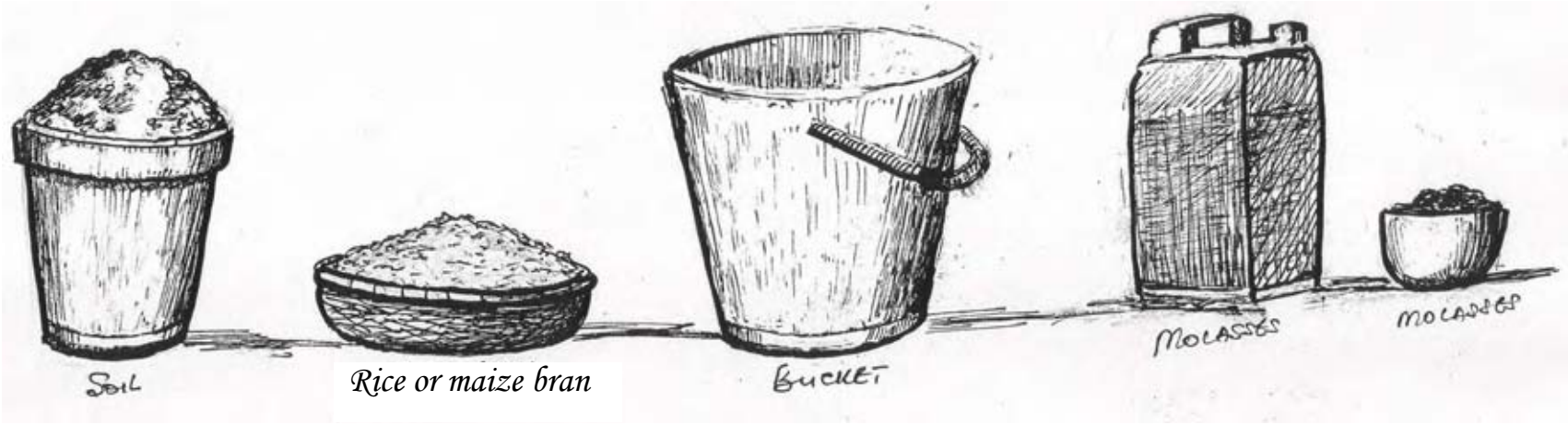
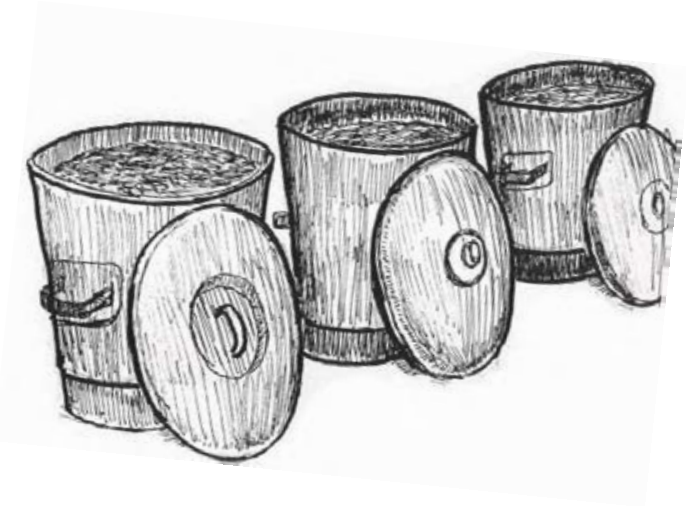
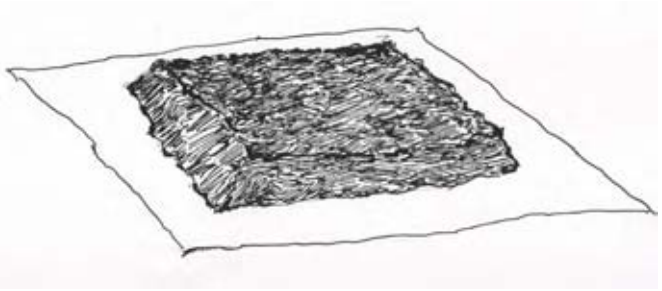
15. Bokashi Seed: (Section 1; Powder Type)

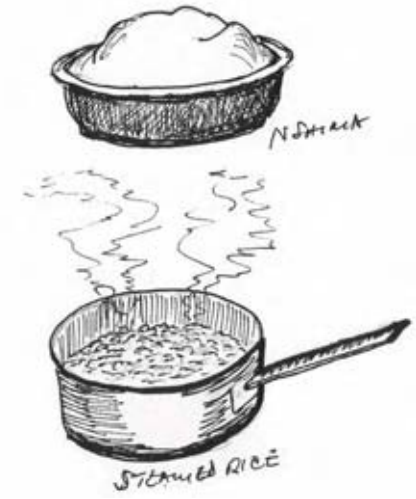
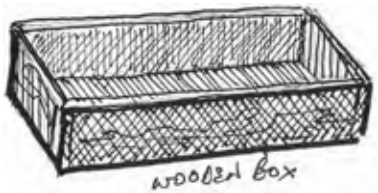
Step	Materials to be collected	
0	**Following materials are for about 25 heaps of Bokashi compost**: (a) Materials absolutely necessary ・ Virgin soil: 1/10 bucket (2.0 kg) ・ Rice bran: 1 bucket (6.0kg) or Maize bran: 1 and 1/4 bucket (8.0kg) ・ Molasses 0.5 litter ・ Plastic bucket: 1 unit ・ Water 40 litters (b) Materials preferably added ・ Steamed rice 1 grab	It is recommended to collect soil from canal bottom, under the beneath of big tree, bamboo bush, and paddy field. When choosing maize bran in stead of rice bran, put more amount (8.0 kg compare to 6.0 kg for rice) as it reduces its volume when mixed with water more than rice bran does.
		

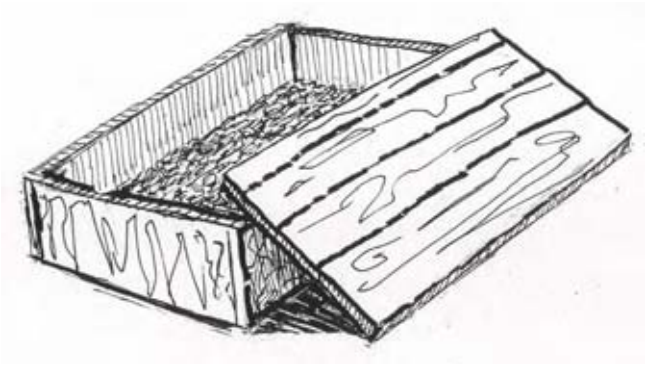
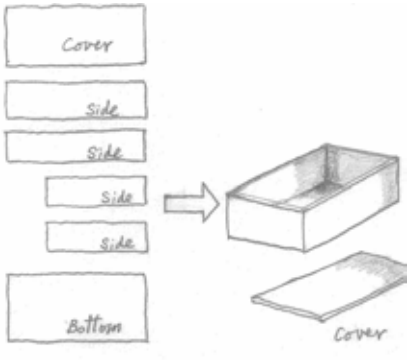
Step	Process	Description	Remarks
1		**<u>Collect soil:</u>** Collect soil from various places to gather various types of indigenous microorganism in different places.	It is recommended to collect soil from canal bottom, under the beneath of big tree, bamboo bush, paddy field, and upland. In these places, there usually are higher populations of effective microorganisms. Before measuring the soil, mix all the soils from different places so as to increase a chance of obtaining more varieties.
2		**<u>Mix the soil and rice bran:</u>** Mix 2 kg of soil (approximately 1/10 of bucket) and 3 kg of rice bran (or 4kg of maize bran), and pour 1 litter of morasses with some water little by little. Mix all those materials thoroughly.	It is recommended to mix the soil and bran with an approximate ratio of: Soil : Rice bran = 2:3 Soil : Maize bran = 2:4

Step	Process	Description	Remarks
3		**<u>Check the moisture:</u>** Examine the moisture of the mixture to see if it contains about 40% moisture. Note that too much moisture inhibit the growth of microorganisms.	You can measure the approximate moisture content of the material by following: 1) Grab a handful of material and press it by hand 2) If it easily fall apart, the moisture content is too low 3) If the material keeps its shape even if you shake it on you hand, the moisture content is too much. 4) If it keeps its shape on you hand and collapse when you shake, the moisture content is most suited.
4		**<u>Keep the mixture for about 3 days:</u>** Keep the mixture in a bucket for about three (3) days. The temperature will become high (about 40 degree Celsius) by fermentation. Then, you can find mold on the surface of the mixture after 2 to 3 days of mixing.	On the 2nd day, it is optionally recommended to put a fist-sized steamed rice-ball or otherwise Nshima on/in the mixture to get more molds. You can add peals of some sweet fruits such as banana, pawpaw, mango; they also facilitate the molds formation.

Step	Process	Description	Remarks
5		**<u>Increase the volume of the mixture:</u>** Mix with the amount of rice bran and water, and check the moisture of the mixture if it contains about 40%. After you have confirmed molds a lot on the surface of the mixture and surface of rice balls, Nshima and/or sweet fruit peals, say about 4-7 days from the preparation, take out the content of the bucket and spray on a floor. Then, add same amount of rice bran (3kg) or maize bran (4kg) to the content. Add some water to keep the moisture content around 40%. It is to increases the volume of the mixture, so-called Bokashi-seed.	
6		**<u>Dry the mixture:</u>** Turn up the mixture once a day (no water should be added) and cover it with banana leaves or plastic sheets. Then, continue it for a couple of days until the material becomes dry, approximately 15%. Then pack it in small plastic bag, bucket or sack to prevent it from moisture.	With moisture content of about 15% or below, Indigenous Micro-organisms (IMOs) can remain inactive. When you make Bokashi compost, add the 500g dried mixture, Bokashi-seed, in one heap. By pouring water on the materials of Bokashi compost, IMOs become active again. They decompose organic matters in the Bokashi.

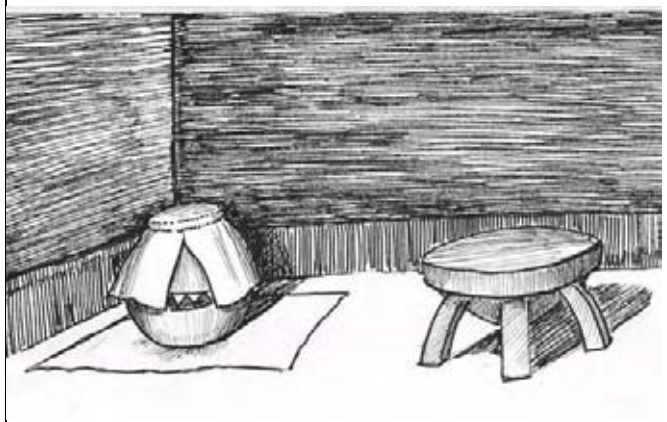
(Section 2; Liquid Type)

Step	Materials to be collected	
0	**Following materials are for about 10 heaps of Bokashi compost**: (a) Materials absolutely necessary ・ Wooden box: 30cm (length) x 20cm (width) x 6cm (height) ・ Steamed rice or Nshima: enough amount to fill half thickness of the wooden box ・ Morasses: 1 litter (or crude sugar) ・ Pot 1 pod (earthen or plastic) (b) Instruments: ・ Shovel 1 unit	
	    	

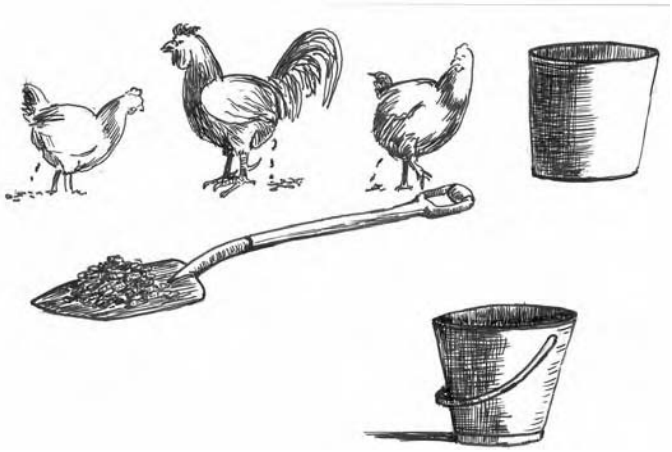
Step	Process	Description	Remarks
1		**<u>Pack steamed rice in the wooden box</u>** Prepare a wooden box (purchase a pre-made box or make it). Pack steamed rice with the thickness of 3 cm, or a half of the box height. Flatten the surface of rice and then cover a wooden box with the cover or a sheet of paper and tie with a string.	**<u>Make a wooden box</u>** Make a wooden box with a size of approximately 30 cm (length) x 20 cm (width) x 6 cm (height). 
2		**<u>Dig a pit</u>** To bury the wooden box, dig a pit with a shovel of about 20-30 cm in depth at a place where organic matter is abundant and thus a larger population of IMOs can be expected.	**<u>Place to be buried with steamed rice</u>** Under bamboo grove or big trees having much rotten leaves and weeds at their foot We may add water onto the ground if the soil around the box is too dry. Always keep moisture but do not flood the area. When it is rainy season, cover the pit with plastic sheet to protect the box from rainwater coming in.

Step	Process	Description	Remarks
3		**<u>Put a wooden box into the pit;</u>** Bury the wooden box into the pit surrounded by rich leaf mold. The top of the box should be more than 20cm below earth. Then, refill the pit with soil.	In some case, box need to be kept for just three days during hot season to 10 days during cool season.
4		**<u>Dig out the wooden box</u>** Dig the pit 5 to 6 days after burying and take the box out of the pit. If you see white mold on the surface of the rice or Nshima, it is microorganisms originally from the soil.	

Step	Process	Description	Remarks
5		**<u>Put molded rice into the pot</u>** Put molded rice into an earthen or glazed pot, and then put 1 litter of morasses or crude sugar corresponding to 1/3 of steamed rice or Nshima. Then cover the pot with paper and tie with a string tightly.	
6	*IMO Concentrate* 	**<u>Keep them for a week and completion of IMO concentrate</u>** After a week or so, it looks like muddy or liquid but rice remains to some extent. This is the completion of Indigenous Microorganism (IMO) concentrate.	

Step	Process	Description	Remarks
7		**How to Make "Bokashi" using IMO** It is simple to use the IMO concentrate. Dilute the IMO concentrate into 2 % IMO solution. This means 100cc of IMO concentrate can be diluted into 5 litters of water. Then, shower the diluted solution when mixing the materials of Bokashi. IMOs in diluted solution facilitate the decomposition process of the organic matters. For the details of making Bokashi compost, please refer to the technical manual No. 13.	
8		**How to preserve IMO** Liquid type IMO concentrate, or Bokashi-seed, can be kept for long time. To do so, add 0.5 litters of molasses liquid to 1 kg of IMO concentrate and keep the pot in a cool place. If you keep it in the pot together with the molasses liquid, the IMO concentrate can be effective for about one year.	

16. Liquid Fertilizer

Step	Process	Description	Remarks
1		**<u>Collect Materials</u>** ✓ Container (ex. 20L can) ✓ Chicken dropping: 1/3 to 1/2 of the container ✓ Other livestock dropping (as complement) ✓ Water	Chicken dropping is one of the best materials for making manure as it is rich in nitrogen, phosphorus, and potassium. Different from cow dung or other livestock dung, nitrogen in chicken dropping is far stable and hardly evaporates, advantageous to making manure. If chicken dropping is rarely available, however, other livestock dung is also applicable.
2		<u>Fill the container with chicken dropping and animal dung</u> Put all the droppings and manure into the container to be 1/3 to 1/2 of the container. Fill it with water to about a few centimeters from the top.	Do not cover the container as it will release gasses during the fermentation.

Step	Process	Description	Remarks
3		**<u>Leave it for Fermentation</u>** Keep it under shed for three (3) to four (4) weeks for fermentation. For faster fermentation, stir it thoroughly once or twice a day.	Fermentation is facilitated by bacteria. To activate the aerobic bacteria, aeration is effective. Also, solid materials will easily be deposited at the bottom of the container. Therefore, stirring is highly recommended.
4		<u>Dilute and Apply it</u> Pour the finished liquid fertilizer into another container or watering can. And dilute it by adding 4 times of amount of water. The finished solution should have a color of weak iced tea, therefore, it is sometimes called as “manure tea” Pour it at the bottom of the plants. A cup of the liquid fertilizer is applicable to one plant.	Soluble contents can be easily absorbed by plants. Therefore, liquid fertilizer is best applicable to additional fertilization. The residue in the container should not be thrown away. It should be used as a material for compost making.

17. Recommended Cropping Systems

Step	Cropping System	Description
1		***Relay Cropping <Winter Maize and Climbing Bean>*** Maize is sown in row at 75cm between rows and 20cm between each plant in a row. After at least 4 weeks after sowing maize, but before the harvest, plant climbing bean so that the bean can use maize stalks as stakes. Climbing beans can produce 3-4 times more yield than bush beans. Expected profit from this system is roughly 533,750ZMK/0.5 lima with good management.
2		***Two-by-Two System <Winter Maize and Soy Bean>*** Instead of establishing the rows of maize with 90cm of uniform intervals, establish two rows close (50cm) and create wider gap (100cm or more) with next two rows. And in the wide gap, plant legume crops in two rows. This is why it is called 2 by 2 system. Common bean, Soybean, green gram, and groundnuts can be used in this system. By creating a wide space, legume crops can receive more sunlight and thus a total production can be increased. Expected profit from this system is roughly 533,750ZMK/0.5 lima with good management.

Step	Cropping System	Description
3		***Mixed Cropping <Cabbage-Tomato>*** Tomato acts as a physical barrier against insects like Diamondback moth and it also has a characteristic to reduce the population of insect with its repellent odor. Tomato is first transplanted. Two weeks later, cabbage is planted in alternate rows. Expected profit from this system is roughly 1,282,000ZMK/0.5 lima with good management.
2		***Mixed Cropping <Cabbage-Onion>*** Onion is famous with its repellant effect against common insects including aphids. Therefore, onion is a useful intercrop for many crops. One of recommended combination is with cabbage and carrot. However, combination with pea is not recommended. Expected profit from this system is roughly 1,715,750ZMK/0.5 lima with good management.

18. CONSERVATION AGRICULTURE UNDER IRRIGATION

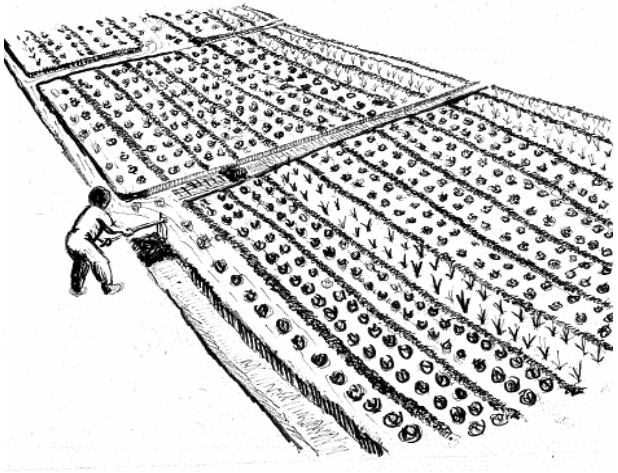
Step	Rationale and Outline of the System	
0	**Principle** - Develop a system that will least disturb the soil - Leave as many residues as possible to add more organic materials to the soil **Expected Benefits** 1) Prevented soil erosion 2) Improved soil fertility ・ Increased organic matter content ・ Higher moisture retention 3) Deeper rooting system 4) Simplified weed management with depressed weed populations 5) Increased yield in a long run (Research result[1]) ・ Maize Yields: 60 – 70% ・ Cotton Yields: 40 – 60% ・ Legume Yields: 40 – 50% **Expected Drawbacks** - Need time in order to see results - Availability of suitable legume seed - Challenges in weed management **Necessary Materials** - No specific materials but need systematized farming practices - Herbicide - Legume crop	**Expected Beneficiaries** Conservation Agriculture is recommendable for those who are associated with: 1) Low crop productivity and production 2) Declining soil fertility and erosion 3) Inefficient use of fertilizers and other expensive farm inputs

[1] CONSERVATION AGRICULTURE IN ZAMBIA, Staff Orientation Workshop, 5th July 2010, by Rasford Kalamatila (PPT)

Step	Process	Description	Remarks
1		**<u>Making Ridges as a Base</u>** In the conservation agriculture, ridges are to be formulated ONE time only and to be used repeatedly. In this arrangement, furrow irrigation is to be applied, in which water is conveyed in between the ridges by gravity. For smooth watering, do not make the ridge too high like *Fundikila*. If the ridge is too high, you cannot do the furrow irrigation and you will end up watering by hand.	Recommended size of the ridges is as follows: ▪ Interval: 90 cm or narrower ▪ Station spacing: 30-50cm Although interval in rain-fed maize is commonly 90-120cm, it should be smaller in irrigated agriculture. While, wider spacing is recommended. Once you establish the ridges for the first time, you do not have to cultivate the land any more. Cultivation is managed by the root system of the crop themselves.
2		**<u>Planting the First Crop</u>** Plant the first crop where ridges are arranged as mentioned above. First crop can be cultivated in a normal way as you usually do.	**<u>Selection of the First Crop</u>** When irrigated agriculture is to be carried out after rain-fed maize, the maize can be regarded as the first crop. When it is a new attempt, let's try planting legume crops first: soybean, cowpea, etc. Through fixing nitrogen in the air, legumes help improve the soil fertility in the long run.

Step	Process	Description	Remarks
3		**<u>Making Soil Cover</u>** Just after harvesting the first crop, cut down the stems of the crop and leave the residues on the ridge, covering the surface of the ridge. Cover cropping has a number of beneficial effects. Typical ones are listed on the right column. (Illustration is a case of maize)	**<u>Benefit of Soil Cover:</u>** ▪ Reduction of soil erosion caused by water and wind ▪ Increase of the rainfall infiltration rate ▪ Reduction of moisture loss by evaporation ▪ Reduction of the temperature ▪ Improvement of conditions for germination ▪ Increase in organic matter content of the surface soil layer ▪ Stimulation of biological activity in the soil ▪ Suppression of weed growth
4		**<u>Drilling Holes</u>** You may wonder how you can sow seeds on the ridges that are covered by residues. In this system, seeds are to be sown in spots. So, drill small holes on the ridge by penetrating the cover crop or, if the residues are still hard, by shifting a small portion of the residue for the spot. Recommended spacing of the plant stations is 30-50cm.	When applying chemical fertilizer, apply it besides the plant stations. It increases the efficiency of fertilizer use. In the next season, sow seeds at the same stations because soil of those stations is softer (see next).

Step	Process	Description	Remarks
5		**<u>Sowing Seeds/Seedlings</u>** In this system, plant population at the early stage should be more intensified than conventional farming. If you are cultivating maize, for example, put 3-4 seeds per hole instead of 1-2 seeds. It increases the survival rate of the plants at the early stage. After a few weeks, thin out the plants by removing unhealthy individuals. Two plants per hole are recommended to remain, given enough spacing.	**<u>Cultivation by the Plants</u>** Plants' root system cultivates the soil instead of you. So, once the system is established, you do not have to cultivate any more. 
6		**<u>Crop Management</u>** After sowing, management practice is quite same as conventional farming. You may still encounter the weed problem especially for the first year. But, as you continue it for a couple of years, weed problem will be reduced due to the accumulated residues on the surface. (Illustration is a case of Tomato)	**<u>Effects of Increased Organic Matter Content</u>** ▪ Increase in the stability of surface aggregates ▪ Increase in the capacity of the soil to retain nutrients and water ▪ Stimulation of the soil biological activity

Step	Process	Description	Remarks
7		**<u>Continuation of the CA</u>** After the harvest, cut down the plant stems and cover the soil surface again. This is the preparation of next conservation agriculture. Now that the ridge is prepared and the soil is cultivated by the previous crop, next copping can be started immediately. Crop rotation among cereals (maize), legumes (soybean), and deep rooted crops (sun flower) is also recommended by the FAO for conservation agriculture.	**<u>Recommended Combinations</u>** ▪ Maize (R) – Soybean (I) ▪ Soybean (I) – Tomato (I) ▪ Wheat (R) – Green Maize (I) ▪ (I): under irrigation (R): under rain-fed Note: as crop residues could be a habitant of insects, leaf vegetables, such as Chinese cabbage, rape and cabbage, may not be suitable for the conservation agriculture.
8		**<u>CA under Sunken-bed irrigation</u>** Conservation agriculture can be also managed under the sunken-bed irrigation system. Without making ridges, make an earthen band surrounding a piece of flat area where irrigated water stays for minutes. Procedure is same as the one under the furrow irrigation system.	**<u>Protect Your Soil</u>** Soil fertility in Northern and Luapula provinces is generally quite poor and acidic. To cope with this problem, let's be proactive protecting and improving your farmland. Conservation agriculture is one of effective agricultural practices you can apply with irrigation by yourself.

Reference

The Part II of this Technical Manual was prepared based on PD method developed in IFIC, JICA. The word of “PD method” comes from “Process Description method”. This is a JICA technology transfer method of producing both an operation manual and (audio) visual aids using photos or illustrations, which are portrayed by superposing on the photos, of a series of actual activities of a work. The process description is made by: 1) taking a series of photos of a work, and 2) describing the activities in the photos by step mostly by counterpart personnel, through which the counterpart will acquire the skill and knowledge necessary for the work and also the manual is produced simultaneously. Hideyuki KANAMORI (1994): Effective Technology Transfer by PD Method (in Japanese), Journal of the Japanese Society of Irrigation, Drainage and Reclamation Engineering, Vol.62, No.12, pp.7-12

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1. Technical manuals, leaflets and posters prepared under the Study on the Capacity Building and Development for Smallholder Irrigation Schemes in the Republic of Malawi, March 2005

Trigonal Prop Supported Weir (in addition to the above):

2. Design Alternatives on Rural Irrigation Structures, Hideyuki KANAMORI, Institute for International Cooperation, JICA, March 1995
3. The People who Reclaimed Water and Soil (in Japanese), pp.171, August 5, 1994, The Japanese Society of Irrigation, Drainage and Reclamation Engineering
4. Thesaurus of Technical Terms of Civil Engineering, PP.669, February 15, 1999, Japan Society of Civil Engineering (relating to Sei-gyu in page 3-11 of the technical manual)

Permanent Weir:

5. Guideline on Design and Construction of Water retailing walls in Zambia, Irrigation Engineering Section, TSB, MACO, May 2001
6. Design and Construction of Small Dams, Small Holder Irrigation and Water Use Programme (SIWUP), TSB, MACO, March 1998

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7. Guidelines for Designing and Evaluating Surface Irrigation Systems, Irrigation and Drainage Paper 45, FAO 1989
8. Guidelines on Design and Construction of Water retaining Walls in Zambia, May 2001, Ministry of Agriculture, Food and Fisheries, TSB, Irrigation Engineering Section
9. Design & Construction of Small Dams, March 1998, SIWUP, TSB, Ministry of Agriculture, Food and Fisheries, Lusaka, Zambia
10. Training Manual No. 4, A manual prepared jointly by C. Brouwer, International Institute for and Reclamation and Improvement and K. Prins consultant, M. Heibloem, FAO Land and Water Development Division, 1989

Bokashi, a Type of Quick Making Compost Manure:

11. How to make Bokashi (in Japanese), Nobunkyo, March 2003, and How to make and use compost manure (in Japanese), Nobunkyo, February 1995

Conservation Farming

12. CONSERVATION AGRICULTURE IN ZAMBIA, Staff Orientation Workshop, 5th July 2010, by Rasford Kalamatila (PPT)
13. MACO/FAO Conservation Agriculture Scaling-up Projects in Zambia, Funded by the Royal Norwegian Government and the European Union (PPT)
14. Manual on integrated soil management and conservation practices, FAO (2000)