Utilization and construction of pit silos

APPROPRIATE TECHNOLOGIES FOR DEVELOPMENT

Peace Corps
INFORMATION COLLECTION AND EXCHANGE
REPRINT R-15A

JUNE 1976
MARCH 1977
SEPTEMBER 1982

INFORMATION COLLECTION & EXCHANGE

Peace Corps' Information Collection & Exchange (ICE) was established so that the strategies and technologies developed by Peace Corps Volunteers, their co-workers, and their counterparts could be made available to the wide range of development organizations and individual workers who might find them useful. Training guides, curricula, lesson plans, project reports, manuals and other Peace Corps-generated materials developed in the field are collected and reviewed. Some are reprinted "as is"; others provide a source of field based information for the production of manuals or for research in particular program areas. Materials that you submit to the Information Collection & Exchange thus become part of the Peace Corps' larger contribution to development.

Information about ICE publications and services is available through:

Peace Corps
Information Collection & Exchange
1111 - 20th Street, NW
Washington, DC 20526
USA

Website: http://www.peacecorps.gov
Telephone : 1-202-692-2640
Fax : 1-202- 692-2641

Add your experience to the ICE Resource Center. Send materials that you've prepared so that we can share them with others working in the development field. Your technical insights serve as the basis for the generation of ICE manuals, reprints and resource packets, and also ensure that ICE is providing the most updated, innovative problem-solving techniques and information available to you and your fellow development workers.

Ensilage hay and pasture crops

by J. B. Shepherd, R. E. Hodgson, N. R. Ellis, J. R. Mc Calmont

Several factors influence the type of fermentation produced, the nature and extent of the losses occurring during fermentation and storage, and the quality of the silage produced. Among them are the maturity and chemical composition of the crop, the ratio of soluble carbohydrates to the mineral base content of the crop, its percentage of moisture when stored, the rapidity and completeness with which air is excluded from the silo, and atmospherical temperatures when the crop is ensiled.

In handling the crop for silage, the farmer should cut the forage when it has a high content Or protein and carotene and when the yield of total digestible nutrients per acre is high. He should ensile it in a way that will produce a good palatable silage with the least loss of feed nutrients and the least wear and tear on the silo.

In doing so, he will need to give proper consideration to the stage of maturity at which to cut; the moisture content at which to store; the need for and use of preservatives; the length of cut to use; the distribution and packing of the crop in the silo; and the sealing out of the air when the silo is full.

To produce grass silage that meets those specifications requires first that it be cut at an immature stage while it is still reasonably high in protein and carotene and relatively low in crude fiber This stage corresponds closely with that recommended for early-cut hay from the various crops.

Most grasses should be cut after the heads have emerged but before the plan have started to bloom.

The moisture content of the crop at the time of ensiling is the most important factor in determining the character of the silage fermentation, the extent and character of the losses through seepage and fermentation, and the quality of the silage produced.

An excessively high moisture content leads to large losses of liquid. Too little (under 60 percent) results in molding and spoiling of the silage.

When crops are ensiled with a moisture content of more than 70 percent, fermentation takes place at a rapid rate, there is considerable seepage from the silo, and losses of most feed nutrients, except carotene, are large. If no treatment other than chopping is given, the type of fermentation will be desirable and the silage will be of good quality provided the crop ensiled consists principally or entirely of grasses or cereals that are cut after heading out and that contain a medium or low amount of protein. On the other hand, the type of fermentation will be undesirable and the silage will be of poor quality and have a strong offensive odor if the ensiled crop consists principally or entirely of legumes or of grasses and cereals that are cut before heading out and that have a high protein content.

When wilting is not possible because of unfavorable weather, the same results can be obtained by adding 5 to 15 percent of dry hay as the crop goes through the chopper. When the moisture content of the crop is reduced to 68 percent or below, the fermentation rate is reduced and seepage from the silo is eliminated. The best silage is made when the moisture of the material is not above 68 percent or under 60 percent. But occasional loads may contain as much as 70 percent or as little as 55 percent of moisture without materially affecting the quality.

Wilting high-moisture crops for silage, as we have indicated, not only produces a mild, palatable silage that will be consumed in normal roughage amounts; wilting also reduces the losses of nutrients (except carotene) that usually occur when the silo is filled with comparable unwilted materials.

But care should be taken not to wilt the crop too much, and the part that is wilted most should be placed in the lower part of the silo. The walls of silos used for wilted silage should be air-tight and smooth.

Salf has little effect on the fermentation process and is of little practical value in silage making.

Grasses and cereals cut after heading out or a mixture of such crops with legumes can be made into a mild, good-quality feeding silage without preservatives when ensiled in the fresh green state. The fermentation rate will be slowed down, fermentation and storage losses will be reduced, and the palatability of the silage will be increased by wilting the crop slightly before ensiling.

Immature grasses and cereals cut before heading out, or crops consisting principally or entirely of legumes, can be made into good silage by wilting them down to a moisture content of 68 percent or slightly less.

Wilted silages made without preservatives usually have an acidity within the PH range 4.0 to 5.0, depending on the crop.

The aim should be to wilt the crop slightly, to a moisture content between 65-70 percent but not below 60 percent. If the leaves become dry and curled, the wilting may have progressed too far unless the crop is heavy and the underside of the swath is in an unwilted state. The crop will have wilted sufficiently when the leaves and stems become limp. me stems can be readily twisted in two and the broken ends will have a dark, moist, but not excessively juicy, appearance. On rubbing the chopped crop between the hands, the material will feel cool and moist, but no free water will appear when a ball of the chopped crop is squeezed in the hands.

One or two hours on a good drying day may be sufficient to wilt the crop to the desired moisture level unless the crop is very heavy or very high in moisture. On a good drying day, therefore, the crop should not be cut too far ahead of loading and silo filling. During prolonged dry weather, crops cut at the usual stage will be ready to ensile within a few minutes after mowing. On very humid days, a half day to a day may be required to wilt the crop sufficiently. During rainy spells, the mowed crop may sometimes be in the field 2 or 3 days before it wilts enough to be siloed.

When rain interferes with silo filling operations, the rain-wet portion can be siloed without wilting by filling the silo at the slow rate of 3 to 4 feet a day so that some heat will be generated; or it can be siloed at a normal rate by running dry hay (10 to 20 percent), ground dry grain (5 to 12 percent), or molasses (3 to 5 percent), through the cutter with the wet crop.

Except for short and very immature crops put up under special conditions, it is necessary to chop the crop as it is siloed. The length of cut to use will depend upon the moisture content at which the crop is siloed. If the moisture contort is 72 percent or more, the cutter should be set for a 1/2 - to 5/8- inch theoretical cut. Crops with a high moisture content will pack well with this comparatively long cut.

When the moisture content of the crop is 70 percent or less as ensiled, the cutter should be set for a shorter cut of not more than one-fourth to three-eighths inch. If the crop is wilted considerably, the cut used should not exceed one-fourth inch. Here, too, many of the stems go through crosswise with an actual longer average length, and this short cut must be used in order to get the crop to park satisfactorily and exclude the air. The drier crop is not apt to clog the blower when a short cut is used. Failure to use a fine cut when the crop is wilted will prevent close packing, will cause considerable air to be trapped in the silage, and also will cause some mold.

When the silo is being filled, the crop material should not be allowed to pile up in the center of the silo. It should be kept well distributed over the entire area and well tramped near the wall. This is particularly important when the crop is wilted slightly. Good distribution and thorough packing are absolutely necessary in the top part of the silo.

Only heavy, unwilted crops should be used for the last few loads so that enough weight and pressure will be provided to force the air out and keep it out. to preservative will be needed in this wet top layer even if the crop is high in protein, because the material at the top warms up sufficiently to prevent undesirable fermentations and naturally makes a mild, palatable silage.

The rate at which the silo is filled affects the rapidity with which the air is eliminated from the silo and, consequently, the temperature which the ensiled mass attains. If the silo is tight and is properly filled and sealed, the temperature will seldom exceed 100° F., except at the top, and may sometimes not exceed 90°. If the ensiled material is high in moisture, or if the weather is cool, silo temperatures will be lower than when the crop is wilted or the weather is warm. When the silo is filled with a high-moisture crop, particularly in cool, moist weather, there may be an advantage in filling at a slow or moderate rate; that will allow the ensiled material to warm up slightly. That procedure also will help to prevent an undesirable type of fermentation.

When the silo is filled during a long dry spell or with a wilted crop, it should be filled rapidly in order to hold silo temperatures down to a desirable level. Spoilage is apt to occur on the surface of the ensiled material if more than 2 days elapse between filling periods. When such an interval occurs, the top of the material should be kept tramped thoroughly in the meantime, and any spoiled silage removed before filling is resumed. Where one crop only partially fills the silo and another crop is put in some time later, the silo should be tramped, sealed, and weighted down between fillings to keep silage temperatures and losses as low as possible.

Harvesting silage crops

PROJECT ENSILAGE - MALI

Most grasses should be cut after the heads have emerged but before the plants have started to bloom. Dalays in harvesting beyond the early heading stage in grasses decreases palatability and digestibility of the forage. Each day's delay decreases digestibility about 0.5 percent, which in turn results in a decline in production of the animal fed silage from too nature a grass.

If the percentage of water in the silage is too high, an undesirable type of fermentation often occurs. The losses of nutrients are increased, and strong-smelling butyric acid is formed, instead of lactic and acetic acid. If the forage is too dry, it is apt to mold.

Harvesting silage crops can be classified as "direct cutting," where the forego is ensiled directly after being field cut, or "wilting," where the forage is partially field dried so that it contains 60-70 percent of moisture when stored.

In wilting forages, one to two hours on a good drying day may be sufficient to wilt the crop to the desired moisture level. You can estimate moisture content by a squeeze test. Squeeze a handful of the chopped forage into a ball and hold it 20 to 30 seconds, then quickly release your grip. The condition of the ball shows About how much moisture it contains. Following is a guide for estimating moisture content:

CONDITION OF FORAGE BALL	APPROXIMATE MOISTURE CONTENT
Ball holds shape, considerable free juice	over 75%
Ball holds shape, little free juice	70 - 75%
Ball falls apart, no free juice	60 - 70%
Ball falls apart readily	below 60%

Another means of quickly judging the degree of wilting achieved, is visual. If the leaves become dry and curled, the wilting may have proceeded too far. The crop will have wilted sufficiently when the leaves and stems become limp, or, the stems can be readily twisted in two and the broken ends will have a dark, moist, but not excessively juicy appearance.

Wilting has the advantage of not only reducing the nutrient loss from leaching due to excess water, but also increases the amount of sugar per pound of forage.

Wilting, as compared to direct cut silage has the disadvantage, that excluding air from wilted silage in the silo is more difficult. The lighter, wilted silage will not pack as tightly in the silo. For this reason, if the wilting process is followed, the last few layers of silage put in the silo, should not be left to wilt. In this way, additional weight will be placed on the top of the silage, which pushing down, will help to force out any air within the silo.

Wilted silage made without preservatives usually has an acidity within the PH range of 4.0 to 5.0, depending on the crop.

It should be kept inmind, that in a dry season or with rather mature crops, the forage need not be wilted.

PROJECT ENSILAGE - MALI

CHEMICAL ANALYSIS OF GRASS SILAGE

From test pit silos made in Chad, 1971-72, the following analysis of a silage sample was made. The grass used was roetebella exalta, with no additives:

Dry matter	35.2 percent
Total Digestible nutrients	45 - 50 percent
Protein	5.6 percent
Fat	1.5 percent
Fiber	35.0 percent
Ash	14.5 percent
Non protein	50.0 percent

PROJECT ENSILAGE - MALI

BALANCED RATIONS

Balancing a ration involves finding a combination of feeds that will supply the required nutrients for an animal of a given weight. For example, the daily requirements of an 800 pound yearling finishing steer are:

Dry matter	19.8 Ibs.
Digestible protein	1.6
Total Digestible nutrients	14.3
Calcium	.044
Phosphorus	.044
Carotene	.45 mg.

To maintain weight, a beef cow needs about 2 pounds of dry matter daily per 100 pounds of live weight.

PROJECT ENSILAGE - MALI

SILAGE ADDITIVES

Often times, the fermentation of high moisture forego is unpredictable and for this reason, preservatives are sometimes added. additives should do at least one of these things to be of help:

- Provide fermentable carbohydrates (60 to 100 pounds - 7 gallons - of molasses per ton increases the auger content) so that enough acid forms during fermentation to preserve silage properly.

- Furnish additional Acids directly to increase acid conditions. (liquid P202 can be used in amounts of 9 Ibs. of 68 percent phosphoric acid per ton).

- Directly or indirectly reduce the amount of oxygen present.

- Absorb some seepage that might otherwise be lost.

When the crop is wilted, less of the preservatives are needed, because at that moisture level the fermentation process is slowed down, less undesirable fermentation is produced, and the losses (except of carotene) are usually small.

Additives which can be used with grass silage:

- Mixing in green corn or sorghum
- Molasses or whey
- Cereal grains
- Acids such as phosphoric
- Treat with sulphur dioxide gas
- Use sodium bisulphite - 81 Ibs or powder per ton.

Handy silage preservative guide

Silage

	Kind and Amount of Preservative to Add per Ton of Green Silage							Sodium	Kylage
CROP	Molasses (12 lbs.=1 gal.)	Ground Shelled Corn or Cereal Grains Citrus Meal, or Citrus or Beet Pulp	Corn and Cob Meal	Phosphoric Acid. 75% (13.2 lbs.=1 gal.)	Whey, Dried	Whey, Liquid	Sulfur Dioxide Gas (SO_2)	Sodium Metabisulfite ($Na_2S_2O_5$)	Kylage (a mixture of calcium formate and sodium nitrite)
	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)
Legumes:									
Alfalfa, clover, etc.	60	150	200	20	40	400	5	8-10	6
Soybeans	100	200	250	30	60	600			
Grass-legume mixture: Clover, and timothy, etc.	40	125	150	15	30	350		8	5
Grasses and cereals: Timothy, oats etc.	30	75	100	10	20	250		8	4

Characteristics of high quality hay

In order to make or to buy superior hay, stock-men need to know what constitutes hay quality. They need to be acquainted with those recognizable characteristics of hay which indicate high palatability and nutrient content. If in doubt, the animals will tell them, for they like and thrive on high quality hay.

The easily recognized characteristics of hay of high feeding value are:

1. It is made from plants cut at an early stage of maturity, thus assuring the maximum content of protein, minerals and vitamins, and the highest digestibility.

2. It is leafy, thus giving assurance of high protein content.

3. It is bright green in color, thus indicating proper curing, a high carotene or provitamin A content, and palatability.

4. It is free from foreign material, such as weeds, stubble, etc.

5. It is free from must or mold and dust.

6. It is fine stemmed and pliable - not coarse, stiff and woody.

7. It has a pleasing, fragrant aroma; it "smells" good enough to eat.

Cure properly so that (a) the hay can be stored safely without heating excessively or becoming moldy, and (b) the maximum leafiness, green color, aroma, nutrient value and palatability shall be retained. To the end that these desired objectives may be achieved, the following information is pertinent:

a. <u>Moisture content:</u>

Freshly cut forage contains 75 to 80 per cent moisture; where as the maximum moisture content for safe hay storage is as follows:

- For loose hay - 25% moisture
- For baled hay - 20 to 22% moisture (the lower figure for larger bales)
- For chopped hay - 18 to 20% moisture
- For cubes - 16 to 17% moisture.

Hay of a higher moisture content than indicated should not be stored because (1) its value may be greatly lowered due to mold or to nutrient losses accompanying fermentations, and (2) of the ever present danger of spontaneous combustion and a costly fire.

Two rule-of-thumb methods used by farmers in determining when hay is dry enough for storage are:

(1) The Twist Method: Twist a wisp of the hay in the hands. If the stems are slightly brittle and there is no evidence of moisture on the twisted stems the hay can be stored safely.

(2) The Scrape Method: Scrape the outside of the stems with the finger or thumb nail. If the epidermis can be peeled from the stem, to is not sufficiently cured. If the epidermis does not peel off, the hay is usually dry enough to stack or put in the mow.

* HAY QUALITY

Many conditions and characteristics are either associated with or determine the nutritive quality of hay. It is impossible to predict from one known characteristic of hays the amount of animal response that will be obtained. Among the more important known conditions or characteristics affecting hay quality are: (1) the time during the season and the growth stage at which forage is harvested, (2) whether the forage represents a first growth (not previously harvested or grazed during the same season) or an aftermath growth, (3) leaf content, (4) extent to which the harvested forage is damaged by weather mud handling, (5) physical form in which it is fed, and (6) forage species.

HAY MAKING POINTERS

The following hay making pointers are frequently of interest and pertinent:

1. Brown hay: Brown hay results when, due to inclement weather, hay wilted to about 50 per cent moisture content is stacked or placed in storage. The damp mass soon ferments extensively, and heats (preferably not higher than 175° F.). As a result of this action, the hay darkens in color, from dark brown to nearly black. Also, it becomes sweet, aromatic and palatable. But as a result of the fermentation and heating to which it is subjected, the forage is lowered in digestible protein, in total digestible nutrients, in vitamin content, and in feeding value.

Because of its lowered nutrient and feeding value and the danger of spontaneous combustion, therefore, the intentional making of brown hay is not recommended.

2. Salt and other so-called preservatives:

Farmers in many countries of the world have, traditionally, added about 20 pounds of salt per ton of new hay, in the belief that the salt would prevent the hay from molding and heating. Carefully controlled experiments have failed to substantiate claims that salt will prevent excess heating or sweating; nor has it prevented spontaneous combustion of hay However, when salt is used in moderate amounts it may improve the color, aroma, and palatability of poor quality hay. It is recognized, too, that much higher levels of salt quantities sufficiently high to harm animals may prevent mold.

Recently, so-called "hay preservers", most of them consisting chiefly of ordinary baking soda, have appeared upon the market. Usually the directions recommend the addition of 1 to 3 pounds of these products to each ton of damp hay, and "guarantee" that there will be no heating or molding. To date, controlled experiments have failed to substantiate the claims made for these products.

3. Spontaneous combustion:

Wet hay ferments and generates heat. Sometimes this results in spontaneous combustion and fire, usually about a month to six weeks after storing. Here are the facts:

a. Symptoms of heating: The warning signals are: hay that feels hot to the hands, strong burning odor, and visible vapor.

Storage of forage

During the interval from cutting until the forage is dry enough to keep in storage, a progression of events promotes losses and deterioration of the quality and feeding value of the forage. These field losses generally originate from three sources: Respiration and fermentation (chemical and bacteriological), mechanical damage, and weather damage. The amount of destruction caused by the three factors varies according to conditions and determines the amount of field losses. Field operations should be managed to keep these factors to a minimum.

Freshly cut forage is living material. The plant cells continue to respire, and plant enzymes continue active for some time after the crop is cut. In addition, micro-organisms naturally contained in the forage continue activity as long as air is present and shore is sufficient moisture These fermentation processes affect principally the soluble carbohydrate fractions and the carotene. If drying is prolonged, however, important losses in dry matter and protein may also occur. Losses amounting to 5 to 15 percent of the total crop have been found to occur from so-called field fermentation losses.

The methods of handling the forage in the field should be designed to promote the most rapid evaporation of moisture so that these losses may be kept to a minimum.

Hay that is drier than it need be for safe storage is very susceptible to leaf shattering, and such hay usually is graded lower in quality because of lack of leaves.

Leaching and bleaching also cause losses when forage is dried in the field. Rain falling on partly dried forage produces losses that result from shattering of the leaves and from the leaching of soluble nutrients from the forage. Various workers have shown that hay that has been rained on is lower in protein, nitrogen-free extract, and carotene and higher in crude fiber than hay not rained on. Rain promotes mold development and this also contributes to nutrient loss and lowered feeding value. Excessive exposure of forage to the sun increases its vitamin D value but causes a decrease in color and carotene content.

Field-cured hay generally will sweat after it is stored. If it is undercured, it will heat in the mow and this heating produces losses in dry matter and feeding value. Frequently such hay will lose 5 to 15 percent of its dry matter and nutrients while in storage. If heating is excessive in the mow, brown and black areas of charred and burnt hay may develop and, as is all too frequently the case, heating may continue until spontaneous combustion occurs and the hay and storage barn are burned. Brown and black hay appears to be palatable to livestock, but numerous investigations have shown that this type of hay has a decidedly lowered feeding value.

When partly dried forage is placed on a barn hay finisher, it is still wet enough to allow rapid fermentation to take place. Air moving through the mass of hay carries with it the moisture evaporated from the forage. The temperature of the air will govern how much moisture it will pick up. Heated air will pick up more moisture than unheated air, and drying will be hastened if the air is heated before it enters the drier. The heat created by fermentation may also increase the temperature of the air and thereby increase its water-holding capacity. It is important to spread the forage evenly over the drying system and to have the same degree of packing throughout. The air will then flow evenly through the forage and the hay will dry thoroughly in all parts of the mow. The hay dries from the bottom up, and when the top layer is dry enough to prevent heating, the lower layers are even drier.

The drying should be completed as rapidly as possible to retard fermentation. The longer fermentation takes place the greater the losses of dry matter and nutrients because optimum temperature and moisture conditions are present for microbiological activity.

Corn or sorghum silage vs. grass silage

Frequently stockmen are confronted with making a choice between corn or sorghum silage and grass silage. Under these circumstances, the following facts are pertinent:

1. Where adapted, corn or sorghum will generally produce a greater tonnage of feed per acre than grass silage.

2. Good quality corn or sorghum silage can be made more consistently and with greater ease than good quality grass silage.

3. Corn or sorghum silage is generally more palatable than grass silage, even when the latter is carefully preserved.

4. Grass silage is generally higher in protein and carotene but lower in total digestible nutrients than corn or sorghum silage (generally, grass silage contains about 90 per cent as much T.D.N. as corn silage, but it will equal corn silage in T.D.N. where 150 pounds of grain per ton have been added as a preservative). Thus, grass silage generally requires the addition to the ration of less protein supplement but more total concentrates than corn or sorghum silage. This would indicate that corn or sorghum silage would be slightly preferable to grass silage in high roughage finishing rations for beef cattle and sheep, whereas grass silage would be preferable in high roughage rations for dairy animals and young beef cattle and sheep.

5. Grass silage is higher in carotene content but lower in vitamin D, unless made by the wilting process, than corn or sorghum silage.

6. Grass silage can be produced in those areas where the climate is too cool and the growing season too short for corn or sorghum silage.

7. The production of grass silage will result in less soil washing than the production of corn or sorghum silage on lands subject to erosion.

Effect of silage on Milk Odor and Flavor:

Silage sometimes affects the flavor and odor of milk. This effect may be somewhat more pronounced with some silages than with others The dairyman will do well, therefore, to feed all silages after, rather than before, milking.

* LOSSES

Some losses are incurred in the ensiling process regardless of the procedures used. Field losses vary with the degree of field drying. Losses in the silo can be grouped under three main headings: (1) surface spoilage, (2) seepage, and (3) gaseous or fermentation losses.

SURFACE SPOILAGE

The amount of surface spoilage is a function of the degree of exposure to air and water. Losses of 20% or more can occur in stack silos. Each 1 cm of surface spoilage represents approximately 3 cm of silage lost. The most effective way to reduce loss from surface spoilage is to reduce the surface area exposed or to provide suitable protection such as a plastic cover.

SEEPAGE

Storage losses tend to be higher with direct-cut materials, due to squeezing out water and movement of feed nutrients out of the silo with the water. In a high-moisture silage 50% or more of the dry matter losses may be due to seepage. These losses usually increase with the percent moisture of the ensiled forage and &dine height of the silo. A horizontal silo will have less seepage loss because of lower vertical pressures. In general, silages with leas than 70% moisture have little or no seepage loss.

GASEOUS LOSS

Gaseous or fermentation loss is due to respiration by the plant in the silo and the subsequent bacterial fermentation. Both of these factors result in loss of dry matter in the silo. Some of this is unavoidable; but unnecessary loss can result because of entry of air into the silo, failure of PH to decline rapid and existence of unfavorable fermentations. Adherence to principles of good silage making will keep this loss at a minimum.

* SILAGE-MAKING PRACTICES

One of the basic problems in making high-quality silage is the variability of the product even under apparently similar conditions. Generally, the following practices have resulted in making a good grass-legume silage.

1. Use a crop of high quality.

2. Harvest forage at the proper stage of growth.

3. Fine-chop. length of cut for unwilted material should be 6-25 cm in length; for wilted material 6-12 cm in length.

4. Field-dry to 65% or less to produce either a wilted or low-moisture silage, or use an additive.

5. Use a silo which excludes air and water.

6. Fill the silo rapidly and pack thoroughly.

7. Use a suitable seal to exclude air.

8. Leave silo until ready to use the feed.

Pit silos

The pit silo is shaped like the conventional tower silo, but is inverted into the ground. It resembles a well or cistern. The walls of a pit silo may or may not be lined. Where the water table is low enough that the silo will not become filled with water, such as in semi-arid areas, the pit silo is very satisfactory.

In comparison with tower silos, pit silos have the following advantages:

1. they are never damaged by storm or fire,
2. they require less reinforcing
3. they minimize silage loss because of not having doors,
4. less expensive and practical for the African farmer.

Requisites of a good pit silo

1 That its size be inkeeping with the number and kind of animals to be fed daily, the length of the feeding period and the amount of forage available for ensiling.

2 That the sidewalls are straight and smooth in order to prevent the formation of air pockets.

3 That it be of adequate depth thus making for better packing and less surface area exposed: factors which will help to keep spoilage losses to a minimum.

4 mat it be conveniently located and accessible from standpoint of both filling and feeding.

5 That it be located in a well drained area.

6 That the soil structure be such that the sidewalls will not collapse. (Where there is deep sand, it is not recommended that a pit silo be dug)

Advantages of silage

1 It retains a higher proportion of the nutrients of plants. Thus grass silage preserves 85% or more of the feed value of the crop.

2 It is feasible to produce a top quality feed during times of inclement weather when it would be impossible to cure properly hay or fodder.

3 It is the cheapest form in which the whole plant can be processed and stored.

4 It practically aleviates the danger of fire loss to feed.

5 It is the most satisfactory and economical way in which to preserve a number of by-products of feeds. For example: peanut vines, millet and sorghum that is planted too late, etc..

6 It is a better source of protein and of certain vitamins, especially carotene, and perhaps some of the unknown factors, than dried forage.

7 It is a very palatable feed and slightly laxative in nature.

8 It makes for less waste, the entire plant being eaten; an important consideration with coarse stemmy forages.

9 It makes possible the production of the maximum quality of feed per acre or hectare of land.

10 Cattle, sheep, and goats like it.

Kinds of silage

A great variety of crops can be and are made into silage. A rule of thumb is that crops and forages that are palatable and nutritious to animals as pasture as green feed, or as dry forage also make palatable and nutritious silage. Likewise crops and forages that are unpalatable and unnutritious as pasture, as green feed, or as dry forage also make unpalatable and unnutritious silage.

The varieties of grasses and legumes that can be used depends on those that are available in each locality. Some of the more common forages found on African savannas which make good silage are hyparrhenta sp., andropogon gayanus, roettebbia exaltata, peanut greens, millet, sorghum, bean vines, and many others.

Characteristics of good silage

In order to make good quality silage, farmers need to know what constitutes silage quality. They need to be acquainted with those recognizable characteristics of silage which indicate high palatability and nutrient content. The easily recognized characteristics of silage of high feeding value are:

1 Odor - it has a "clean" rather pleasing acid odor, in contrast to the foul or objectionable odor of poor silage.

2 Taste - the taste is pleasing; but not bitter or sharp.

3 Absence of mould and rot - there is no visible mold, and it is not musty or slimy.

4 Uniformity - it is uniform in moisture and color. Generally green or brownish silage is good. Tobacco brown or dark brown silage indicates excessive heat, and black silage is rotten and should not be fed.

5 Animals acceptance - animals like and thrive on good silage.

The ensiling process

The ensiling process is principally governed by the interaction of three factors: 1, the bacteria on the plant material, 2, the composition of the plant material placed in the pit silo, 3, the amount of air entrapped or allowed to enter the stored forage.

The ensiling process refers to the changes which take place when green forage is stored in a pit silo in the absence of air. An understanding of these changes is likely to lead to the production of more high quality silage.

The entire ensiling process requires two to three weeks, during which time the following aerobic bacteria (with air) and anaerobic bacteria (without air) predominate:

Aerobic bacteria - the living plant cells of forage continue to respire, or breath; consuming the oxygen of the silage - entrapped air, producing carbon dioxide (CO_2) and water (H_2O), and releasing energy or heat. Simultaneously, aerobic yeasts and molds thrive and multiply. During this period the temperature may rise to about 100 degrees fahrenheit. The bacteria on the plant material when harvested are largely aerobes. These bacteria, along with the facultative bacteria increase in number and their activity aids in the exhaustion of oxygen (O_2) From the silage mass.

Anaerobic bacteria - when the available oxygen of the entrapped air has been completely consumed by the respiration of the plant and aerobic bacteria, a four to five hour transition period takes place whereby anaerobic bacteria conditions prevail. Chiefly acid forming and proteolytic bacteria are formed. The lactic acid bacteria increase in number. Despite the fact that the lactic acid bacteria may originally be present in such small numbers that they are difficult to isolate, they are always adequate in numbers to produce good silage, under suitable conditions. Even a very few lactic acid bacteria, given proper conditions, may increase to several hundred million per gram of silage in three or four days.

Simultaneously, the molds and yeasts die, but continue to function as enzyme systems which produce alcohol and other end products.

The combined anaerobic activity produces the following changes:

1 The carbohydrates and sugars (especially the sugars) are broken down into lactic acid (the acid in sour milk), some acetic acid (the acid in vinegar), and certain other acids and alcohols. The sugars that are broken down are largely sucrose and monosacharides, glucose and fructose.

2 Some of the proteins are broken down into ammonia, amino acids, amines, and amides.

3 The acidity finally reaches a point where the bacteria themselves are killed, and the silage-making process is completed. Silage in a good pit silo will remain unchanged for a long period of time during the dry season months in African savannas.

The acid development "pickles" the plant material by reducing the ph to 4.0 or below. The low ph inhibits further bacterial growth and enzyme action and preserves the silage. Also it inhibits proteolytic and putrefactive bacteria from growing, which cause rotting and putrefaction.

The presence of small amounts of ethyl and other alcohols is desirable, because they combine with the acids to form compounds which impart to silage the characteristic aroma

Dangerous silage gases

Gases formed during fermentation may become hazardous when making and feeding all types of silages unless precautions are observed. The gases are heavier than airand may accumulate near the surface of the silage in pit silos. <u>Pit silos are always dangerous</u>, even after filling.

It has been long known about the suffocating effect of carbon dioxide (CO_2) gas formed in silage. It is the most common and most dangerous of gases from silage, because it is invisible.

It has also been recognized that nitrogen dioxide gas is formed by high-nitrate silages and can cause a sometimes fatal disease called nitrogen dioxide pneumonia in man and livestock. Some plants such as legumes, oats) barley, wheat, corn, sorghums, many pasture grasses and certain weeds appear to accumulate especially high concentrations of nitrates during droughts and when grown on high-nitrate soils. When these plants are made into silage, poisonous nitrogen dioxide gas forms until a week or ten days after filling the pit silo.

Carbon dioxide gas may be detected by lowering a lighted lantern into the level of the silage. If the flame goes out, the oxygen content of the atmosphere in the pit silo is dangerously low. Nitrogen dioxide gas can be detected by 1: its yellow or yellowish brown color or 2: by means of starch-iodide paper (obtained from drugstores or chemical supply houses), which turns blue in the presence of nitrogenous compounds.

Precautions against silage gases

Before entering a pit silo, swing a piece of canvas, a tree branch, a burlap bag, or something to agitate the air and dilute gases that may be present with oxygen from the air. Adequate ventilation is essential.

Notice: A victim of silo gas should be moved into fresh air as soon as possible, and artificial respiration should be applied, and taken to a physician immediately.

Selecting a site for a pit silo

When selecting the site for a pit silo, the following must be considered:

1: depth of loose sand,
2: depth of water table,
3: availability of forage
4: convence of feeding the silage,
5: flood plains during rainy season,
6: shade.

When selecting a site where the sand is deep, (more than two feet), there is a tendency of the side walls to be unstable. When the pit silo is empty, the side walls generally cave-in. Therefore it is recommended that pit silos be dug where there is less than two feet of sand.

Before choosing a site, one must always determine the depth of the water table. In many areas of African savannas, the water table is near the surface, especially near rivers. One good method of determining the depth of the water table, is to look down an open well near the proposed site, or ask the villagers how deep the water is in their well. Always remember, the water table usually descends at the onset of the dry season, and ascends during the rainy season. Do not put silage in a pit silo that contains water.

Select the site of pit silos where forages are readily available. When forages are readily available, less time is consumed transporting cut forages to the pit silo.

Select a site that will be convenient to feed silage to livestock. Preferably near where livestock are usually tethered.

The site location should never be in a flood plain. Usually the water table is near the surface, and during the rainy season, the sidewalls are more likely to cave-in.

It is preferred that the pit silo be located between two large trees or on the east side of a large tree. It is important that the shade cover the hole during the heat of the day. If no shade is available, the silage will be more apt to dry out after the silo is opened. Shade is also necessary for the workers while filling

Proper size of pit silo

The diameter and depth of the pit silo should depend on the number and kind of animals to be fed from it and the length of the feeding period. The silo should be of such that two to four inches of silage will be removed from the entire exposed surface daily to prevent spoilage.

The size of the pit silo required may be computed from determining the length of the feeding period and kinds of livestock to be fed. Knowing the number of animals of each kind to be fed, the entire amount of silage which will be consumed daily, and the length of the feeding period, the total tonnage of silage needed can be estimated. By referring to table 1, one can determine the proper size and dimensions for a pit silo that will suffice the needs of individual farmers.

The amounts of silage commonly fed per head daily to the various classes of livestock are estimated as follows:

2 - 3 year old oxen	25-30 pounds
3 - 8 year old oxen	30-50 pounds
sheep	2-3 pounds per 100 lbs. live wt.
goats	2-3 pounds per 100 lbs. live wt.

Example:

Mr. Keita owns two oxen, ten sheep, and ten goats. be wants to store enough silage to feed all his livestock during the dry season. How large must he make his silo.

Step 1 Determine the length of dry season or the number of days he must feed his livestock silage. In this case we sill say five months or 150 days.

Step 2 His two oxen will eat an estimated 60 pounds of silage each day, with the sheep and goats eating an estimated total of 60 pounds of silage each day, making a grand total of 120 pounds of silaged needed each day.

150 days X 120 pounds of sillage = 18,000 pounds or 9 tons

Mr. Keita needs an estimated nine tons of silage to meet his livestock needs for the coming dry season. Refer to table 1, a pit silo with a diameter of 12 feet and a depth of 5 feet of settled silage will suffice his needs.

Table 1

Depth of settled silage	Total quantity of settled silage, from the top to the depth indicated, in silos having a diameter of:			
	10 feet (tons)	12 feet (tons)	14 feet (tons)	16 feet (tons)
1	1	1	1	2
2	2	3	4	5
3	3	5	6	8
4	5	7	9	12
5	6	9	12	16
6	8	11	15	20

7	10	14	19	25
8	11	16	22	29
9	13	19	26	34
10	15	22	29	38
11	17	24	33	43
12	19	27	37	48
13	13	30	41	53
14	23	33	44	58
15	25	36	48	63

From USDA circular number 603, by J.B. Shepherd and J.E. Woodward: with all decimals rounded off to the nearest whole number.

Digging a pit silo

Remembering that a pit silo can be used for several years, the following observations should be considered when digging the pit: 1; shape of pit, 2; having pit repaired for filling at proper time, 3; keeping the sidewalls straight, 4; keep top edge of pit free from piled soil.

There are basically three shapes one can make a pit silo, round, square or rectangular. The shape of the pit depends entirely upon the wishes of the farmer. From the standpoint of experience, round pit silos are recommended over square or rectangular shapes. Round silos have the following advantages: 1, silage will tend to settle more uniformly which is desirable for high quality silage, 2, corners are eliminated, which have a tendency to form air pockets causing spoilage, 3, with round silos increase volume can be gotten from a given site.

It is recommended that the pit be readied for filling prior to the time when the forages are at their best for harvesting. Pit silos should be prepared for filling immediately following the rainy season in African savannas.

When making a new pit silo, it is important that the sidewalls be kept straight and smooth. Often there is a tendency for the sidewalls to slope inwards as the pit gets deeper, thus having a larger diameter at the top compared to the bottom. Having the sidewalls smooth and free of holes, roots or stones, reduces the possibilities of air being entrapped which may cause some spoilage and the silage will also settle more uniformly.

If using a pit silo from previous years, all rotten and moldy silage should be removed. Sidewalls should be straightened if portions have fallen in during the preceding rainy season.

While digging the pit silo, it is recommended that the soil from the pit be piled a minimum of one to two feet from the edge of the pit, thus eliminating the possibility of soil being pushed into the silage by workers while moving about in filling the pit silo.

Filling a pit silo

Filling a pit silo properly will pay dividends during the African savanna dry season when feed for livestock is difficult to obtain. When filling a pit silo in African savannas, the following points should be considered: 1, cutting forages to be chopped, 2, tools, 3, transporting forages to pit silo, 4, chopping the silage, 5, tramping chopped silage, 6, amount of time required to fill a pit silo, 7, workers.

Cutting - The kinds of forages to be cut will depend upon the availability of local grasses, legumes, crops and crop residues. Nevertheless, a large volume of forages must be cut and placed near the edge of the pit silo. Cutting the forages in the late afternoon and placing at the edge of the pit for chopping the following morning has been found to be a satisfactory system for these reasons: 1, cutting the forages in late afternoon for chopping the following morning allows the plants to wilt somewhat before putting into the pit silo. Water evaporated from the plant juices before putting into the silo decreases the amount of nutrients that will escape from the silage in the plant juices and water that normally drain from the silage mass. Wilted forage increases the amount of sugar per pound of forage, because part of the water is removed, thus improving the quality of chopped silage. 2, Workers usually do not like to cut forage during early morning hours when plants are heavily covered with dew. Cutting forages in late morning hours or late afternoon when forages are dry improves work efficiency.

Cutting forages and chopping without wilting is also an approved practice when making silage. The system used depends upon the wishes of the farmer

When cutting forages, if the grasses or legumes tend to be stemmy, cut plants higher from the ground using only the succulent and leafy part of the plant, eliminating the coarse, woody stem of more mature plants. For high quality silage, cut only leafy succulent forages.

Tools - Tools used to cut forages depend on what is available locally, local made knives and machettes have been found to be satisfactory for cutting and chopping forages. Factory made machettes, military machettes and scythes are also very satisfactory for cutting forages, when available.

It is recommended that a file be kept available for workers to sharpen knives and machettes when necessary. It has been found that work efficiency is greatly improved when tools are kept sharp.

Transporting - Transporting cut forages to the pit silo depends upon what the farmer has available and how far forages are located from the, pit silo. Ox drawn carts have proved to be very satisfactory in transporting cut forages to pits. Where ox drown carts are not available, carrying bundles of cut forages on the workers head has been found to be satisfactory. Attaching bundles of cut forage on the backs of horses and/or donkeys has been done successfully for long distance transporting. However the method used, transporting cut forages to pit silos must be economical and practical for the farmer. Transporting cut forages long distances could prove to be both uneconomical and unpractical

Chopping - Chopping cut forages into two to four inch lengths improves the quality of silage; makes forages more palatable, especially coarse, mature forages causes the silage to pack more tightly excluding the air, and, increases the volume of forages that can be put into a given pit silo.

Where forage chopping machinery is not available, manual methods can be successfully accomplished by placing logs at the edge of the pit silo. With workers sitting by the log, placing forages on the log towards the pit silo, using machettes or locally made knives, silage can be chopped into two to four inch lengths falling directly into the pit silo. This method has been found to be practical and well accepted by local farmers who are making silage for the first time.

Tramping - While filling a pit silo with chopped silage, it is very important that the silage be periodically tramped. Tramping the chopped silage facilitates packing and excludes air pockets that may cause spoilage. It is most important that the edges be well tramped where there is more of a tendency for air pockets to form. Remember, one cannot over tramp silage in a pit silo. Before entering a pit silo, precautions must be taken that no dangerous silage gases are present.

Time - Filling a pit silo as quickly as possible will further insure high quality silage. It is recommended that a minimum of one to two feet of chopped silage be added daily until the pit silo is completely filled. The time required to fill a pit silo depend upon the following: 1, size of pit, 2, number of workers, 3, availability of forages, 4, method of transporting forages, 5, local factors such as holidays, sickness, deaths, etc..

Workers - The number of workers participating will greatly influence the time necessary to completely fill a pit silo. Farmers should avoid when possible, attempting to fill a pit silo alone. It is highly recommended that farmers work cooperatively in filling pit silos. The more workers available, the more quickly the silo can be filled, thus improving the over-all quality of the silage.

Sealing pit silo's

When the pit silo has been completely filled with chopped forages and has been well tramped, it is necessary to seal the silage mass so that it may be properly preserved. On African savannas where pit silos have been successfully used, the following has been found to be very satisfactory, acceptable, and practical.

Cover the entire silage mass with a layer of long grass, bannana leaves, palm tree leaves or dry grass, anything that will prevent soil from being mixed with the chopped silage. Thence the entire surface of the silage mass is covered with 18-24 inches of soil.

When the pit silo has been properly sealed, two to four days afterwards, the silage mass will have settled approximately one foot or more, depending upon how well the chopped silage was tramped before sealing. The weight of the soil cover aids in forcing out any entrapped air pockets, thus further eliminating possibilities of spoilage.

Opening pit silos

Keeping in mind the number of animals that will be fed daily, it is necessary, after the silo is opened, that two to four inches of silage or more be removed from the exposed surface daily. Therefore the amount of silage a farmer exposes when opening a pit silo, will depend a great deal upon how much silage he will need each day. By removing the daily minimum of two to four inches of silage, reduces the time silage near the surface is exposed to the air, thus curtailing loses caused by spoilage.

When only a small number of animals will be fed daily from a pit silo, it is suggested that the pit silo be divided into three vertical sections. Thus only a portion of the pit silo will be opened at a time. When only a portion of the silage is exposed, the minimum of two to four inches of silage will more likely be removed from the exposed surface when a small number of animals are to be fed.

When removing silage from the pit silo, care should be taken not to cause loose soil to fall on exposed silage. The soil should be placed at least 2; inches from the edge of the pit, when opening each section Soil mixed with the silage reduces its palatability.

After soil has been removed from the silage, one will find between four to six inches of spoiled silage on both the top and sides of the silage mass. This small amount of spoiled silage is normal and <u>must</u> be thrown away and <u>not</u> fed to livestock. This thin layer of spoiled silage forms a seal following the ensiling process.

Termites

In many areas of African savannas, heavy termite infestations exists. When introducing silage to farmers one of the first questions they ask is "will termites eat the silage stored in pit silos?"

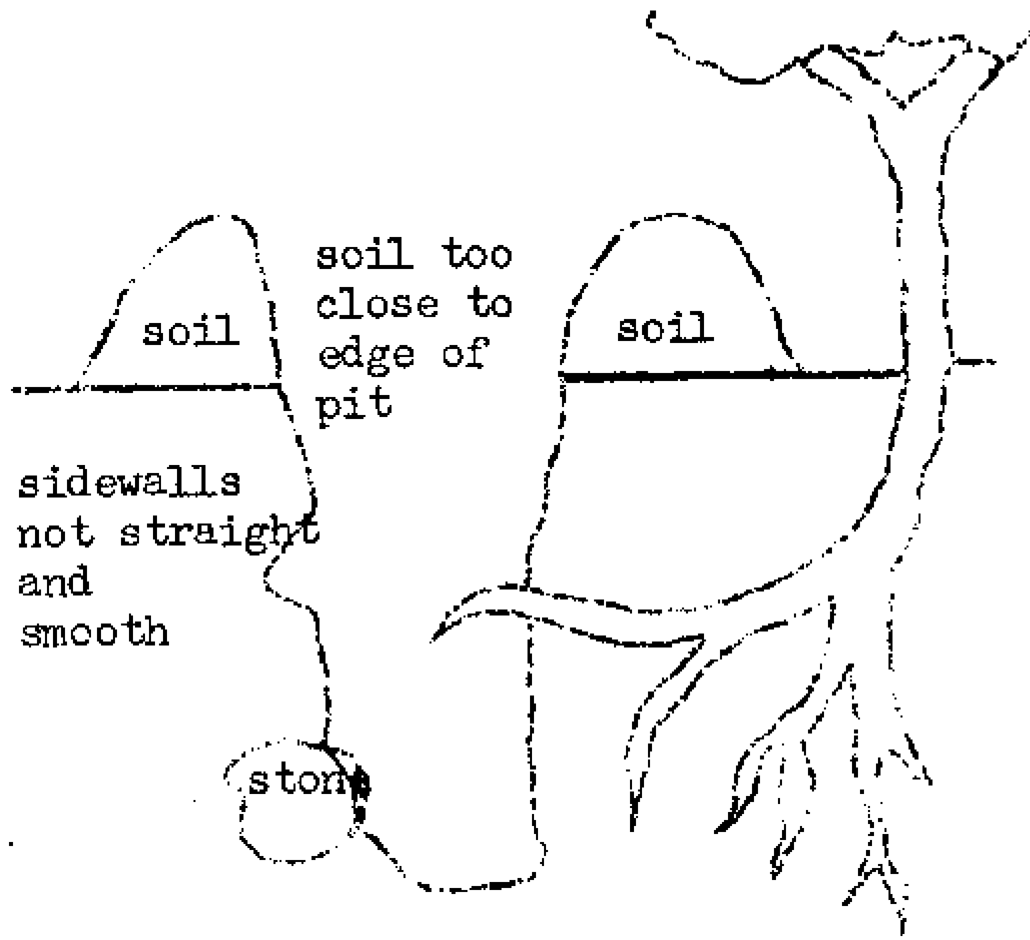
Thus far, experience and studies have indicated that termites will not eat well preserved silage. It is suspected that due to the low ph or well preserved silage that perhaps the acidity may discourage termites from damaging silage.

Pit silos have been filled where termites were visible on the sidewalls while filling, but no detremental effects have been observed while the silage was being removed during the dry season.

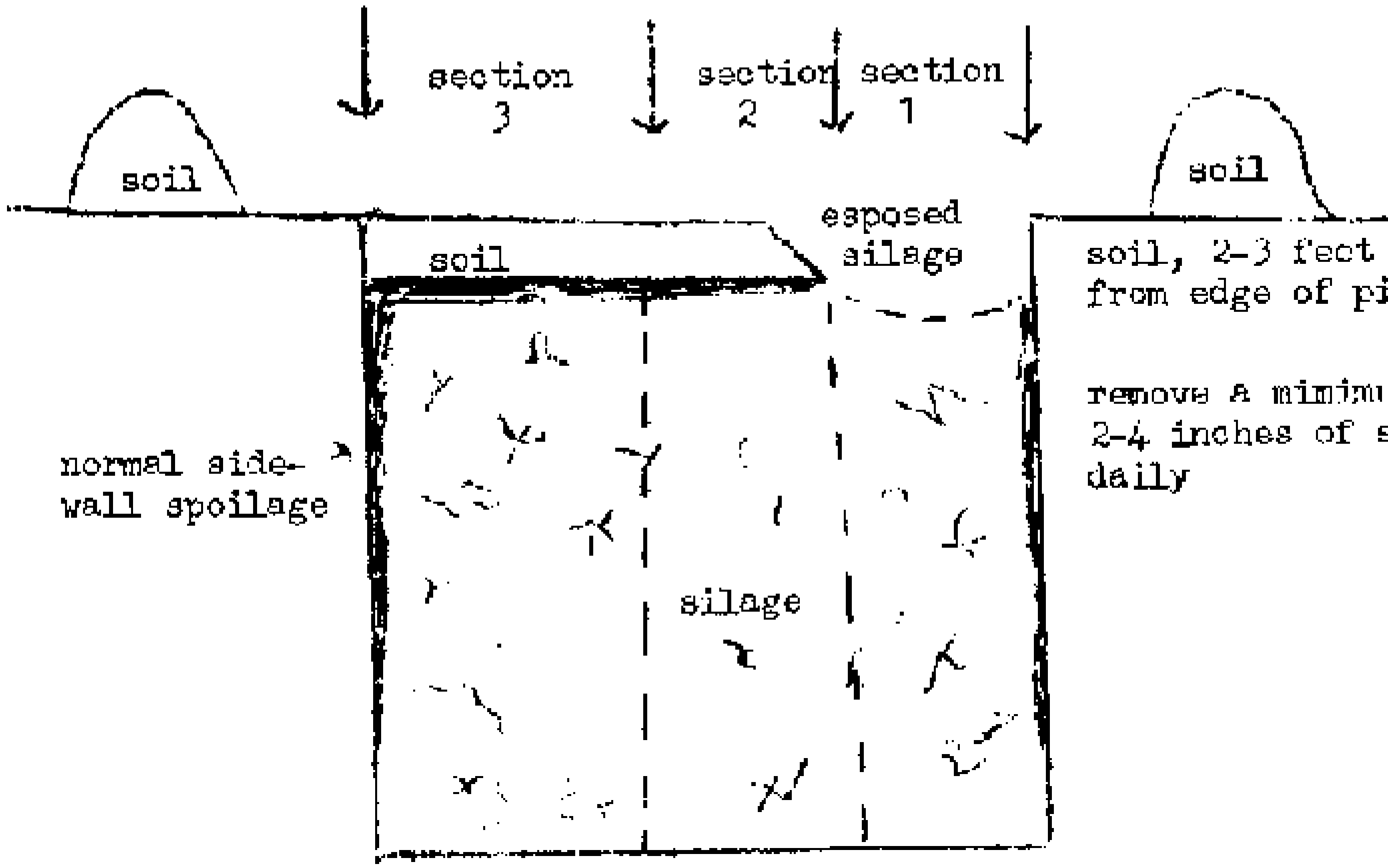
Termite infestation has been occasionally observed in the thin layer of silage that normally spoils next to the sidewalls, but no infestation or damage has been noted in the usable silage.

Written by: James E. Diamond PCV - Chad, 1971

Soil too close to edge of pit



Sideview of an opened pit silo



sideview of an opened pit silo

Project ensilage - Interim report

A joint project between the Animal Husbandry Service and the Peace Corps, Republic of Mali

Interim Report
August 1974.

Prepared by James Lajoie,
PCV/Mali.

In 1973 under the combined efforts of the Service de l'Elevage (the Livestock Service) the Union Laitière de Bamako, or ULB (the State Dairy Company), and the Peace Corps, a stage program was initiated in Mali to establish the use of pit silos as a means of feeding sedentary cattle during the rainless months from November to May when there is no grass for the cattle to graze. Ten experimental silos were done on a demonstration basis within the two milk zones of the ULB. When these silos were opened in March and April, 1974, all but one (which had been filled late in the silage season) produced high-quality silage. Dairy cows fed from these pits showed immediate increases in their milk production. In addition, farmers who fed their oxen on silage during the dry season noticed themselves a distinct difference compared to previous years in the additional strength of their oxen when cultivating started. They stated that the condition and health of their oxen plays a major roll in determining the amount of cultivating they can do.

As a result of this pilot effort, not only does each farmer who pioneered a demonstration pit silo last year wish to do additional ones this year, but other farmers in the surrounding areas have expressed a definite interest in doing their own pits. In these villages it is no longer a question of finding volunteers to do the pits as it was last year, but rather a question of how to make the pit silo technique available to everyone who is interested.

Looking at it from the administrative side, one example of the reaction to the pit silo technique can be found in the Cercle of Rangaba. (A Cercle is an area designating an administrative unit similar to a County) last year, only one pit silo was dug in that Cercle. As a result of its success, the Commandant de Cercle has proposed the setting up of an extention program which will find a pit silo in every major village within the Cercle this year.

The results of the experimental pit silos done in the zones of the ULB show the potential impact of this project on the dairy industry of MALI. Cows fed on silage increased remarkably their productivity during the dry season. Previous years' statistics show that there is a drop of 95% in milk collection from the rainy season to the dry season chiefly due to a lack of feed. For example, the Dialokoro zone of the ULB, which normally produces 1,500 liters daily during the months of August and September, produces a maximum of only 75 liters daily during the months of February, March, April and May. It is obvious from tines statistics that dairy cows produce little or no milk during the dry season, and the resulting factor is that ULB is forced to use reconstituted dry milk to keep up production.

Looking more closely at last year's results, it is possible to take the example of the demonstration pit done in Bankoumana by El Hadji Missera. Under the close observation of Issiaka Sy, the Chef de Collect de l'ULB, data was kept on how the pit was used. During the two-month period in which the pit provided feed, El Hadj Missera fed two work oxen and two milk cows uniquely on silage. Because of a shortage of forage, he also had to supplement the diet of the rest of his herd with silage from the pit. The observed and recorded results after two months showed that his cows increased their daily milk production by 62% over previous years, and that his work oxen were a lot stronger before cultivating time than the year before. It should be noted that, the results of El Hadj Missera's s pit silo are only a partial indication of the concept's potential since the pit was used to feed more cattle than intended.

Based on records kept during the months of April and May, 1974, the increase in productivity as a result of silage showed a monetary gain of 1,125 Malian Francs per cow per month. (This figure is based on 24 liters per cow per month before silage and 39 liters per cow per month after silage, at 75 MF per liter.) Applying these figure to an average-sized herd of 35 to 50 cattle would show a substantial increase of yearly income. (The present per capital income in Mali is approximately 30,000 MF or $60.)

As a result of the encouraging indications of the experimental project, the Service de l'Elevage and the Peace Corps launched a pit silos extension program with the funding support of AID. Seven volunteers and ten Malian counterparts began implementing the program in July, 1974, in the regions of Bamako, Segou, and Sikasso.

Each team of a Volunteer and his one or two counterparts has a Land Rover to facilitate their contact and support of the pilot farmers. They carry cut their work in close collaboration with the Regional structure of Elevage personnel.

It is anticipated that each team will be able to realize fifteen to twenty pit silos the first year in the new zones. The overall aim is to have farmers see the benefit of having a pit solo, so that the technique will then be disseminated by farmers telling and showing others the advantages of having a pit silo and how they are done.

Another group of Volunteers, eight extension workers and their counterparts, are scheduled to begin work in June, 1975, to cover areas in the legions of Kayes and Gao in addition to other zones in Sikasso and Bamako where there are concentrations of sedentary cattle.

Nutritional Biochemistry Section

National Zootechical
Research Center
- BAMAKO-

Sender: Peace Corps
B.P. 85
Bamako, Mali

Type:	(Pennisetum, Andrapogon Gayanus) Grass silage, slightly witted	[1]H_2O %	Dry Matter %	Protein %	= Fat %	Fiber %	N-Free Extract %	Mineral Matter %	Calcium %	Phosphoru s %	Magnesium %
Location:	Bamako	1.75	[*]98.25	5.50	1,68	39.61	43.74	9.57	.20	.23	.160
			[+]100	5.59	1.70	40.31	44.51	9.63	.203	.234	.162
	Bankoumana	5.05	94.95	5.53	2.24	36.17	32.16	13.90	.33	.16	.145
			100	5.82	2.25	38.09	44.40	14.60	.34	.16	.152
	Dialakoroba	2.64	97.36	4.56	1.62	36.00	33.30	24.52	.36	.18	.204
			100	4.68	1.66	36.97	34.97	25.18	.369	.18	.209
	Roursalé	2.69	97.31	6.36	1.40	33.56	48.90	9.78	.27	.09	.194
			100	6.53	1.43	34.48	50.25	10.05	.27	.10	.199
	Tabakoro	2.95	96.05	3.75	1.91	39.91	34.59	18.84	.30	.21	.243
			100	3.90	1.98	41.51	36.01	20.65	.31	.218	.252

[1]. Water content was not immediately taken when silage was delivered to the laboratory. There was a 4-6 weeks lapse time,

[*] Upper number indicates analysis done with percentage of H20 in silage.

[+] Lower numbers indicates analysis done with 100% dry matter

Project ensilage - Termination report

A joint project between the Livestock Veterinary Service and the Peace Corps, Republic of Mali

Termination Report
May 1976.

JAMES CHANEL LAJOIE
Volunteer Coordinator,
Pit Silo Project, 1974-1976
Mali, West Africa

INTRODUCTION

In July of 1974, under the combined efforts of "Le Service de l'Elevage" (Livestock Veterinary Service) and the Peace Corps, a silage program was initiated in Mali. The purpose of this program is to establish the use of pit silos as a means of feeding labor oxen and dairy cows during the rainless months from November to May when there is no grass for the livestock to graze on.

Under the guidance and advise of the Veterinary Service, zones were selected throughout the country where concentrated extension efforts would be carried on by each silage team. Each team consisted of one Peace Corps Volunteer and one or two Malian counterparts. The teams were directly under the supervision of the heads of the veterinary sectors who were responsible for the effectiveness and outcome of all work carried on in their zones. Each team had as a means of mobility, a Land Rover and two mobylettes. There was also a coordinating team consisting of a Malian National Coordinator and a Peace Corps Volunteer Coordinator, which was responsible for the general supervision of the project.

The goal of each team was to make contact with the various villages throughout their zones and introduce the pit silo technique through demonstration pits, financed with project funds. The thought behind providing these financed demonstration pits was to show the villagers positive proof of the technique with minimum risk on their part, thereby arriving at a faster extension of the technique. A common problem in extension work is getting the villagers to change traditional methods that barely work and to accept methods that are more effective. In the minds of the villagers, they know that what they've been practicing has gotten them by, if only barely, and that the possibility of trying something new can result in total failure, which is a risk factor most cannot afford to take.

The actual silage technique used in this program consisting of having the villager dig a circular pit 3 meters in diameter by 2 meters in depth and fill it with natural grasses. The grasses are chopped into small pieces with locally available machetes, and packed tightly by stamping each layer.

Once the pit is filled a superficial layer of uncut grass, hay or millet stocks is added before the silo is covered with dirt. The placement of the pits varied within each zone due to differences in topography and vegetation The intention was to place "the pits reasonably close to where the cattle would be watering during the dry months and where there would be some available shade. This was not always possible. The pits were expected to provide 8-9 tons of silage for 3-4 head of cattle (15 kilos per head per day) for 150 days. The villagers used indigenous materials to dig, carry, and chop the grasses, and to fill the pits.

APPROACH AND EXECUTION

From the initial contacts made by each team they had an overall impression that the villagers were very enthusiastic and willing to contribute to the work effort involved in silage making. Some of the zones had previous exposure to the idea of silage through an extension effort made ten years earlier. This exposure was limited to literature covering the execution of silage techniques and was not followed up by having on the spot technicians helping control the few error factors which can cause silage to spoil. Needless to say, a lot of pits were dug but were unsuccessful.

The initial contact made by most teams was done at village meetings where all the local cattle raisers were summoned. The silage technique and the beneficial results it could provide, i.e. healthier oxen at the onset of cultivation time, higher milk yield etc. was explained to them in their local language by the Malian counterpart. To facilitate the summoning of villagers for these meetings, teams discovered that working through local administration provided effective results. Telegrams or administrative short wave radios were used to announce the arrival and intentions of the silage teams. During these meetings, with the advice of the village chief and the local veterinary agent, one or more pilot cattlemen were selected to supervise and control the usage and distribution of the demonstration pit silo. Also, names of volunteers who wanted to participate immediately without waiting to see results, were also taken. All this took place one to two months before the actual digging started.

After the initial contact stage, the teams went into the execution stage the actual digging the pits. Working calendars were set up and tentative dates were sent to villages informing them as to when the silage technicians would be arriving.

It was at this point that most teams started encountering their first problem - that of actually getting the holes dug, filled and closed in a minimum period of time. The important thing to remember here is that for ideal silage, grasses should be cut at the flowering stage. In Mali, at tile moment of flowering it is still raining, so getting the pits filled and covered in a minimum period of time is very crucial. Many teams found that unfortunately, the filling period often coincided with other village cultivating activities such as harvesting their grain crops. As a result this cut down the availability of people who could work on the completion of pits. The mobility and persistence on the part of each team played a major role at this moment in determining the quality of silage and the degree of successful acceptance of the technique on the part of the villagers.

During the filling of the pits, it was difficult in many cases to get the people to effectively and sufficiently pack the grasses. The first few efforts were always fun and different, but as the need increased to keep the grasses packed tighter, the willingness on the part of the workers decreased. Some teams resorted to using the local tom-tom players in helping to establish a rhythmic dancing atmosphere, other used tape cassetes with lively music. One team used a 200 liter barrel full of water, which they rolled around the pit as workers chopped grasses into the hole. This proved to be quite effective although it was somewhat tedious for those having to push the barrel.

Once all the pits were filled in each zone, the teams surveyed the decension of the grasses in each pit and instructed the pilot villagers to add more dirt This was initially done to keep any possible air from entering into the silage and causing spoilage. Actually in almost all cases, we found that the amount of dirt originally put on the pits at the time of covering was enough to safety protect the silage. Also the follow-up surveillance helped in controlling possible rain run-off into the pits. Some teams automatically, at the time of closing a pit, dug small drainage run-off ditches around each pit. It was small factors of this nature that often times made the determining difference in whether a villager would be rewarded for his effort by finding good silage at opening time or finding black rooting grasses and becoming very discouraged with the whole thing.

From the first years efforts put out by seven silage teams, 6 located in Soudanian zones and one located in a Sahelian zone, 180 pits were dug and filled. Upon the opening of these pits at the onset of the dry season, 85% gave an excellent digestable silage, feeding 750-800 labor oxen and dairy cows .

A very consistent finding among almost all tile teams at the time of opening, was that the silage had decended alot more than expected. Pits decended anywhere from 75 cm to 125 cm. It was realized at this time that these pits could not possibly contain 9 tons of silage. As was mentioned above, the effectiveness of packing the grasses is very important and this becomes quite evident at the time of opening. Taking all of this into consideration the pits still provided 2_-3 months of feed which in previous years had not existed.

USAGE AND DISTRIBUTION PROBLEMS

When pits were opened, often times confusion set in concerning the distribution and usage of the silage. In the cases when demonstration pits were done collectively, whereby villagers agreed to provide 3-5 head of cattle belonging to different owners, the choosing process left many feeling cheated out of their share of the silage. Upon seeing that green, edible feed was actually being produced from the pits, villagers that had participated in the work felt they should be able to feed their cattle. The idea of the pit being there for demonstration purposed was quickly forgotten and many pits were emptied in 2-4 week periods.

The simple fact that villagers were so anxious to use the silage is a strong enough indication of the potential role the silage technique can plays Once again the importance of technical surveillance and contact is a key factor in getting the villagers to realize what can be achieved through their own efforts.

Another situation encountered by the teams was that villagers misunderstood the value of having green fresh fodder as opposed to dry straw, during a time of year when very little feed is to be found. The teams found that villagers were taking silage out of the pits and leaving it out to dry before actually feeding it to their cattle. One factor contributing to this thought pattern was the different smell of silage. Villagers found that upon initial contact with silage, cattle often refused to eat it. Some pits were abandoned at this point until the teams come around and convinced the villagers that cattle would accept the different smelling feed if straw was first mixed with the silage and then gradually eliminate-d from the mixture. This proved to be a very effective technique in getting cattle to accept silage. In most cases the cattle accepted silage immediately upon presentation.

CONFERENCE

Between the end of the first silage season and the onset of the second season, a conference was held in the national capital. The original seven teams were present along with eight newly formed teams. Most of the new teams had already spent time in their new zones making initial contact with local villagers and arranging a work calendar for the upcoming season.

During the two day conference, old teams presented and discussed their extension approaches and the various problems which they encountered during the first season. This enabled the newly formed teams to realize and anticipate the potential problems they'd have to deal with in their extension work. One of the problems consistently brought out at the conference was how the introduction of money for the financing of pit silos often left the villagers confused. In their minds, having the availability of technical assistance was enough justification to at least try the technique. They couldn't understand why the pits were being paid for if they were the ones who were to gain by having feed for their cattle.

The general consensus was that it was much better to approach the extension of silage making from a non-monetary standpoint. Villagers realizing the possible benefits of silage wouldn't expect to be aided financially. With this approach it still left the teams with the option, if they encountered too much difficulty, of financing a demonstration pit.

The conference was also very effective, on a coordinating level, in explaining many misunderstood administrative necessities which existed during the first years work. Most importantly, the conference served as a unification of our ideas and efforts.

SECOND SEASON

During the second year of silage making, a variety of extension approaches were tried and used by the different teams. Some of the first year teams who had covered large zones found that it cut down their effectiveness and therefore used a more concentrated approach of contact. They were able to provide a more intensive program of technical assistance. Other teams chose to dig pits only in the villages that were administrative centers and invited village chiefs and leading cattlemen from surrounding villages to attend the demonstration of silage making. Of those teams who financed demonstration pits, some chose to pay the pilot villagers half the money at the time of closing the pits and the other half at the time of opening.

In many zones there were already local agents representing such agricultural operations in rice, cotton and peanut productions. These agents are distributed in different villages helping villagers improve their crop production. In these zones, almost all preparation of fields for cultivation is done through animal traction. Silage teams started working directly with these agents and incorporated the teaching of silage making into their already existing implementation programs. By using villagers that were contracted by these operations, the teaching and learning of new work methods was easily facilitated. Silage falls naturally into their needed feeding program because the villagers are striving for higher crop production. They easily realize that stronger oxen can plough more acreage in a shorter period of time. Most operations already teach their participants how to stock hay, so for them to learn silage making complimented their overall effort.

During the second year of silage making many first year participants were disappointed to find their pits had been completely filled with water during the rainy season and erosion had worn away the walls. Before being able to refill these pits, they had to bail out all the water and reshape the walls, which made a much larger hole them the previous year. Also, the dirt needed to cover the pit after filling had been washed away. This extra work discouraged the villagers to the point where many didn't want to refill their pits the second year. Those who did, found that refilling the newly reshaped pits took longer than the previous year because of the enlarged sizes. Some preferred digging new pits rather than using the old ones.

It was during this period that teams started realizing the importance of modifying the actual pit digging and construction design. The most widely accepted solution was to diminish the depth of the pits and construct walls, 5075 cm high, out of mud bricks. At the same time, the importance of constructing overhead hangars was reemphasized, not only for the use of stockpilling millet stocks, peanut vines and hay, but for helping to minimize the amount of rain water entering the pit.

RESULTS

At the end of the second year of the program, 15 teams, 5 of which were located in Sahelian zones, had dug and filled 525 pit silos. Of this total, almost all pits have given fresh green silage. The villagers who have fed their cows and cattle silage over the dry months have noticed considerable change in their animals weight and strength as compared to animals who didn't have silage to eat. Milk cows have continued giving milk during this period, where previously they had given none.

Silage fed oxen are able to plough in one day what it took three days to do before being fed silage. Before silage was introduced, these same animals couldn't make it through a full day's work.

Reports have been received of cattlemen who have bought weak and undernourished oxen during the dry months for next to nothing, used silage, and produced three months later, animals strong enough to do full days work ploughing fields.

The role of the extension agents is one of perserverence, persistance and many hours of patience without ever really knowing how much headway is actually being made. To change the hard and set ways of very traditionally minded people, when environmental changes no longer support methods they've learned to depend on throughout the years, this is the backbreaking work of extension work.

In our particular situation, that of trying to teach villagers a feed preservation method which can be applied with locally available tools, the continuance of such an effort lies in the ability of one villager being able to pass on to his neighbor what he has learned through practical application, better known as "The Snowball Effect". It is here that we find the true depth and penetration of an effective extension program.

Silage making in Mali is just barely taking shape in the minds of those who have participated and for those who have seen the results. It's a long way from being well accepted and widely used but it is off to a good solid start.

CONCLUSION

One of the most vital factors in the success or failure of a program, besides having independent financial funding, is properly selecting the service with which the project will be working. The major crippling clement of almost all the silage teams, and that which caused discouragement, disagreement and retardation of work progress, was the fact that the service which the project was working through, had very little support facilities of their own. They were lacking in budgetary funds to support the functioning and maintenance of their own vehicules and equipment. Silage teams often found themselves not only having to regulate their own needs but having also to support the needs of entire sectors of the service. The constant unnecessary drain posed by this situation caused many interpersonnel problems among team members and supervisory personnel which could not always be regulated in time by the coordinating team. Needless to say, this cut down the effectiveness of the work accomplished.

Now, after two years of trial, error, and improvement on our extension work techniques, there can be seen developing, easier avenues of approach and penetration. The hit and miss method of going from village to village in each zone and hoping to convince the people of the validity of our silage making technique, often left a large gap in communication and results, considering the amount of time and effort involved.

The avenues I'm referring to all load to the already established and organized operations throughout the country. These operation, i.e. cotton, peanut and rice, have their own cadre of agents placed throughout their production zones, helping cultivators learn new farming techniques which aids in developing higher crop production. These agents have already broken through the mental barrier villagers have of accepting new methods and ideas. These farmers are using work implementation programs which the operations have outlined for them, and they are seeing positive results.

As mentioned earlier, some silage teams have worked with operation agents in their zones and have found an uncomparable difference in the ease of incorporating silage making into existing programs as opposed to dealing with independent villagers. Silage teams using this level of contact could work directly with agents in each zone, showing them how silage is produced and then letting the agents themselves assist their program participating villagers. Once the agents understand the process well enough, they could incorporate silage into the yearly work program. Using this approach, silage foams would take on more of a supervisory role, working in and among different operations and their immediate personnel.

What this would do in effect, is allow the silage team the freedom of not having to be attached to any one service. Peace Corps Volunteers could still have counterparts from each operation assigned to work directly with the silage effort, but this does not mean that the Volunteer would be attached to that particular operation.

An important prerequisite in establishing a sound extension program is foreseeing the administrative needs and providing enough personnel to carry on the functions. The coordination team should not be burdened and taken away from their primary role as for most contact with field teams by having to occupy 90% of their time straightening out accounting, billing and banking difficulties which could be taken care of by a competent secretary.

Also, before a project is started and people are placed into field positions, all aspects of the necessary money distribution and justification procedures should be well understood by all parties concerned i.e. field teams, funding agency, banking service and coordinating team.

Enough time should be allowed, before the actual starting of a project, to prepare and receive all the necessary equipment needed for a thoroughly effective extension team. Throughout the two years of the silage program the teams were constantly hindered by the lack of equipment i.e. camping beds, gasoline barrels, jerry cans, which could have facilitated their work load.

Lastly, an improvement on the now existing work involved technique Or silage making is necessary. Under the present method, a lot of dirt has to be shifted on and off the pit each year. Much of the dirt is lost during the rainy season and mew dirt has to be carried in. This increased the work load and discouraged the villagers. A possible solution would be to fill sacks with dirt and stack them on the silage. The same dirt could be reused on a yearly basis. Also, the silo itself has to be built on a more permanent designs, i.e. pit with 50-75 cm wall around it and overhead straw roof or hangar. The present design is not feasible on a yearly bases.

Once again, the need to eliminate these already forseen problems emphasizes the immature stage of this possibly strong and penetrative technical program. It's only when you start seeing problems and their possible solution, that programs arrive at their sought for goals.

James C. Lajoie

6427 Thornhill Drive
Oakland, California 94611
Tel. (415) 339-1848

Since 1961 when the Peace Corps was created, more than 80,000 U.S. citizens have served as Volunteers in developing countries, living and working among the people of the Third World as colleagues and co-workers, Today 6000 PCVs are involved in programs designed to help strengthen local capacity to address such fundamental concerns as food production, water supply, energy development, nutrition and health education and reforestation.

Loret Miller Ruppe, Director
Edward Curran, Deputy Director Designate
Richard B. Abell, Director, Office of Program Development

Peace Corps overseas offices:

<u>BELIZE</u>
P. O. Box 487
Belize City

<u>BENIN</u>
BP 971
Cotonou

<u>BOTSWANA</u>
P.O. Box 93
Gaborone

CAMEROON
BP 817
Yaounde

CENTRAL AFRICAN REPUBLIC
BP 1080
Bangui

COSTA RICA
Apartado Postal 1266
San Jose

DOMINICAN REPUBLIC
Apartado Postal 1414
Santo Domingo

EASTERN CARIBBEAN
Including: Antigua, Barbados, Grenada, Montserrat, St. Kitts-Nevis, St. Lucia, St. Vincent, Dominica "Erin Court"
Bishops Court Hill
P. O. Box 696-C
Bridgetown, Barbados

ECUADOR
Casilla 635-A
Quito

FIJI
P.O. Box 1094
Suva

GABON
BP 2098
Libreville

GAMBIA, The
P.O. Box 582
Banjul

GHANA
P.O. Box 5796
Accra (North)

GUATEMALA
6a Avenida 1-46
Zona 2
Guatemala

HONDURAS
Apartado Postal
C-51
Tegucigalpa

JAMAICA
9 Musgrove Avenue
Kingston 10

KENYA
P. O. Box 30518
Nairobi

LESOTHO
P. O. Box 554
Maseru

LIBERIA
Box 707
Monrovia

MALAWI
Box 208
Lilongwe

MALAYSIA
177 Jalan Raja Muda
Kuala Lumpur

MALI
BP 85
Bamako

MAURITANIA
BP 222
Nouakchott

MICRONESIA
P. O. Box 336
Saipan, Mariana Islands

MOROCCO
1, Zanquat Benzerte
Rabat

NEPAL
P. O. Box 613
Kathmandu

NIGER
BP 10537
Niamey

OMAN
P.O. Box 966
Muscat

PAPUA NEW GUINEA
P.O. Box 1790
Boroko

PARAGUAY
c/o American Embassy
Asuncion

PHILIPPINES
P.O. Box 7013
Manila

RWANDA
c/o American Embassy
Kigali

SENEGAL
BP 2534
Dakar

SEYCHELLES
Box 564
Victoria

SIERRA LEONE
Private Mail Bag
Freetown

SOLOMON ISLAND
P.O. Box 547
Honiara

SWAZILAND
P.O. Box 362
Mbabane

TANZANIA
Box 9123
Dar es Salaam

THAILAND
42 Soi Somprasong 2
Petchburi Road
Bangkok 4

TOGO
BP 3194
Lome

TONGA
BP 147
Nuku' Alofa

TUNISIA
BP 96
1002 Tunis-Belvedere
Tunis

UPPER VOLTA
BP 537-Samadin
Ouagadougou

WESTERN SAMOA
P.O. Box 880
Apia

YEMEN
P. O. Box 1151
Sana'a

ZAIRE
BP 697
Kinshasa