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Insight of the Adoption Trends and Challenges Faced by Jatropha Farmers in Yatta District, Kenya

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Abstract
From 2004 to 2009, there was entry of *Jatropha curcas* promotion agencies mainly Non-Governmental Organizations and private investors in the country aimed at increasing the adoption of the plant especially in the arid and semi-arid areas. By 2009, the average *Jatropha* adoption was low at 15.4% among the smallholder farmers in Yatta District in spite of the perceived role the plant could play in biodiesel production, provision of rural employment and rehabilitation of degraded land compared to traditional crops that included maize at 86.4%, beans at 31.2% and pigeon peas at 47.5%. The goal of this study is to assess the adoption trends of *Jatropha* in Yatta District, analyze promotion strategies used by agencies to promote *Jatropha*, assess if knowledge on *Jatropha* benefits influenced its adoption and finally establish challenges experienced by *Jatropha* farmers in Yatta District. The study applied both quantitative and qualitative research methods. Questionnaire surveys, focus group discussions, in-depth interviews and observations were employed to identify challenges experienced by *Jatropha* farmers. Questionnaires were administered to 240 respondents selected through multi-stage sampling technique. Results showed that there was little *Jatropha* cultivation before the boom, it went up significantly during promotion period but dropped significantly soon after the exit of the promotion agencies. Further, it was found that promotion strategies used were ineffective, knowledge on *Jatropha* benefits did not significantly influence its adoption and there were major challenges experienced by *Jatropha* farmers in the study area that contributed to the termination of its cultivation. It was concluded that *Jatropha* farmers in Yatta District technical, institutional, socio-economic and cultural challenges. It is therefore recommended that *Jatropha* production in Yatta District is not a rational option at the moment due to the many challenges experienced by farmers such as lack of market, non-improved germplasm, and little technology on *Jatropha* management among others discussed in the paper. Also before promoting the plant in the region, it is necessary to carry out further research on pests and disease control and improved *Jatropha* seeds in order to improve on yields and have a biofuel policy in place to ensure streamlined *Jatropha* value chain and development of biofuels industry as a whole.
Keywords: Challenges; ASALs; Biofuels; *Jatropha*; Yatta District.

1. Introduction

Liquid fuels derived from biomass also referred to as biofuels are emerging as alternative fuels that could help manage the problem of the ever-increasing demand of oil by providing energy security, mitigating the environmental problems arising from use of fossil fuels and stimulating rural development in Africa (Yamba, 2007). Small-scale biofuel production and use leads to no net increase in atmospheric carbon and could contribute to a reduction of GHGs (UNDESA, 2007).

Developing countries see biofuel production as a way of stimulating rural development, creation of employment and saving foreign exchange (Gustafson, 2001). Biofuels can make a significant impact to the Kenyan economy by substituting part of her fossil fuel dependency and thus reduce the import bill. Biofuels are able to revolutionize economies of agricultural farming communities, especially in Arid and Semi Arid Lands (ASALs). Since these areas, comprise 80% of Kenya's land area and support only 20% of the population, they are characterized by adverse climatic conditions leading to low agricultural production and low vegetation cover (GoK, 2007). Due to the low population, the ASALs are considered to have large tracks of land with marginal agricultural activities. Biofuels can also reduce negative health and social impacts such as indoor air pollution and time spent on collection and transport of wood and dung by women and children by replacing traditional cook-stoves (UNDESA, 2007).

Jatropha was regarded as one of the most promising crops for securing energy supply and for socio-economic development in developing countries. *Jatropha* is a small tree or large bush that develops fruits containing seeds with an oil content of 32% to 40%, which can be transformed into biodiesel (Achten W., et al., 2008). Promoters of *Jatropha* argued that the biodiesel from *Jatropha* does not compete directly with food production since the whole plant is toxic and hence non-edible. They also argued that *Jatropha* had potential to grow on degraded soil with little management practices although these claims were later differed by (Iiyama, et al., 2013) who argued that it requires fertilizer, water, and good management if improved yields were to be realized. The unproved characteristics of *Jatropha* had raised expectations for positive environmental and socio-economic impacts from biodiesel production.

During the *Jatropha* boom, there was a renewed interest by the Kenya government and key development agencies to promote biofuels production especially in the ASALs. There were various organizations and programs spread across the ASALs of Kenya that promoted *Jatropha*. They included the Green Africa Foundation (GAF), Mpeketoni *Jatropha curcas* project, Nyumbani Eco-village, Vanilla *Jatropha* Development Foundation (VJDF), and private companies such as Better Globe Forestry Limited (BGFL), Green Fuels Limited (GFL) and Energy Africa Limited (EAL). Pilot programs on *Jatropha* were undertaken in Eastern, Rift valley, Coast and Nyanza provinces (GTZ, 2008). In Eastern regions, *Jatropha* cultivation trial was undertaken in Yatta District in Machakos County.

Despite the potentially important role *Jatropha* could have been played in Yatta District and notwithstanding the many agencies such as NGOs, private investors and churches involved in the promotion of *Jatropha* cultivation in the country, its uptake was lethargic. This may perhaps have been as a result of the promotion strategies employed and many challenges experienced by *Jatropha* farmers such as; unavailability of land for *Jatropha* cultivation, lack of awareness among the farmers on the existence of the plant or importance of its cultivation, high costs of its production, lack of market and/or lack of marketing facilities for the sale of *Jatropha* produce and lastly lack of finances, seedlings/ seeds and technical support on management practices.

2 Materials and Methods

2.1 Location and Size

Yatta District which lies in Machakos county covers an estimated area of 2497 km^2 and is located within a latitude of 1.47 (1° 28' S) and a longitude of 37.83 (37° 49' E). The district borders Thika District to the North Western side, Kitui and Mwingi districts to the Eastern side, Machakos District to the Southern side, Maragwa District to the North and Mbeere District to the North Eastern side (Figure 1).

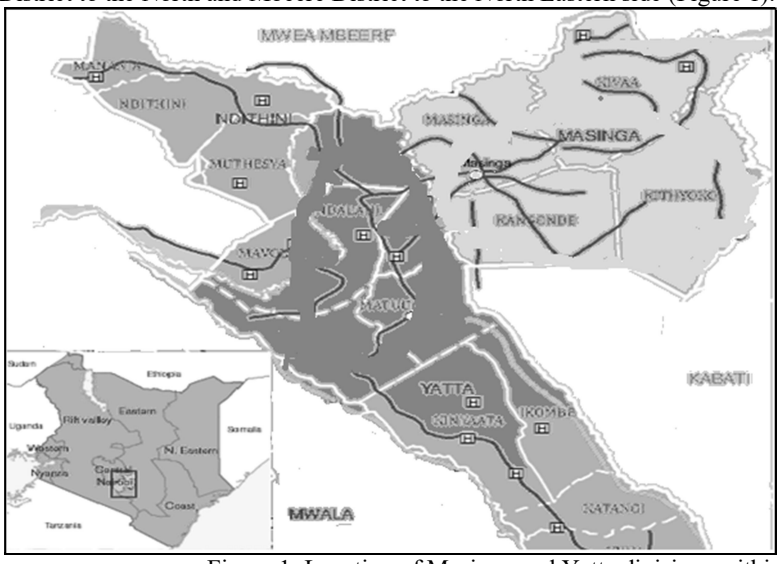
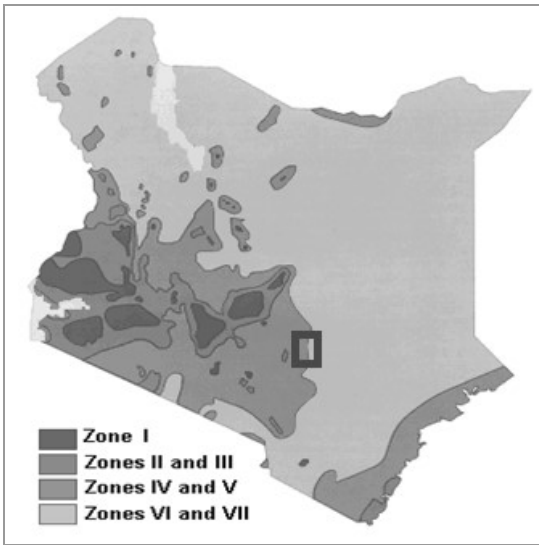


Figure 1: Location of Masinga and Yatta divisions within Yatta District

Source: (UN, 2009)

2.2 Climate, Topography and Soils

Yatta District lies in Zone IV - V of the Agro-climatic classification of Kenya in Figure 2. Climate of Yatta District is generally warm and dry during most part of the year except for some torrential and erratic rains experienced in the months of March and December. The mean monthly temperature ranges from 29 ^{0}C in the coldest months to 36 ^{0}C in the hottest months resulting in low or no yields in rain-fed agriculture. Despite these low yields, agriculture remains an important source of livelihood in the district currently.



Zone 1 — High potential for production, some part too cold and wet for optimum Production; Some forest land; Annual rainfall is above 2000mm

Zones II and III — Land suitable for crops where most food is grown; Forests and derived grasslands and bush lands especially Zone II. Land of high agricultural value (intensive livestock and crop production), low forest potential especially Zone III. Annual rainfall lies between 800mm - 2000mm

Zones IV and V — Marginal, high risk areas but still some crops grown; rangelands in most parts of zone V. Annual rainfall lies between 400mm - 800mm

Zones VI and VII — Marginal cropping, except under irrigation; Annual rainfall lies between < 200mm and 400mm

Figure 2: Agro-climatic Zones in Kenya

Source: (Braun, Sombroek, W.G., van der Pouw, & B.J.A., 1982)

Topography of the district is varied and rises from 500m above sea level on the southern part of the district to 1200m above sea level in the northern part. As indicated, a huge proportion of the district is semi-arid and receives very little and erratic rainfall. There are two rainy seasons, the long and the short rains. Annual average rainfall varies from 350-600mm with high attitude areas receiving more rainfall than low attitude regions. However there has been gradual decline of rainfall since 1992 (GoK, 2004).

Soils in the district are mainly sandy, rocky and acidic. Vegetation in the district ranges from indigenous trees to wood shrubs and grassland and varies with altitude although most indigenous trees have been depleted due to human activities like charcoal production.

2.3 Socio-economic and Demographic Characteristics

According to the 2010 census report, the district has a population of approximately 424,500 people with 84,900 households consisting of 48.8% male and 51.2% female. Majority of the population is middle aged with 56.7% of the total population being between 20 – 35 years (GoK, 2010). People tend to settle around water sources and where soils are fertile hence a big chunk of land in the district under-utilized.

Yatta District consists mainly of peasant farmers who keep livestock and grow drought resistant crops on small farms though there has been a continuous failure of crops since early 1990s due to reduced rainfall. Population in the district is slowly moving from agricultural activities to dependence on charcoal production and sand harvesting for their livelihood. Minimal farmers who live along the Yatta canal grow horticultural crops for sale such as, kales, cabbages, tomatoes and onions while those living in other dry parts of the district grow other drought resistant crops such as katumani maize, cow peas, pigeon peas, millet and green grams (GoK, 2002).

There is a recurrent food shortage in the district because the soils are poor and rains are not adequate to enhance good yields thus the population dependents regularly on relief food. According to the welfare monitoring survey of 1997, Yatta District has 87.3 % of the population living below the poverty line (GoK, 2002). It is however clear that due to the high poverty levels in the district, most people rely on traditional biomass as the major sources of energy leading to increased deforestation and indoor air pollution therefore extensive *Jatropha* cultivation would play an important role in creating job opportunities and reclaiming degraded land.

2.4 Sampling Method

A multi-stage sampling technique was used in this study as illustrated in Figure 3 and systematic random sampling method was used to select the respondents.

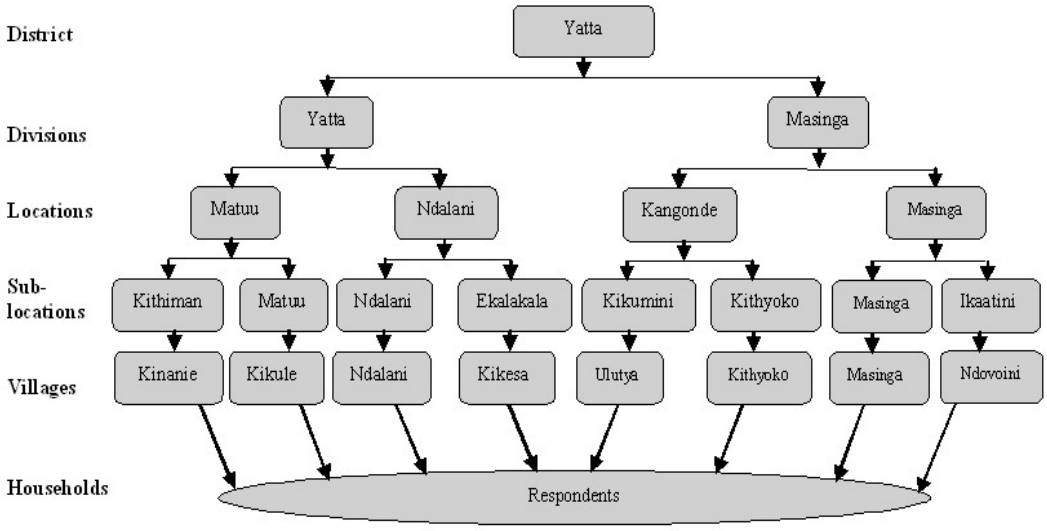


Figure 3: A schematic diagram of the sampling layout

This method was critical due to the extrapolation of sample results to district scenario. Yatta District was selected purposively since it was one of the districts where *Jatropha* activities were undertaken by promoting agencies. Cluster sampling method was employed to select two divisions purposively because they had the highest number of promoting agencies present. Cluster sampling method was further used to choose four locations randomly in the selected divisions because they have naturally occurring borders and groups were used rather than individuals. Systematic sampling was used to pick 2 sub- locations from each location because the names of all sub-location in selected locations were provided in a list form. The first and third names were singled out from each list containing the names of sub-locations in a location provided at the district resources center giving a total of 8 sub-locations. One village was selected from each sub-location on the basis of its location whereby the village at the extreme eastern border was picked.

Selection of respondents from each village was done using systematic random sampling method. Village shopping centers were used as starting points for selection of households then heading to the west and following identified village roads or paths households were picked at intervals of five whereby after selecting the first household, 5 households were skipped then the sixth household selected as second household. The process was repeated until 30 households were picked in each of the 8 villages.

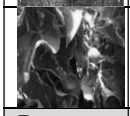
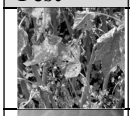
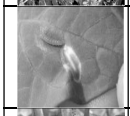
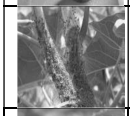
Questionnaires were administered to household heads but where the head was not available, the spouse was interviewed or any adult present in case the spouse was absent too. A total of 240 respondents were selected to constitute the sample. Sample size was determined using sample size algorithm as described by (Israel, 1992) based on the total number of households in the district which was 84,900, appropriate sample size was found to range from 215 to 280.

2.5 Data Collection

Data was collected using a structured questionnaire, FGDs, observation and use of key informants such as government officials and NGO officials.

Questionnaire was administered to farmers to collect information pertaining to adoption and challenges they experienced as *Jatropha* farmers. In total, 240 farmers were interviewed. Nineteen of the respondents were found to have returned insufficient data, so these were removed from the database resulting in a sample size of 221. In-depth interviews were held with District Agricultural Officer (DAO) and NGO officers. The observation method was used to confirm methods of *Jatropha* cultivation and storage methods. Observation was used to identify *Jatropha* disease and pests. The observation method was used to confirm methods of *Jatropha* cultivation and storage methods. Observation was used to identify *Jatropha* disease and pests Table 1.

Table 1: *Jatropha curcas* Pests and Diseases

Diseases	Name	Symptoms
	Wilt	Young and fully grown plants collapse in a very short time as if they do not get water. Indeed they do not get water, because the vascular system blocked by the fungus. The disease spreads from one plant to another, sometimes trough flood and open channel irrigation.
	Mites	Young plants get very thick and sturdy leaves with veins almost on top of the leaf service. Growing points will dry and the plant stops growing until a new flush starts provoked by rain or irrigation. It is a typical disease of nursery plants and recently planted plantations.
	Powdery Mildew	White powdery fungus mainly on younger leaves and stems. Most *Jatropha* plants get this disease in areas with low average temperatures and relatively high humidity. Although recently reported in dry areas.
	Leaf spotting	Red-whitish spots on leafs. Infects even grown *Jatropha* plants and may lead to falling of leaves and decline in yields.
Pest	**Name**	**Damage caused**
	Golden beetle	Causes harm as it eats young leaves and shoots, particularly on young plants.
	Leaf Miner	Physical damage, mainly on leaves
	Leaf Webber	Physical damage by causing web-like features on plant mainly on leaves
	Scutellarid bug	Sucks on fruits, diminishing yield

Source: (Achten W., et al., 2008)

2.6 Data Analysis and Presentation

Analysis was carried out using SPSS. Additionally, Pearson's Chi square (χ^2) test was used to determine statistical significance of the challenges reported, access to NGO training, communication channels used and adoption level in the District. Graphs, tables and percentages were used to resent the results.

3 Results and Discussions

3.1 Characteristics of Respondents

Socio-demographic characteristics of the respondents were established based on gender, marital status, age, education, monthly household income and the size of the household. Male headed households were significantly more among the adopters at 76.54% and non-adopters at 62.57% (Table 2).

Table 2: Socio-economic Characterization of *Jatropha* Adopters and Non-adopters

		ADOPTERS (N = 34)		NON-ADOPTERS (N = 187)		TOTAL (N = 221)		
Characteristic	**Category**	**N**	**%**	**N**	**%**	**N**	**%**	**p**
Gender (Household head)	Male	26	76.47	117	62.57	143	64.70	0.000
	Female	8	23.53	70	37.43	78	35.29	
Age	> 18 ≤ 30	6	17.65	94	50.27	100	45.25	0.000
	> 30 ≤ 45	28	82.35	43	22.99	71	32.13	
	> 45 ≤ 60	0	0	40	21.39	40	18.10	
	> 60	0	0	10	5.35	10	4.52	
Marital Status	Married	26	76.47	117	62.57	143	64.70	0.005
	Single	2	5.88	10	5.34	12	5.42	
	Divorced	3	8.82	28	14.97	31	14.02	
	Widowed	3	8.82	32	17.11	35	15.83	
Respondent Occupation	Small Business	3	8.82	96	51.34	99	44.80	0.139
	Peasant Farmer	31	91.18	91	48.66	122	55.20	
Monthly Household Income (KShs)	< 3000	16	47.06	42	22.46	58	26.24	0.025
	> 3000 ≤ 6000	7	20.59	69	36.90	76	34.39	
	> 6000 ≤ 9000	5	14.71	51	27.27	56	25.34	
	> 9000	6	17.64	25	13.37	31	14.03	
Education level	Informal	3	8.82	42	22.46	45	20.36	0.010
	Primary	3	8.82	93	49.73	96	43.44	
	Secondary	28	82.35	43	22.99	71	32.13	
	College	0	0	9	4.81	9	4.07	
HH size	Between 1-3	2	5.88	34	18.18	36	16.29	0.001
	Between 4-6	25	73.53	118	63.10	143	64.71	
	over 7	7	20.59	35	18.72	42	19.00	

This could have been contributed by the fact that land ownership in the African society belongs to men although women who do most of the farming. Majority of the adopters (82.35%) were aged between 30 to 45 years probably because this is the most productive age in human life and the adopters were striving to achieve economic stability through *Jatropha* cultivation. However, although most of them had secondary education level (82.35%), they were peasant farmers (91.18%) perhaps because of the high level of unemployment in the country especially for people with basic education. Most of them had a monthly income of less than 3000 KShs (47.06%) since farming in the region is not rewarding because of the unreliable rainfall patterns. While majority of non-adopters were aged between 18 to 30 years (50.27%) and had monthly income range of between 3000 to 6000 Kshs. Monthly income for the non-adopters was higher than for adopters which was a likely reason why adopters were seeking for additional means of livelihood in *Jatropha* cultivation. Majority of both adopters (73.53%) and non-adopters (63.10%) had an average household size of between 4 to 6 members which agrees with (GoK, 2010) that most of the household sizes in the county lie within that range.

3.2 Trend of Jatropha curcas Adoption

As indicated in (Munini C. et al., 2013b), on average only 15.4% of the farmers in the district were involved in *Jatropha* cultivation. This was low compared to other major crops grown in the District which included maize at 86.4%, beans at 31.2% and pigeon peas at 47.5%. This was probably because farmers had been growing these crops longer and they had sufficient knowledge on their cultivation practices and had government support compared to *Jatropha*. Still since the hypothetical *Jatropha* benefits were not realized, despite the numerous programs that promoted its cultivation in the District, farmers remained reluctant to cultivate it.

The low adoption in the district was to a great extent attributed to numerous factors identified and analyzed as key drivers for sustainable adoption process reported in (Munini C. et al., 2013b). Some of the factors included inefficient strategies used in promotion, land unavailability, low profitability compared to main crops grown, poor plant management without any inputs and a myriad of challenges identified such as lack of market and marketing facilities, inadequate knowledge on cultivation practices and the attitude of farmers towards *Jatropha*. This finding concur with Mitchell (2008) that some of the key issues that could inhibit take up of *Jatropha* are land unavailability, low profitability of *Jatropha* as compared to other crops and market unavailability.

Farmers who grew *Jatropha* before 2002 were 8.8% in the District. There was a sharp increase in adoption in the district by 2006 to reach its highest level of 44.1% as indicated in Figure 4.

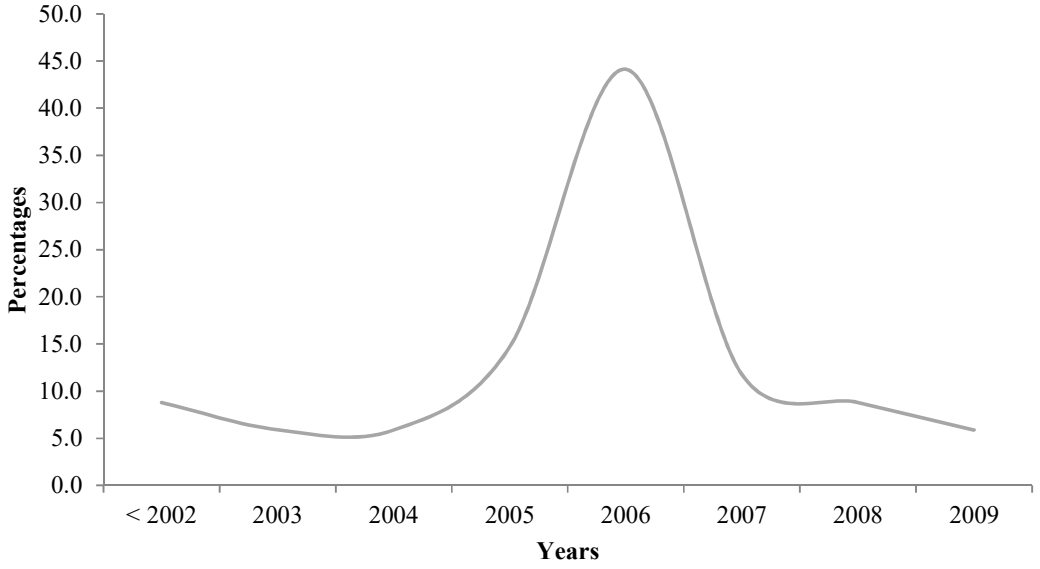


Figure 4: Trend in Adoption of *Jatropha* in Yatta District

In 2007 one year after distribution of free planting materials and trainings by GAF began, adoption levels dropped significantly in the district to 11.8%. Subsequently there was a steady reduction of *Jatropha* take up since the exit of the NGO.

The low adoption of *Jatropha* witnessed before 2002 in both divisions was partly attributed to low awareness on the perceived economic and environmental benefits that were associated with *Jatropha* cultivation then. All the farmers who grew *Jatropha* before 2002 indicated it was for cultural purposes; for protection against evil spirits. Increased adoption of *Jatropha* in 2006 was to a greater part attributed to entry of GAF in the district to promote *Jatropha* cultivation. Although adoption was significantly increased in 2006, 70.6% of *Jatropha* farmers preferred the hedgerow cultivation system Table 3.

Table 3: Cultivation Systems Applied in Yatta District

	Plants planted initially					Surviving plants during survey			
Cultivation system	**%**	**Mean**	**Min**	**Max**	**Std. Dev**	**Mean**	**Min**	**Max**	**Std. Dev**
Hedgerow	70.6	51	20	80	23.37	13	7	35	7.24
Monocrop	5.9	375	250	500	176.77	35	25	45	14.14
Intercrop	23.5	60	30	80	22.678	17	10	24	6.77

This implied that *Jatropha* coverage in the area was negligible because on average of 13 plants were surviving under hedgerow cultivation mode, 35 under monocrop and 17 for intercrop modes. On average 77 plants survived out of the average 97 *Jatropha* plants grown per household implying that not all land allocated for *J. curcas* cultivation was actually under *J. curcas* because of high plant failure during early years of growth (Munini C. et al., 2013b).

3.3 Promotion Strategies Used by Agencies to Enhance Jatropha Cultivation

NGOs and private investors were the main agencies promoting *Jatropha* in Yatta District. Green Africa Foundation was a focal NGO in the promotion of *Jatropha* in Yatta District. Among strategies it employed was provision of *Jatropha* planting materials, and training farmers on nursery practices and expected *Jatropha* benefits. Asked why they grew the plant, 82.36% of the adopters reported they grew *Jatropha* because they obtained the planting materials freely either from neighbors and friends or from GAF Table 4.

Table 4: Reason for Growing *Jatropha*, Planting materials and Sources of Planting Materials

Reason for growing *Jatropha*	**Frequency % (N = 34)**	**Source of planting material**	**Planting material type**
Obtained free planting materials	17.65%	Neighbours and friend	Cuttings
	14.71%	Neighbours and friends	Seeds from mature *Jatropha* trees
	50.00%	GAF	Seeds
For shed	2.94%	Neighbour and friends	Cutting
Cultural purposes (Protect farms from evil spirits)	8.82%	Found them in their farms	Not aware
Biodiesel production	2.94%	Green fuels Kenya Limited	Seedlings
	2.94%	GAF	Seedlings

Distribution of free planting materials by agencies to farmers in efforts to increase adoption amounted to giving subsidies and thus did not guarantee sustained adoption. Minimal yields of 0.125kg/tree/annum realized for hedgerows reported by (Munini C. et al, 2013a) and non-establishment of a *Jatropha* extraction plant also contributed to reduced adoption from 2007 onwards. This finding agree with (Sharma & Pradesh, A., 2006) who pointed out that giving farmers free planting materials did not guarantee a sustained adoption and instead it creates a dependency syndrome among the *Jatropha* farmers. Also agrees with (GTZ, 2009) that as farmers got near-nil yields of *Jatropha* seeds in the first 2-3 years and estimates were very low for 4-6 years (<1.0 kg/tree), many abandoned the crop.

Economic viability of *Jatropha* production is a factor of production cost, yield, and market price. Farmers' decisions on adopting *Jatropha* production depend upon the returns that they expect to generate. Gross margin of *Jatropha* was not competitive compared to cultivation of maize, beans and pigeon peas in Yatta District (Munini C. et al., 2013a). (Iiyama, et al., 2013) also argued that *Jatropha* requires fertilizer, water, and good management in order to produce optimal yields.

3.4 Level of Training on Jatropha curcas Benefits

Although 41.2% of all farmers interviewed had prior *Jatropha* knowledge either through formal trainings or informal sources, uptake was only 15.4% Table 5.

Table 5: Level of Training among Adopters and Non-adopters

	Adopters (N = 34) %	**Non-adopters (N = 187) %**	**Total (N= 221) %**	**Trained on**	**By whom**	**Duration of the training**
Formal Training	8.8	3.8	4.5	- *Jatropha* Nursery practices - Plantation establishment and management - *Jatropha* potentials	GAF	1 week
Informal knowledge	91.2	26.7	36.7	- Expected benefits with the establishment of a *Jatropha* extraction plant	Informal sources	N/A
No prior knowledge	N/A	69.5	58.8	N/A	N/A	N/A

Being aware of its potential benefits, plantation establishment and management did not translate to its take up. This was probably because only 4.5% of farmers interviewed had been trained formally or they were not convinced about *Jatropha* due to high reliance of informal sources of knowledge which contributed 89% of knowledge source with formal training contributing a meager 11%.

Lower adoption compared to awareness levels was also attributed to unwillingness by farmers to engage in non-food crop taking into consideration that the region is prone to perennial droughts and food shortages.

3.5 Communication Channels Used in Awareness Creation

The manner in which information on *Jatropha* was disseminated to farmers was important to boost awareness levels. Neighbors and friends were the major sources of awareness creation at 76.9% of information while the least used was the church at 1.1% as shown in Figure 5.

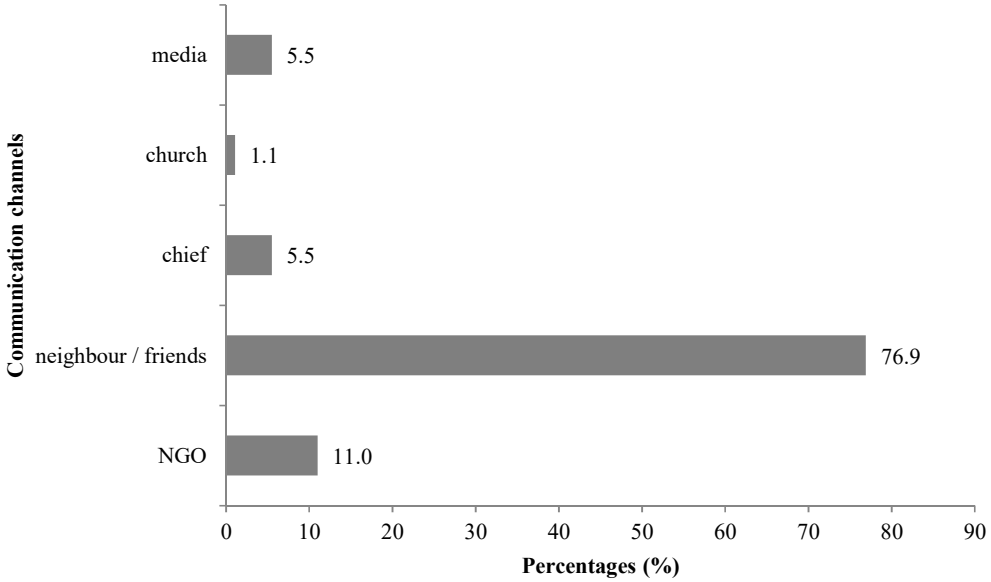


Figure 5: Sources of information used to create awareness

Neighbors and friends were the key sources of information and hence the credibility of information disseminated to farmers was questionable. Little success in the establishment and development of *Jatropha* farms had a negative impact on yields.

Provincial administration specifically area chiefs in the area were involved in the mobilization of farmers during bazaar meetings. They also provided insight on benefits that can possibly be obtained from *Jatropha* plant. Credibility of information passed on by area Chiefs was questionable as they are short of knowledge on *Jatropha* production and value chain development.

3.6 Impediments to Enhanced Jatropha curcas Adoption in Yatta District

Barriers hindering augmented *Jatropha* cultivation in Yatta District were identified and grouped in to five broad categories namely: technical, environmental, institutional, socio-economic and cultural.

3.6.1 Technical Constraints Experienced during *Jatropha curcas* Cultivation

Lack of knowledge on the scientific method of cultivating of *Jatropha* was a significant constraint under the technical constraints pointed out by farmers at 85.3% in the district ($p = 0.000$). However, lack of knowledge on nursery practices was not a significant constraint ($p = 0.170$). Lack of awareness on how to extract oil from *Jatropha* nuts was another major constraint reported as indicated in Table 6.

Table 6: Technical Constraints Experienced in Yatta District

Technical constraints	**N**	**p**
Inadequate knowledge on scientific cultivation of *Jatropha*	29	0.000
Inadequate technical guidance and information	25	0.006
Inadequate knowledge on how to extract *Jatropha* oil	25	0.006
Inadequate knowledge on raising *Jatropha* nurseries	21	0.170

Inadequate knowledge on raising *Jatropha* nurseries was perceived as less important constraint by *Jatropha* farmers because majority of farmers in the region were not willing to venture in to the business of raising and selling seedlings owing to the dry conditions of the place.

3.6.2 Environmental Constraints Experienced during *Jatropha curcas* Cultivation

Inadequate rainfall to enable survival of young *Jatropha* plants was indicated as a major environmental constraint as shown in Table 7.

Table 7: Environmental Constraints in Yatta District

Environmental constraints	N	p
Inadequate rainfall	31	0.000
Pest and disease attacks	29	0.000
Extreme degraded soil conditions in the farm	15	0.493

An attack by pest and diseases was ranked second in the district. The constraint that was insignificant was extremely degraded conditions of soil in the farms at 44.1% in the district (p = 0.493).

Pests and diseases were reported in 82.4% of *Jatropha* farms in Yatta District. Wilt disease was significantly the highest accounting for 58.8% (p = 0.000) followed by mites at 44.1% and the least reported disease was powdery mildew at 26.5% as indicated in Table 8.

Table 8: Diseases Reported by farmers

Disease Name	Prevalence in %
Wilt	58.8
Mites	44.1
Powdery Mildew	26.5
Leaf Spotting	35.3

Wilt disease was the most severe because it infected young *Jatropha* plants making them to wither and eventually die. This disease contributed greatly to the low survival of *Jatropha* plants during the first year of growth. Leaf miner was the main pest at 82.4% farms followed by golden beetle at 73.5% while the least reported pest was scutellarid bug at 41.2% as indicated in Table 9.

Table 9: Insect Pests Reported by Farmers

Pest Name	Prevalence in %
Golden beetle	73.5
Leaf webber	50.0
Scutellarid bug	41.2
Leaf Miner	82.4

Leaf webber was the most severe as it formed web like cover on stems inhibiting development of new shoots. This reduced seeding and growth of leaves making the plant impoverished. Although there was high pest and disease attacks, pest and disease control was not practiced. This agreed with (Mogaka, et.al., 2014) that many farmers in Bondo, Kibwezi and Kwale Districts reported pests, mainly golden beetle and red spider mite and diseases mainly fungi, powdery mildew, and leaf spotting and further agreed that only few farmers applied pesticides.

3.6.3 Institutional Constraints Experienced during *Jatropha curcas* Cultivation

Lack of marketing facilities to sale *Jatropha* nuts was one of the significant constraints reported at 94.1% in the district (p = 0.000) as shown in Table 10. Lack of finance facilities was an important constraint too reported at 91.2% overall in the district (p = 0.000). As indicated in Table 10, most of the institutional constraints were significant constraints apart from lack of motivating agencies (p = 0.640) and inadequate training facilities in the area (p = 0.732)this implying that they were not viewed as important constraints.

Table 10: Institutional Constraints in Yatta District

Institutional constraint	N	p
Lack of marketing facilities	32	0.000
Lack of financing facilities	31	0.000
Non-availability of oil extraction unit	29	0.000
Absence of procurement policy by government	27	0.000
Lack of motivation agencies in the area	17	0.640
Inadequate training facilities	18	0.732

The institutional constraints partly agreed with findings of Meena (2005) that lack of policies to guide stakeholders and investors could adversely affect *Jatropha* adoption. Likewise, sustainable adoption of *Jatropha* cultivation is greatly influenced by market availability and accessibility. Farmers in Yatta District pointed out that lack of a ready market and inadequate knowledge to process *Jatropha* by-products like soap compounded their plight.

Lack of knowledge on extraction of *Jatropha* oil by farmers would inhibited take up of *Jatropha* cultivation. Muller (2007), agreed by indicating that the success of *Jatropha* cultivation in Mbinga region in Northern Tanzania was attributed to the distribution of pressing equipments by Sun Biofuels and the ready market for the oil to run gensets in lighting nearby villages and social institutions. Technical findings agreed strongly with Neelam (2006) who indicated that lack of knowledge about management of *Jatropha* trees and lack of a complete *Jatropha* value chain limited its adoption.

Further, Tattersall (2007) pointed out that the successful commercialization of *Jatropha* cultivation in

Mali Simiji village was due to the availability of extraction plants at farmer level for domestic lighting and generators for street lighting. In consequence of market unavailability and shortage of marketing facilities in Yatta District, it was common to observe ready *Jatropha* nuts hanging on the trees not harvested and as a result, some yield certainly go to waste each year.

3.6.4 Socio-economic Constraints Experienced during *Jatropha curcas* Cultivation

Lack of market for *Jatropha* produce was a significant constraint reported in the district at 97.1% (p = 0.000) as indicated in Table 11.

Table 11: Socio-economic Constraints in Yatta District

Socio-economic constraints	**N**	**p**
Lack of market for *Jatropha* nuts	33	0.000
Non-improved varieties of *Jatropha* seeds	29	0.000
Insufficient labor during work season	25	0.006
Inadequate land for *Jatropha* cultivation	21	0.170
Lack of irrigation facilities for raising seedlings	19	0.493
Non-availability of planting materials	13	0.170
High cost of production inputs	11	0.090

As a result of lack of market majority of the *Jatropha* farmers had stored their *Jatropha* harvests as indicated in Figure 6.

Figure 6: *Jatropha curcas* farmer displaying stored yield

Lack of clear market was a big challenge among *Jatropha* adopters in Yatta District. This was contributed to the fact that much of the emphasis was on production and there was a clear disconnection from the processing and marketing stages (Iiyama, et.,al, 2014). As reported also in (Iiyama, et.al., 2014), the only existing market was an unsteady one for seeds and other propagation materials from fellow farmers.

Non-improved varieties of *Jatropha* seeds that could result to high yield was an important constraint at 85.3% (p = 0.000). As indicated in Table 5 above, socio-economic constraints that were not significant were inadequate land for *Jatropha* cultivation (p = 0.170), lack of irrigation facilities (p = 0.493) and non-availability of planting materials (p = 0.170).

3.6.5 Cultural constraints Experienced during *Jatropha curcas* Cultivation

Reluctance by farmers to venture in to a new crop was a significant constraint identified by the adopters accounting for 88.2% in the district (p = 0.000). However, as shown in Table 12, only 47.1% of respondents in the district associated *Jatropha* plant with evil spirits. Consequently, traditional beliefs associated with *Jatropha* plant was not a significant constraint (p = 0.732).

Table 12: Cultural Constraints in Yatta District

Cultural constraints	**N**	**p**
Reluctance to cultivate a new crop	30	0.000
Traditional beliefs associated *Jatropha*	16	0.732

3.7 Government Involvement

Little efforts particularly by the government to enhance *Jatropha* cultivation in the country contributed

significantly to the observed low adoption in the study area. There was no involvement of agricultural extension officers in either promotion of *Jatropha* or provision of extension services to *Jatropha* farmers. Government officers involved in the promotion were the area chiefs who lacked capacity on *Jatropha* management practices. There is no biofuel policy in existence in Kenya to stimulate *Jatropha* development which contributes greatly to the low take up.

Although *Jatropha* is publicized as a potential crop that could enable all the actors in biofuel value chain benefit this study revealed that current conditions are not consistent with the expected outcomes. From the investor perspective, it may not be worthwhile to invest in *Jatropha* biodiesel production due to the low profits realized. For smallholder farmers, the desired rural economic benefits would hardly be achieved by simple introduction of *Jatropha* production to communities without supervision of all actors, and energy security would not be attained under prevailing policies.

According to Tanja *et al.,* (2009), the government can play a vital role in securing favorable conditions of *Jatropha* production, formulating effective policies and enacting regulatory and legal frameworks aimed at sustainable production of biofuel industry and utilization. Government involvement through legislation of proper fiscal policies related to biofuels could enhance access to finance by smallholder farmers.

Ministry of energy officers indicated that the ministry in 2006 a released biodiesel strategy that made a number of prudent recommendations to promote and develop the biodiesel industry in Kenya. Ministry of energy also indicated that *Jatropha* cultivation in Kenya was at its emerging stage. After the production of a draft biodiesel strategy paper in 2009 by a National Biodiesel Committee which was comprised of a few leading Kenyan NGOs and participants from private, public sectors and NGOs, to provide guidelines on production that complied with existing policies. However, the plans and strategy never materialised and interest faded after the collapse of the hype (Iiyamaet al., 2014).

KARI indicated that many of the *Jatropha* projects that were driven by NGOs and development organizations seemed primarily focused on selling seeds and getting *Jatropha* trees planted as quickly as possible. In the rush to move forward, too little attention was paid to coordinated research and development of high yielding seed provenances and general agronomic advancements of growing *Jatropha*. Improved germplasm was important for optimal *Jatropha* yields (Iiyama, et al., 2013).

4. Conclusion and Recommendation

Conclusion

Based on the results and discussions in preceding sections, the following conclusions are drawn;

There was low *Jatropha* adoption in Yatta District despite free planting materials being dished out to farmers. This was due to inadequate knowledge on management practices of *Jatropha*, low awareness levels, lack of profits, unavailability of markets for *Jatropha* nuts, poor climatic conditions in study region, and land unavailability for *Jatropha* cultivation as mentioned in Munini et.al. (2013b).

Awareness did not influence *Jatropha* cultivation as inefficient promotion strategies were used to create awareness. Among the inefficient promotion methods included; giving free planting materials without proper training on how to grow them, promoting *Jatropha* in chief's meetings and poor criterion of selection of farmers to be trained on *Jatropha* cultivation.

Lack on of knowledge on value addition on *Jatropha* nuts harvested impacted negatively to market availability hence the low adoption in Yatta District.

Until technology becomes available to provide solutions that are economically competitive, socially and culturally acceptable, and readily available, it is unlikely that *Jatropha* will benefit significantly rural households in cash and non-cash ways due to the numerous technical, socio-economic, institutional, environmental and cultural challenges experienced by *Jatropha* farmers in the District.

Recommendation

It is recommended that *Jatropha* production in Yatta District is not a rational option at the moment due to the many challenges experienced by farmers such as lack of market, non-improved germplasm, and little technology on *Jatropha* management among others discussed in the paper. Also before promoting the plant in the region, it is necessary to carry out further research on pests and disease control and improved *Jatropha* seeds in order to improve on yields and have a biofuel policy in place to ensure streamlined *Jatropha* value chain and development of biofuels industry as a whole.

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