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AN ASSESSMENT OF PRODUCTION LIMITS OF HOMESTEAD AND FIELD BOUNDARY "LIVE FENCE" JATROPHA BIOFUEL IN MALAWI: A MODELLING APPROACH

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Abstract

There are global concerns on large-scale production of biofuels on account of sustainable production, deforestation, loss of biodiversity, competition for land and water resources, food security and rising food and feed prices. For countries with limited land base and high population density such as Malawi successful production of biofuels will depend on the use of agricultural wastes (e.g. ethanol from molasses) and the growing of biofuel crops on marginal lands or field and homestead boundaries as live fences. This study sought to analyze using a numerical model the national production limits of jatropha-based (Jatropha curcas L.) biofuel production in Malawi grown as live fences on homesteads and smallholder field boundaries in order to guide investments in the biofuels sector.

Modeling results indicate that jatropha oil production from live fences from homesteads in Malawi could produce between 12 to 40 million litres of bio-diesel annually under a low yield scenario (1.75 kgs per tree per year) and between 24 to 79 million litres annually under a high yield scenario (3.5 kgs per tree per year). For smallholder field boundaries between 29 to 97

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million litres could be produced annually under the low yield scenario and between 59 to 194 million litres annually under a higher yield scenario. These figures are significant and compare favourably with bioethanol production from sugarcane molasses for Malawi at 32 million litres per year and warrant financial investments in bio-diesel production from jatropha grown as live fences on field and homestead boundaries.

Keywords: *biofuels, biodiesel, jatropha, boundary live fences, homestead, modeling, Malawi*

1.0 Introduction

First-generation biofuels are facing heavy criticism regarding socio-economic, environmental, food security and agricultural commodity prices impacts (Batidzirai *et al.*, 2012). These concerns centre on sustainable production, deforestation, loss of biodiversity and competition for land and water resources. Further, there are concerns about impacts on food security and rising agricultural commodity prices (for both food and feed). Current biofuels crops are not efficient energy producers and require vast arable lands reducing potential land available for food production thus impacting on food security. There are also worries about GHG emissions associated with land use changes for some biofuels (e.g. corn and sweet sorghum ethanol) with the exception of sugarcane ethanol and jatropha grown on marginal lands or field boundaries (Jansen and Rutz, 2012). Caution must therefore be exercised in land use and farming systems to ensure that the production of energy crops for biofuels do not degrade land, water and natural eco-systems, lead to biodiversity loss or undermine food security. Socially, biofuels production must not undermine food security or lead to rising food and feed prices (Jumbe, 2012).

Large-scale biofuels production is suitable for countries with large surplus land such as Mozambique, Zambia and Tanzania. For countries with limited land base and high population density such as Malawi (NSO, 2009), successful production of biofuels will depend on the use of agricultural wastes (such as ethanol from sugarcane molasses) and the growing of biofuel crops on marginal lands or on field and homestead boundaries as live fences. An assessment of the biofuels sector in Malawi (Jumbe *et al.*,2009) has shown that ethanol from sugarcane wastes and jatropha growing on marginal lands and homestead and field boundaries hold most promise in case of Malawi. The bio-ethanol and bio-diesel produced in this case are mainly for import substitution of fossil fuels to meet domestic demand and not for export.

Currently, Malawi is facing fuel shortages of diesel, petrol and paraffin due to shortages of forex and thus in country biofuel production could substitute for the imported fuel. Potential for biofuel exports to EU and US are limited by subsidies and other trade barriers in those countries. This study sought to analyze using a numerical model the national production limits of jatropha-based biofuel in Malawi grown as live fences on homesteads and smallholder field boundaries. The key research question addressed was how much Jatropha biodiesel can be produced nationally from homesteads and smallholder field boundaries as live fences and whether such production is significant to warrant private sector investments. The results are meant to guide the development of the biofuels sector in Malawi

2.0 Study Objectives

The main objective of this study was to analyze using a numerical model the national production limits of jatropha-based biofuel production in Malawi grown as live fences on homesteads and smallholder field boundaries. The key question addressed was how much Jatropha biodiesel could be produced nationally from rural homestead and smallholder field boundaries as live fences and whether such production is significant to warrant private sector investments. The specific objectives were:

1 Quantify for Malawi, the number of trees and litres of jatropha oil that could be produced nationally from rural homesteads boundaries under different yield and adoption scenarios.
2 Quantify for Malawi, the number of trees and litres of jatropha oil that could be produced nationally from smallholder field boundaries under different yield and adoption scenarios.
3 Compare Jatropha oil production under these conditions with bio-ethanol production from sugarcane molasses and whether such production is significant to warrant private sector investments.

3.0 Methodology

The number of Jatropha trees from rural homesteads nationally were estimated using rural population district figures based on the 2008 population census (NSO, 2009) projected to 2012 figures using district growth rates from the 2008 census. The population figures were converted to homestead numbers using average district household sizes from the same census. It was assumed a rural homestead was about 0.06 ha (30m x 20m) and a recommended jatropha spacing along the perimeter of the homestead of 1m. Knowing the number of homesteads and the number of jatropha trees per homestead, total number of trees at district (28), regional (3) and national levels were calculated assuming varying farmers' jatropha adoption rates (10%, 25%, 33%, 50% and 75%). For various reasons, adoption rates should practically range from 10% to 33% and will never reach 100 percent as not all farmers can grow Jatropha on the homestead boundary. Other farmers will have none while others will grow other tree species.

The number of Jatropha trees from farmers fields nationally were estimated using total cultivated area for each district based on land area from each district and the ratio of cultivated area to land area at agricultural development division level (ADDs) obtained from Ministry of Agriculture (MoAFS, 2011). A field size of 0.8 ha (2 acres) per household was assumed across the country. This is double the observed plot sizes especially in Southern Region but this was done in order to minimize crop shading from jatropha grown as a live fence. The 0.8 ha was converted to a perimeter distance assuming the length is 1.5 times the width and jatropha is grown using a spacing of 2m along the field boundary. Knowing the number of fields and the number of jatropha trees per boundary field, total number of trees from field boundaries at district (28), regional (3) and national levels were calculated assuming varying farmers' jatropha adoption rates (10%, 25%, 33%, 50% and 75%) and not 100 percent for the same reasons as outlined above.

The number of jatropha trees at district, regional and national levels from homesteads and field boundaries were converted to quantity of seeds using two jatropha yield scenarios. The low yield scenario was 1.75 kg jatropha seeds per tree per year while the high yield scenario was 3.5 kg jatropha seeds per tree per year. The low yield scenario is reflective of the first 4 years of jatropha while the high yield scenario is reflective of the yield expected from year five upwards.

Jatropha oil production was estimated using typical extraction rates of four kilograms of jatropha seeds producing one litre of jatropha oil (Janske van Eijck et al. 2012).

4.0 Results and Discussions

The results of the analyses are shown in Table 1 for rural homesteads for two yield scenarios (1.75 and 3.50 kgs/tree/year and adoption rates of 10, 25 and 33 percent. Table 2 shows results for smallholder field boundaries for similar yield scenarios and adoption rates. Both tables indicate number of jatropha trees (in millions) to be grown as well as jatropha oil production in million litres per year. The results indicate significant jatropha oil production as bio-diesel can be generated from live fences of smallholder homestead and field boundaries.

Numerical model results indicate that jatropha oil production from live fences from rural homesteads in Malawi could produce between 12 to 40 million litres of jatropha bio-diesel annually under a low yield scenario (1.75 kgs per tree per year) and between 24 to 79 million litres annually under a high yield scenario (3.5 kgs per tree per year). For smallholder field boundaries between 29 to 97 million litres of jatropha bio-diesel could be produced annually under the low yield scenario and between 59 to 194 million litres annually under a higher yield scenario. These figures compare favourably with bio-ethanol production from sugarcane molasses for Malawi currently pegged at 32 million litres per year and warrants private sector investment in jatropha bio-diesel on live fences on homestead and field boundaries.

Promoting jatropha in homesteads and field boundaries as a live fence could generate significant jatropha oil for biodiesel in Malawi and help save forex. Investors should be made aware of this potential but there is need to work out operational logistics on how to organize smallholder farmers to produce jatropha in homesteads and field boundaries as an additional household income source. Farmers could be organized in farmers associations and cooperatives to take advantage of this opportunity. Large population districts of Malawi where jatropha does well could first be targeted.

Table 1: Jatropha oil production from Malawi rural homesteads under two yield scenarios of 1.75 kg per tree and 3.50 kg per tree.

Low yield scenario A : 1.75 kg Jatropha seed per tree per year						
Adoption Rate	**10%**		**25%**		**33%**	
Region	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**
North	3.29	1.44	8.24	3.6	10.87	4.76
Central	11.47	5.02	28.69	12.55	37.87	16.57
Southern	12.68	5.55	31.70	13.87	41.84	18.31
Malawi	27.44	12.01	68.63	30.02	90.58	39.64
High yield scenario B : 3.50 kg Jatropha seed per tree per year						
Adoption Rate	**10%**		**25%**		**33%**	
Region	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**
North	3.29	2.88	8.24	7.21	10.87	9.51
Central	11.47	10.04	28.69	25.10	37.87	33.13
Southern	12.68	11.09	31.70	27.74	41.84	36.61
Malawi	27.44	24.01	68.63	60.05	90.58	79.25
Assumes a rural homestead size of 0.06ha (30m x 20m) and a jatropha spacing of 1m, a perimeter of 100m and 100 trees per homestead. Jatropha production at 1.75kg and 3.50 kgs of seed per tree and 4kg seeds make 1 litre of jatropha oil.						

Table 2: Jatropha oil production from Malawi smallholder field boundaries under two yield scenarios of 1.75 kg per tree and 3.50 kg per tree.

Low yield scenario A : 1.75 kg Jatropha seed per tree per year						
Adoption Rate	**10%**		**25%**		**33%**	
Region	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**
North	9.31	4.07	23.28	10.18	30.72	13.44
Central	30.38	13.29	75.94	33.25	100.25	43.86
Southern	27.47	12.02	68.67	30.04	90.65	39.66
Malawi	67.16	29.38	167.89	73.45	221.62	96.96
High yield scenario B : 3.50 kg Jatropha seed per tree per year						
Adoption Rate	**10%**		**25%**		**33%**	
Region	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**	**Trees (million)**	**Oil (million litres)**
North	9.31	8.15	23.28	20.37	30.72	26.88
Central	30.38	26.58	75.94	66.45	100.25	87.71
Southern	27.47	24.04	68.67	60.09	90.65	79.32
Malawi	67.16	58.76	167.89	146.91	221.62	193.91
Assumes a field boundary size of 0.8ha (100m x 80m) and jatropha spacing of 2m in order to limit crop shading giving a perimeter distance of 365.1m and 183 trees per plot. Jatropha production at 1.75kg and 3.50 kgs of seed per tree and 4kg seeds make 1 litre of jatropha oil.						

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