OPTIMAL FARM PLAN IN ALLEY CROPING SYSTEM OF AGROFORESTRY IN NIGER STATE OF NIGERIA

*MOHAMMED, D., **ABUBAKAR, S.B. AND ***NDANITSA, M.A.
*Forestry Research Institute of Nigeria, North – East Arid Zone Research Station, Damasak/Maiduguri, Nigeria.
**Department of Crop Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University Lapai, Nigeria.
***Department of Agricultural Economics and Extension Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria.

ABSTRACT

The study sought to determine the Optimal Farm Plan for Alley Cropping System of Agroforestry Management in Niger State of Nigeria. A random sampling technique was used to select 42 respondents for the survey. Data were collected through schedule interview using structured questionnaires. Data were analyzed using linear programming model. The result of the analysis shows that only Citrus lemon enterprise should be carried out on a 0.69ha land in the area, which will yield an optimal income of ₦63,474.32. Capital was the most limiting resource in the area. It was therefore recommended that farmers in the area should divert their resources to the production of Citrus lemon only.

INTRODUCTION

Agroforestry is a collective name for land use system and technologies where woody perennials (tress, shrubs, palms, etc) are deliberately used on the same land-management units as agricultural crops and/or some animals in some form of spatial management or temporal sequences, Bene *et al* (1978) and Kings and Chadlan (1978) defined Agroforestry as the intimate association of different plant communities on the same piece of land.

Raintree (1993) observed that in agroforestry system, there are both ecological and economic interactions between the different components. This definition implies that:

i. Agroforestry normally involves two or more species of plants (or plants and animals) at least one of which is perennial.
ii. An agroforestry system always has two or more output
iii. The cycle of an agroforestry system is always more than one year; and
iv. Even the simplest agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a monocropping system.

The objective of agroforestry is to create sustainable land management strategies which increase the overall yields of the land, also compatible with the environment and local cultural practices. Properly applied, it is a system that is both productive, environmentally sound and has the potential not only to increase food, fuel and income for farmers or herders on marginal land but also to help stop destruction of the world's forest lands.

Benefits of Agroforestry

Agroforestry fulfils three major benefits which encompasses the concepts of food security and objectives of National Food Security. They are environmental and socio-economic benefits.

Environmental benefits: Like improving soil fertility, preventing degradation, desertification and soil erosion, preventing sighting of reservoirs, rivers and streams, regulating stream flows, preventing flood and land slides and providing esthetics etc.

Social benefits: Production of goods for households consumption like fuel-wood, building posts, fodders and forage, fruits and honey, fibers and flosses, medicines, gums and resins, materials for making agricultural implements.

Economic benefits: Employment and cash income, forest seedling raising, tree growing and tending, sale of fuel wood, poles, fruits and honey, medicines, gum and resins materials for rural hand carpentry and so on.

Agroforestry Types and Practices

There are several types of agroforestry system. These include Agro-silvocultural practices, silvopastoral, Agro-silvopastoral, Multipurporse Forest Tree Production practices. These practices are likely to be appropriate for any local need or environment and they can be modified to suit a particular situation. Some practices are similar to each other and at times the distinction between them may be arbitrary. These agroforestry practices form a continuum as the landscape does and can fit together in various ways depending upon the environment and the goals of the local community.

Moreoften than not, the sub-systems of agro-forestry management include, improved Fallow, Taungya, Alley cropping, Multi layer trees, Multi purpose trees on crop land, plantation crop combination, Home gardens, Trees in soil conservation and reclamation, Shelterbelt and windbreaks, live hedges, Trees on range land of pastures, Plantation crops with pastures and animals, Plantation crops with pastures and animals, Home gardens involving animals, Multipurpose woody hedge-rows, Agricultural with trees and Aqua forestry.

Alley Cropping

Alley cropping is a farming system where arable (food) crops are grown in the interspaces of forest growing leguminous trees or woody shrubs. Kang (1981) defined alley cropping/farming as an agroforestry technology in which woody species are planted in hedges and agricultural species alley in between hedges of 4 – 5m.

Kang (1986), gave the following reasons for adoption of alley cropping:

i. To replace shifting cultivation and bush-fallow systems with a stable farming system which give the beneficial features of traditional fallow system.

ii. To allow a piece of land to be cropped continuously with sustained productivity.
iii. To use prunnings from the leguminous trees and shrubs as mulch and/or green manure to maintain soil fertility and reduce fertilizer requirement.
iv. To promote soil and water conservation, particularly on a slopping land.
v. To reduce weed growth during the dry season and also to reduce the need for bush fires of land clearing.
vi. To provide supplementary browse for small ruminants (especially from legumes involved in the system).
vii. to provide stacking materials for yams and fire wood as fuel wood.

A number of trees and shrubs are particularly suitable for alley cropping but only a few have been tested so far. Those that are already tested in International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria include *Gliricidia sepuim, Flemingia congesta, Leucaena leucocephala, Acacia barterri* and *Gmelina arborea,* while the arable crops suitable include Maize, Cowpea, Soybeans, Pepper, Tomatoes, Cassava etc.

A critical assessment of the performance of alley farming in Niger State however reveals that the systems is bedeviled with a number of technical, financial, institutional and human resource problems which jeopardize the confidence of the farmers due to low income from low productivity. It is useful therefore to develop an optimum farm plan for Alley cropping farmers that will be profitable and sustained for a very long period of time by the user in specific situations. For example, Tsoho (2005) used Linear Programming (LP) approach to examine the possibilities of combining Tomato/Onion/Pepper and Tomato/Onion be carried out on 0.39 and 0.62 hectares of land respectively, and concluded that this will yield an optimum returns to labour and management of N31,806.15k.

METHODOLOGY

The study area was Etan Fadama in Wuya Kede. The community is in Kede Tifin District of Mokwa Local Government Area (LGA). Mokwa LGA has a population of 242,858 people (N.P.C., 2006). The Fadama is cultivated by small-scale farmers who are mostly Hausa migrants from the neighbouring states of Kebbi, Zamfara, Sokoto, Kaduna, Jigawa and Karo. Sometimes they provide supplementary irrigation for their crops in the alleys.

The sampling size of the study was 42 farmers that practice alley farming technology. Random sampling was however used to draw this sampling size and to give equal opportunity for each farmer of being selected. Data for the study was collected using interview guide with aid of a well structured questionnaire. The information were collected between December 2009 and January 2010.

In terms of measurement of the variables, the resource constraints in the study area include land, labour, capital and the supplementary irrigation water. The various levels of constraints were determined by what the "representative" farmer in the study area had. According to Okuneye (1985), "a representative farm can be used to depict a typical farm in sample". A representative farmer was taken to be the farmer who used the arithmetic mean of each of the resources, as their components can be found on majority of the farms they represent.

- **Land Constraint**: Represent the arithmetic mean of land cultivated by the farmers in the area, and was measured in hectares (ha).
- **Labour Constraint**: Aggregated family, communal and hired labour measured in mandays was obtained and the total labour used per hectare must be less than or equal to this value. A man-day refers to an average man working for eight (8) hours.
- **Capital Constraint:** The maximum own capital available was obtained by determining the arithmetic mean of farmers expenses (costing capital items) or purchased inputs like fertilizers, seed/seedlings, agrochemicals, fuel, fertilizers etc. The mean capital devoted to each crop (forest and arable) determined and summed up to obtain the total capital used in the study area.
- **Supplementary Irrigation (Water) Input Constraint:** irrigation was carried out by respondents in the area to supplement the natural rainfall. This is for arable crops in the alleys. The average water input expressed in ha-cm was similarly obtained.

In addition, the basic activities in the use refers to the enterprises carried out (i.e. crops cultivated), and only those enterprises carried out by up to 6 percent of the total respondents were considered appropriate for the analysis (Muhammad – Lawal, 2003). These enterprises include.

X_1 (*Citrus lemon)* The only tree (Forest) plant
X_2 (Sole rice)
X_3 (Tomato)
X_4 (Pepper)

- The activities are defined in units of one hectare (1ha), for each of the enterprises.

RESULTS AND DISCUSSION

Table 1 and 2 revealed the summary of the linear programming result depict the level of alley farming activities in the area. As shown in table 1 (appendix), only X_1 (*Citrus lemon)* activity should be carried out on a 0.69ha of the Fadama land in the area. This is capable of yielding an optimal income of N63,474.32. similarly table 2 (appendix) shows that capital is the most limiting resource. It has a shadow price of N7.62. Other resources are in surplus.

CONCLUSION AND IMPLICATION FOR POLICY

The study shows that respondents in the area are generally small holder farmers engaged in alley cropping system. They posses little investment capital, land and labour as well as irrigation facilities. Based on the findings, it could be concluded that the optimal enterprises combination with the highest return to owner's labour and management is *Citrus lemon,* on 0.69ha of Fadama land.

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APPENDIX

1. Linear Programming Model: This was used to develop the optimal the optimal farm plan in the study area. The Linear Programming (LP) fitted was estimated as:

$$\text{Max. } Z = E(P_j q_j - C_j)$$
$$= \sum_{j=1}^{m} a_{ij} X_{ij} \leq B_i$$
$$= X_j \leq O \; (j=1\text{-}m)$$

Where:

Z = Returns to owners labour and management (N/ha)

Pj = Price of jth crop per unit, in N

Qj = Quantity of jth crop in calorie /kg

Cj = Total Variable cost of labour and purchased inputs

Aij = Per unit of requirement of the jth activity carried out

M = The number of activities and its ranges from 1 – 4.

Jth = Resources, ranges from 1 – 4

Bi = The level of jth resources

Where: b1 = Average from size (ha)

b2 = Average labour available per farmer in mandays/ha

b3 = Average capital employed per farmers in N/ha

b4 = Average water input (supplementary irrigation) employed in ha-cm.

2. Optimal Enterrise Combination Model: The Enterprise include:

X_1 = *Citrus lemon*

X_2 = Sole Rice

X_3 = Tomato

X_4 = Pepper

These activities are defined in units of one hectare (1ha) for each of the enterprises.

The LP model estimated is:

$$\text{Max. } Z = 46716.02X_1 + 861X_2 + 13345.76X_3 + 35801.38X_4$$

Subject to :

Land = $1X_1 + 1X_2 + 1X_3 + 1X_4 \leq 0.95$ha

Labour = $142.34X_1 + 94.13X_2 + 108.55X_3 + 91.02X_4 \leq$ 145.21man-days.

Capital = $2193.46X_1 + 14672.55X_2 + 14864.33X_3 + 17648.76X_4 \leq$ N16832.92.

Supplementary irrigation water = $136.82X_1 + 172.15X_2 + 123.75X_3 + 189.06X_4 \leq$ 188.72ha-cm

Where Z= Return to Labour and management

3. **Table 1: Summary of Linear Programming**

No.	Variable	Solution	Opportunity cost	Objective Coefficient	Min. Obj. Coefficient	Max. Obj. Coeffiecient
1	X_1	+0.54762822	0	+567527.14	15228.011	- Infinity
2	X_2	0	+35279.472	+9714.5694	- Infinity	+5403
3	X_3	0	+36404.421	+16665.573	- Infinity	+5078
4	X_4	0	+30638.049	+33720.812	- Infinity	+7432

Max: Objective – N63,474.32 Source: Field Survey, 2010

4. **Table 2: Resource Constraints**

No.	Constraints	Status	RHS	Shadow Price	Slack or Surplus	Min. RHS	Max. RHS
1	Land	Loose	≤ +0.7300	0	+0.064	+0.652	+ Infinity
2	Labour	Loose	≤ +183.32	0	+52.54	+96.306	+ Infinity
3	Capital	Tight	≤ +133642.79	+7.6244	0	0	+1406

4	Supplementary Irrig. H_2O	Loose	$\leq$ +106.18	0	9.67	+92.71	+ Infinity

Max: Objective = N63, 474.32 Source: Field Survey, 2010