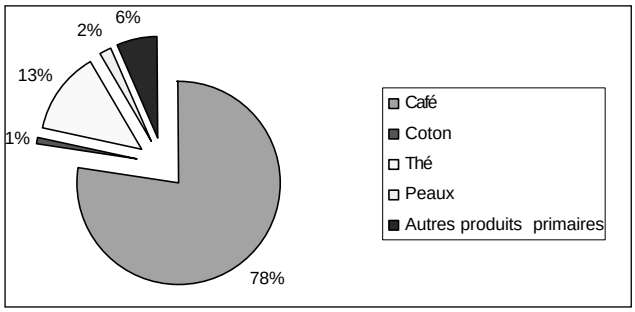
L'OTB est une société publique créée en 1971 par le décret présidentiel n° 1/79 du 30/07/1971. Elle est régie actuellement par le décret n° 100/157 du 5 septembre 1997. Son rôle est de promouvoir la théiculture au Burundi et partant, de contribuer à l'apport en devises et de procurer des revenus aux théiculteurs. L'OTB a pour unique actionnaire l'Etat. Cet organisme est divisé en 6 unités à savoir le siège situé à Bujumbura et les complexes théicoles de Teza, Rwegura, Tora, Ijenda et de Buhoro. A travers ses départements agronomique, industriel, commercial et financier, le siège appuie les complexes théicoles pour ce qui concerne les questions techniques, commerciales, administratives et financières. Trois services sont rattachés directement à la direction générale: un service d'approvisionnement, un service de contrôle de gestion et un service de gestion du personnel.

Huit cents personnes travaillent de manière permanente au siège de l'OTB. Celles-ci interviennent au niveau de tous les maillons de la filière. Outre ce personnel permanent, il y a également une main-d'œuvre temporaire équivalent à environ huit millions hommes-jours par an, ce qui équivaut approximativement à quatre mille travailleurs à temps plein. Cette main-d'oeuvre intervient surtout en période de pointe comme par exemple pendant la cueillette.

Au niveau de la recherche, c'est l'Institut des Sciences Agronomiques du Burundi (ISABU) qui intervient dans la filière. L'OTB a aussi d'autres partenaires socio-économiques avec lesquels il échange des biens et services.

Importance économique de la théiculture

De 1990 à 1999, le thé a représenté en moyenne 13% des recettes annuelles d'exportation et 9,3% de la valeur ajoutée créée par les cultures d'exportation. Sur la même période, la part du thé dans le produit intérieur brut aux prix du marché (PIBm) est d'environ 0,4%.



Graphique 1: Part du thé et autres produits dans les recettes d'exportation.

Source: BRB, Banque de la République du Burundi, Economie burundaise, Rapport annuel BRB, 1999 (1).

La valeur ajoutée créée par le thé a connu une évolution variable au cours des années. Les années 95-96-97 ont été fort médiocres. Trois causes principales expliquent cette situation particulière. D'abord, au début de l'année 94 jusqu'en 95, les cours mondiaux ont chuté. Ensuite pendant la période 95-97, l'OTB a enregistré des productions faibles suite à la conjoncture socio-politique du pays. Enfin, l'embargo économique imposé au Burundi en 1996 par les pays voisins a encore aggravé la situation.

Analyse des évolutions de quelques variables clés dans la filière

1. Superficies en production

L'OTB possède deux structures d'encadrement à savoir les blocs industriels (BI) et les périmètres villageois (PV). Les blocs industriels sont des plantations de théiers appartenant aux complexes industriels qui assurent la transformation de la feuille verte tandis que les périmètres villageois correspondent à l'ensemble des parcelles de théiers entretenues par les exploitants agricoles. Les superficies en production des périmètres villageois avoisinent 6.000 hectares alors que les blocs industriels sont de l'ordre de 2.000 hectares.

La crise socio-politique qui secoue le Burundi depuis octobre 1993 a occasionné une réduction des superficies en production, surtout au cours de l'année 1997. Il faut signaler que le complexe théicole de Teza a été le plus touché: environ 54 hectares de théiers ont été brûlés et environ 100 hectares sont en croissance libre suite au manque de suivi et d'entretien.

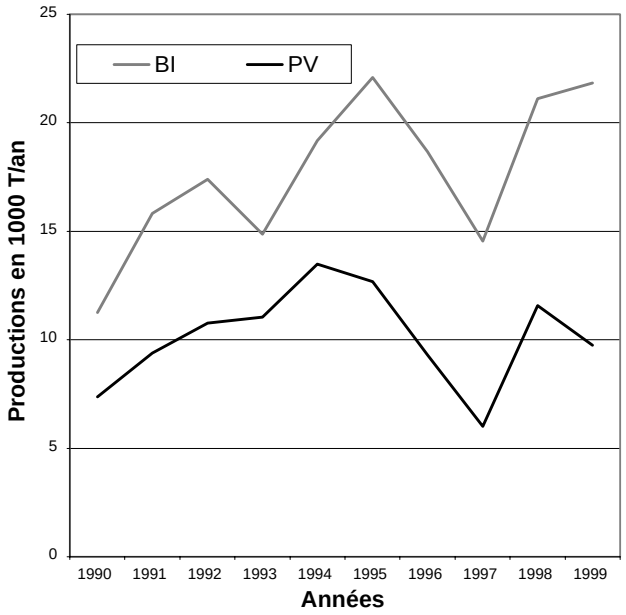
2. Rendement

Dans les périmètres villageois, le rendement en feuilles vertes le plus élevé déjà atteint est de 4,9 tonnes par hectares, soit environ 1 tonne de thé sec par hectare alors qu'en blocs industriels, il est de 7 tonnes de feuilles vertes par hectare. Comparés aux périmètres villageois, les rendements des blocs industriels sont élevés. Plusieurs facteurs expliquent cette situation. D'une part, les blocs industriels sont dans les mains d'une structure étatique qui a des moyens pour optimiser la production des théiers. Ainsi, certains facteurs comme la maîtrise de la phytotechnie du théier, le nombre de jours de cueillette, le rendement du cueilleur et la régularité de la main-d'œuvre ont permis d'améliorer les rendements. D'autre part, dans les périmètres villageois, il y a beaucoup de jeunes plantations de théiers qui entrent en production chaque année. Ces jeunes plantations ont un rendement faible, ce qui dans l'évaluation des rendements globaux abaisse la moyenne générale. D'autres facteurs comme le mauvais entretien des plantations, la sous-cueillette, le détournement des engrais sur des cultures vivrières réduisent la performance dans les périmètres villageois.

3. Production de la feuille verte

L'analyse de la production faite sur dix ans montre que dans les périmètres villageois, la production a augmenté jusqu'en 1992 pour baisser en 1993. Sous l'effet de la crise socio-politique, la production en feuilles vertes dans les périmètres villageois est passée de 17.513 tonnes à 15.112 tonnes, soit une réduction

d'environ 13,7%. Après 1993, la production reprend et dépasse même son niveau d'avant la crise mais à partir de 1995, on observe une baisse des productions. Cette situation est entre autres inhérente au manque de suivi des parcelles de théiers étant donné que les populations sont déplacées suite aux attaques des mouvements rebelles.



Graphique 2: Evolution de la production des feuilles vertes (1000 T)
BI= blocs industriels - PV= Périmètres villageois.
Source: Graphique élaboré à partir des données de Mac Sys (7).

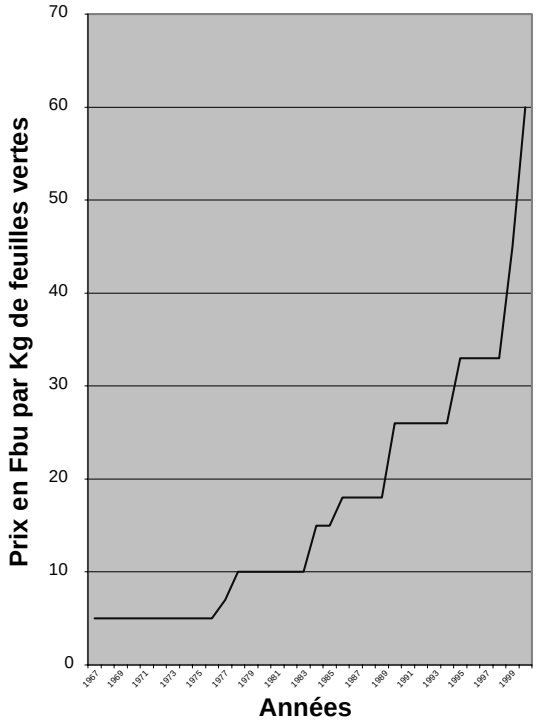
Dans les blocs industriels, on assiste au même scénario mais d'une façon moins marquée car une légère réduction de la production commence en 1995 et s'accentue en 96 suite aux attaques ciblées de l'environnement des plantations des complexes théicoles de Teza et de Rwegura.

Commercialisation du thé au Burundi

Plus de 40.000 théiculteurs livrent des feuilles vertes aux complexes théicoles de l'OTB. Les ventes de la feuille verte se font deux fois par mois mais les théiculteurs ne sont payés que six fois par an.

Comme le montre le graphique 3, le prix par kilo de feuilles vertes a évolué par paliers. Ce prix est passé de 5 Fbu/kg en 1967 à 60 Fbu/kg en 2000, soit une moyenne annuelle de 11,5 Fbu/kg de feuilles vertes. La fixation du prix au producteur ne relève pas d'une technique rigoureuse et formalisée. Après consultation du Ministère de l'Agriculture et de l'Elevage et celui du Commerce et de l'Industrie, l'OTB définit une fourchette de prix. La limite supérieure est constituée par le prix du marché mondial duquel on défalque tous les frais de production et de commercialisation. La limite inférieure est le prix en dessous duquel le planteur villageois a intérêt à remplacer la théiculture par d'autres cultures plus rentables.

Dans la commercialisation du thé sec, environ 95% est exporté à raison de 50% aux enchères de



Graphique 3: Evolution du prix d'achat au producteur à prix courants (Fbu/kg de feuilles vertes).
Source: Rapports techniques OTB (8) et Buzingo (2).

Mombassa et 45% à des ventes directes aux privés. Le solde, soit 5% de la production est consommé localement.

Difficultés auxquelles la filière doit faire face

• *Capacité des usines en voie de dépassement et vieillissement des équipements*

En 1998, les usines de Teza, Tora, Ijenda, Rwegura et Buhoro avaient respectivement atteint 76%, 75%, 86%, 113% et 42% en terme de productions réalisées par rapport à leurs capacités installées (OTB, 1998). Les équipements sont vétustes. Parfois, les théiculteurs ne reçoivent pas au moment opportun les engrais pour leurs théiers.

• *Irrégularité de la qualité du produit*

Selon Flémal (2), le thé burundais est apprécié pour la constance du produit et l'éclat de sa liqueur. La mauvaise cueillette, les mauvaises conditions de transport, la mauvaise manutention, le non-respect des paramètres d'usinage et la défaillance des équipements sont les causes majeures de la dégradation de la qualité du thé burundais. A côté de cela, il y a aussi un manque de maîtrise de la dégustation par les teamakers.

• *Non-maîtrise des coûts en amont et en aval de la filière*

Combiné à la dévaluation du franc burundais, l'éloignement et l'enclavement géographique du Burundi par rapport aux marchés du thé expliquent l'augmen-

tation continuelle des frais commerciaux et les longs délais d'encaissement (Tableau 1).

Tableau 1

Evolution des frais commerciaux sur les principaux marchés d'exportation du thé burundais (Fbu/kg de thé sec)

Marché	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Enchères Londres	77	83	88	91	95	105	110	115	130	250
Enchères Mombassa	27	27	30	35	35	38	60	69	80	Voie n.u.
Ventes directes aux privés	43	50	50	59	66	74	78	95	110	150

Voie n.u.: Voie non utilisée suite à l'embargo imposé au Burundi par les pays voisins.
Source: OTB (8) Plan de redressement et de développement de l'Office du Thé de Burundi à court terme (1998-2000). Page 15; Rapport du Département commercial, OTB (1999).

La commercialisation du thé nécessite un important fonds de roulement étant donné que les délais d'encaissement sont longs alors que les charges d'exploitation pour les thés vendus sont payées au plus tard dans les deux mois qui suivent la production.

4. Provisions pour risque de change sur emprunts extérieurs

Le risque de change est l'un des problèmes financiers les plus cruciaux auquel fait face l'OTB. De 1994 à 1999, les provisions constituées pour risque de change sur les emprunts extérieurs s'élevaient à environ 4,371 milliards de francs burundais[4].

Tableau 2

Evolution des provisions pour risque de change sur les emprunts extérieurs (en milliers de Fbu[1])

Années	1994	1995	1996	1997	1998	1999
Provisions	727.374	694.877	466.188	542.344	1.619.976	320.073

Source: Mac Sys (7) Etude préparatoire à la libéralisation de la filière théicole.

Cette évolution est due au fait que 95% de la production du thé est exportée et que parallèlement, l'Etat burundais oblige l'OTB de tenir sa comptabilité en monnaie nationale et de céder ses recettes en devises à la Banque Centrale. C'est cette dernière qui fixe le taux de change.

Perspectives de la filière

Pour réussir sa libéralisation, il s'avère primordial de chercher des solutions alternatives aux différentes contraintes qui pourraient compromettre l'avenir de la filière et proposer une structure transitoire de gestion de la filière.

• *Chercher des solutions aux problèmes techniques qui se posent avant l'ouverture de la filière aux privés*

Rendre compétitives et rentables les usines de thé: pour ne donner qu'un seul exemple, depuis 1994 jusqu'aujourd'hui, l'usine de Buhoro connaît un résultat d'exploitation négatif, ce qui engendre une situation de non rentabilité financière qui affecte le bilan global de l'OTB. Avant de libéraliser un tel complexe, il faudrait mettre sur pied des mécanismes permettant d'accroître le degré d'efficience de son système productif.

Mener une étude économique sur l'extension des unités de production: le problème de surcharge des usines qui survient surtout pendant les mois de mars à mai suite à une haute production, suscite une étude technico-économique approfondie en matière de possibilité d'extension des capacités d'usinage. Cependant, on devrait s'assurer de la valorisation de l'investissement pendant les périodes de production normale.

Traçabilité du produit et prime de qualité: si le comportement du marché obéit à la loi de l'offre et de la demande, la qualité de la feuille produite reste le facteur décisif pour les petits producteurs. Pour arriver à préserver la régularité dans la qualité de son produit, l'OTB devrait former des tea-makers. L'instauration d'une prime de qualité devrait non seulement améliorer la qualité du thé mais aussi la traçabilité du produit.

Vers une valorisation des enchères régionales: en adoptant la dynamique commerciale autour des enchères régionales, telle que Mombassa, la filière pourrait réduire les coûts commerciaux.

Vers une réforme dans la gestion du risque de change sur les emprunts extérieurs: en vue de réduire le risque de change encouru par l'OTB, l'Etat devrait autoriser celui-ci à céder à la Banque de la République du Burundi le montant en devises défalqué de ses engagements annuels.

Vers une nouvelle politique des prix aux producteurs: le système actuel de paiement basé sur un prix fixe de la feuille verte déterminé au niveau national et généralement pour plusieurs années est particulièrement démotivant pour les planteurs villageois et explique pour une partie le manque de motivation des exploitants et par là, les mauvaises performances des plantations. Il faudrait par exemple instituer un ratio entre le prix d'achat de la feuille verte et le prix de vente moyen du kg de thé sec.

4 1 US $= 850 francs burundais

D'un modèle étatique au modèle libéral et privé via un modèle communautaire basé sur l'approche participative.

Jusqu'à présent, le producteur bénéficie d'interventions étatiques en amont de la filière. Avec l'ouverture de la filière, la politique économique va changer tout le système d'organisation et de gestion de la filière. Au niveau de la politique des prix par exemple, c'est la confrontation de l'offre et de la demande qui va déterminer le prix de la feuille verte.

Comme le montre le schéma suivant, dans le modèle étatique, l'OTB intervient de la production jusqu'à la commercialisation. Il fournit des intrants aux théiculteurs: les plants de théiers, les engrais et les pesticides.

La libéralisation suppose la suppression de toutes ces interventions. Les complexes théicoles devront éclater en éléments individuels tout en transformant leurs relations avec les théiculteurs. Dans un premier temps, l'OTB pourra jouer le rôle de régulation dans la filière. Une libéralisation via **une approche participative communautaire** semble indiquée pour le Burundi. Dans cette perspective, le théiculteur devient l'élément central de la filière et n'est plus réduit à un simple facteur de production. Il devient un acteur à part entière dans la gestion et l'organisation de la filière. Cette approche va favoriser la création des groupements de planteurs qui vont être représentés dans une structure interprofessionnelle. C'est au niveau de cette structure que les théiculteurs vont négocier la convention collective les concernant, notamment en matière de prix au producteur.

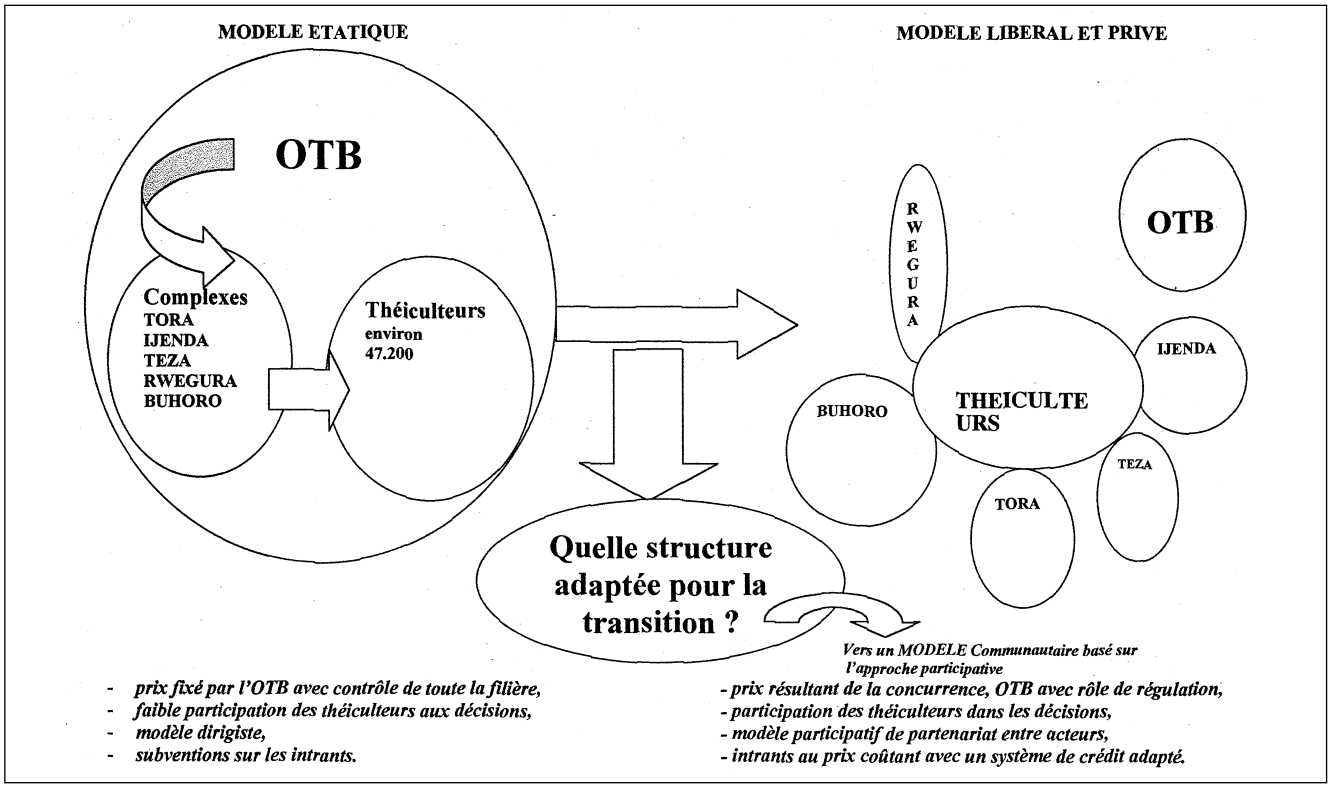


Schéma: Modèle communautaire basé sur l'approche participative.
Source: Conception des auteurs.

Références bibliographiques

1. BRB, Banque de la République du Burundi, 1999, Economie burundaise.
2. Buzingo E., 1981, Bilan de 18 années de théiculture au Burundi et perspectives d'avenir. Faculté des Sciences Agronomiques de Gembloux, Gembloux. pp 2-6.
3. Flémal J., 1986, La culture du théier au Burundi. AGCD. Publication du service agricole, n°8, 150 pages.
4 Guillaumont S. & Guilaumont P., 1994, Ajustement et Développement. L'expérience des pays ACP. Edition economica, Paris. 393 pages.
5. Hubert J-P. & Otoul Ch., 1989, La théiculture dans les exploitations familiales de la région naturelle du Mugamba. Publication ISABU, n°138, 120 pages.
6. Kaneza E., 1999, Analyse des mécanismes d'affectation du surplus dans la filière thé. Inédit. Université du Burundi. Faculté des Sciences économiques et administratives. Mémoire de licence, 134 pages.
7. Mac Sys, 2000, Etude préparatoire à la libéralisation de la filière théicole. Rapport provisoire. Bujumbura, pp 9-119.
8. OTB, Office du Thé du Burundi, 1998, Plan de redressement et de développement de l'Office du Thé du Burundi à court et moyen termes (1998-2001). Bujumbura, pp 2-44.

T. Nkunzimana, Burundais, Ingénieur agronome avec un diplôme spécial en économie rurale. Doctorand à l'unité d'économie rurale, Université Catholique de Louvain, Faculté d'ingénierie biologique, agronomique et environnemental, Place Croix du Sud 2/15, B-1348 Louvain-la-Neuve, Belgique.

A. Thonon, Belge, Doctorat en économie rurale, Professeur à l'Université Catholique de Louvain, Faculté d'ingénierie biologique, agronomique et environnementale, Responsable de l'unité d'économie rurale, Place Croix du Sud 2/15, B-1348 Louvain-la-Neuve, Belgique.

P.-F. Ndimira, Burundais, Doctorat en économie rurale. Directeur Général de la Compagnie de Financement pour le Développement (COFIDE) B.P. 139, Ngozi-Burundi. Professeur à l'université du Burundi, à l'Université de Ngozi (Burundi) et à l'Université de Gand (Belgique).

TROPICULTURA, 2002, **20**, 4, 198-202

The Distribution, Incidence, Natural Reservoir Hosts and Insect Vectors of Rice Yellow Mottle Virus (RYMV), Genus Sobemovirus in Northern Nigeria

M.E. Abo*[1], M.N. Ukwungwu[2] & A. Onasanya[1]

Keywords: Distribution– Incidence– Reservoir hosts– Insect vectors– Rice Yellow Mottle Virus– Sobemovirus– Nigeria

Summary

Field visits and surveys were carried out in Niger, Kano, Bauchi and Gombe states of northern Nigeria at tillering and panicle initiation stages of rice in the years 2000 and 2001 to determine the distribution, host plants and occurrence of insect vectors of Rice Yellow Mottle Virus (RYMV). Farmers' cultural practices and field situations were also assessed. Visual inspection based on the Standard Evaluation Scale (SES) and enzyme linked immunosorbent assay (ELISA) methods were used in detecting RYMV infection. RYMV presence was established in all the four states surveyed. The virus was widely distributed in Kano state. The insect vectors of RYMV, such as Trichispa sericea *Guerin,* Chaetocnema pulla *Chapius,* Chnootriba similis *Thunberg and* Conocephalus longipennis *de Haan, were found in the 4 states. Outbreaks of* T. sericea *occurred in many farmers' fields in Kano state. RYMV was detected more frequently on* Oryza sativa *L. than on* O. longistaminata *Chev. & Roehr and* Echinochloa pyramidalis *Hitche and Chase. Virus infection was not established in any other grass species, sedges and broadleaf plants tested. It is evident therefore, that RYMV has a narrow host range and is found more frequently in the* Oryzeae*.*

Résumé

Distribution, incidence, hôtes des réservoirs naturels et insectes vecteurs du virus de la panachure jaune du riz (RYMV), genre sobemovirus dans le Nord du Nigeria

En 2000 et 2001, des visites de terrain et des enquêtes ont été réalisées dans les états du Niger, de Kano, de Bauchi et de Gombe dans le Nord du Nigeria pendant les stades du tallage et de l'initiation paniculaire du riz en vue de déterminer la distribution, les plantes hôtes et la fréquence des insectes vecteurs du virus de la panachure jaune du riz (RYMV). Les pratiques culturales et l'état des champs des paysans ont été également évalués. Une inspection visuelle basée sur l'échelle d'évaluation standard (SES) et les méthodes ELISA ont été utilisées pour détecter l'infection par le virus de la panachure jaune. La présence du RYMV *a été établie dans les quatre états étudiés, avec une plus large distribution dans l'état de Kano. Les insectes vecteurs du RYMV tels que* Trichispa sericea *Guerin,* Chaetocnema pulla *Chapius,* Chnootriba similis *Thunberg et* Conocephalus longipennis *de Haan étaient présents dans les 4 états. Des pullulations de* T. sericea *se sont produites dans beaucoup de champs paysans dans l'état de Kano. Il a été constaté que le* RYMV *était plus fréquent sur* Oryza sativa *L. que sur* O. longistaminata *Chev. & Roehr et* Echinochloa pyramidalis *Hitche et Chase. L'infection par le virus n'a été établie chez aucune autre espèce herbacée, de laîche et de plantes latifoliées testées. Il est donc évident que le RYMV possède une gamme d'hôtes étroite et se rencontre plus fréquemment chez* Oryzeae*.*

Introduction

Rice yellow mottle virus (RYMV) was first reported in West Africa in 1975 (16). It has been reported to occur in almost all the West African countries where rice is grown (3, 4). RYMV was first noticed in Nigeria over 20 years ago (10, 18, 19).

RYMV belongs to the sobemovirus group (9). It is transmitted through mechanical contacts and inoculations (1, 5). Chrysomelid and phytophagous coccinelid beetles and insects also transmit it as well as insects with chewing and biting mouthparts such as the long-horned grasshoppers (*Conocephalus* spp.) (1, 2, 5, 6).

The disease is characterized mostly by mottling and yellowing of the leaves of infected plants. Orange coloration is also noticed in some rice varieties. The

1 National Cereals Research Institute Badeggi, P.M.B. 8, Bida, Nigeria, West Africa.
Present Address: Association pour le développement de la riziculture en Afrique de l'Ouest (ADRAO) 01 BP 2551 Bouaké 01 Côte-d'Ivoire, West Africa.

2 Association pour le développement de la riziculture en Afrique de l'Ouest (ADRAO) 01 BP 2551 Bouaké 01 Côte-d'Ivoire, West Africa.

Received on 09.08.02. and accepted for publication on 16.09.02.

intensity of symptom expression depends on the genotype (20). Infected plants also exhibit delayed flowering and poorly exerted panicles bearing sterile and discolored spikelets (20). Die off may occur in very susceptible rice varieties. Yield loss ranges from 25 to 100% depending on the date and time of infection as well as the genotype (18).

RYMV is indigenous to Africa (3) and came to limelight with the introduction of exotic rice varieties from south-east Asia coupled with the intensification of cropping practices without dry season gaps (21). This situation as well as inadequate testing of exotic rice varieties before introduction led to the disruption of the apparent equilibrium established between the local rice host and RYMV (3, 4).

There have been reports of weeds serving as reservoir hosts of RYMV in some countries in Africa (4, 5, 8, 13, 15). Similar studies have not previously been carried out in Nigeria. However, there is ample evidence that the incidence of the disease is increasing in the country. Thus, it is suspected that there might be some natural reservoir hosts and insect vectors of the virus in the rice ecological system in Nigeria.

In view of the importance and increasing incidence of RYMV in Nigeria (3), it has become necessary to establish the status of RYMV and the occurrence of its insect vectors on farmers' fields in the country. Additional goals of this study were to detect the natural reservoir hosts on which the virus subsists. Furthermore, some of the cultural practices of the farmers, which are likely to predispose rice to RYMV infection and insect infestation, were assessed.

Materials and methods

Field visits, surveys and samplings

Four states (Niger, Kano, Bauchi and Gombe) in northern Nigeria were surveyed in the years 2000 and 2001 for the distribution of RYMV and its reservoir hosts. The occurrence of the insect vectors of the virus was also investigated. The visits and surveys were carried out at tillering and panicle initiation stages between August and November each year.

In each state 10 farmers' fields were examined for the presence of RYMV. Rice and weed species with and without RYMV-like symptoms were randomly sampled on the bunds, edges of the fields, within the rice fields and in the vicinity of the RYMV-infected plants. The visual diagnostic symptoms of RYMV are yellowing and mottling of leaves as well as severe stunting in some rice genotypes. In other genotypes orange coloration is noticed. The sampling of the insect vectors of RYMV was carried out with a sweep net and aspirators on the fields surveyed. Ten sweeps were made diagonally across each field. The insects caught in the net were collected in sample bottles closed by a perforated cover with a closable opening. Thereafter, the insects known to be vectors of RYMV (1, 5) were identified and recorded. The non-vectors of RYMV were discarded. In each state surveyed, the types of rice varieties commonly cultivated and farmers cultural practices were noted.

Visual assessment method

The Standard Evaluation System (SES) (11) on a scale of 1-9 was used. Scale 1 means no visible symptoms while scale 9 denotes leaves turn yellow or orange, stunted and death of plants. The presence of RYMV in the plants was confirmed by Enzyme Linked Immunosorbent Assay (ELISA) method (7, 14).

Serological method

Antigen Coated Plate (ACP)-ELISA (14) was performed as followed: ELISA plates were coated with 1:10 (W/V) of rice samples previously ground in phosphate buffered saline (PBS)-Tween (T) containing 2% polyvinyl pyrollidone (PVP) and kept overnight in the refrigerator at 4 °C. The plates were washed with PBS-T. Blocking was done with 5% skimmed milk solution dissolved in PBS-T for 30 minutes at 37 °C. The excess milk was discarded without washing with PBS-T and 100 µl/well of homologous antisera (dilution 1:1000) in PBS-T was applied. The plates were incubated for 2 hr at 37 °C. After washing with PBS-T, 100 µl/well of goat-anti rabbit alkaline phosphatase conjugate (dilution 1:10,000) in PBS-T-PVP containing 0.2% BSA was applied and the plate incubated for 2 hr at 37 °C. After another round of washing, 100 µl/well of 1 mg/ml (p-Nitrophenyl phosphate) substrate diluted in 10% diethanolamine, pH 9.8 was applied and the plate was incubated for 1 hr at 37 °C. The absorbance at 405 nm was read using an automated Dynex MRX ELISA reader after 1 hr. Values were considered as positive when the reading was equal to or greater than twice the mean absorbance of the virus-free control sample.

Results and discussion

The results of the distribution of RYMV in four states of northern Nigeria are presented in Table 1.

Kano State had the highest incidence of RYMV. The disease was detected in six locations in Kano state, three in Niger state and one each in Bauchi and Gombe states. Some farms in Kano and Gombe states were destroyed by RYMV. The commonly cultivated rice varieties in these states included FARO 44 (Sipi), FARO 29 (BG90-2), FARO 35 (ITA 212), WITA 4, which are known to be highly susceptible to RYMV (Table 1). It is estimated that 80% of the 160 ha of land at Kadawa irrigation scheme in Kano state is set aside for rice cultivation alone. FARO 44 (Sipi), FARO 35 and WITA 4 are grown on a large scale at this irrigation scheme where RYMV incidence was found to be high.

In Kano state farmers grow rice during the rainy season and wheat under irrigation during the dry season between November and January. In Niger state, rainfed and dry season rice cropping is practiced in some areas. At Dadin Kowa in Gombe state, the irrigation channel had broken down during the survey period and farmers had to rely mainly on rainfall for rice cultivation. This situation caused some farmers, particularly those that planted rice late after the onsets of rains, to loose their rice crop to drought. Here, RYMV

Table 1

Incidence of Rice Yellow Mottle Virus (RYMV) and rice varieties commonly grown by farmers in some northern states of Nigeria

Rice varieties	[a]RYMV Susceptibility level	States	Locations	% RYMV Incidence in the field
Sipi (FARO 44), Ex-china, FARO 29 (BG90-2)	S	Bauchi	-Bauchi town peri-urban, Gombe road, Bauchi	25
FARO 29 (BG90-2), FARO 44 (Sipi), FARO 35 (ITA 212), ITA 306, WITA4	S	Kano	-Kadawa irrigation scheme, Hadejia-Ja'amare River Basin Development Authority, Garun Malan	>75
FARO 44 (Sipi), FARO 35 (ITA 212), FARO 29 (BG90-2), WITA 4	S	Kano	-Kura irrigation scheme, Hadejia Jama'are River Basin Development Authority, Garun Malan	>75
FARO 29 (BA90-2), FARO 35 (ITA 212), FARO 44 (Sipi), WITA 4	S	Kano	-Watari irrigation scheme, Bichi Road, Bagwai	>75
FARO 44 (Sipi), FARO 35 (ITA 212)	S	Kano	-Rano Road, Bunkure	50
FARO 44 (Sipi), FARO 29 (BG90-2)	S	Kano	-Zawaciki Village, Kumbosto	25
FARO 44 (Sipi)	S	Kano	-Koya, Madobi	25
FARO 29 (BG90-2), FARO 44 (Sipi), ITA 306,	S	Gombe	-Upper Benue River Basin Development Authority irrigation rice fields, Dadin Kowa	>75
FARO 29 (BG90-2), BOUAKE 189, WITA 4, WITA 8, WITA 9, FARO 29 (BG 90-2), FARO 35 (ITA 212)	S	Niger	-Edozhigi	50
FARO 29 (BG90-2), BOUAKE 189, WITA 4, WITA 8, WITA 9, FARO 35 (ITA 212)	S	Niger	-Wuya	25
FARO 29 (BG90-2), FARO 35 (ITA 212)	S	Niger	-Doko	25

[a]S = Susceptible on a scale of 9 (IRRI 1996)

and its insect vectors were found in abundance in the drought stricken fields. In all the states cattle grazed on the stumps, ratoons and volunteer rice after the rice harvest. While the cows were feeding they dropped dung in the fields. Cow dung has been implicated in the transmission of RYMV in Madagascar (17). Some farmers abandoned the RYMV-infected portions of their rice fields and did not always destroy rice plants. These practices contribute to additional sources of RYMV inoculum in the field. Farmers in these states are known to apply fertilizers in their farms. In most cases however, they do not follow the recommended dosage. The sickle used by these farmers to harvest rice is another source of contamination. This source of infection by sickle has been established (22). RYMV-infected seedlings from the nursery are another potential source of inoculum from which RYMV is introduced into the field (17).

These observations are in line with the earlier report by Thresh (21) that the introduction of exotic rice varieties from Southeast Asia coupled with intensification of cropping practices through irrigation facilities has brought RYMV to the limelight in Africa. In this study RYMV infection was detected where exotic rice varieties were grown on a large scale under irrigation. Due to the high incidence of RYMV on FARO 35 (ITA 212) at the Kadawa irrigation scheme, farmers were advised to replace this variety with RYMV-tolerant ones. However, it was found that where the RYMV incidence was low the susceptibility of the varieties to RYMV was moderate. On the other hand where the incidence of RYMV was rated as high the susceptibility of the varieties to the virus disease was also high. This suggests that these susceptible varieties should be withdrawn and replaced with tolerant varieties in areas where RYMV incidence is rated as very high.

The insect vectors of RYMV identified in the states during the survey are presented in table 2.

Trichispa sericea Guerin, *Chaetocnema pulla* Chapius, *Chnootriba similis* Thunberg and *Conocephalus longipennis* de Haan, which are vectors of RYMV (1, 5) were found in the four states. However, serious outbreaks of *T. sericea* accompanied by rice damage were found only in Kano state, and particularly in Wasai, Minjibir, Koya and Dawakin Tofa areas. *C. pulla* was found in large numbers at Dadin Kowa in Gombe state.

The rice and weed species sampled are presented in table 3.

The ELISA tests showed that samples collected on rice and *Echinochloa pyramidalis* Lam. Hitche and

Table 2

The occurrence of insect vectors of Rice Yellow Mottle Virus (RYMV) in four northern states of Nigeria

States	Caught insect vectors of RYMV in each state
Bauchi	*Conocephalus longipennis* de Haan, *Chaetocnema pulla* Chapius.
Gombe	*Chaetocnema pulla* Chapius, *Conocephalus longipennis* de Haan, *Chnootriba similis* Thunberg.
Kano	*Trichispa sericea* Guerin, *Chaetocnema pulla* Chapius, *Conocephalus longipennis* de Haan, *Chnootriba similis* Thunberg.
Niger	*Chaetocnema pulla* Chapius, *Conocephalus longipennis* de Haan, *Chnootriba similis* Thunberg, *Trichispa sericea* Guerin.

Chase were infected naturally in the field. However, RYMV was detected more frequently in *Oryza sativa* L. (rice) than in *O. longistaminata* Hitche and Roehr and *E. pyramidalis* (weed). RYMV was not detected in any other plant species sampled.

The results from this investigation have established that RYMV is present in northern Nigeria and is widely distributed in Kano state. Its incidence is also increasing due to intensification of rice cropping and with the introduction of exotic rice varieties. The principal insect vectors of RYMV are found in these states where RYMV infection has been detected. It is possible that the cropping practices, the presence of mobile insect vectors and other factors enumerated above have brought the RYMV to the limelight in northern Nigeria. This study confirms that the host range of RYMV is narrow and restricted mostly in the family graminae.

Acknowledgements

This was a ROCARIZ/WARDA and NCRI collaborative project funded under the ROCARIZ/WARDA Task force on Crop Protection.

Table 3

Field-collected rice and weed species and their RYMV status as determined by enzyme-linked immunosorbent assay (ELISA)

Plant samples	Detection of RYMV infection by ELISA (A405 nm)
Grases	
Oryza sativa L.	0.4 (++)
O. longistaminata Chev et Roehr	0.2 (+)
Leersia hexandra Sw.	0.1 (-)
Imperata cylindrical L.	0.1 (-)
Echinochloa pyramidalis L.	0.2 (+)
Panicum maximum L.	0.1 (-)
Panicum spp	0.1 (-)
Digitaria debilis Desf. Wild.	0.1 (-)
D. horizontalis L.	0.1 (-)
Eleusine indica L.	0.1 (-)
Leptochloa caerulensens Steud	0.1 (-)
Sacciolepsis africana C. E. Hubbard	0.1 (-)
Zea mays L.	0.1 (-)
Saccharum officianarum L.	0.1 (-)
Triticum aestivum L.	0.1 (-)
Sedges	
Cyperus difformis L.	0.1 (-)
C. esculentus L.	0.1 (-)
C. incompressus C-B.	0.1 (-)
Scripus jacobi C.E.C. Fischer	0.1 (-)
Fimbrystilus spp	0.1 (-)
Broad leaves	
Ludwigia spp	0.1 (-)
Sphenoclea zeylanica Gaert.	0.1 (-)
Nymphaea lotus L.	0.1 (-)
Lindernia diffussa (L.) Wett	0.1 (-)
Ipomoea aquatica Forsk	0.1 (-)
Marsilea crenata (L.)	0.1 (-)

++ = Frequent detection of RYMV
\+ = Occasional detection of RYMV
\- = Negative detection of RYMV

Literature

1. Abo M.E., 1998, The mode of transmission of Rice yellow mottle sobemovirus, Ph.D thesis, Ahmadu Bello University (ABU), Zaria, Nigeria, 148 pp.
2. Abo M.E., Alegbejo M.D., Sy A.A. & Misari S.M., 2000, An overview of the mode of transmission, host plants and methods of detection of Rice yellow mottle virus. Journal of sustainable Agriculture, 17, 19-35.
3. Abo M.E., Sy A.A. & Alegbejo M.D., 1998, Rice yellow mottle virus (RYMV) in Africa: Evolution, Distribution, and Economic Significance on Sustainable Rice Production and Management Strategies. Journal of Sustainable Agriculture, **11**(2/3), 85-111.
4. Awoderu V.A., 1991, Rice yellow mottle virus in West Africa. Tropical Pest Management, 37, 356-362.
5. Bakker W., 1975, Rice yellow mottle virus. CMI/AAB Descriptions of Plant Viruses, No. 149.
6. Banwo O.O., Makundi R.H., Abdallah R.S. & Mbapila J.C., 2001, Identification of vectors of rice yellow mottle virus in Tanzania. Archives of Phytopathology and Plant Protection, **33**(5), 395-403.
7. Clark M.F. & Adams A.N., 1977, Characteristics of the microplate methods of enzyme linked immunosorbent assay for the detection of plant viruses. Journal of General Virology, 34, 475-483.
8. Fauquet C.M. & Thouvenel J.C., 1977, Isolation of the Rice yellow mottle virus in Ivory Coast. Plant Disease Reporter, 61, 443-446.
9. Hull R., 1988, The sobemovirus group. *In*: Koenig. 1. R. (ed.). The plant viruses with monopartite RNA genomes, Plenum Press, New York. 259p.
10. IITA (International Institute of Tropical Agriculture), 1979, Annual Report, Rice Research Programme, IITA, Ibadan, Nigeria. Pp 33-34.
11. IRRI (International Rice Research Institute), 1996, The International Rice Testing Program – Standing Evaluation System (ITP-SES) for Rice, Los Baños, Laguna, The Philippines. 4th Edition, p 25.
12. Koenig R. & Paul H.L., 1982, Variants of ELISA in plant virus diagnosis. Journal of Virological Methods, 5, 113-125.
13. Konate G., Traore O. & Coulibaly N.N., 1997, Characterization of Rice yellow mottle virus isolates in sudano-Sahelian areas. Archives of Virology, 1425, 1117-1129.
14. Jaegle M. & Van Regenmortel M.H.V, 1985, Use of ELISA for measuring the extent of serological cross-reactivity between plant viruses. Journal of Virological Methods, 11, 189-198.

15. Okioma S.N., Muchoko R.N. & Gathuru E.M., 1983, Alternate hosts of Rice yellow mottle virus in the Lake Victoria basin in Kenya. Tropical Pest Management, 29, 25-29.

16. Raymundo S.A. & Buddenhagen I.W., 1976, A rice disease in West Africa. International Rice Commission Newsletter, 29, 51-53.

17. Reckhaus P.M. & Andriamasintseheno H.F., 1997, Rice yellow mottle virus (RYMV) in Madagascar and its epidemiology in the northeast of the island. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, **104**(3), 289-295.

18. Rossel H.W., Thottappilly G., Adeoti A.A. & Alam K.Z., 1982a, A new record of Rice yellow mottle virus disease in Nigeria. International Rice Commission Newsletter, 29, 51-53.

19. Rossel H.W., Thottappilly G. & Buddenhagen I.W., 1982b, Occurrence of Rice yellow mottle virus in two important rice-growing areas of Nigeria. FAO Plant Protection Bulletin, 31, 137-134.

20. Thottappilly G. & Rossel H.W. 1993, Evaluation of resistance to Rice yellow mottle virus in Oryza species. Indian Journal of Virology, **9**(1), 65-73.

21. Thresh J.M., 1991, The ecology of tropical plant viruses. Plant Pathology, 40, 324-339.

22. Tsuboi T., Goto A., Boua B., Sy A.A. & Kato H., 2001, *In*: Sy A.A., Hughes J. & Diallo A. (eds). Outbreraks of Rice yellow mottle virus disease and its epidemiological consequences in lowland rice in the Bandama river basin of Yvory Coast. Proceedings of the 1st International symposium on rice yellow mottle virus held at WARDA headquarters, Bouake, Yvory Coast from 18-22 September 1995. Pp 93-99.

M.E. Abo, Nigerian, Ph.D, Crop Protection/Plant Virology, Ahmadu Bello University, Nigeria and currently Assistant Chief Research Officer, National Cereals Research Institute Badeggi, P.M.B. 8, Bida, Nigeria, West Africa. Present Address: Association pour le développement de la riziculture en Afrique de l'Ouest (ADRAO) 01 BP 2551 Bouaké 01 Côte-d'Ivoire, West Africa.

M.N. Ukwungwu, Nigerian, Ph.D , Entomology, University of Ibadan, Nigeria and currently Assistant Director, National Cereals Research Institute Badeggi, P.M.B. 8, Bida, Nigeria, West Africa.

A. Onasanya, Nigerian, HND, PGD Molecular Microbiology, Research Assistant Virology & Molecular Biology, Association pour le développement de la riziculture en Afrique de l'Ouest (ADRAO) 01 BP 2551 Bouaké 01 Côte-d'Ivoire, West Africa.

*Adresse pour la correspondance: Dr M.E. Abo, Unité de pathologie des plantes, Association pour le développement de la riziculture en Afrique de l'Ouest (ADRAO) 01 BP 2551 Bouaké Côte-d'Ivoire. Courrier électronique: e.abo@cgiar.org ou meabo2002@yahoo.com

Oman Traditional Date Palms: Production and Improvement of Date Palms in Oman

A.S. Al-Marshudi[1]

Keywords: Date palm– Oman– Production– Marketing

Summary

Date production in the world is confined to a small number of countries, most of them being Arab. However, date industry in the Arab world is not yet fully developed and concerted efforts are still needed to fully utilize the tremendous date tree potential as a commodity that can be consumed in the local market or processed for export.

Date palm cultivation is one of the most important agricultural activities in Oman. It occupies more than 82% of total fruit crop area and about 42% of total agricultural land. Not only is domestic demand met, but a surplus for export is also generated. Tremendous development has occurred in the production and distribution of dates during the last two decades. However, the contribution of dates to total agriculture exports was found to be low.

This paper presents date palm crop in terms of its traditional practice and economic development in Oman. Results show that the quality of dates produced has not yet met approved standards and, therefore, the return to producers is not maximized.

Résumé

Le palmier dattier traditionnel d'Oman: production et amélioration de la culture du palmier dattier à Oman

La production de dattes dans le monde ne concerne qu'un nombre limité de pays, avec les pays arabes constituant la majorité. Cependant, l'industrie des dattes dans le monde arabe est encore à l'état embryonnaire et des efforts énormes restent à fournir afin de bien utiliser le grand potentiel du palmier dattier pour la consommation locale du fruit et aussi pour l'augmentation de l'exportation.

La culture du palmier dattier est une des activités agricoles les plus importantes à Oman. Elle occupe plus de 82% de la superficie totale fruitière et à peu près 42% de la superficie totale agricole. La production actuelle couvre non seulement la demande locale mais engendre aussi un surplus pour l'exportation. La production et la distribution des dattes ont connu un développement important pendant les deux dernières décennies.

Ce papier examine les techniques de cultures tradionnelles ainsi que le développement économique du secteur dattier à Oman. Le problème de la qualité des dattes est traité en particulier. L'étude a montré que la contribution des dattes à l'exportation est restée faible et a tendance à la baisse.

Introduction

Date palm is reckoned to be the oldest fruit tree in Oman. Dates, being the main food source in the past, are widely considered to be a strategic source of food security. In line with the dietary requirements of the modern consumer, dates are high in fiber (about 6.5%), contain 'brown' sugar (70%), mainly glucose and fructose, and have a negligible fat content. Thus, they contain most of the dietary constituents essential to the human body in the form of easily digested sugars, fat, proteins, minerals and vitamins (10, 13).

In Oman, although socio-economic changes had a negative effect on traditional date palm cultivation, they have not lead to the disappearance of the date palm crop. On the contrary, the country's economic progress created the impetus and a vehicle to find new ways to introduce modern techniques in agricultural practices and processing methods. Presently, date palm development and improvement in terms of disease control and introduction of new technology is a government concern, while date processing factories remain a concern of the private sector.

The overall picture is now one of a continuous new endeavor aimed at improving the growing areas through the introduction of labor-saving methods in cultivation, modern irrigation systems, improved packaging, industrialization of dates and diversification of date palm by-products by better utilization of lignocelluloses residues of the palm tree.

In many areas of the sultanate, date palm trees are very well developed in terms of cultivar selection, planting, harvesting, marketing and storage. Most of the traditional palm tree practices are still carried out by farm-

[1] Department of Agricultural Economics and Rural Studies, College of Agriculture, Sultan Qaboos University, P.O. Box 34 Al-Khod 123, Sultanate of Oman
Received on 17.04.00 and accepted for publication on 17.09.02.

ers with only slight variation or with no change at all, since most modern techniques are not applicable by a majority of farmers. The last agricultural census (11) showed that date palm trees occupy around 35,469 ha, about 82.6% of the total fruit producing area, and include more than 8 million trees. The census also indicated the distribution of the date palm tree in each region. For example, the Batinah region occupies first place in terms of palm tree area with 42%; Al Sharqiyah, 21%; Dhaklia, 15%; Dhahira, 14%; Muscat, 6%; and Musandam, 2%. Total production of dates has averaged more than 170,000 tons/year and the average production per tree has been around 29 kg. More than 200 date varieties are produced in Oman.

The objective of this paper is to present a review of the traditional date palm cropping practices over the last decade and suggest ways in which the products can be improved. The major goal is to describe the traditional market system used to market date production and recommend some improvements.

Country profile

Oman is situated at the southeastern part of the Arabian Peninsula. The Republic of Yemen borders the country to the south and Gulf of Oman and Arabian Gulf to the north. To the west of the country are located Saudi Arabia and the United Arab Emirates while the Indian Ocean and Arabian Sea boarder the country to the east (Figure 1). Different weather systems dominate in various parts of the country. Two distinct seasons are winter (November to April) and summer (May to October). Summer is very hot and dry with maximum temperatures as high as 50 °C. The winter is very mild. Rainfall varies from less than 50 mm in central Oman, rising to more than 300 mm in the Northern Oman Mountains, and shows wide year to year variations.

Figure 1: Map of the Sultanate of Oman.
This map is not an authority on International Boundaries.
Source: http://www.worldbank.org/

Oman enjoys a long coast line that extends for more than 1,700 km. The surrounding seas contain rich aquatic life. Fisheries constitute an important economic resource.

Plate 1: Traditional date palm garden in Oman.

According to Food and Agriculture Organization (FAO) statistics, total world production of dates in 1996 hit a new record of 4,492,000 tons with an almost 21.4% growth since 1991 (Figure 2). Sultanate of Oman ranked eighth in the list of date producers. Iran emerges as the World's largest producer, followed by Egypt (Figure 3).

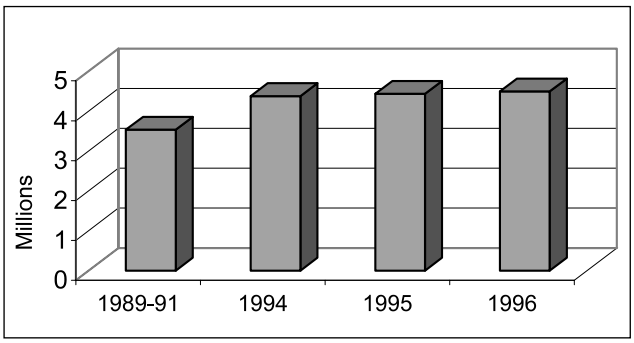


Figure 2: World date production (in tons) during the period 1989-1996, FAO Statistics

It is difficult to determine the exact origin of date palm cultivation in Oman. It is possible, as El Mardi stated (6), that the tree is a mutation or hybrid of a wild palm. On the other hand, Al-Baker (1) reported that the tree originated in Western India, Southern Iran and on the western coast of the Arabian Gulf. These areas are easily within reach of the Omani people with their strong maritime tradition. The moment of the first cultivation of the tree in Oman is not known, but Omanis have known dates ever since they started to sail around the seas of this region and this for more than during seventeen centuries (6).

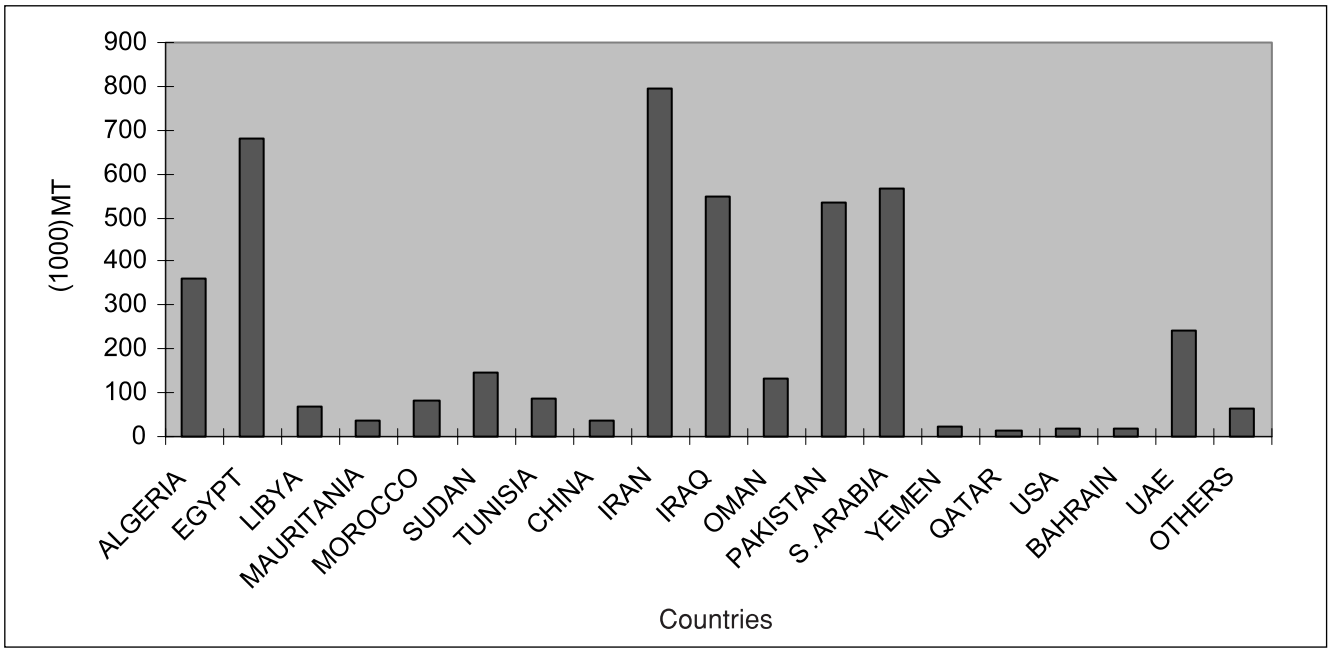


Figure 3: Total world production of dates during 1996, FAO Statistics.

The date palm has retained its value for the desert population because of its good adaptation to the environment and the wide range of benefits it provides. These benefits can be summarized as follows:

1. To many desert inhabitants, date palm trees represent an important source of nutrition. Its products can be used the year round. Fresh mature dates are used during the June and October period. In addition, dates can be processed and stored for the remaining months of the year simply by using traditional ways of packing in jars or bags.
2. It is very often used as a source of income. It provides building materials, and its leaves and fibers are used for making crates, boxes, ropes and baskets.
3. Traditionally, the palm tree is considered as a good shade tree. People tend to build their houses in the middle of palm tree gardens. Similarly, shades can be constructed from leaves in order to protect animals from high temperatures during summer periods.
4. Recently, farmers have started to mix palm tree leaves with other by-products in order to produce animal manure.

A number of studies have shown large variations in palm tree population densities, production and yield per tree. The reason for the difference, mainly lies in the evolution in cultivars and methods of cultivation of the date palm tree over the last 90 years. For example, Popenoe (19) mentioned that Oman was credited with 4 million date palms, the larger part of which was on the Batinah coast. He reported two things: first, Samail (a village situated in the internal) produced the highest average yield per tree in the industry. Second, total annual exports of Oman were estimated at 30,000 tons. Wilkinson (26) stated that the average yield of Batinah region palms was 34 kg, whereas the Samail's estimate was as high as 45 kg. Vittoz (25) observed that there are 3.5 million palm trees in Oman of which 15% are located in the interior and 30% in the Batinah region. FAO (8) indicated that the estimated annual production of Omani dates is 50,000 tons and the number of date palms averaged 1 million for the 1961 to 1978 period. Currently, as estimated by the census carried out by the Ministry of Agriculture and Fisheries (10), the total number of palm trees is 8 million, occupying 35,469 ha which represents 82.6% of the total fruit area.

Available information collected mainly from the Ministry of Agriculture and Fisheries from 1982 to 1999 shows an increasing trend of both production and area planted with palm tree (Figure 4). However, it is important to note that during the last 6 years the area under cultivation did not increase whereas production doubled. This can be attributed primary to two reasons. First, to the introduction of new techniques in planting, and second, to more fertilizer application.

Traditional market

Schultz (22) viewed traditional agriculture as "that sector of a poor underdeveloped country which has attained a particular long-run equilibrium with respect to the allocation of factors of production at the disposal of farmers and with respect to investment to increase the stocks of such factors». Todaro (23) stated the "most of the traditional farmers, if not all of them, have existed outside formal organisations, institutions and government policies. Since they have had to feed themselves first, survival instead of development has been their dominant goal". Achieving subsistence is still the major objective of third world peasant agriculture.

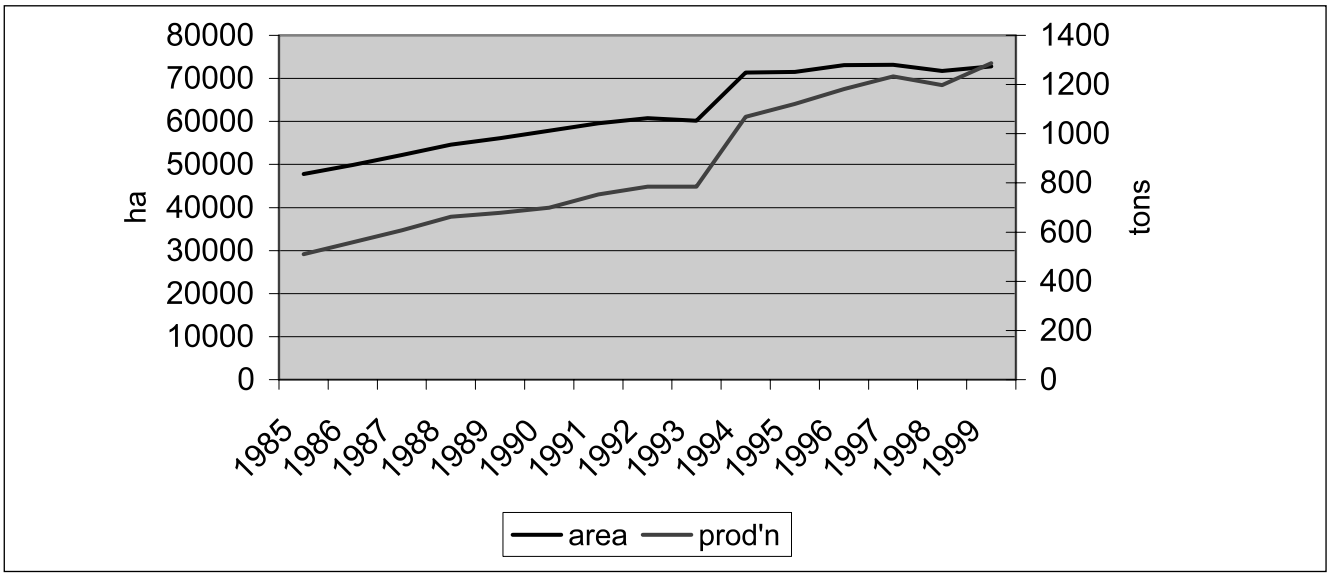


Figure 4: Date production and area increases in Oman for the period 1982-1995.
Source: Ministry of Agriculture and Fisheries.

A more general view states that traditional farmers are generally referred to as those producers that are poor, small in scale, rural in attitude and illiterate. It is widely hypothesised that these producers are traditional in their way of thinking, in their production system, in their decision-making and in their way of life, which is driven by their overall objective of subsistence and survival. Dates production and marketing in Oman is still performed traditionally. For many decades, traditional farmers have been considered as subsistence producers with a main objective to only supply enough food for the family needs

Dates are sold in a variety of ways. Some are auctioned when they are still on the tree. Some are sold in the local market either fresh or more commonly dried (in Arabic called *tamar*).

Traditional date markets seem to be important to farmers and consumers. Information provided by previous studies (19) and by the author's own observations, reveals that the operation of these markets calls for analysis of their structure and operation in order to suggest some improvements. Commercial dates come to the market from three different sources: farmers, merchants and processors. Historically, commercial dates come in two forms, fresh and dry.

Fresh date market auction

This type of auction is conducted when harvests are still on the tree. Farmers who will have a surplus will be involved in this operation. Just after the fruit is ripe, all people in the village will be informed about the day time and place of the auction. An auctioneer or caller (in Arabic called *dallal*) conducts the auction. There will be a recorder (in Arabic called *qabith*) present during the auction in order to record information on selling and buying.

The caller will open the auction by calling one of a number of standard phrases that serve to announce the auction is about to start. Once the caller considers that enough potential buyers have collected, he will start the bidding. The steps of each bid are decided by the caller and the rise in price depends on the varieties and quality of the dates offered. Thus, the caller goes round and calls for quotes. Payment is usually made in cash.

At any stage during the auction, the prospective seller can withdraw either because he feels that insufficient people are present or because he considers the final price called is not high enough. Generally, however, attempts to persuade him to accept the arrived-at price will be made not only by the buyer but by the caller as well. When the seller accepts the auction price, it is recorded along with the names of the seller and the buyer. After the sale is made it is the responsibility of the recorder to make sure that the seller receives his money and that the buyer pays. From the total selling value obtained through the auction, a deduction of 6% is made. Fortly percent of the 6% go to the caller while the remaining amount goes to the recorders as fee.

To sum up, fresh dates are sold while they are still on the tree. The sale takes place in each farmer's field. Normally, the buyers come from the same area surrounding the farms in which the auction takes place. The buyer will buy dates while the seller or the owner has to continue to irrigate and give access to pick up the date fruits.

Dried date auction

In the past, dried dates were taken to the traditional market by donkey or camel. Today, vehicles are used for transportation. Dried date auction deals with harvested dates that are packed in either plastic sacks or jars. Normally, dates for human consumption are packed and washed in a plastic jar, whereas dates that are deformed or insect-infested are packed in plastic sacks/bags. Both will be sold in the same local market. The same auctioning principle will be applied as for

fresh dates auction with a caller and recorder. The only difference, however, is that in this auction the traders, who trade dates to neighboring Gulf States (GCC), will compete with local consumers. Several Omani date traders operating from local traditional markets take the fruit all the way to Dubai (UAE) and beyond to other GCC states to get higher profits.

Traditional market improvement

Local markets are expanding and are increasingly becoming focal points for success or failure of local products. It has been observed that increases in food demand, due to natural growth of the rural population, were met by increased amounts of imported food. The pressures on traditional markets to offer high quality food are increasing and the government has intervened in a variety of potentially supportive ways. Examples are establishment of infrastructure, directly by constructing new places for traditional markets, and indirectly by building roads (from rural areas to local markets). An effective marketing system ensures the production of marketable produce and can add value to produce by transferring it from areas of surplus to areas of shortage. Adequate infrastructure and services to facilitate such transfer may include the provision of storage and transportation facilities, grading and packing services and the dissemination of market information (which is the basis of production decision making).

In Oman there is a tradition of entrepreneurship and a certain amount of prestige is associated with trading activities. In this context, it is unwise to disregard the potential role of the private individual. The local entrepreneur generally has low operating costs, and is knowledgeable about the market. Thus, two factories were established by the government in 1975 to process dates and hence stimulate production and marketing. Now these factories have been privatised and are operated by the private sector.

However, only an authority such as the government can devise and implement pricing policies, quality control and selective import restrictions to assist local producers. These may be the ways in which the government can intervene in the development and improvement of the local markets. The local economy, however, is still basically a subsistence economy, where the family is still the basic economic production unit using limited modern technology. This lack of a commercial orientation has much to do with storage and transportation limitations.

Traditional irrigation

The majority of date palm gardens in Oman is irrigated by *Falaj* system. The *falaj* system is a flooding system of irrigation which depends on gravity. Growers irrigate their palms for a couple of hours. All they need to do is to manage water into each area (24). The farm is irrigated once a week in the summer and every two to three weeks during winter season. *Falaj* water is either inherited or bought from the village *falaj* committee that is responsible for water distribution (19). However, in Batinah region most palm farms are irrigated from wells. Water is drawn from these wells by diesel or electric pumps that have now replaced animal power used to draw water in the past.

Plate 2: Traditional Aflaj system.

Recommendation and future perspectives

Since the 70's the Ministry of Agriculture and Fisheries has attempted to improve the production of date palm trees through targeted extension programmes and financial support for various cultural practices (11). In spite of the achievements, date quality remains a major concern for Oman. Appearance, composition and packaging have not always been up to standard and have negative effects on local consumer purchases and Omani dates competitiveness in foreign markets.

It has been estimated that average annual Omani per capita consumption of dates is 60 kg. With a population of 2.28 million for the year 2000, annual local consumption of dates can be calculated at 115,400 tons. Based on the total Omani production of dates in 2000 (13), a surplus of 164,630 tons, which represents 69% of the annual production, goes to waste or to animal feed. This excess production is expected to be utilized for industrialization into value-added products and can be considered a good potential for export.

It has been indicated by the Foreign Trade Statistic, published yearly by the Royal Police Custom Department, that average yearly date export for 1995-1999 was only 7,000 tons, representing an average of only 2.5% of total production. The low level of exports can be attributed to a number of reasons. First, most dates are packed by traditional farmers or wholesalers, who have limited resources with which to produce high quality products. Second, consumers' differentiation based on date variety and price usually plays a secondary role.

However, the Omani government has realized the problem of date quality. Therefore, a number of measures have been implemented. These can be summarized as follows:

1. An Omani standard for Omani date products has been issued and approved locally in 1985.
2. The Ministry of Agriculture and Fisheries (MAF) has conducted a comprehensive study on date treatment, pressing and packaging according to international market norms and standards.

3. The MAF also conducted many research programmes through local institutes intended to increase productivity and improve quality.
4. The College of Agriculture, Sultan Qaboos University, has carried out comprehensive studies in 1997 in an attempt to improve date quality.

However, the government has to ensure that date palm producers maintain high standards of quality. This means that producers have to be informed about good management techniques in order to manage palm trees properly throughout all production stages. Extension centers can play an important role in conveying quality standard requirements to farmers. Date experts recognize that quality should start at the farm with proper cultural techniques. Good quality dates depend on adequate irrigation, fertilization, protection from pests, pollination, and harvesting. Post-harvest techniques for good quality dates include appropriate handling, transportation, processing, packaging, storage and distribution. However, post-harvest techniques can only preserve quality provided by the farmer. Assistance to farmers should promote cultural practices and provide guidance on how they could get improved high yields and better quality dates to the market.

In support of date palm producers, MAF has also established, since 1976, two date processing plants at Nizwa and Rustaq in addition to two date collection centers at Mudhaibi and Samail. The function of the processing plants can be summarized as follows:

1. to buy dates from farmers at reasonable prices;
2. to sort, process and pack dates at a level of high - quality and
3. to store and distribute date products to retail, consumer and foreign markets.

In 1996, all processing date plant facilities were privatized. The Dates of Oman Company now operate these plants.

It is well recognized that processing factories are the only link between traditional palm date producers and foreign markets. Therefore, government needs to establish a committee that consists of members from traditional producers and Oman date companies. This committee will have to study the problems and recommend solutions for the problems that the date palm sector is facing. Thus, for the future development of traditional date farmers and palm factories, and to explore new products and derivatives, Ministry of Agriculture and fisheries in Oman should establish new horizons for applied research in the following areas:

1. identify the technical and marketing problems arising from production and marketing of existing farms and factories and find solutions through applied research. The areas of research would involve improving competitiveness and marketability of dates, and storage and shelf life of the products.
2. Innovations for new product development using date products based on traditional dishes. For example, production of syrup and pastes from dates, production of dates' powder as baby food and pre-mixed cake powder.

Conclusion

Dates dominate agricultural production in Oman. They are the traditional national staple and were Oman's main source of income before oil. However, Oman has undergone some drastic changes that have impacted consumption patterns. These socio-economic changes included improvement in living standards, continuous urban drift and introduction of technology. The overall picture drawn from general examination of traditional date palm production in Oman reveals the importance of the sector for the country's economy. Thus, some development or changes may be required to find solutions to some high priority problems. However, attempts to undertake these actions require careful consideration of prevailing social rules and habits. It is well recognized that any suggested changes of an existing system may bring problems of greater complexity.

The most prevalent view in Oman is that quality standards of dates (fresh and dried) are still deficient. Cases of blemished, damaged, moldy and souring dates have been encountered at farm and market levels. Furthermore, high food demands, due to population increase, along with external international competition call for improvement in the existing date palm industry.

Literature

1. Al-Baker P.H. & Jabhar A., 1972, The date palm. A review of its past and present status; and the recent advances in its culture, industry and trade. Al-Ani Press, Baghdad.
2. Central Bank of Oman, 1995, Annual Report. Ruwi, Sultanate of Oman.
3. College of agriculture, 1997, Dates quality improvement in the Sultanate of Oman. A comprehensive Document. Sultan Qaboos University Press, Sultanate of Oman.
4. College of Agriculture, 1995, Traditional agriculture and fishing in the Sultanate of Oman. Sultan Qaboos University, Sultanate of Oman.
5. Development Council, 1991, Oman facts and figures. Sultanate of Oman.
6. El Mardi M.O., 1995, Traditional date culture. College of Agriculture. Sultan Qaboos University Press, Sultanate of Oman.
7. FAO, 1997, Oman Agricultural Review, ROM. www.Oman.net/fao/htmp.
8. Food and Agriculture Organization (FAO), 1982, Date production and protection. FAO plant production and protection paper 35. FAO. Rome, Italy.
9. Japan International Cooperation Agency (JICA) , 1990, The Study on a master plan for agricultural development. Sultanate of Oman. Final Report, Vol. **5**.
10. Kasapis S., 2000, Dates: A fruit of promis for the food industry. Mirat Al J'ama Buliten Issue 50. Sultan Qaboos University Press, Oman.
11. MAF, 1993, National agricultural census. Sultanate of Oman
12. MAF, 1995, The Progression of agricultural and fisheries development from 1970 to 1995, Ministry of Agriculture and Fisheries, Sultanate of Oman.
13. Mikki M.S., 1999, Present status and future prospects of dates and dates palm industries in Saudi Arabia. Journal of Industrial Cooperation in the Gulf states. Issue 77.

14. National Conservation Strategy, 1992, Ministry of Municipally, Sultanate of Oman.
15. Oman 1999, Ministry of Information, Ruwi, Sultanate of Oman.
16. Oman Daily Newspaper 2001, Dates palm production level. 25 August No.7379.
17. Omezzine A. & Zaibet L., 1998, Agricultural water management: management of modern irrigation system in Oman," Agricultural Water Management 37, 99-107.
18. Omezzine A.,Chebaane H & Zaibet L., 1997, Reallocations of agricultural water in Oman. A potential advantage in higher valued crops. International Symposium on water and Arab Gulf Development, Center of Arab Gulf Studies, University of Exeter, UK.
19. Popenoe P.B., 1913. Date growing in the old and new worlds. West India Gardens. Altadena, California pp. 316.
20. Statistical yearbook, various issues. Ministry of National Economy, Sultanate of Oman.
21. Suttan Sally., 1984, The Falaj- A Traditional cooperative system of water management," Waterline, Vol **2**, No.3.
22. Schultz T.W., 1964, Transforming traditional agriculture. New Haven: Yale University Press.
23. Todaro M.P., 1989, Economic development in the third world. 4th edition. LongMan.
24. University of Durham, Agriculture, Research and Development Surveys, Northern Oman, Final Report, Vol. **IV**, A, 1978.
25. Vittoz J., 1979, Le palmier-dattier en Oman. Fruits. Vol. **34**(10), 609-621.
26. Wilkinson J.C., 1977, Water and tribal settlement in Southeast Arabia. Oxford Research Studies in Geography, Clarendon Press.

A.S. Al-Marshudi, Omani, S. Msc. Agriculture Economic (University of London). Department Superintendent, Dept. of Agriculture Economic & Rural Studies, Sultan Qaboos University, Oman.

Remerciements

Depuis 1983, une série de lecteurs anonymes ont été sollicités par le Secrétariat de Tropicultura pour examiner d'un œil critique les documents proposés comme articles originaux pour les numéros déjà publiés.

A raison de deux lecteurs, voire trois, par article reçu, cela correspond à une masse importante de temps consacré par tous ces bénévoles à entretenir la qualité de notre publication. La préservation de leur anonymat nous empêche de les remercier individuellement ici, mais tous doivent être certains que leur travail sérieux, rapide et efficace a été apprécié à sa juste valeur. Merci à tous !

C'est l'occasion de faire appel à d'autres qui, chacun dans sa spécialité, permettraient de mieux répartir ce travail pour améliorer encore la qualité. Le Secrétariat recevra avec grand plaisir toute offre dans ce sens.

Dankwoord

Sinds 1983, werd een hele reeks anonieme lezers door het Secretariaat van Tropicultura aangezocht om met kritische blik de dokumenten door te nemen die als oorspronkelijke artikels voor de reeds gepubliceerde nummers werden aangeboden.

Tegen een gemiddelde van twee of drie lezers per ingezonden artikel komt men tot een indrukwekkerde tijd die deze welwillende medewerkers aan het op peil houden van ons tijdschrift hebben besteed.
Vermits zij liefst anoniem blijven kunnen wij hen hier niet persoonlijk danken, maar wij wensen hen toch te zeggen dat hun degelijk snel en doeltreffend optreden ten zeerste gewaarderd werd. Daarom dus, dank U allen !

Dit is meteen de gelegenheid om op anderen beroep te doen die, ieder in zijn specialiteit, kunnen bijdragen tot de taakverdeling om nog betere kwaliteit te kunnen aanbieden. Het Secretariaat zal elk aanbod in die zin in dank aanvaarden.

Dr. Ir. Guy Mergeai

Acknowledgements

Since 1983, quite a lot of anonymous referees have gently assisted the Tropicultura's secretariat by critical analysis of papers submitted for publication as original articles for the past issues.

Two referees, and sometimes three per paper received means a huge total of hours freely spent to keep the level of our review appropriate. It is impossible to list them here due to the anonymous character of the function, but all of them deserve our congratulations for the quick, efficient and high standard work done which has been fully appreciated. Many thanks to all of you !

It is a good opportunity also to call for new referees to still improve the quality of our journal through an enlarged referees team.

The Secretariat will be very pleased to receive any proposition in that sense.

TROPICULTURA, 2002, **20**, 4, 210-216

Contribution à la promotion de la culture du blé (*Triticum aestivum* L.) au Sud Kivu, République Démocratique du Congo: Evaluation du potentiel de rendement de deux génotypes d'origine burundaise, dans différentes zones agro-écologiques locales

T. Munyuli Bin Mushambanyi*

Keywords: Wheat genotypes evaluation– Adaptibility– Genotypes performances– Agroecologies manure-Compost– Cropping seasons– Democratic Republic of Congo

Résumé

Dans les localités (Lemera, Bugobe, Mulungu, Cifunzi), de quatre environnements représentatifs des principales zones écologiques du Sud Kivu montagneux, deux génotypes de blé (Romany & Kenya Nyangumi) ont été évalués pour leur rendement, durant deux saisons culturales, de 1998 à 1999. Les essais multilocaux ont été réalisés dans chaque site d'essai et pour chaque saison culturale suivant un dispositif en split-plot (blocs aléatoires complets et 4 répétitions) avec comme facteur principal la variété et comme facteur secondaire la fumure. Les différences entre les environnements d'une part, et les variétés et les saisons culturales d'autre part, étaient significatives pour ce qui est du rendement. Le rendement obtenu, avec ou sans fertilisation organique, a été, en moyenne, de l'ordre de 1,46 t/ha. Les meilleurs rendements ont été observés à Mulungu (1,83 t/ha) et à Lemera (1,61 t/ha) avec la variété Kenya Nyangumi. Les rendements les plus élevés ont été enregistrés à Bogobe (1,51 t/ha) et à Lemera (1,99 t/ha) avec la variété Romany. La fertilisation organique des cultures entraîne une augmentation de rendement de l'ordre de 10 à 36%.

Summary

Contribution on the Wheat Culture Development in South-Kivu, Democratic Republic of Congo: Yield-performance of Two Genotypes, from Burundi, in Various Local Agroecological Zones

In four sites (Lemera, Bugobe, Mulungu & Cifunzi), two genotypes (Romany & Kenya Nyangumi) were evaluated in contrasting agroecological conditions for their yield adaptibility, during two cropping seasons, from 1998 to 1999. Multilocational trials were set up, in different sites, following a split-plot experimental design, with repeated measurements during two cropping seasons. Genotypes were the main plots and the manures, the subplots. The subplots were randomized with main plots and replicated four times. Differences between environments, genotypes and cropping seasons were significant for the grain yield. The effects of genotypes by environment (G X E) interaction, for grain yield was significant.

The general mean yield obtained when genotypes are combined or not with organic fertilizers is of 1.46 t/ha. The best yields were recorded at Mulungu (1.83 t/ha) and Lemera (1.61 t/ha) sites with Kenya Nyangumi genotype. The high yields were recorded at Bugobe (1.51 t/ha) and Lemera (1.88 t/ha) sites with Romany genotype. The application of organic fertilizers increase the yield of genotypes up to 10- 36%.

Introduction

Le blé (*Triticum aestivum* L.), culture par excellence des régions tempérées (1, 20, 22, 23, 27), est une des graminées alimentaires les plus cultivées et consommées dans certaines parties du monde (17, 24, 26).

Le blé est une culture bien connue dans les zones d'altitude de la région des grands lacs d'Afrique centrale (Burundi, Rwanda, R.D. du Congo), (2, 5, 6, 8, 10, 13). La culture du blé a été introduite pour la première fois au Congo-Kinshasa dès 1920 au Katanga et en 1930 à Nioka. Sa culture y fut pratiquée avec des résultats incertains, par des missionnaires, donc depuis l'époque coloniale (2, 7, 12). La farine de blé est importée, surtout pour la fabrication des pains, beignets, galettes, bouillie et autres pâtes alimentaires.

En 1977, la République Démocratique du Congo avait importé 1.291.000 tonnes de froment pour subvenir

* Département de Biologie, Centre de Recherche en Sciences Naturelles, CRSN-Lwiro, D.S. Bukavu, Kivu, R.D. Congo c/o Petit Séminaire de Mugeri, P.O. Box: 02 Cyangugu, Rwanda.

Reçu le 08.06.99 et accepté pour publication le 13.09.02.

au besoin exprimé par la population (2). Au Sud-Kivu, plus de 1000 tonnes de farine de blé ont été importées, commercialisées et consommées en 1999 (3). Jusqu'à présent, les importations couvrent 60% de la demande totale de la population (3).

En 1996, le prix moyen du kilogramme de farine de blé oscillait entre 0,85 et 1,35 $ US de la ville (Bukavu) vers les milieux ruraux.

La généralisation de la culture de blé permettrait non seulement de réduire les importations, mais aussi de favoriser la vulgarisation du pain, qui reste encore un luxe pour certaines couches de la population de la R.D. du Congo.

Sur le plan de l'économie ménagère, le prix du kilogramme de blé proposé sur le marché est un prix rémunérateur. Si ce prix reste stable, le blé deviendra une culture vivrière de rente, capable de substituer l'actuelle culture vivrière de rente devenue trop marginale dans la région: le manioc.

Dans le souci de remplacer partiellement les importations massives du froment par une production nationale ou locale (2) et de freiner ainsi donc l'érosion des devises (plus de 14.000 $ U.S./année), quelques essais de culture de blé sont, à nouveau réalisés par des missionnaires au Sud-Kivu d'altitude (territoire de Kabare), depuis 1996 (7). Le facteur prévalant à la rénovation de ces initiatives est surtout le climat local, favorable à la culture du blé (7).

Les variétés utilisées sont importées de la France et de l'Italie (7). De 1996 à 1998, les rendements, enregistrés avec ces variétés, oscillaient entre 200 et 400 kg/ha suivant la zone agro-écologique (1600 à 2500 m d'altitude) où sont localisées les exploitations (7).

Les rendements et la qualité boulangère du froment produit localement sont faibles. La faible performance de ces variétés a été attribuée à leur mauvaise qualité des sols utilisés (7).

Le développement de la culture du blé dans la région, passera par la sélection des variétés adaptées et/ou par l'introduction des variétés à haut rendement, qui se sont adaptées dans les régions aux conditions agro-écologiques similaires à celle du Sud-Kivu montagneux. La fertilisation du blé étant un des facteurs limitant à la production du blé en Afrique, les chercheurs ont très souvent recommandé la fertilisation minérale (N.P.K.), (6). Le prix des engrais minéraux sur le marché local est un prix prohibitif. Ceci oblige de chercher la substitution dans la série des engrais organiques, moins onéreux et localement disponibles, à moindres coûts pour les petits exploitants dotés de faibles ressources.

Cet article présente le comportement (au point de vue rendement) de deux variétés de blé venues du Burundi, dans 4 environnements écologiquement différents au Sud-Kivu d'altitude. Les essais ont été répétés sur deux saisons culturales différentes, dans le but de trouver la saison la plus favorable (saison de maximalisation du rendement) à la culture dans la région.

Matériel et méthodes

1. Attributs des caractéristiques agro-écologiques des sites d'essais

Les variétés ont été évaluées, de 1998 à 1999, dans quatre environnements représentatifs (Figure 1) des principales zones écologiques, du Sud-Kivu montagneux favorables à la culture du blé. Ces quatre sites d'essai sont situés dans des localités appartenant aux territoires de Kabare et de Kalahe (28°19'- 29°1'E, 14°2'- 2°36'S) du Sud-Kivu (Est de la République Démocratique du Congo).

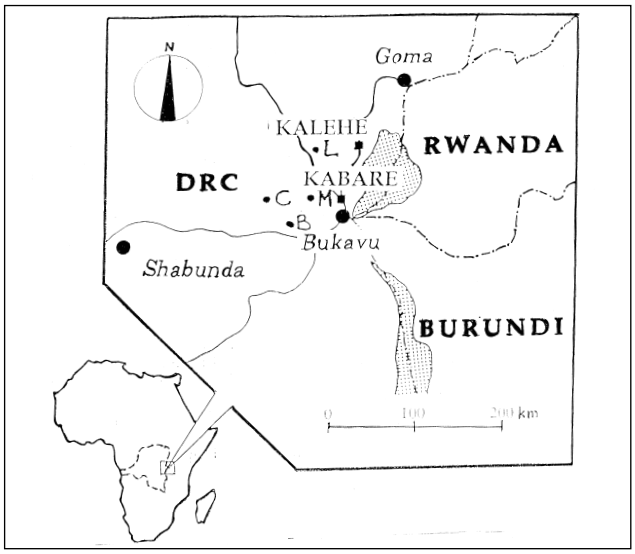


Figure 1: Localisation des sites d'essai

B: Bugobe – C: Cifunzi – M: Mulungu – L: Lemera
Source : Kizungu *et al.* (1996)

Dans cette partie du pays, le climat de type AW3 est un climat tropical humide tempéré par l'altitude. Il connaît deux saisons, une pluvieuse de 9 mois (septembre à mai) et une sèche de 3 mois (juin à août).

La moyenne annuelle des pluies dans la région oscille entre 1350 et 1800 mm, celle de la température entre 14,5 et 23,5 °C et celle de l'humidité relative entre 70 et 80%. Les territoires concernés par l'étude ont un relief montagneux vallonné par endroits, s'élevant de 900 m pour atteindre, à certains endroits, plus de 3100 m d'altitude (14). Le sol de la région est un ferrisol (14, 18, 28).

Le tableau 1 présente les attributs des caractéristiques agro-écologiques des sites d'essais.

2. Matériel végétal

Les deux génotypes (Romany & Kenya Nyangumi) utilisés dans ces essais sont des cultivars issus du commerce. Ils ont été obtenus à l'Institut des Sciences Agronomiques du Burundi (ISABU). Ils sont considérés au Burundi comme étant des cultivars précoces et tolérants aux stress biotiques et abiotiques. Les deux variétés sont considérées comme des variétés améliorées et adaptées aux hautes altitudes au Burundi. Ces cultivars donnent une farine de bonne valeur boulangère et un rendement oscillant entre 2,9 et 3,8 t/ha

Tableau 1

Attributs caractéristiques des sites d'essai où les génotypes de blé étaient plantées, en essais multilocaux, durant deux saisons culturales consécutives (1998A- 1999C)*

	Sites d'essai			
Caractéristiques	Bugobe	Mulungu	Cifunzi	Lemera
Altitude (m)	1950	1715	2200	2450
Pluies, moyenne annuelle (mm)	1500	1650	1550	1710
Température, moyenne annuelle (°C)	18,5	19,5	17,6	16,7
Humidité relative (%)	77	74	72	78
Pente du terrain (%)	4	2	3	5
Type d'habitat	Bas-fond	Plaine	Colline	Colline
Types de sols	SABL	SNAG	SAL	SAS
pH (eau) moyen	5,733	5,9	6,3	7,5
Précédents culturaux	PT	A& PT	A& S	PP& PT
Végétation environnante	Friche	Friche	Friche	FM

SABL: sols argileux, bruns et lourds
SNAG: sols noirs à argiles gonflantes
SAL: sols argilo-limoneux
SAS: sols argilo-sableux
PT: pomme de terre
A& PT: arachide et pomme de terre
A& S: arachide et sorgho
PP& PT: petit pois et pomme de terre
FM: forêt de montagne
* Source: station pédo- climatologique de l'Institut National pour l'Etude et la Recherche Agronomiques (INERA), Station de Mulungulu (Kivu, R. D. Congo).

en station de recherche, et entre 0,5 et 2,4 t/ha en milieu paysan (2, 5, 8). Par rapport au Kenya Nyangumi, la variété Romany est caractérisée par la formation des talles de grande dimension et par les feuilles de petite dimension.

Vers la fin du cycle végétatif, les tiges du Kenya Nyangumi sont plus hautes que celles de Romany (P. Ndayiragige, Communication personnelle, 1999).

La culture du blé du Burundi est localisée sur la crête Congo-Nil (2, 4, 5, 6, 7, 8), région où les conditions agro-écologiques sont similaires à celles trouvées sur les hautes terres de l'Est du Sud-Kivu (Kabare, Kalehe, Haut plateaux d'Uvira, Fizi Lemera, Mulungu, Cifunzi, Bugobe, …).

3. Type de fumure appliquée

La fertilisation est une nécessité dans la culture du blé si l'on veut obtenir des bons rendements (6).

Dans le souci de réduire la dépendance vis-à-vis de la fumure minérale, en culture de blé au Sud-Kivu, deux types de fumure organique ont été préparés et testés dans cet essai: le compost et le fumier.

Nous avons utilisé le fumier issu d'une ferme d'élevage bovin laitier de la région. Le compost a été fabriqué, dans chaque site d'essai, à base de végétaux morts); {(feuilles de bananier (20%), de *Tithonia diversifolia* (20%), de *Setaria* sp. (10%), de *Calliandra* sp. (30%), de sous-produits agricoles (fanes d'arachides et d'haricots) (10%) et des purins et/ou des cendres de bois (10%)}. Le remplissage des compostières se faisait une fois toutes les deux semaines. La compostière est remplie par plusieurs couches successives et alternes de végétaux et du sol mélangé au purin de vache et/ou au cendre de bois. Les compostières sont montées avec les matériaux locaux (branche d'*Eucalyptus* ou de *Dracaena altimontana*).

Le compostage a duré six mois dans chaque site d'essai. Le niveau de fertilité des sols des sites d'essai était faible à moyenne (Tableau 2). Les valeurs des teneurs en éléments nutritifs (N, P, K, Ca, Mg, Na) se retrouvent en dessous (Site de Bugobe et Mulungu) ou à la limite (Sites de Cifunzi et Lemera) du niveau critique pour la culture du blé (Tableau 2); se référant aux normes d'interprétation des analyses des sols élaborés par V. Rutunga et Mutwewingabo en région des grands-lacs d'Afrique centrale (19).

Tableau 2

Valeurs moyennes des principales propriétés chimiques, de l'horizon cultural (AP= 20 cm) de profondeur, des terrains de sites, de 4 environnements représentatifs du Sud- Kivu montagneux (R. D. Congo) où le blé a été cultivé en essais multilocaux (1998A- 1999C)

Propriétés	Bugobe (n= 6)	Mulungu (n= 6)	Cifunzi (n= 8)	Lemera (n= 8)
pH (eau)	5,3 ± 5,8	5,8 ± 6,1	6,3 ± 6,8	7,5 ± 5,2
C (%)	2,5 ± 1,12	2,9 ± 3,4	3,52 ± 3,29	3,31 ± 2,78
N (%)	0,15 ± 0,11	0,11 ± 0,16	0,18 ± 0,19	0,21 ± 0,35
C/N	16,6 ± 10,18	26,36 ± 21,25	9,5 ± 117,3	15,76 ± 7,94
P (mg/kg)	3,1 ± 1,83	3,3 ± 0,95	8,59 ± 5,3	10,35 ± 17,04
K (méq/100 g)	0,17 ± 0,24	0,19 ± 0,12	0,3 ± 0,14	0,5 ± 0,4
Ca (méq/100 g)	0,23 ± 0,11	0,31 ± 0,12	0,34 ± 0,29	0,24 ± 0,34
Na (méq/100 g)	0,2 ± 0,15	0,28 ± 0,20	0,4 ± 0,15	0,41 ± 0,3

n: nombre d'échantillons analysés
C: carbone organique
N: azote total
P: phosphore assimilable
K: potassium
Ca: calcium
Na: sodium

La teneur en éléments minéraux du fumier et du compost utilisés est donnée dans le tableau 4. Le fumier est plus riche que le compost.

Tableau 3

Valeur fertilisante moyenne du fumier et du compost utilisés dans les essais multilocaux dans quatre environnements représentatifs du Sud- Kivu (1998A & 1999C)

Eléments minéraux	Compost (n= 4)	Fumier (n= 6)
K (%)	0,66 ± 0,56	0,95 ± 0,78
Na (%)	0,0094 ± 0,00089	0,067 ± 0,088
P (%)	0,098 ± 0,078	0,51 ± 0,42
N (%)	0,88 ± 0,19	0,31 ± 0,49
Ca (%)	0,21 ± 0,19	0,31 ± 0,49
Mg (%)	0,15 ± 0,168	0,21 ± 0,39

n: nombre d'échantillons analysés
C: carbone organique
N: azote total
P: phosphore assimilable
K: potassium
Ca: calcium
Na: sodium
Mg: magnésium

Pour le fumier, les échantillons ont été prélevés à différentes périodes de l'année. Pour le compost, les résultats présentés sont les moyennes de quatre sites. Les analyses chimiques du compost, du fumier ainsi que des sols de sites d'essai ont été réalisés par le laboratoire de pédologie de l'Institut National pour l'Etude et la Recherche Agronomiques. Les analyses ont été réalisées 3 semaines avant le semis du blé.

4. Méthodologie

Le dispositif expérimental utilisé dans chaque site et pour chaque saison culturale, était un dispositif split-plot (blocs aléatoires complets et quatre répétitions) avec comme facteur principal, la variété, et comme facteur secondaire, la fumure (Figure 2). Le dispositif expérimental comprend six traitements, deux génotypes et trois niveaux de fertilisation.

Deux essais ont été réalisés par site, un essai en saison culturale A (saison débutant en septembre et prenant fin en janvier) et un essai en saison culturale C (saison débutant en février et prenant fin en juin) suivant le calendrier agricole de la région.

Pour les deux types d'essais, les labours (30 cm), au niveau de l'horizon A du sol, ont été faits à la houe.

Le compost et le fumier ont été enfouis au moment du labour trois semaines avant le semis. Ils ont été apportés au sol à l'état semi-sec.

Les semis ont été effectués le 1er mars 1998 (en pleine saison culturale C) et le 15 octobre 1998 (en pleine saison culturale A).

Les semis ont été réalisés aux écartements de 22 x 15 cm, pour obtenir une densité moyenne de semis d'environ 300.000 plantes/ha, pour chacune des deux variétés. La parcelle élémentaire était de 15 m² (5 m x 3 m). Aucun traitement phytosanitaire n'a été effectué.

5. Paramètres mesurés

Les observations ont été réalisées sur 12 m² à l'intérieur de chaque parcelle unitaire. Elles ont porté sur la mesure du rendement au moment des pesées. Les 3 m² restant sur les bordures de la parcelle unitaire ont permis de mesurer quelques composantes du rendement: le nombre d'épis/plant et le nombre de grains/épi.

Les récoltes ont eu lieu le 25 juin 1998 (pour les essais conduits en saison culturale C) et le 24 février 1999 (pour les essais conduits en saison culturale A).

Les récoltes ont eu lieu à la maturité complète des épis. Elles ont été effectuées manuellement en utilisant une machette. La pesée a été effectuée avec une balance de précision de 100 g près. Après la récolte et la pesée, le rendement a été converti en tonnes par hectare à 13% d'humidité.

	V1			V2		variétés (génotypes)*
F0	F1	F2	F0	F1	F2	Bloc I
V1- F0	V1- F1	V1- F2	V2- F0	V2- F0	V2- F2	niveau de fertilisation** combinaisons
	V1			V2		
F1	F2	F0	F1	F2	F0	Bloc II
V2- F1	V2- F2	V2- F0	V1- F1	V1- F2	V1- F0	
	V1			V2		
F2	F0	F1	F2	F0	F1	Bloc III
V1- F2	V1- F0	V1- F1	V2- F2	V2- F0	V2- F1	
	V1			V2		
F0	F1	F2	F0	F1	F2	Bloc IV
V2- F0	V2- F1	V2- F2	V1- F0	V1- F1	V- F2	

*Génotypes V1: variété Romany – V2: variété Kenya Nyangumi
**Fertilisation F0: pas de fertilisation – F1: fertilisation avec 35 t/ha (compost) – F2: fertilisation avec 35 t/ha (fumier)

Figure 2: Dispositif expérimental mis au point dans chaque site par saison culturale.

Les résultats obtenus (rendement en t/ha des grains secs) ont été soumis à une analyse statistique (analyse de la variance) pour dégager la signification de l'effet de l'environnement, l'effet génotype et l'interaction génotype x environnement (11, 19).

Résultats et discussion

Le tableau 4 présente les effets des environnements sur les composantes du rendement des variétés testées; de ce tableau, on constate que le nombre d'épis/plant varie dans 'ensemble de 1,02 à 1,2. Le nombre des grains/épi varie, quant à lui, de 10 à 17,5 dans l'ensemble. La saison influe sur le nombre des grains/épi. Ces résultats corroborent ceux obtenus au Burundi (5, 6).

Tableau 4

Effets d'environnements et des traitements sur les composantes de rendement du blé au Sud-Kivu montagneux, Est de la R.D. Congo (1998- 1999): moyenne de 2 saisons culturales (A et C)

		Environnements			
Traitements	Composantes	Bugobe	Mulungu	Cifunzi	Lemera
V1- F0	np	1,1	1,1	1,1	1,2
	ne	12,5	12,5	12	15
V1- F1	np	1,1	1,10	1,02	1,1
	ne	14,5	13,5	16	18,5
V1- F2	np	1,12	1,2	1,1	1,1
	ne	14,5	17,5	13	21
V2- F0	np	1,02	1,05	1,02	1,02
	ne	10,5	13,5	12,5	10
V2- F1	np	1,05	1,02	1,05	1,1
	ne	12,5	17,5	12,5	13,5
V2- F2	np	1,05	1,1	1,12	1,1
	ne	14	15,5	14	15,5

np: nombre moyen d'épis/ plant
ne: nombre moyen de grains/épi

L'analyse de la variance du rendement a montré des effets significatifs (Tableau 5) pour les traitements et l'interaction traitement x environnement, qui indiquent un comportement différentiel des génotypes (combinés ou non aux fumures organiques) dans chaque environnement. Les interactions traitement x saison et environnement x saison ont été aussi significatives. Ceci indique que les rendements observés sont affectés par la saison de plantation et les conditions écologiques du site de plantation (Tableaux 5, 8, 9). L'interaction traitement x environnement x saison a été significative, en indiquant le fait que les rendements des cultures ont varié selon la qualité des génotypes, des conditions écologiques et de la saison de la plantation (Tableau 5). Le rendement moyen général du blé pour cet interaction a été de 1,46 t/ha (Tableau 6).

Les rendements des variétés s'accroissent sensiblement lorsqu'elles reçoivent une fertilisation organique (fumier ou compost). Dans cet essai, nous avons

Tableau 5

Analyse combinée de la variance du rendement de blé dans quatre environnements du Sud- Kivu montagneux (Est de la R. D. Congo). Test F

Origine de la variation	Degré de liberté	Carré moyen
Traitements (T)	5	15,981**
Environnements (E)	3	0,6183
Saisons culturales (S)	1	0,087
Traitements (T) x Environnements (E)	15	5,98003**
Traitements (T) x Saisons culturales (S)	5	17,60872**
Environnements (E) x Environnements (E)	3	4,569733**
Traitements (T) x Environ. (E) x Saisons culturales (S)	15	7,0066**
Erreur	120	0,9844

** : Tests F significatifs au niveau de probabilité de 1%.

Tableau 6

Effets des traitements sur le rendement et le pourcentage d'accroissement de rendement du blé dans 4 environnements représentatifs du Sud- Kivu montagneux, R. D. Congo (1988- 1999)

Génotypes	Fumure organique	Traitements	Rdt (t/ha) moyen	T (%)	
				Saison A	Saison C
	-	V1- F0	1,36	-	-
Romany (V1)	Compost	V1- F1	1,56	10,6	29,3
	Fumier	V1- F2	1,49	13,37	29,7
	-	V2- F0	1,17	-	-
Kenya(V1)	Compost	V2- F1	1,59	34,31	31,4
Nyangumi	Fumier	V2- F2	1,57	36,87	36,2
Moyenne générale	-	-	1,46	-	-
PPDS (P= 0,05)	-	-	0,24	-	-
CV (%)	-	-	8,49	-	-

PPDS (P= 0,05): la plus petite différence significative à 5% du niveau de probabilité
CV (%): coefficient de variation en pourcentage
T (%): pourcentage d'accroissement du rendement de blé cultivé sur les parcelles amendées par le fumier ou le compost, par rapport au témoin cultivé sur terrains non amendés.
Rdt: rendement

enregistré des accroissements de rendement dus à la fumure organique. Ces accroissements oscillent entre 10,6% et 29,3% en saison A et entre 13,37% et 29,7% en saison C lorsque la variété Romany est associée à l'application de compost et de fumier, respectivement (Tableau 6).

Ces accroissements sont de l'ordre de 31,4% et 34,31% en saison A, et de l'ordre de 36,2% et 36, 87%

Tableau 7

Variation du rendement moyen (t/ha) de 6 traitements dans 4 environnements du Sud- Kivu montagneux, Est de la R. D. Congo (1998A- 1999C)

			Environnements et leurs altitudes			
Génotypes	Fumure	Traitements	Bugobe (1950 m)	Mulungu (1715 m)	Cifunzi (2200 m)	Lemera (2450 m)
	-	V1- F0	1,18	1,21	1,33	1,53
Romany (V1)	Compost	V1- F1	1,43	1,34	1,58	1,98
	Fumier	V1- F2	1,51	1,37	1,48	1,93
	-	V2- F0	1,13	1,47	1,15	0,93
Kenya(V1)	Compost	V2- F1	1,40	1,77	1,49	1,60
Nyangumi	Fumier	V2- F2	1,29	1,83	1,56	1,61
PPDS (P= 0,05)			0,46	0,47	0,48	0,49
CV (%)			18,18	16,55	17,3	15,48

PPDS (P= 0,05): la plus petite différence significative à 5% du niveau de probabilité.
CV (%): coefficient de variation en pourcentage.

Tableau 8

Effets d'environnements et des saisons culturales sur le rendement du blé au Sud-Kivu montagneux, Est de la R. D. Congo (1998- 1999)

	Rendement moyen (t/ha)	
Environnements (sites d'essai)	Saison A	Saison C
Bugobe (A: 1950 m)	1,74	0,91
Mulungu (A: 1715 m)	1,33	1,67
Cifunzi (A: 2200 m)	1,39	1,47
Lemera (A: 2450 m)	1,30	1,88
Coefficient de variation (%)	19,8	18,3

A: altitude du site d'essai.

Tableau 9

Effets des traitements et des saisons culturales sur le rendement du blé au Sud-Kivu montagneux à l'Est de la R. D. Congo (1998- 1999)

		Rdt (t/ha) moyen		
Génotypes	Fumure organique	Traitements	Saison A	Saison C
	-	V1- F0	1,47	1,16
Romany (V1)	Compost	V1- F1	1,62	1,50
	Fumier	V1- F2	1,66	1,51
	-	V2- F0	1,059	1,28
Kenya(V1)	Compost	V2- F1	1,46	1,69
Nyangumi	Fumier	V2- F2	1,38	1,76
CV (%)	-	-	12	11,48

CV (%): coefficient de variation en pourcentage.
Rdt: rendement.

en saison C lorsque Kenya Nyangumi est associée à l'application de compost et de fumier respectivement (Tableau 6). Au Burundi, l'application à la volée, au moment du semis, de la fumure minérale (40- 40- 40 de NPK) procure un supplément de production de 16%- 35% (6). Nos résultats corroborent ceux obtenus au Burundi. En utilisant la fertilisation organique, on atteint de façon satisfaisante des accroissements de rendements de même ordre que ceux obtenus au Burundi. La fumure organique pourrait substituer dans une certaine mesure les engrais minéraux (NPK) en culture de blé au Kivu montagneux. Les paysans pratiquant déjà la culture pourraient utiliser la fumure organique, en lieu et place des engrais minéraux, dans le but d'améliorer la qualité et la quantité de la production.

Les génotypes (cultivés avec ou sans application de fumures organiques) se sont comportés différemment au point de vue rendement en fonction de la variation des conditions agro-écologiques des environnements (Tableau 7).

Les rendements les plus significativement élevés ont été enregistrés à Mulungu (1,87 t/ha) et à Lemera (1,61 t/ha), (Variété Kenya Nyangumi avec fumier); et à Bugobe (1,51 t/ha) et à Lemera (1,98 t/ha) pour la variété Romany avec application de fumier (Tableau 7). Les rendements obtenus dans nos environnements, sont aussi observables au Burundi (5, 6) d'où proviennent les semences utilisées.

Les deux variétés testées produisent beaucoup plus que celles actuellement utilisées, dans des conditions du Sud-Kivu montagneux, et présentent des potentialités intéressantes pour la promotion de la culture du blé dans la région. Ces résultats préliminaires obtenus en station doivent cependant être confirmés en milieu paysan avant de promouvoir la diffusion de ces variétés dans la région.

La sélection variétale en station de recherche devrait dès maintenant commencer en vue de trouver des variétés à haut rendement et adaptées aux différents environnements de la province.

Références bibliographiques

1. Abou El-Defan J.A., El-Kholi H.M.A., Rifaat M.G.M. & Abd-Allah A.E., 1999, Plant responses are often dramatic in sandy soils due to low N- P-K content of these soils. Egyptian Journal of Agricultural Research, vol.**77**, n°2, 513-522.
2. Anonyme, 1986, Point de la recherche agronomique et zootechnique au sein de la Communauté Economique des Pays des Grands Lacs (C.E.P.G.L.), IRAZ, Gitega, Burundi, 402 pp.
3. Anonyme, 2000, Rapport de l'inspection agricole de la province du Sud-Kivu, R.D. Congo. Rapport pour l'exercice de l'année 1996 à l'année 2000, Bukavu, 138 pp.
4. Autrique A., 1988, Maladies et ravageurs des cultures de la région des grands-lacs d'Afrique centrale, AGCD n° 24, ISABU, 232 pp.
5. Autrique A. & Schalbroeck J.J., 1989, Incidence de la date de semis sur la croissance et le rendement du blé dans le Mugamba (Burundi), Agronomie tropicale, **43**, 3, 289-300.
6. Baragengana R. & Schalbroeck J.J., 1988, Contribution à l'étude de la fertilisation minérale du blé dans la région du Mugamba (Burundi), Tropicultura, **7**,1, 17-23.
7. Bishweka Chimenesa A., 1999, La culture du froment en Afrique Centrale (Sud-Kivu). Recherches africaines, N° 4, pp, 99-112.
8. Bruyer R., 1957, Les cultures d'altitude au Rwanda-Urundi, Kisozi, INEAC, 1957, 14 pp.
9. Carême C. & Saghier T., 1991, Conséquences de la nuisibilité des mauvaises herbes sur la production du blé d'hiver en Tunisie: les seuils d'intervention et la rentabilité du désherbage, Tropicultura, **9**, 2, 53-57
10. Goeteyn R., 1973, Résultats d'un essai comparatif variétal de froment à Rwerere (Rwanda), (1967-1971), Note technique, ISAR, Rwanda, n° 36, 22 pp.
11. Gomex K.A. & Gomez A.A., 1984, Statistical procedures for agricultural research. John Wiley & Sons U.S.A.
12. Joumain & Vendenput R., 1953, La culture du froment au Kivu, Ministère des colonies, Direction de l'agriculture, des forêts et de l'élevage, Bruxelles, Belgique, 932 pages.
13. Kamate M. & Kambaza T., 1983, Tentative de la relance de la culture du blé dans les zones de Beni et Lubero (Nord-Kivu). Une expérience de la minoterie de Matadi (MIDEMA). Bulletin de l'I.S.D.R./Bukavu, AMUKA, n° 26, 8ème année, 20 pp.
14. Munyuli Bin Mushambanyi T., 2000, Etude préliminaire orientée vers la production des chenilles consommables par l'élevage des papillons *Anaphe infracta*, Tropicultura, **18**, 4, 208-211.
15. Mwonya R., 1999, The maize and wheat network addresses gender issues. ASARECA/Agriforum, n° 9, 1-4.
16. Payne T., 2000, Impact of maize and wheat research in Eastern and Central Africa: Results of recent studies. ASARECA/Agriforum, n° 10, 7-9.
17. Pecrot A. & Léonard A., 1960, Carte des sols et de la végétation du Congo Belge et du Rwanda-Urundi. Dorsale du Kivu, publication de l'I.N.E.A.C., Bruxelles, 100 pp.
18. Petrova N., Hsam Sai L.K., Setsov P. & Zeller F.J., 2000, Identification of powdery mildew and leaf rust resistance genes in common wheat (*Triticum aestivum* L. em. Thell.) cultivars grown in Bulgaria and Russia. FAO/IPGRI, Plant genetic resources newsletter, 2000, n° 122, 32-35.
19. Rutunga V. & Mutwewingabo G., 1987, Normes d'interprétation des résultats d'analyses du sol. Institut des Sciences Agronomiques du Rwanda (ISAR-RUBONA), 230 pp.
20. Sally B.K. & Sharp E.L., 1988, Selection and evaluation of three spring wheats with slow-rusting resistance to *Puccinia graninis* f.sp tritici. Plant disease, 72, 413-415.
21. Sharma R.C., 1992, Analysis of phytomass yield in wheat. Agronomy Journal. Vol. **84**, 6, 926-929.
22. Sharma R.C. & Smith E.L., 1986, Selection for high and low harvest index in three winter wheat populations. Crop science, 26, 1147-1150.
23. Sherif S., 1983, Studies on the virulence of some physiological races of leaf rust of wheat in Egypt. Ph. D. thesis, Faculty of Agriculture, Cairo Univesity, 167 pp.
24. Soltner D., 1990, Les grandes productions végétales. Céréales-plantes sarclées et oléoprotéagineuses- Prairies, 17ème édition, collection Sciences et techniques agricoles, Paris, 468 pages.
25. Sys C., 1960, Carte des sols et de la végétation du Congo Belge, Publication de l'I.N.E.A.C., Bruxelles, 84 pp.
26. Tanner D.G., 2000, The maize and the wheat network: catalysing for better research and impact. Agriforum, n° 11, 12-13.
27. Taya G., Tarekegne A. & Tanner D.G., 2000, Estimation of optimum plot dimensions and replication number for wheat experimentation in Ethiopia. African crop science journal. Vol. **8**, 1, 11-23.
28. Vendenput, 1981, Les principales cultures d'Afrique Centrale, AGCD, Bruxelles, 1251 pp.
29. Vessereau A., 1988, Méthodes statistiques en biologie et en agronomie. Edition J.B. Ballière, Paris, 538 pp.

T. Munyuli Bin Mushambanyi, Congolais (R.D.C.), Ir. Agr., Chercheur au Département de Biologie, Centre de Recherche en Sciences Naturelles, CRSN/Lwiro, D.S. Bukavu, Kivu, République Démocratique du Congo.

NOTES TECHNIQUES TECHNISCHE NOTA'S

TECHNICAL NOTES NOTAS TÉCNICAS

Effect of Transplanting on Yield and Growth of Grain Sorghum (*Sorghum bicolor* (L.) Moench)

* G.O. Agbaje & J.A. Olofintoye

Keywords: Transplanting– Seedling– Nursery– Sorghum

Summary

An experiment was carried out to study the effects of transplanting on growth and grain yield of three varieties of Sorghum bicolor*, 'Ilorin local', SK 5912, and SSV10. Seedlings from each variety transplanted at 2, 4 and 6 weeks after planting (WAP) were compared with directly seeded plants used as control. Results show that at 8 WAP with seedlings transplanted at 2 WAP were taller than the other transplants, but shorter than directly seeded plants. Transplanting caused delay in flowering, but at this stage, height of transplants was comparable to directly seeded plants in SK 5912 and SSV10, while in 'Ilorin local' the transplants were significantly shorter at P< 0.05. Dry matter accumulation and grain yield was comparable among transplants but lower than those of directly seeded plants. However, grain yield of seedlings that were transplanted at 2 WAP was statistically comparable with directly seeded plants at P< 0.05.*

Résumé

Effet de la transplantation sur la croissance et le rendement du sorgho (*Sorghum bicolor* (L.) Moench)

*Une étude sur l'influence de la transplantation de jeunes plantes obtenues 2, 4 et 6 semaines après semis (SAS) a été réalisée. Trois cultivars «Ilorin local', SK 5912 et SSV10» de sorgho (*Sorghum bicolor *(L.) Moench) ont été utilisées dans cet essai en comparant la croissance et le rendement des plantes transplantées avec ceux des plantes témoins (sorgho semé directement dans le champ). Les résultats obtenus après 8 semaines de transplantation ont montré que les plantes témoins étaient les plus grandes de tous les traitements étudiés et que le traitement 2 SAS était plus grand par rapport aux autres plantes transplantées. La transplantation était corrélée au retard de floraison. Au stade floraison, la hauteur des plantes transplantées des cultivars SK 5912 et SSV10 n'était pas significativement différente par rapport aux plantes témoins, tandis que les plantes d'Ilorin local étaient significativement (P< 0,05) plus petites. L'accumulation en matières sèches des plantes transplantées était significativement plus petite par rapport aux plantes témoins. Le rendement en grains était significativement plus élevé et comparables pour les plantes témoins et les plantes 2 SAS par rapport aux traitements 4 SAS et 6 SAS.*

Introduction

Yields of both indigenous and improved sorghum varieties (*Sorghum bicolor* (L.) Moench) are very low in Nigeria varying from 0.95 to 1.61 tons per hectare (9). The reason for low yield include poor crop establishment due to serious attack on dibbled seeds and emerging seedlings by various birds such as *Ploceus cuculatus*, *P. capitalis*, *Lamprotonis chalybaeus* etc. Also, the practise of transplanting sorghum seedlings of varying ages by farmers in the savannah areas of Nigeria linked to inadequate knowledge of the age at which seedlings should be transplanted, may contribute to low grain yield of the crop.

Transplanting as a method of crop establishment dates back to the early biblical times (400 BC) and is still an important worldwide system of production (7). Transplanting sorghum has been reported for India, Japan, Mali, Cameroon, Republic of Chad, Nigeria and Senegal (1, 2, 3, 5). Transplanted sorghum is popularly known as « Masakwa» or 'Firki sorghum' in Chad basin between Nigeria and Republic of Chad in West Africa (3).

Transplanting has been observed to cause growth retardation, yield reduction and physiological disorder

Department of Crop Production, Faculty of Agriculture University of Ilorin, Nigeria.

*Present address: Institute of Agricultural Research and Training Obafemi Awolowo University, PMB 5029, Ibadan, Nigeria.

Received on 26.04.96. and accepted for publication on 06.09.02.

(4, 6, 10, 11). All transplants experience check in growth, which may kill plants under extreme condition or cause significant variability within the crop on the field (7). However, transplanting of seedling at early vegetative stage had been reported to reduce the detrimental effect of transplanting on grain yield (1, 8). This study seeks to establish the age at which sorghum seedlings can be transplanted with minimal effects on grain yield.

Material and methods

An experiment was carried out between July and December in 1987 at the Teaching and Research Farm of the University of Ilorin, Nigeria, in order to compare grain yield of sorghum from directly seeded plants to that established with transplants of different ages.

Three varieties of sorghum, i.e. SK 5912 (V_1), SSV10 (V_2) and 'Ilorin local' (V_3) (Table 1) were established by direct seeding (T_0) and by transplanting at 2, 4 and 6 weeks of seedling age, called T_1, T_2 and T_3 respectively. The twelve treatment combinations were arranged in a randomized complete block design and replicated three times with an individual plot size of 6 x 3 m^2. Each plot had five ridges with a planting space of 0.20 x 0.75 m^2 at two plants per stand. The seeds of directly seeded plants were treated with Aldrex 40 (Aldrin insecticide) before planting to prevent birds from picking them on the field. Plants to be transplanted were established in the nursery on the same day the directly seeded were planted on the field. The nursery seedlings with their leaves detopped were transplanted at two seedlings per stand into the field at 2, 4 and 6 weeks after seeding. Three manual weddings were carried out post-planting at 2, 7 and 9 weeks after planting WAP and Nuvacron (monocrotophos insecticide) was sprayed after each weeding operation at 40 ml of chemical solution to 15 litres of water. Urea (46% N) and single super phosphate (18% P_2O_5) fertilizer was applied at the rate of 60 kg N and P_2O_5 per hectare, respectively. Fertilizer was applied to directly seeded treatments using a combination of 20 kg N and 60 kg P_2O_5 per ha at 2 WAP, and 40 kg N per hectare at flowering. In transplanted treatments, urea was applied in three split doses using 10 kg N per ha in the nursery, 20 kg N and 60 kg P_2O_5 per hectare at 3 weeks after transplanting and 30 kg N/ha at flowering.

Table 1

Characteristics of sorghum varieties used in the experiment

Varieties	Sources	Height	Photoperiod reaction
SK 5912 (V_1)	*IAR, Nigeria	Short	Neutral
SSV10 (V_2)	IAR, Nigeria	Short	Neutral
Ilorin local (V_3)	Ilorin market	Tall	Short-day

*Institute of Agricultural Research (IAR), Zaria, Nigeria.

Parameters recorded were height of plants at 8 weeks after first date of seeding, and at flowering, days to 50% flowering, dry matter at flowering and grain yield. Height was measured using a measuring tape from the plant's base to the tip of the tallest foliage and days to 50% flowering was obtained by visual assessment. Whole dry matter was measured by harvesting five plants per plot and drying them in the oven at 70 °C for two to three days until constant weight. Grain yield per hectare was obtained from harvesting the three middle rows and moisture content of the grain was corrected to 15%.

The data collected were subjected to statistical analysis using analysis of variance (ANOVA) technique and Duncan Multiple Range Test (DMRT) for mean comparison.

Results and discussion

Plant height

Height of transplants established at T_2 and T_3 are comparable and are both shorter than those of T_0 and T_1 at 8 WAP (Table 2). T_0 with a mean height of 1.21 m was reduced by 61.15% due to transplanting at T_1 and 72.0% at both T_2 and T_3 (Table 2). There was no varietal influence on height at this stage (Table 3). At 50% flowering, plant height was significantly influenced by variety, method of planting and their interaction (Table 3). The interactive effects are shown in Table 4, where Ilorin local showed a decline in plant height when seedlings are transplanted. In the other varieties, SK 5912 and SSV10, differences in plant height between transplanted and directly seeded plants were not significant at $P< 0.05$.

Table 2

Means of height at 8 WAP (HWAP, m), height at flowering (HF, m), days to 50% flowering (DF, day), dry matter yield at harvest (DM, g/plant), 100 seed weight (SW, g), grain yield (GY, t/ha) in three sorghum varieties under transplanting and direct seedling

Varieties	HWAP	HF	DF	DM	SW	GY
V_1	0.57a	2.13b	116.82a	102.40a	3.12a	1.41a
V_2	0.56a	2.26b	117.90a	94.67a	3.10a	1.34a
V_3	0.57a	3.81a	125.63b	106.31a	2.96a	0.93a
Planting method						
T_0	1.21a	3.04a	110.62b	158.52a	2.92a	1.72a
T_1	0.47b	2.71b	121.64a	95.40b	3.10a	1.32ab
T_2	0.35c	2.52b	123.16a	82.91b	3.02a	0.91b
T_3	0.33c	2.71b	125.13a	67.55b	3.10a	0.83b

Means in the same columns with same letters are not significantly different at 5%.

Days to 50% flowering and dry matter yield

Ilorin local variety being photoperiod-sensitive (2) attained 50% flowering about nine days later than both improved varieties (Table 2). Directly seeded plants (T_0) flowered 11 - 15 days earlier than transplants

while flowering among transplants was attained between 121 - 125 days after seeding (Table 2). Dry matter yield was significantly influenced by planting method with yields of all transplants being comparable but lower than that of directly seeded plant (Tables 2 and 3).

Grain yield and 100 seed weight

100 seed weight ranged 2.9 – 3.1 g with no significant difference between treatments (Table 3). Total yield of 1.72 t/ha obtained from directly seeded plants was not different statistically from 1.32 t/ha obtained from seedlings established at 2 WAP. However, a decline of 51.74% and 47.09% in grain yield could be observed when seedlings transplanted at 4 and 6 WAP respectively is compared to directly seeded ones (Tables 2 and 3).

Table 3

Mean square (MS) of ANOVA of treatments in table 2

Sources of variation	Degrees of freedom	MS of					
		HWAS	HF	DF	DM	SW	GY
Block	2	0.001	0.04	15.75	2592.76	0.08	0.59
Variety (V)	2	0.001	10.46*	276.33*	429.67	0.11	0.88
Planting Method (T)	3	1.24*	0.36*	382.18*	14348.26*	0.09	1.42
Interaction (T x V)	6	0.01	0.37*	14.59	621.67	0.15	0.37
Error	22	0.21	0.09	29.93	1899.29	0.07	0.36
CV %		16.94	10.99	4.56	43.12	8.91	49.8

*Significant at 5% level, F – test.

From the results, shorter heights observed in transplants at 8 WAP could be due to transplanting shock experienced during uprooting from the nursery. Retardation in growth of transplanted crops such as tomato, rice and maize due to uprooting has been reported earlier (6, 7, 8, 10). However, transplants of varieties SK 5912 and SSV10 gave comparable heights to directly seeded plants at flowering (Table 4). This could be due to the ability of these varieties to easily regenerate new roots after transplanting and resume active nutrient uptake earlier than Ilorin local in which transplants remain shorter than directly seeded ones. Similar results in which some crop species have better ability to recover from transplanting shock by prompt regeneration of new roots after transplanting has been reported (7).

Table 4

Interactive effects between planting methods and varieties on plant height (m) of sorghum at 50 % flowering

Treatment	SK 5912	SSV 10	Ilorin local	Treatment mean
T_0	2.25a	2.19a	4.59a	3.00a
T_1	2.07a	2.35a	3.70b	2.70b
T_2	2.28a	2.01a	3.32b	2.50b
T_3	1.91a	2.48a	3.62b	2.70b
Variety mean	2.13a	2.48a	3.81b	

CV = 10.99%

Means in the same columns with same letters are not significantly different at 5% levels (DMRT).

Transplanted sorghum varieties came to 50% flowering later in time (Table 2) probably due to delay in resumption of other development processes in the plant after uprooting as result of transplanting stress. Other effects of transplanting on sorghum included reduction in dry matter content of the whole plant and a 47 – 52% reduction in grain yield of plants transplanted at 4 and 6 weeks of age. However, grain yield of seedling transplanted at 2 WAP was comparable to directly seeded ones at $P< 0.05$ (Table 2). Since only limited quantities of assimilates are available to be partitioned for grain yield due to low dry matter in transplanted seedlings and a decrease in grain filling period due to late flowering, reduced yields, in transplants are justified. However, due to early transplanting of seedlings at 2 WAP, a comparable yield was still obtained to that of directly seeded plants as grain filling related processes are still far off. This agrees with findings in which early transplanted rice and sorghum plants gave comparable yields to directly seeded plants (1, 8).

The present results imply that early transplanting of *Sorghum bicolor* seedlings at 2 WAP into the field can indeed be performed without causing prejudice to subsequent crop development.

Acknowledgements

The authors wish to thank the Head of Department of Crop Production, University of Ilorin, for the permission to publish the work.

Literature

1. Balasubramanian A., Theetharappan T.S., Prasad, M.N. & Thangavelu O., 1982, Studies on nursery management of transplanted Sorghum. Sorghum improvement Conference of North America, University of Arizona. Sorghum Newsletter 25, 46.
2. Curtis D.L., 1965, Sorghum in West Africa. Field Crops Abstract, **18**(3), 145–151.
3. Dixit M.L. & Shrotriya G.C., 1986, Sorghum: The Chad 3basin Challenge. African Farming Nov/ Dec. Pp 57–61.
4. Horiuchi, 1970, Comparative study of growth pattern of finger millet and soybean under broadcasting and transplanting Report of Tokai Branch of Crop Science Society of Japan 85, 9–14.
5. Horiuchi T. & Yasue T., 1980, Growth response of native millet to the differences between direct sowing and transplating. Jap. Journ. Crop Sci, **49**(4), 593–601.
6. Khahra A.S., Brar H.S., Sharma R.K., Dhillon B.S. & Malhotra V.V., 1990, Transplanting of maize during the winter in India. Agron. J. 82, 41–47.
7. Mckee J.N.T., 1981, Physiological aspects of transplanting vegetable and other crops 1. Factors which influence re-establishment. Horticultural Abstract **51** (5), 262–268.
8. Murthy K.S. & Sahu G., 1979, Effect of age of seedling at normal transplanting on growth and yield of rice varieties. Indian Journal of Agric. Sci. **49** (10), 797–801.
9. Norman D.W., Breeden P., Kroeker W.J., Pryor D.H., Huzinga B. & Hays H.M., 1976, The feasibility of improved sole crop sorghum production technology for small scale farmers in Northern Guinea Savanna Zone of Nigeria. Samaru Research Bulletin. Pp 216.
10. Reddy B.B., Gosh B.C. & Reddy M.H., 1987, Effect of transplanting date and seedling age on stand establishment and grain yield of rice in rainfed lowland conditions. Expl. Agric. 23, 201–206.
11. Singh S.P., 1980, Studies on rice-wheat cropping system in the foot-hills of Himalayas. Oryza **17** (1), 48–51.

G.O. Agbaje, Nigerian, M.Sc. Crop Production Research Fellow, Institute of Agricultural Research and Training, Obafemi Awolowo University, P. M. B. 5029, Ibadan, Nigeria.

J.A. Olofintoye, Nigerian, Ph.D. Agronomy, Senior Lecturer, Department of Crop Production, University of Ilorin, P. M. B. 1515, Ilorin, Nigeria.

INDEX

INDEX AUTHORS

INDEX COUNTRIES

INDEX SUBJECTS

ORGANIZACIÓN

Naturaleza de la entidad responsable de la publicación y el asunto de la revista TROPICULTURA
Agri-Overseas a.s.b.l. es una asociación creada con el objetivo de establecer relaciones profesionales de interés común entre todos aquellos quienes obran para el desarrollo rural en los países del Sur. Esta asociación publica la revista científica y de información «Tropicultura» dedicada a los problemas rurales en los países en desarrollo.
Esta revista es editada trimestralmente con el apoyo de la Dirección General de la Cooperación Internacional (D.G.C.I.), Ministerio Belga de Asuntos exteriores, Secretaría de Estado para la Cooperación al Desarrollo, y aquel de la región de Bruselas - Capital.

Agri-Overseas a.s.b.l. se compone de miembros individuales y de las instituciones belgas siguientes: las cuatro Facultades en Ciencias agronómicas de Bélgica (Gembloux, Gent, Leuven y Louvain- La- Neuve), las dos Facultades en Medicina veterinaria (Gent y Liège), el Departamento de Salud animal del Instituto de Medicina tropical de Emberes (Antwerpen), la Sección interfacultaria de Agronomía de la Universidad Libre de Bruselas, las Facultades Universitarias de Nuestra Señora de la Paz (Namur), la Fundación Universitaria Luxemburguesa (Arlon), la Dirección General de la Cooperación internacional.

Consejo de administración
El consejo de administración de Agri-Overseas se compone del Profesor Vercruysse, Presidente; del Dr. Ir. G. Mergeai, Administrador Delegado; del Dr. E. Thys, Secretario; del Profesor Honorario Dr. Ir. J. Hardouin, Tesorero a.i.; del Profesor Dr. B. Losson, miembro.

Comité de redacción
El comité de redacción se compone del Dr. Ir. G. Mergeai, Redactor en jefe, y de los siguientes redactores delegados: el Profesor Dr. J. Deckers para «la Ecología, la Fertilidad de los suelos y los Sistemas de explotación», el Profesor J.-C. Micha para «la Pesca y la Piscicultura», el Dr. E. Thys para «la Producción animal y los Animales de caza», el profesor Dr. Ir. P. Van Damme para «la Agronomía y la Silvicultura», el Profesor J. Vercruysse para «la Salud animal». La secretaría trata directamente los otros temas en lo que posee competencia (economía, sociología,...).

Secretaría de redacción
1A, Square du Bastion, B- 1050 Bruxelles – Bélgica
Teléfono : ++32.(0)2.550 19 61/ 62; Fax.: ++32.02.514 72 77
Email:ghare.tropicultura@belgacom.net / mjdesmet.tropicultura@belgacom.net

Distribución
La distribución de la revista TROPICULTURA es gratuita y puede ser obtenida con un simple pedido escrito, dirigido a la secretaría de redacción.

ALCANCE DE LA REVISTA

TROPICULTURA publica artículos originales, informes de investigación y síntesis, resúmenes de libros y tesis, así como informes de películas y soportes audiovisuales en lo que concierne a todas las áreas vinculadas al desarrollo rural: producciones vegetales y animales, ciencias veterinarias, ciencias forestales, ciencias del suelo y de la tierra, Ingeniería rural, ciencias del medio ambiente, bioindustrias, industria agro-alimentaria, sociología y economía.

INSTRUCCIÓN A LOS AUTORES

Los manuscritos serán inéditos y no habrán sido sometidos a una publicación anteriormente o simultáneamente. Se pueden redactar en uno de los cuatro idiomas siguientes: ingles, español, francés y holandés. Los manuscritos están dirigidos al redactor en jefe a través del servicio postal, en tres ejemplares, en forma de documento en papel o directamente a la dirección electrónica de la secretaría de redacción, en forma de archivos adjuntos. Se redactarán en cara simple, en doble espacio (27 líneas de 60 caracteres por página en formato DIN A4), con un margen de 3,5 cm mínimo alrededor de la superficie imprimada. Ellos contendrán un máximo de diez páginas de texto (excluyendo la primera página, los resúmenes y las referencias bibliográficas).
La primera página llevará: el título, el título abreviado (máximo 55 caracteres), los apellidos y nombres completos de los autores, la dirección profesional completa de cada uno, los agradecimientos eventuales. El apellido del autor corresponsal será marcado mediante un « * » y su dirección completada por sus números de teléfono y telecopia y de su dirección electrónica.
Las páginas siguiendo la primera página presentarán: (i) los resúmenes (max 200 palabras) en el idioma del manuscrito y en ingles, precedidos del título traducido y seguidos de un máximo de seis palabras claves dentro de cada uno de los dos idiomas; (ii) el texto principal; (iii) la bibliografía; (iv) los cuadros numerados por medio de cifras árabes; (v) las ilustraciones identificadas sin ambigüedad por un número al verso; (vi) las leyendas de los cuadros y las ilustraciones. Todas las páginas serán numeradas en continuo. Las figuras serán dibujadas de manera profesional. Las fotografías serán proporcionadas no montadas, bien contrastadas sobre papel brillante.

El primer depósito de un articulo a la redacción podrá hacerse en forma impresa o en forma electrónica. En la medida de lo posible, después de la aceptación del artículo para publicación, el autor dará su ultima versión, revisada y corregida, sobre un disquete (o en forma de archivo adjunto). El software Word es recomendado pero una versión ASCII o RTF de los archivos es aceptada.
El texto estará generalmente dividido en introducción, material y método, resultados, discusión, conclusiones. La subdivisión del texto no sobrepasará de dos niveles. Los subtítulos, muy concisos serán conformados en minúsculas y jamas no serán subrayados.
Las referencias estarán citadas dentro del texto por medio de números ubicados entre paréntesis. En caso de citación de varias referencias, sus números se sucederán por orden ascendente.
Las referencias bibliográficas serán clasificadas por orden alfabético de apellidos de autores y por orden cronológico para un autor dado. Ellas estarán numeradas en continuo , comenzando por la cifra 1.
Para los artículos de revistas, las referencias comprenderán: los apellidos de los autores seguidos de las iniciales de los nombres, el año de publicación, el título completo del artículo en el idioma de origen, el nombre de la revista, el número del volumen subrayado, los números de la primera y de la ultima página separadas por un guión.
Ejemplo: Poste G., 1972, Mechanisms of virus induced cell fusion. Int. Rev. Cytol. 33, 157 – 222.
Para las monografías, los elementos siguientes son esenciales: los apellidos de los autores seguidos de las iniciales de los nombres, el año de publicación, el título completo de la obra, el apellido del editor, el lugar de edición, la primera y la ultima página del capítulo citado, el número total de páginas de la obra. Los informes de conferencias se tratan como monografías, además, ellos mencionarán si es posible el lugar, la fecha de la reunión y el (los) editor(es) científico(s).
Ejemplo: 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, i*n*: B.W. Volks & S.M. Aronson (Editors), Sphingolipids and allied disorders, Plenum, New York, 205 p.

Una comunicación personal será mencionada en el texto por las iniciales del nombre, seguidas del apellido, comunicación personal y el año. Ejemplo (W.R. Allan, comunicación personal, 1988). Esta referencia no se volverá a tomar dentro de las referencias bibliográficas.

Las referencias anónimas serán mencionadas numéricamente en el texto y en las referencias bibliográficas. Anónimo (año). Título. Fuente (donde las informaciones pueden ser encontradas.)
El comité de redacción se reserva el derecho de rechazar todo artículo no conforme a las prescripciones mencionadas en la parte superior.
Los artículos están sometidos a uno o a varios lectores escogidos por la redacción y esos lectores se mantendrán anónimos por los autores.
En caso de aceptación del artículo, la redacción exigirá un compromiso de los diferentes autores a ceder sus derechos de publicación a TROPICULTURA.

TROPICULTURA

2002 Vol. 20 N° 4

Four issues a year (October –November – December)

CONTENTS

TROPICULTURA IS A PEER-REVIEWED JOURNAL INDEXED BY AGRIS, CABI AND SESAME

GDIC DGCI

IPM COLOR PRINTING
☎ 02 218 68 00 - Fax 02 217 84 41
E-mail: ipm@pophost.eunet.be