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ORGANIC FERTILIZER FROM THE DRY ALKALINE FAMILY FERTILIZER LATRINE (DAFL)

(Lab results)

By: Gabriel Flores/CEMAT

1. INTRODUCTION

The use of organic fertilizers in Guatemala has been carried out for a long time through the utilization of vegetal wastes, such as the leftovers of citronella *(Cymbopogon nardus)*, lemon grass *(C. citratus and C. Flexuosus)*, coffee pulp, stubble and residues of several crops; applied directly or by way of the compost bins. Manures of different animals have also been used, either fresh or processed. Another practice is the utilization of "green fertilizers", several of which have been used, among them the "choreque" (*Lathyrus nigrivalvis*), the velvet bean *(Schizolobium derringianum)*, the rice bean (*Phaseolus calcaratus*) and the cowpea *(Vigna sinensis)*.

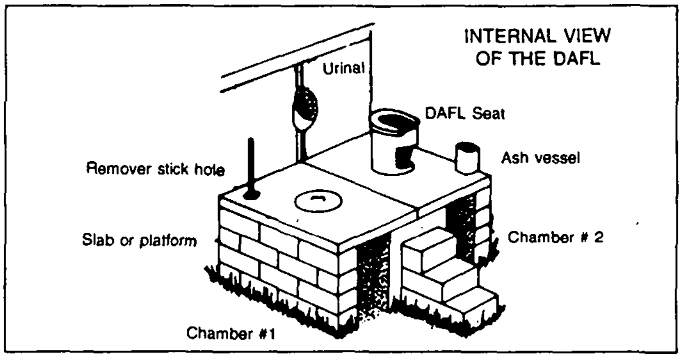
Based on experiences from Japan and China, where human excreta are directly applied on crops, CEMAT investigated in 1978, a method of excreta disposal that would allow the utilization of excreta as fertilizers. The result was the adaptation of the "Vietnamese Double Septic Tank" to the local conditions of our country, and after undergoing certain modifications in its design, it was finally called: Dry Alkaline Family Fertilizer Latrine (DAFL).

2. WHAT IS THE PRINCIPLE OF THE DAFL?

The DAFL consists of two chambers separated by a central division. Each one of them has a cement slab with a central hole where a special seat is placed; it separates the excreta from the urine and prevents the contents of the chambers from getting wet (Figure 1). The pipes that conduct the urine from the seat to the outside are made of polyvinyl, and the deposit to collect it, can be made of any material, but with a narrow neck, to avoid the entrance of flies and the propagation of unpleasant odors.

The use and maintenance of the DAFL latrine is relatively simple, but its introduction requires education for the users. After every defecation, the user must pour an equivalent amount in volume of a desiccant material, such as ash from wood or a mixture of lime and dry soil in a 1:4 proportion.

Figure 1
DAFL design showing the chambers, seat and urinal



Periodically, the material of the chamber in use is agitated to make the level of material more uniform and to homogenize the biomass in progress. The DAFL chambers are filled up in a period of 3 to 12 months, depending on the number of people and the frequency of use. When the first chamber is filled up, the material is allowed to rest, and the seat is moved to the second chamber to repeat the process. When the second chamber is filled up, it is the right time to remove the bio-fertilizer from the first chamber, which has to be observed to see if it is dry enough to be used in the field, or else, it will have to be exposed to sunlight during a period of 3 to 4 days to improve its aspect and insure its sanitary quality.

On the other hand, the urine collected in the deposit outside the DAFL latrine, may be stored for a period of 1 to 2 weeks in order to

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concentrate it, destroying thus any remaining bacteria that may be present, after which it can be used in the cultivations as foliar fertilizer.

3. LAB TESTS

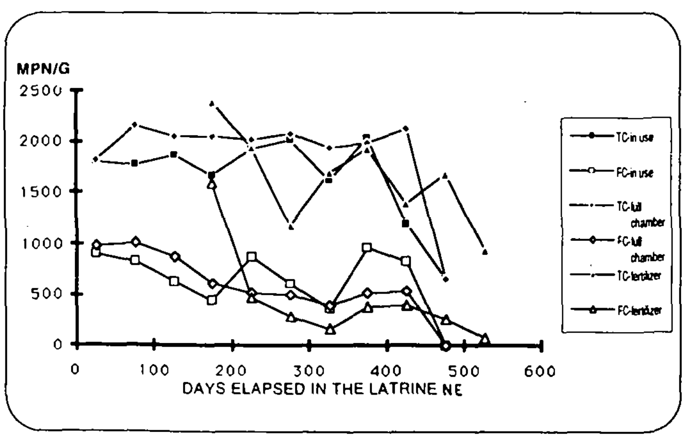
CEMAT has standardized simple and reproducible methods to guarantee the sanitary quality and also know the physico-chemical properties of the fertilizer produced in the DAFL latrines, these being the following.

3.1 Coliform bacteria analysis

The quantification of coliforms is carried out by the technique of the most probable number per gram of sample (MPN/g), which shows the presence of total coliform bacteria (TC) and fecal coliforms (FC), these being extremely useful to measure fecal contamination, or in its default, the death of bacteria subject to the DAFL alkaline desiccation process.

The analyses carried out by CEMAT reveal that there is a decrease in the TC and the FC as the processing time increases in the chambers. In addition, the FC's that are of clinical importance die more quickly that the TC's, obtaining counts of zero or very close to zero in the fertilizer samples (Graph 1).

Graph 1
Coliforms according to age of sample

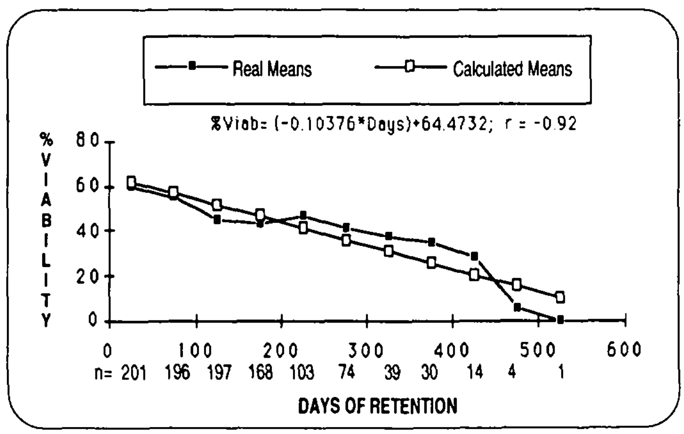


3.2 Parasite counts and viability

This test is carried out to determine the total load of parasites present in the sample and their capacity to infect humans. A microscopic technique is employed on a laminar plate, using a supravital dye to demonstrate morphology alterations in each of the stages of the parasite eggs. The *Ascaris lumbricoides* eggs are utilized as indicators to measure the death of helminth eggs, since they are, among others, the most resistant to the different waste treatment systems.

In the analysis performed on 1,027 DAFL latrine samples that presented *A. lumbricoides* eggs, their death was demonstrated as the DAFL alkaline desiccation process advances (Graph 2).

Graph 2
Mean viability according to age of sample



3.3 Determination of pH, humidity and organic matter

The pH determination carried out potentiometrically reveals that the DAFL bio-fertilizer is of an alkaline nature, being above pH 8, in comparison with the pit latrines whose samples are acid in nature. The alkaline nature of DAFL fertilizer is caused by the material added during the process. The humidity, expressed as a percentage, is determined through a weight difference before and after subjecting the sample to temperatures of 100-110°C for 24 hours. The analyses carried out indicate that the DAFL samples loose humidity as the retention time in the chambers increases and a greater amount of desiccant material is added (Table 1). About the organic matter, it is determined through the Walkey & Black method, in a similar way as it is performed on soil samples, calculating first the easily oxidable organic carbon, and then multiplying it by the van Bemmelen factor (1.724) to obtain, in a approximate manner, the total organic matter. The contents of organic matter decrease as the retention time of the sample increases with values as low as 4 percent dry basis (DB) (Table 2).

3.4 Determination of chemical elements

The determination of percent chemical elements dry base was carried out in the following manner: Nitrogen (N) determined by the Kjeldahl Method; phosphorous (P_2O_5) by the colorimetric method of vanadic-molybdate; and potassium (K_2O), calcium (Ca), magnesium (MgO), iron (Fe), manganese (Mn) and Zinc (Zn) were determined by the atomic absorption method. The results indicated that the DAFL fertilizer contents are low in N (0.36%), moderate in P_2O_5 (3.77%) and high in K_2O (8.2%) and CaO (8.13%); while, the micro elements were found in relatively low values (see table 2).

4. RECOMMENDATIONS FOR APPLICATION TO CROPS

The agriculturist users of DAFL latrines have utilized the fertilizers in different empiric forms, often ignorant of the adequate form to apply it; due to this, CEMAT's staff carried out, for several years, agricultural tests, in a joint manner with farmers, in order to find the best ways of using it in each one of the crops. The main activity areas have been: Las Mercedes, Patzún, and San José Calderas, Itzapa, both in the Department of Chimaltenango; and Oratorio in La Union, Zacapa. The crops tested were: spinach (*Spinacia oleracea*), red beet *(Beta vulgaris)*, potatoes *(Solanum tuberosum)*, carrot *(Daucus carota)*, cauliflower *(Brassica oleracea* var *botrytis)*, peas *(Pisum sativum)*, corn *(Zea mays)*, beans *(Phaseolus vulgaris)*, broccoli *(Brassica oleracea var italica)*, pumpkin *(Curcubita pepo)*, beet *(Beta vulgaris* var *cicla)* and radish *(Raphanus sativus)*. The results and statistical analyses of some of these crops are presented in table 3.

It is complicated to determine the DAFL fertilizer doses to be applied, since its composition is variable; in addition, the soils, climates and crops where it is applied are different. However, some general recommendations, such as the following, may be issued.

4.1 It is recommendable to carry out a process of final exposition of the fertilizer to sunlight to insure its sanitary quality, improve its physical aspect, and make easier its handling in the field. The process consists of exposing the fertilizer to sunlight during 3-4 days and sifting it, to obtain a dry and fine material, eliminating rests of wood and other materials that have been deposited together with the desiccant material.

4.2 The form of application may be in furrows, in holes, by areas, or per plant, depending on the type of crop. The application stages for each form of application are presented in Table 4.

4.3 The DAFL fertilizer may be applied by itself or mixed with other organic fertilizers (dry manures, dehydrated chiken dung and rubbish) in a 1:1 ratio. It can also be mixed with chemical fertilizers to compensate for the deficiency of some macro-nutrients, especially nitrogen. The selection of the chemical fertilizer will depend on the availability of elements in the soils and the crop's requirements. In the municipality of Aguacatán, Huehuetenango, the following fertilizers have been mixed: urea, 20-20-0, 15-15-15 and 16-20-0.

4.4 The DAFL fertilizer may inhibit the germination of seeds or burn the small plants when they get in direct contact with it; for this reason it is recommended to apply a layer of soil between the seeds and the fertilizer.

4.5 Due to the difficulty to determine the DAFL fertilizer dose to be applied, it is recommended to carry out brief experiments for each crop depending on the conditions of each region.

TABLE 3
COMPARISON OF MEASUREMENTS USING THE 5% TUKEY

Crop	Variable(*)	Treatment	Means	Category (a)
Spinach	fresh weight of plants (Kg)	D+CH	0,053	A
		D+U	0,052	A
		D	0,049	A
		CH	0,048	A
		C	0,027	B
Red Beet	fresh weight of roots (Kg)	D+CH	0,047	A
		D	0,033	A
		CH	0,024	A
		C	0,019	B
Red Beet	Diameter of roots (cm)	D+CH	0,012	A
		D	0,009	A
		CH	0,007	B
		C	0,006	B
Cabbage	fresh weight of foliage (Kg)	D	0,04	A
		CHM	0,03	A
		DD+CHM	0,03	A
		D+CHM+Ur	0,02	B
Cabbage	fresh weight of foliage (Kg)	D	2,00	A
		CH	1,22	B
		D+CH	1,04	B
		C	0,99	B
Cabbage	length of leaves (m)	D1	0,38	A
		D2	0,32	B
		D+Ur	0,30	B
		D+CH+Ur	0,30	B
Peas	fresh weight of plants (Kg) 53 d.a.c	D	0,034	A
		CH	0,025	A
		D+CH	0,017	B
		C	0,007	C
Peas	dry weight of plants (Kg) 53 d.a.c	D	0,005	A
		CH	0,004	A
		D+CH	0,003	A
		C	0,001	B
Peas	dry weight of plants (Kg) 81 d.a.c.	D1	0,02	A
		D2	0,017	A
		D1+Ur	0,015	A
		D2+Ur	0,005	B
Peas	height of plants (m) 81 d.a.c.	D+CH	1,82	A
		CH	1,71	A
		D	1,64	A
		C	1,16	B
Pumpkin	fresh weight of plants 9 weeks a.c. (Kg)	D+CH	0,091	A
		CH	0,088	A
		CHM+CH	0,073	A
		D	0,044	B
		C	0,037	B
Greenhouse Corn	fresh weight of foliage Kg 2 m.a.c. x	D+CH	0,070	A
		D	0,058	A
		CH	0,040	B
		C	0,018	C
Greenhouse Corn	fresh weight of foliage 2 m.a.c. x	D+CH	0,011	A
		D	0,010	A
		CH	0,007	B
		C	0,003	C
Greenhouse Corn	fresh weight of foliage (Kg) 2 m.a.c. x	D+CH	0,059	A
		D	0,055	A
		CH	0,048	B
		C	0,036	C
Beet II greenhouse	fresh weight of foliage	D+CH	0,036	A
		D	0,021	A
		CH	0,013	B
		C	0,007	C
Radish in greenhouse	fresh weight of foliage 44 d.a.c. Kg x	D	0,036	A
		D+CH	0,032	A
		CH	0,025	A
		C	0,019	B

NOTA: D=DAFL; CH=Chemical; U=Urine; C=Control; CHM=chicken manure Ur=urea; D1=simple doses of DAFL; D2=double doses of DAFL.
(a) Different letters: difference between groups
(*) d.a.c.= days after cultivation; m= months.

4.6 The urine may be applied pure to big trees, and diluted in orchards. The dilution used will depend on the form of application. When it is poured at the plant's footing it is diluted 1 part urine to 4 parts water. When it is fumigated, the dilution is one quarter of a pint of urine for every 4 gallon tankful.

4.7 Some farmers have used urine as insecticide or fungicide; nevertheless, recommendations cannot be given, because no scientific information is available.

TABLE 1
PHYSICO-CHEMICAL PARAMETERS OF DAFL AND PIT SAMPLES

Type of Sample		pH		Humidity (%)		Ash (%) (a)	
	Cases	m.	s.d.	m.	s.d.	m.	s.d.
DAFL							
chamber in use	1836	8,96	1,16	48,56	19,23	75,01	194,06
full chamber	1200	9,46	0,56	34,69	10,94	83,39	6,85
fertilizer	102	9,55	0,49	28,43	10,01	82,50	5,84
Pit latrine	59	6,89	1,08	84,89	14,12	33,59	18,59

Note: m = mean of the samples s.d.= standard deviation (a) values expressed on dry basis

TABLE 2
AGROCHEMICAL EVALUATION

Chemical elements of the DAFL fertilizer				
Element	Formula	No.	m(a)	s.d.
Carbon	C	47	2,68	0,91
Organic Mat.	TOM	47	4,66	1,58
Nitrogen	N	10	0,36	0,11
Phosphorous	P_2O_5	12	3,77	0,53
Potassium	K_2O	12	8,20	1,67
Calcium	CaO	12	8,13	3,05
Magnesium	MgO	12	0,81	0,29
Iron	Fe	12	0,20	0,06
Manganese	Mn	12	2,45	0,95
Zinc	Zn	12	0,24	0,1

Note: m=mean, s.d.=standard deviation
(a) values expressed on dry basis

TABLE 4
WAYS AND STAGES OF APPLICATION OF THE DAFL FERTILIZER

Way/stage	BC	BT	C	T	AC	AT
In furrow	X	X	X	X	-	X
In hole	X	X	X	X	-	X
By plot	X	X	-	-	-	-
By plant	-	-	-	-	X	X

BC=before cultivation; BT=before transplant; C=during cultivation; T=during transplant; AC=after cultivation; AT=after transplant.

ORGANIC FERTILIZER PRODUCTION QUICK AND SIMPLE WITH THE COMPOSTER

Based on the Document "La abonera Mejorada" (The Improved Composter) from ALTERTEC, Momostenango, Guatemala.

It is no secret that the use of organic fertilizers greatly benefits agriculture, specifically in those countries where chemical fertilizers are no longer available to small farmers, who need the maximum output from the small piece of land they own.

A low cost alternative to produce organic fertilizer is the latrine, in which organic materials (residues and waste of plants and animals) and soil, are mixed, resulting as a final product, a balanced organic-fertilizer which could substitute any chemical fertilizer and correct the soil's nutritional deficiencies.

1. MATERIALS THAT MUST BE FED TO THE COMPOSTER

It is recommended that the composter be loaded with the following materials:

1.1 Of vegetal origin

1.1.1 Foliage of at least three of the following plants: elder (*Sambucus mexicana*); red bean tree (*Erythrina guatemalensis*); aliso (*Alnus acuminata*); oaktree (*Quercus* spp.); guachipilin (*Diphysa carthaginensis*); madrecacao (*Gliricidia sepium*); leucaena (*Leucaena leucocephala*); palo de zope (*Piscidia piscipula*).
1.1.2 Harvest waste: corn stubble, wheat bran or the leftovers from crops as beans, sorghum, barley, cane, coffee, oats, bananas, etc. Orchard residues are also valuable.
1.1.3 Rubbish, leaves and herbs: the accumulated residues of cleaning jobs of the land (either by cleaning or burning); herbs that are cut in cultural activities and withered tree leaves are other valuable resource.
1.1.4 Kitchen residues: fruit peels, vegetable residues, etc.

1.2 Of animal origin

1.2.1 Manures of rabbits, chicken, goats, cows, sheep, horses and pigs (the latter, as long as they are handled hygienically); preferably fresh.
1.2.2 Feathers, hair, blood, bones, viscera, etc. The bones must be broken in small pieces or crushed to form a fine powder.
1.2.3 Urine.

1.3 Other materials

1.3.1 Clay, ash or mill water (corn mill runoff). Any of the three may be used, when available.
1.3.2 Soils: preferably fertile. Soils balance humidity, improve the acid condition and retard fermentation.
1.3.3 Water: may be from rain, wells, springs, rivers or ravines. If by any reason, it is not possible to obtain water, add enough green material.
1.3.4 Round wooden sticks to make breathing holes.

2. MATERIALS THAT SHOULD NOT BE USED IN THE COMPOSTER

1) Chemical pesticides.
2) Chemical fertilizers.
3) Residues with plagues and/or diseases.
4) Materials that are too acid or of difficult decomposition like pine, cypress, bermuda grass leaves, etc; the wooden branches and trunks of trees are also of hard decomposition.
5) Succulent plants like the prickly pear, cacti, pineapple, etc. These sprout again and are of difficult decomposition.
6) Toxic or poisonous plants like tobacco, narcissus, hemlock, castor-oil plant, pinyon, eucaliptus, etc.
7) Plastics, glass, cans, etc. They do not decompose, so they should not be included.

3. IMPORTANT CONDITIONS THAT THE COMPOSTER SHOULD HAVE

3.1 Oxygen/air

Just as any other living being, the macro and micro organisms contained in the composter need air to live and work. The composter does not have to be too compacted or too humid to avoid spoiling and the generation of unpleasant odors.

3.2 Water

In every function of life, water is always present. Humidity is essential to the biologic process of the composter.

4. HOW TO STIMULATE THE DECOMPOSITION AND THE BIOLOGICAL PROCESS IN THE COMPOSTER

The decomposition or fermentation of organic residues takes place naturally through bacteria, fungi and other microorganisms that produce changes due to their biological activity.

During fermentation, the temperature raises to 70°C, staying there for some time; decreasing afterwards gradually to 38°C.

Most bacteria resist temperatures of a maximum of 70°C, but there are others that do not resist. Temperatures greater than 70°C help destroy the majority of the germs and pathogens, but the beneficial bacteria and fungi may disappear in their totality. When the decomposition takes place in the absence of oxygen, bad odors are produced, becoming an anaerobic fermentation. The aerobic fermentation takes place in the presence of oxygen.

5. CONSTRUCTION OF THE COMPOSTER

There are composters of the aerial and subterraneous types. The composter recommended and explained next, is the aerial one.

5.1 Selection of a place

This must be a flat surface with a good external drainage, and preferably close to the place where the fertilizers are to be utilized.

5.2 Size of the composter

The size must be according to the availability of materials and time to be used. Building a composter with dimensions of 1 meter of width, by 1 meter of length, by 1 meter of height (1 m^3), produces approximately 10 hundredweights (hwt) of fertilizer in an average time of thirty days. The approximate relationship is 10 hwt of fertilizer per cubic meter. Example, if we build a composter of 2x5x1 meters (10 cubic meters) we will have approximately 100 hwt of organic fertilizer.

5.3 Placing of the layers of materials

First, we pour a little ash, clay or mill water on the ground surface. Secondly, we add a layer of dry materials of vegetal origin (15 centimeters approx.). Third, we add a layer of green materials, of vegetable origin (15 centimeters approx.). Fourth, we spray a little water with a sprinkler. Fifth, we add a five-centimeters layer of manure of animal origin. Sixth, we add a layer of fertile soil and/or organic fertilizer of three centimeters approx. Seventh, we pour a little ash, clay or mill water. Eighth, we repeat again the second, third, fourth, fifth, sixth, and seventh steps; and so on, until we finish the existing materials.

5.4 Breathing holes

It is advised to place a breathing hole per each cubic meter of composter, using a rustic wooden stick or bamboo, if it is available. In a 10 cubic meters composter, we may place 10 sticks, which upon removal are converted into breathing holes.

5.5 Covers

When the construction of the composter is finished, it will have to be covered with soil, straws, plastic and other material available. In very rainy places, the composter has to be covered, so the materials will not rot due to excessive water. In addition, it is advisible to avoid the entrance of flies and other harmful insects.

6. NECESSARY MAINTENANCE

6.1 Overturns

It will depend on the time in which we need the fertilizer. If we wish to have the fertilizer in a month, for example, we may overturn it once a week and add sufficient water. If the composter is a big one, and most of the materials are dry, we may think of a three months outcome, overturning it every 15 days. There may be composters of up to six months; when we have large amounts and materials that are of difficult decomposition, then we overturn the material once a month.

6.2 Taking temperatures

If at the third day after the composter is filled we notice that it does not heat up, we must overturn it and add more water, green material or manure. If the composter is too hot, that is above 70°C, we must overturn it and add more water and dry material. Through the breathing hole, we may stick a steel rod or a machete, if it comes out hot and humid, the composter is fine. If it comes out hot and dry, the material inside the composter is burning up, and water must be added. If it comes out wet, but cold, we have to overturn the composter and allow a better ventilation.

7. POSSIBLE TROUBLES

7.1 Odors

In case the composter smells bad and rotten, it means that it is too humid. If it smells like ammonia, it means that it has too much nitrogen. On the other hand, if it smells like fresh soil and has black color, it means that everything is all right in the composter and the fertilizer is ready.

7.2 Presence of insects

The presence of ants is a sign of dryness; the presence of flies or larvae, the excess or lack of water and lack of proper ventilation.

The presence of sprouted weeds on the surface of the composter, is a sign of carelessness and lack of cleanliness (overturns).