Refined Indigenous Knowledge as Sources of Low Input Agricultural Technologies in Sub-Saharan Africa Rural Communities: Nigerian Experience

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Abstract
The majority of farmers in sub-Saharan African are small-scale entrepreneurs whose farm operations are performed with low input agricultural technologies. Many of these technologies are supported with low input farm power and simple machines. Essentially, low input agricultural technologies are embodied in the refined indigenous knowledge systems. These include technologies for land preparation, use of draught animals, natural/organic substitutes for inorganic pesticides and fertilizers, seeds multiplication techniques, mushroom production technique, alternative to electrical incubation technologies, animal protein supplements including silage and hay production technologies, wind mills, simple irrigation and drainage methods, low input processing as well as simple tools technologies. This paper illustrates the above listed low input technologies for sub-Saharan Africa rural agrarian communities using experiences from Nigeria.

Introduction
Agricultural activities/enterprises in sub-Saharan Africa are in the hands of small-scale farmers. These farmers dwell in the rural communities characterized with low population density in either dispersed or nucleated settlements. The hallmarks of these farmers themselves include poverty, which results in low capital investment, low formal education qualification, small farm size, and holding, use of crude implements and use of low agricultural input technologies. Agrarian activities in sub-Saharan Africa are very much affected by seasonal variation because majority of the farmers practice rain fed agriculture. The macro economic and political environments under which sub-Saharan Africa rural communities exist often have little or no regard for the welfare of small-scale farmers. This is reflected in erratic changes of agricultural policy instruments such as placement and lifting of bans on agricultural products competing with local output, unnecessary delays in administration of agricultural credit, high interest rate with little or no moratorium. Other adverse conditions experienced by the farmers include high cost of inputs and technological know-how/farm mechanization leasing services and inefficient extension services.

Idachaba (2006) noted that small-scale farmers suffer from the low political cost of agriculture and rural neglect by political leadership. This results in disdain on agriculture and small-scale farmers. In spite of these problems, agriculture is a dominant industry in sub-Saharan African, which under employed the largest labour force. Over 80 percent of inhabitants of sub-Saharan African engage in agriculture, the marginal productivity of labour is almost zero (Arene and Mkpado, 2004). But they produce about 90 percent of the sum agricultural output in sub-Saharan African (UNDP, 1995). Agriculture- the occupation bequeathed to humanity by nature has thrived on the use of indigenous knowledge as sources of low input technologies. The need for food security in sub-Saharan Africa with increasing population, abundant human and local material resources as well as very limited capital, demands improvement in the use of low input technologies. This will ensure efficiency and sustainability of agrarian practices among the small-scale farmers. The refined/improved indigenous knowledge has been defined as “those technologies conceived, planed and designed within the framework of modern scientific disciplines which may be imported, adopted and indigenized so that local scientists may reconstruct them and improve on the process and quality of the products” (Ikeme and Uvere 1995).

The adverse macro-economic and political environment under which the needy small-scale farmers operate indicates that increasing agricultural production will depend on the use of low input technologies with the view to minimizing cost and producing satisfying output. Refined indigenous knowledge forms a set of easily available low input resource/technologies which efficient usages is imperative to optimizing production (Mkpado and Ugwu, 2006). But lack of proper recognition and efficient usages of the low input technologies have reduced yield of small-scale farmers in sub-Saharan Africa. This paper thus, aims at highlighting the low input agricultural technologies. The leading questions that guided the study are: What are the low input technologies? What are their sources?" And what are their specific uses? Sound answers to the above questions will not only create more awareness of the low input technologies but also motivate extension staff to increase effort on transfer and encouragement of small-scale farmers to adopt them.

Methodology
Coverage: the research covers agrarian practices in sub-Saharan Africa rural communities using Nigeria as an example. Sources of materials are literature search and observation of field activities.

Result and Discussion

Low input technologies in crop sub-sector

Land preparation: The use of ruminant farm animals such as cattle, sheep and goats to clear bushes and old stalk residues of harvested crops is an interesting aspect of mixed farming yielding low input technology for land clearing. The ruminants are let into the field to clear the bush and residue of harvested crops. Tilling and ridging may involve the use of work/draught animals in tilling and ridging the field. With the aid of a yoke/lever, a drawn implement is attacked to a bull /bullocks, under the supervision of a farmer, the land tilling or ridging processes begin.

Low input technologies in organic farming food crop enterprises

Low input technologies used in maintaining soil fertility are ashing cattle manure, green manure, mulching, urine- manure slurry and manure tea technology.

Ashing cattle manure: cattle droppings are burnt on the farm prior to on set of the rains. The burning kills pests and pathogens as well as lowers the frequency and cost of weeding by destroying weed seeds. The ash improves soil P^H and ability of the soil to hold moisture. IIRR (1998) reported that farmers in Zambia use this technology to reduce the cost of chemical fertilizers and irrigation by 50 percent. The practice can be repeated with wood shavings and rice husk

Green manure technology: Green manure consists of fast growing plants on piece of land to improve soil fertility and protect the soil from erosion. This technology includes the use of cover crops and legumes for nitrogen fixation purposes. *Azolla piñata\Anabaena azollae* symbiosis technology: This is a type of green manure used in swamp and irrigated rice production. *Azolla piñata* which is a free floating small fern in symbiosis association with *Anabaena Azallae*- nitrogen fixing algae is a low cost source of nitrogen. This association can fix up to 100-170/kg N_2/ha/yr (Iloba, 1997). In Northern Senegal where farmer apply high Nitrogen rate of about 120 kg/ha about 50% of mineral nitrogen can be produced by Azolla plant. This technology has completely replaced mineral Nitrogen at the recommended rate of 40 kg of N/ha. *Azolla Piñata* also aids weed control under irrigated fields (Iloba, 1997). The farm is usually inoculated with the algae before introduction into the field for optimum yields.

Alley Farming Technology: It is a multipurpose agro-forestry system involving the cultivation of nitrogen fixing tree crops in rows sufficiently spaced to accommodate 4-6 rows of food crops. In other words it is the production of food crops in alleys in between hedge-rows of fast growing trees and shrubs such that biomass from these hedge-rows are occasionally pruned to provide organic materials for soil fertility and staking materials (Ruhigwa, 1995; Kang 1996). It is a source of green manure, improves soil characteristics and status, control erosion and supply fuel wood (Akalusi and Chomini 2006). Nwakpu et al, (2006) have demonstrated the profitability of the low input technology in Ebony state, Nigeria.

Urine-manure slurry technology: Slurry (a thick liquid mixture) of animal manure and urine from a livestock shed makes good organic fertilizer because it is rich in Nitrogen and organic matter (Kuye et al, 2006). It is usually applied directly around the crop stand.

Manure tea technology: Fresh manure from cattle, chickens, goats, rabbits or sheep in a mixture is diluted for folia application/top dressing. It promotes vegetative growth and fruiting (Kuye et al, 2006). Tea manure can also be produced with the entire Tithonia plant *(Tithonia glicidia)* the Tithonia or false sun flower, although not a legume accumulates large amount of Nitrogen and phosphorus from the soil. When it is cut fresh and incorporated in to the soil, it rots quickly releasing its Nitrogen into the soil within two weeks. Sena (cassia) a leguminous tree species commonly used as organic fertilizer takes 4-8 weeks to release all its nitrogen. Tables 1 and 2 contain a number of other sources of green manure. Other sources of low cost input organic manure include compost and farm yard manure which preparation is simple.

Cereals and pulses low input pest control and storage devices: Grains and legumes are commonly stored in airtight containers and bags but due to poor management of the structure, pests, often destroy these valuable. A number of cheap item such as pepper fruits, ash, lime, leaf, back of *Eucalyptus spp* and neem seeds, are active against pests of cereals and legumes such as weevils and beetles. A grinded mixture of two or more of the items applied at the rate of 10-20g per kg of the stored products offers protection for about one year (Nwachukwu, 2007). Powdered cocoyam gives some protection against Flour beetles, due to the presence of calcium oxylate in its tissue. Other storage facilities in which these chemicals can be used include rhombus and cribs.

Low input bio-pesticides in organic farming

Bio-pesticides are cheaper to produce and easy to use. About 235 plant families produce over 24,000 species known and use as bio pesticides (Ahmed Stoll, 1996; Ahaured and Grainge, 1986; Kuye et al, 2006) see table for detailed preparation and use of bio-pesticides. Tithonia plant acts as a natural pesticide against nematodes and many are effective in controlling striga weeds. Tables 4 and 5 contain a number of bio- pesticides and their uses.

Mycorrhizae Inoculation Technology

Some plant nutrients such as copper, zinc, and particularly phosphorus in soils may not exist in sufficient quantity or exist in a state that the crop may have access to them. Vesicular Arbuscular Mycorrhiza(e) VAM which is a typical endomycorrhizal symbiosis is a low input technology to overcome the above problems. During seed treatment, innoculation with VAM spores ensures the effective symbiotic association in root development. Other advantages of VAM mycorrhizal association include reduction in the effects of various fungal pathogens, suppressing the effects of parasitic nematodes on diverse agricultural crops; It has also been shown to enhance water uptake in soybeans; increase plant tolerance to toxic heavy metals, saline soils and drought, decrease transplanting shock and bind soil into semi stable aggregates. Even legume plants with VAM are often better nodulated than non mycorrhizal plants, especially in soils with low available phosphorus. (Mark and Schenck, 1983).

The fungi forming VAM belong to the class of Zygomycetes and the family Endogonaceae, which include the genera Glomus, Gigaspora, Acaulospora, Sclerocystis, and Endogene. These fungi have little or no host specificity and exist in both tropical and temperate region. It has been noted that VAM fungi may not be grown on laboratory culture media (Mark and Schenck, 1993). They can be grown easily in natural habitats after which their spores will be isolated for use during seed treatments of crops with poor root development such as onions or crops with abundant fine feeder roots and root/ hairs but grown on poor soils. Farmers are encouraged to purchase their seeds from research institutes to benefit from these technologies.

Low input technologies for seed multiplication

Stock damping technology: This is an asexual method used in multiplication of seeds of perennial crops such as pineapples, plantains and bananas. The stalk is immersed in a damp sawdust and wood shave mixture and exposed to moderate sunshine. The stalk can be split into two or more if it is very large. Regular watering is required for quick sprouting and development of suckers.

Yam Mini-set Technology: This is used to produce seed yams. It was developed by collaborative efforts of National Root Crops Research Institute (NRCRI) Umudike and the International Institute for Tropical Agriculture (IITA) Ibadan. Seed yams production using the yam mini-set technology is as follows (Uguru 1996; IMADP, 2005):

i) Select healthy ware yams
ii) Cut off the head and tail ends of the selected ware yams
iii) Cut the ware yams into several pieces like dices each about 3 cm long
iv) Cut up each 3 cm disc into four quarters. Each of these now form the mini-set weighing about 35g; while cutting, do not peal off the back of the ware yam.
v) Put about 150 mini set into a

container with lid or a bag, spray 2 sachet of adrine dust on them and cover the container\bag. Shake them very well until all the mini-sets have been dusted with the seed protection dust.

vi) Spread the dusted mini-sets on a dry floor to allow the cut surface to dry cup (curing)

vii) Plant the mini-sets on ridges at 50 cm intra-row spacing by 1m inter-ridge spacing with the cut surface facing upwards. This gives 40,000 stands /ha

viii) Mini-sets should be planted when rains becomes regular

ix) The mini sets can be grouped from head, middle, and tail region of the ware yam. This helps to obtain uniform sprouting, which may aid staking where necessary.

x) Weed the plant at about 3 weeks and 8 weeks after planting respectively.

xi) Control insects such crickets, caterpillar, grasshopper with broad spectrum insecticides

xii) Staking is required in very humid regions

xiii) Within 3-4 weeks of planting, apply 8-10 bags of NPK 15:15:15 per hectare or 10 tonnes of poultry manure at the time of planting and supplement with 4-5 bags of NPK per hectare after 3 weeks.

xiv) Harvesting starts when the veins and leaves are dead. This occurs in about 7-8 months after planting.

xv) The seed yams are stored in barns for planting next season

Low Input Artificial substrate technology for mushroom cultivation

The method is as follows:

1. Select a suitable substrate such as wood logs or fiber from processed palm fruits, maize spathes or other fiber.
2. Allow the substrate to ferment; subsequently pasteurize it.
3. Sterilize the substrate; sterilization can be done by suspending the substrates in jute bags above drums of water such that only steams from the boiling water can sterilize the substrate.
4. Steaming can last for 3-6 hours, then allow to cool
5. Housing: There should be enough light in a mushroom house. Once a print can be read in the day in such a house, it is suitable for mushroom production. However, some mushroom prefer the dark with no ventilation for colonization of the mycelia
6. The cooled substrate is introduced into the room and the desired mushroom spores are introduced on the substrates.
7. Water regularly to sustain the growth of inoculated materials
8. Harvesting can last up to six weeks
9. Harvested mushroom is better packed in paper, which absorbs water and allows air to pass through. 1-1.5 kg of mushroom ca be packed in a box/basket which allows ventilation

Low input technologies in Snail Farming

This is apparent in construction of a snailery. Snaileries of this sort are:

a) **Hutch boxes:** These are pens, which are square, or rectangular, single multi-chamber or wooden boxes with lids. The boxes are placed on wooden slits above the ground. In the middle of the lid is an opening covered with wire netting or nylon mesh. In the floor of the box are a few holes through which excess water can drain out. The boxes are filled with sieved block soil to depth of 18-25 cm. The pen is ideal for hatching and nursery activities.

b) **Trench Pen:** Building a trench pen involves digging a square or rectangular hoe in the ground, of about 50 cm deep, and dividing it up to pens. The sides of the trench pens are built of blocks and the bottom covered with loose sandy soil and gravel. The upper ends are covered with nylon mesh nailed\fitted to wooden frames with a window/door. This pen is ideal for hatchery and nursery operation

c) **Mini-paddock pens:** These are square or rectangular pens usually erected within a large fenced area. They are built of timber or bamboo, with wire netting or nylon mesh. The walls of a mini paddock should be about 50 cm high and dug at least 15 cm into the ground. In order to prevent snails from escaping, horizontal wooden frames are attached to the top of the fence and covered with the mesh. Mini-paddock pens are ideal as fattening pens. Within the pens, plants that provide shelter and/or serve as source of food such cocoyam, sweet potatoes, waterleaf and African spinach are grown.

Low Input Incubation technologies

The waterbed incubator

This was introduced to technical staff of Bauchi State Agricultural Developemnt Programme by Chinese Personnel Courtesy of South-South cooperation (Sulaiman et al, 2006), with little modification to match the materials culture in sub-Saharan Africa for rural populace adoption; it is capable of hatching over 1000 eggs per sequence. The incubator does not require electricity

Materials required are:

1. A hatchery room either thatched house or concrete house, which is well disinfected (2) mud bricks, (3) iron sheets, (4) kerosene, (5) polyethylene bags, (6) wood Ash, (7) blanket (quilt), (8) thermometer, (9) Rice straw or sawdust.

Preparation of waterbed incubator

The steps are:

1. Select a suitable corner of the hatchery room; build two walls with the bricks (mud or cement) to make a rectangular or square with the chosen corner. The height and length should be about 0,8m and 1.7m respectively. Another wall should be built inside the other two sides to make them double walled. The height of the new wall should be 0.9m while the length remains 1.7m. At the height of 0.60m, very strong plywood of 0.45m should be placed on the bricks on either ends of the building before you continue the laying of the blocks. The width is determined by the polyethylene bag to be used. An opening through which the kerosene stove will be passed into the middle of the incubator should be provided.
2. Lay the iron sheet at the same level with the 0.45m plywood (wooden board) to cover the remaining space at the middle; the wooden board should be higher than the iron sheet.
3. Pour wood ash on the iron sheet up to 3 cm thickness and then spread the rice straw on the top of the wooden board. The rice straw should be thicker than the wood ash.
4. Lay the polyethylene bag on the top of the ash and straw. Fill the polyethylene bag with water such that it looks like a pad
5. use blanket to cover the polyethylene bag to conserve heat
6. prepare a good kerosene stove
7. Put the stove under the iron sheet at the middle of the bed with a gap of 22-24cm between the iron sheet and the top of the stove
8. Ensure that the stove produces a steady blue flame that burns uniformly; when the temperature is abut 39^{o}C incubation can start.

C. How to use the incubator

1. Select fertile eggs for incubation with the aid of egg candler
2. Sterilize the selected eggs. This can be done by fumigation
3. Heat the eggs to about 35^{o}C or under sunlight for about 1-2 hours before incubation. This increase the incubation efficiency
4. Set the eggs at the middle of the polyethylene bags and regulate the temperature of the bed as follows:

1st -3rd day	=	39^{o}C
4th -12th day	=	38^{o}C
13th -16th day	=	37.6^{o}C
17th-21st day	=	27^{o}C

5. On the 20th -21st day, remove the hatched chicks to a different room for brooding
6. There should be provision of a support from the 19th day of the incubation to raise the blanked above the eggs just at the middle. This is to make room for the hatching chicks.

Regulate the temperature by lowering or raising the flame of the stove as well as opening or closing air inlet to the hatchery. Eggs should be properly turned about 4 times daily.

Biological -alterative incubation technology

This is practiced by incubating the eggs of less efficient brooders\ incubators with very good natural incubators. A good example is incubating guinea fouls eggs with Nigerian native hens. Once the Nigerian Native Hens begins to lay, the eggs of the Guinea Fowl can be introduced/ substituted in any of the following systematic ways. First, if the eggs are much similar in colour, substitution can take place as soon as the Nigerian Native Hen lays its first egg. Additional eggs other than the one substituted for can be introduced gradually as the laying progresses. Secondly, if the eggs of Guinea Fowl to be introduced vary greatly from that of the Nigerian Native Hen (incubating hen) substitution for one egg only can take place as soon as the Nigerian Native Hen lays its second egg. Substitution / addition of egg other than the one initially substituted can continue from the time of lay of the third egg. No eggs of the Nigerian native hen will be incubated with that of guinea fowls because such eggs will hatch in just twenty-one days and this will disturb the incubation process as the guinea fowl eggs are hatched in 28-31 days. Each incubating hen will have a total of fifteen guinea fowls' eggs or more which it will incubate for 28 - 31 one day. Thereafter it will brood the chick for about 8 to ten weeks. At the end of the breeding period the stock is selected while others are sold. Eggs of both Nigerian Native Hens and that of Guinea Fowls, which are not used for incubation, are sold off.
Production and Profitability of the Enterprise (Mkpado and Ugwu 2006).

Surface irrigation and drainage methods used by wetland farmers in sub-Saharan African

These include Basin irrigation, border irrigation and furrow irrigation.

Basin Irrigation Methods: The farmer divides his field after sound levelling operation into two or more basins using earth bunds. The bunds prevent water from flowing across but infiltrate into the soil. The basin sizes vary depending on the type of soil, stream size, depth of irrigation required, land slope and farm size. Large basins are made on clay soils in contrast to sandy or loamy soils. A larger stream size requires a corresponding increase in the size of the basin. Sloping and undulating surfaces have to be levelled and re-shaped into flat basins to allow easy flow of water from river sources; or that introduced with water pumping machine.

Border Irrigation: It involves splitting of the farmland into strips with small earth bund. Borders are quite similar to basins. But borders slope uniformly away from the water entry points to the entire field. Border also is longer and narrower than basins, which are usually short and broad; because basin is non-shaping portions. Water is introduced naturally or with the aid of water pumping machine

Furrow Irrigation: Water does not flow over the entire soil surface but is restricted to small channels between crops rows. Furrows are usually V-shaped with a width varying from 125-150 cm. Very narrow furrows on heavy soils will encourage fast flow and little infiltration. Heavy soils require wide furrow while sandy soils require narrower furrows. In furrow irrigation, water is better introduced with the aid of water pumping machine.

Surface drainage methods include open or ditch drainage and construction of waterway open drainage: The former makes holes in the farm for collection of excess water. This helps to avoid flooding; open drainage system is often practiced during the rainy season. Waterways are constructed for easy flow of flood from the farm to nearby river, stream or canal.

Low import technologies in Animal feed preparation

Hay Making: The heat for drying of the cut pasture\forage crops (mixture or legume and grass or grass) is supplied by the sun. During the dry season when the rains have ceased, the farmers cut pasture crops and leave them on the field in rows to dry. When they are dried, the farmers gathered them, tie into bundles and store for use during acute shortage of pasture.

Silage making: Silage is produced by controlled fermentation and stored under anaerobic condition. The following process can be used:

1) A rectangular or square pit is dunged and cemented; thick polyethylene is cut to be used to cover the surface.
2) Fresh succulent forage crops like maize, sorghum, legumes and

grass mixtures that have reached sufficient stage of maturity once cut, tie into heaps to bail out some water

3) Put the grasses into the pit and compress them to reduce the amount of air (O_2) in the pit; make sure that the cut forage crops are enough to fill the pit
4) Cover the pit with the polyethylene material and support it with blocks and cover the edges with sand so that the structure will be airtight.
5) The material will ferment and is thus stored under anaerobic condition till needed.

Yam storage: Low input technologies for yam storage are barns, underground storage, platforms and ventilated rooms. In underground storage**,** harvested yams can be stored in shallow pits and covered with sand. Cocoyam and potatoes can be stored with dry methods. Farmers construct ventilated houses with sticks, bamboos and mats for storage of yams. Platforms can be made with sticks inside the rooms where the yams are placed on.

Maggot Swamp Technologies

This technology is used to provide maggot as source of animal protein for poultry and fish. Dead and decaying organic materials that will attract houseflies and sustain the growth of maggot are exposed in the maggot swamp basin. The basin is a shallow pit. The material needed include feathers, animal dung, chicken offal and so on. The maggots are harvested every 2-3 days from each pit and use as supplement to poultry and fish.

Low input technology in fishpond construction

Select clay loamy soil with good topography, marked out the desired pond size. Remove the topsoil, which can be kept for building the walls. Dig the core trench and refill with clay. Dig the middle of the pond starting from one end and use the removed soil to build the walls, plant grasses on top of the walls (Igboachu, 2005). Ram the earth very well install water control devices (inlet and out let) during the construction of the wall for concrete ponds, mounded blocks are used to build the walls while cement, sand and gravel are used for plastering the walls and the bottom. Introduction of water, pond treatment (liming and fertilization) can follow, when the pond is set, fingerlings will be introduced.

Low Input farm Power/Machine for agriculture technologies

This include solar power, wind/wind mills, water pumping machine for irrigation, draught/work animals, bicycles, wheelbarrows, trucks ground nut de-huskers, simple hand operated shelling machines such as maize hand operated shelling machine, hand operated ground nut de-huskers and other hand operated machines.

Agricultural output and development will hardly exist in the absence of solar energy. Specific technologies are associated with the use of solar energy in processing of farm produce. This includes drying of cereals such as maize, rice and sorghum as well as drying of vegetables and spices as well as production of hay. Wind is used in threshing and winnowing of cereals by small-scale farmers; often with the aid of mortar and pestel. Windmill technology is used to provide water for domestic and irrigation purposes.

Beast of burden: These animals especially donkeys are use for transport. The animal can enter into any bend in the field with ease. Feeding and maintenance is cheap since the animal is a ruminant and highly adaptable to the sub-Saharan environment.

Low input technologies for processing high quality cassava flour and starch

High quality cassava flour from improved varieties are processed from cassava roots within 24 hours through the following process:

- Peel and wash freshly harvested cassava roots
- Grate the roots into mash
- Compress to squeeze out water
- Break the pressed mash (cakes) into fine granules
- Spread thinly on clean trays or black poly bags on a raised platform (to prevent contamination by dust, store, etc) and allow to dry
- Package in polyethylene bags or other airtight containers

The harvesting and processing of the cassava starch must be completed within 24 hours, using clean water in order to eliminate discoloration and foul odour, which may adversely affect the appearance and tests of the finished food products. The process includes:

- Peel and wash fresh cassava roots
- Grate or chip and grind smoothly
- Mix with a lot of clean water
- Fitter through a fire mesh sieve or through muslin cloth
- Allow the filtrate to settle. Decant the surplus water
- Wash off the starch residue several time with water until odorless and tasteless
- Put it in a clean bag and press out the water
- Spread thinly one a tray under sun to dry
- Mill the dried cake finely and sift if necessary
- Package in airtight containers for use when required

Conclusion

Refined indigenous knowledge has been illustrated as sources of low input agricultural technologies. The study thus hopes that rural economics should continue to benefit from indigenous technologies, because these technologies are easily adaptable to the circumstances in rural agrarian sector.

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Appendices

Table 1: Organic Material, their quality and how to use

Types	Quality	Content	How to use
Tithonia	High	High in Nitrogen	Incorporate directly into the soil to fertilize crops
Glicicida		Low in lignin	
Lencaena		Low in Phenols	
Caliandra	Fairly high	High in nitrogen, lignin or phenol	Mix with high quality O.M (such as tithonia) before incorporating in the soil.
Maize stalks -low-quality animal manure twigs	Medium	Low in N_2 low in Lignin	Add to compost
	Low	Low in N_2	Leave on the field to help control erosion and retain H_2O
		High in Lignin	

Source: IIRR (1998)

Table 2: Examples of Green manure Crops

Food legumes	Food legumes	Others
Bambara groundnut (Voandzeca subterranean)	Cover (Trifolium Sp)	Pumkins (Cuicurbita sp)
Chickpea (Cicer arietinum)	Lablab bean (Dolichos lablab)	Sweet potato (Ipomea batatas)
Cowpea (Vinga strensis)	Luceme (Alfalfa)	Kikuyu grass (Pennisetun clandestinum).
Green grain (Phasolue aurens)	(Medicago sativa)	
Groundnut (Arachis hypogaea)	Lupin (Lupinus sp)	
Lablab bean (dolichos lablab)	Seatro stylo (Stylothanses spp) Sun hemp (Crotalaria juncea)	
Pigeonpea (Cajanus cajan)	Velvet been (Mucure deeringiana) vetch (Vicia spp	

Kuye et al. (2006)

Table 3: Plants commonly used as bio-pesticides

Plant	Parts used	Major mode of action	Target pest
Acons calamus	Rhizome	Contact poison or repellant	Ants
Alium sativum	Pulp	Fungicide	Psudoperorosora cubensis
Alpinia galangal	Rhizome	Repellent\ contact poison	Dacus dosalis, Nilapavata lugens, aphid rot, brown sopt
Annona muricata	Leaf	Contact poison	Phyllotrita slimata, P. punchata
Annona. squamosa	Leaf, seed	Contact poison	Body house P. sinuata
Azadirachata indica	Leaf, seed	Anti-feed ant growth regulator, repellant ovicidal	Sucking insects, butter Flies, aphids larvae
Curcuma domestic	Rhizome	Contact poison repellant fungicide	Red-mite, thripants, xanthommonas citri, anternaria porri

Cypobogon nardus	Leaf	Repellant	Docos dorsalis mosquito
Deris eliptica	Stalk, root	Contact poison	Various insects
Diosocorea hispida	Tuber	Contact poison	Various insects
Euphorbia fringona	Whole plant	Contact poison	Various insects
Nicotiana tabacum	Whole plant	Contact poison	Various insects
Stemona tuberose	Leaf, root	Contact poison	Various insects
Tinospora crispa	Vine	Anti-feedant	Diamond back moth
Toona tometosa	Leaf	Contact poison growth regulator	Nilapavata lugens, Aphids spp, butterflies
Zingiber serumber	Rhizome	Contact poison	Aphids larvae, butterflies

Source: Chejew et al (1988); Kuye et al. (2006)

Table 4: Promising species of plant sources of bio-pesticides

Plant	Family	Active principles and formulation	Use
Azadirachta indica (neem)		Limonoids (azadirachtin, salanin and others). Aqueous extract from leaf, flower or fruit	Extracts sprayed to control all variety of insects such as locust, borers, mites and termites, nematodes and scales, bugs beetles and diamondback moth and other post-harvest pest.
Acorus calamus (sweet flag)	Araceae	Drying and powdering the rhizome and making an aqueous extract; solvents such as petroleum, et her, ethyl and kerosene	Extract used to make perfumes. Controls ants, clothes moths, fleas, flies fowl lice, mites, mosquitoes moths, rats and pests of stored grains
Alium cepa (onion)	Amaryllidceae	Sulphur and tannings. Aqueous extract of the leaves and bulbs	Effective against fungal disease, mites repellant actions against some insect pests
Allium sativum. (Garlic)	Amaryllidceae	Alkalodis, saponins and tannings found in bulbs and leaves. Powering/pressing followed by aqueous ethanol and methanol extractions employed.	Antibaceira, anti-fungal, anti nematode, and anit-tick actions anit-feedant and repellant actions against
Amona reticulate (Bullock's Heart Apple	Annonaccae	Alkaloids (Linocline and anonaine). Drying, crushing ad powering the seeds and marking aqueous and alcoholic extractions	Mosquitoes, trips and other pest
Chrysantiberum cinerariifolum (Pyrethrum).	Asteraceae	Alkaloid strachydrine, Drying and powerding the flowers then extraction with water, ether, alcohol acctone or kerosene	Fruits for human consumption and for animals fed. Controls erosion on steeply sloping land. Extracts control effectively rice field insects and other pasts.
Derris (Derris)	Elliptica Fabaceae	Root is the primary source of the insecticide rotenone. Formulation obtained by aqueous or ether extraction of the powdered root	Controls a wide array of insect like aphids, cockroaches, flies grasshoppers, mosquitoes, thrips and wireworms.
Lantana (Lantana)	Verbenaceae	Alkaloids (such as lantanine, flavanoids and triterpenoids) obtained by drying followed by acetone and methanol extraction of stems, leaves and flowers	Effective against a variety of insects and nematodes
Mammea Americana (Mammey tree)	Clusiaceae	Actives principles found practically in all plant parts formulation made by extractions with water, alcohol, acetone and petroleum ether from crushed seeds and bark	Controls pests like aphids. Also used as a sand binder and wind break
Ocinum santum lamiaceae (Holy basil)	Lamiaceae	Alkaloids found in leaves, roots stems and buds. Parts are dried and extract with water, ethanol or acetone	Crushed seeds used as a fish poison and toxic to poultry, other animal and human. Has pesticide, repellant and a anti feedant actions. Controls ticks, mites, lice and fleas
Piper nigrum (Black piperaceae peper)	Piperaceae	Alkaloids like methylphroline, piper ovatine chavicine, piperidine and piperine	Used in human food for flavouring. Has medicinal value. Controls verities of fleas, lies, maggots, mosquitoes and nematodes
Vitex negundo verbenaceae (India privet)	Verbenaceae	About 12 alkaloids found as its active principles	Used as cover crops for erosion. Has medicinal properties, controls files cloth moth, rice insects and pests of stored grains
Zingiber officinale zingiberaceae (Ginger)	Zingiberaceae	Aqueous extracts of its rhizomes are sprayed	Rhizome sued as spice. Has medicinal value and sometime used as wind break effectively controls fungal disease
Jatropha curcas	Euphorbiacea	Can be applied. The oil is extracted from the seeds and mixed with water. To make the powder, seeds are air dried and ground very finely	Controls bollworm in cotton, weevils in stored grains, snails which infect rice farms, cockroaches and house flies

Source: Kuye, (1990); Kuye et al. (2006)