VARIATIONS ON A DESERT THEME

applying Israel's arid zone agricultural lessons in Kenya

By R. MUTISO KILONZO

EDITOR'S NOTE: Every once in a while your Editor has the good fortune to come across a young man or woman whose exceptional contributions in the sphere of development should be made known to KIDMA readers, regardless of the academic status of the person concerned. That is why the Editor commissioned Robert Mutiso Kilonzo to write this article in which the young author describes how he was able to apply — with certain important innovations of his own — agricultural lessons learned in Israel's Negev desert, for the benefit of people living in a water-short section of his own country, Kenya.

Photos in this article supplied by the author

Robert M. Kilonzo pruning tree at the Experimental Farm in Israel's Negev Desert, at Avdat

Introduction

Runoff-water harvesting is a technique which was used as long ago as the 2nd millennium B.C. Recent investigations in Israel's Negev Desert have revealed the remains of extensive ancient agricultural systems based on this method, more especially at the site of the experimental farm established near Avdat by Prof. Michael Evenari in 1958 and operated continuously since then.

In 1981 Friends World College offered me a scholarship to study abroad. I chose to study in Israel because I had heard reports of its innovative farming methods which — it was said — had turned desert lands into flourishing fields. That these reports were not at all unfounded I learned for myself when I spent an entire year at the Avdat Experimental Farm, working intensively under the guidance of Prof. Michael Evenari. Hoping to learn skills which I could apply in my home country, Kenya, I explored the methods practised by the ancient farmers, who *harvested* water for both irrigation and domestic uses, through a system of small channels and cisterns which very efficiently collected the occasional flood waters descending upon these otherwise dry areas. After completing one year at the Avdat farm, I spent six months at the nearby Jacob Blaustein Institute for Desert Research, carrying out additional investigations on the principles of run-off farming, involving artificial micro-catchment areas.

I became convinced that — provided the proportions between the catchment area and the area to be cultivated are correct — cultivation can be successfully undertaken *even with a total annual rainfall of less than 100 mm.* In the course of my work I devised a new system, consisting of a small catchment area of 250 m^2, leading to a catchment basin covered with plastic material to prevent water loss. The system enabled us to harvest more than a cubic metre of water from as little as 10 mm of precipitation.

My main aim in these studies and labours was to acquire knowledge and experience which could be put to use in helping to solve problems of the people in Kenya, and more particularly those faced by my own community at the Katheka-Kai cooperative settlement, in Machakos. It was and is my conviction that there exists an urgent need to find an appropriate technology as a first step in development. I wanted to use local resources and to teach our local youngsters the importance of preserving the natural eco-system. My own childhood experience, however, had made it clear that the successful introduction of any new ideas depended upon their acceptance by the entire community. The necessary first step was a farm-wide field survey to assess the situation and to discover which problems were actually the most urgent.

Field Survey

The Katheka-Kai cooperative settlement is located upon a former private estate of more than 1,600 hectares (ha), some 5 km north-west of the town of Machakos. Katheka-Kai's owners form a cooperative society with 200 members; each member family owns two acres (8 ha) of land, aside from a communally-worked coffee plantation. Each member family uses its two acres to grow food crops for its own use, the main crops being maize and beans. A few of the members who have their own small water supply are able to grow other vegetables. The annual rainfall — usually about 500 mm — is not reliable and tends to be unevenly distributed. In recent years there have been some severe droughts, a situation aggravated by the large-scale destruction of forested areas beyond the settlement, trees having been cut down for use as firewood without any effort having been made to replace them. This has led to two consequences:

1. a change in climate in the direction of increasing dryness; and
2. widespread erosion of the soil, with much of the good fertile top soil being carried off during the occasional heavy rains.

For the survey which I made to understand the basic problems I prepared a questionnaire covering two main areas: home activities; and agricultural management. I personally interviewed the head of each family.* Information was sought about the following:

(a) Rate of population growth since 1966, the year in which the cooperative society was formed;
(b) Agricultural methods practised by the local communities and problems encountered in food production;
(c) Water sources and problems of supply;
(d) Use of appropriate technology in community development;
(e) Methods used in soil and water conservation; and
(f) Educational level of the younger people; their occupations; and cultural aspects related to the youth movement.

Results of Survey

The survey had been rather difficult to conduct in practice. In many homes it was hard to obtain accurate information from the parents because of their own lack of education. Often I had to get in touch with younger family members attending school in order to obtain the necessary data. The results of the survey can be summed up as follows:

1. *Population growth*: the annual increase amounts to as much as 4%.

2. *Education*: (a) most of the younger family members (about 90%) attend primary or secondary school.
(b) As many as 95% of youngsters who have completed their schooling are jobless and most do not possess the skills to start an income-generating project; of the 5% who do hold a professional job, most are still partially dependent upon their parents for support.

3. *Water supply:* About 98% of all the families face problems with their water supply, having no nearby source of water. Although there is a considerable amount of water within the area owned by the cooperative society, there is no distribution to members' homes, and most of the existing arrangements relate to irrigating the coffee plantation. At least four times every day women may be seen walking a long distance to obtain water, carrying a tin of 25 litres on their backs. Aside from the strain and effort involved, this water is not of the best quality, having been pumped into uncovered tanks, in which it collects dust from the air and grows algae.

4. *Farming systems:* (a) Although most people are well versed in farming, there is a sad lack of elementary agricultural knowledge which accounts for the fact that yields tend to be low.
(b) About 95% of the families do not produce enough food even for their own use and must buy additional food from the cooperative society.

5. *Soil erosion:* (a) 50% of the farmers visited realised that unless soil erosion is properly controlled, they cannot hope for good yields on their farms. They knew that restoration of the once-forested area (with the aid of an agroforestry tree nursery) would be a solution; at the same time, they did not wish to see (inedible) trees take the place of needed food.
(b) Most of the fields are on slopes, and 50% of the farms have terraces. However, the slopes do not feature plants which could anchor the soil, keeping it from being washed away; and every year a few of the terraces are destroyed by heavy floods, requiring hard repair work from the farmers.

6. *Motivation:* (a) About 90% of the women are highly motivated to do development work but lack field advisers to guide them in carrying out programmes against soil erosion and concerning water conservation. (Currently there are more than ten self-help groups for women.) When they were asked why they cut down large trees for firewood, their answers were the same: in the beginning they did not realise that cutting down trees was a bad thing to do; even now after having been taught the facts of the matter, they continue to do it because they do not have an alternative source to supply their fuel needs.
(b) When men were asked why they were cutting down so many trees to burn bricks they answered that they wanted to be able to build sturdy lasting houses, something for which they need baked bricks. Asked why they didn't replace the trees cut down, they gave as a reason the absence of a tree nursery within a reasonable distance.

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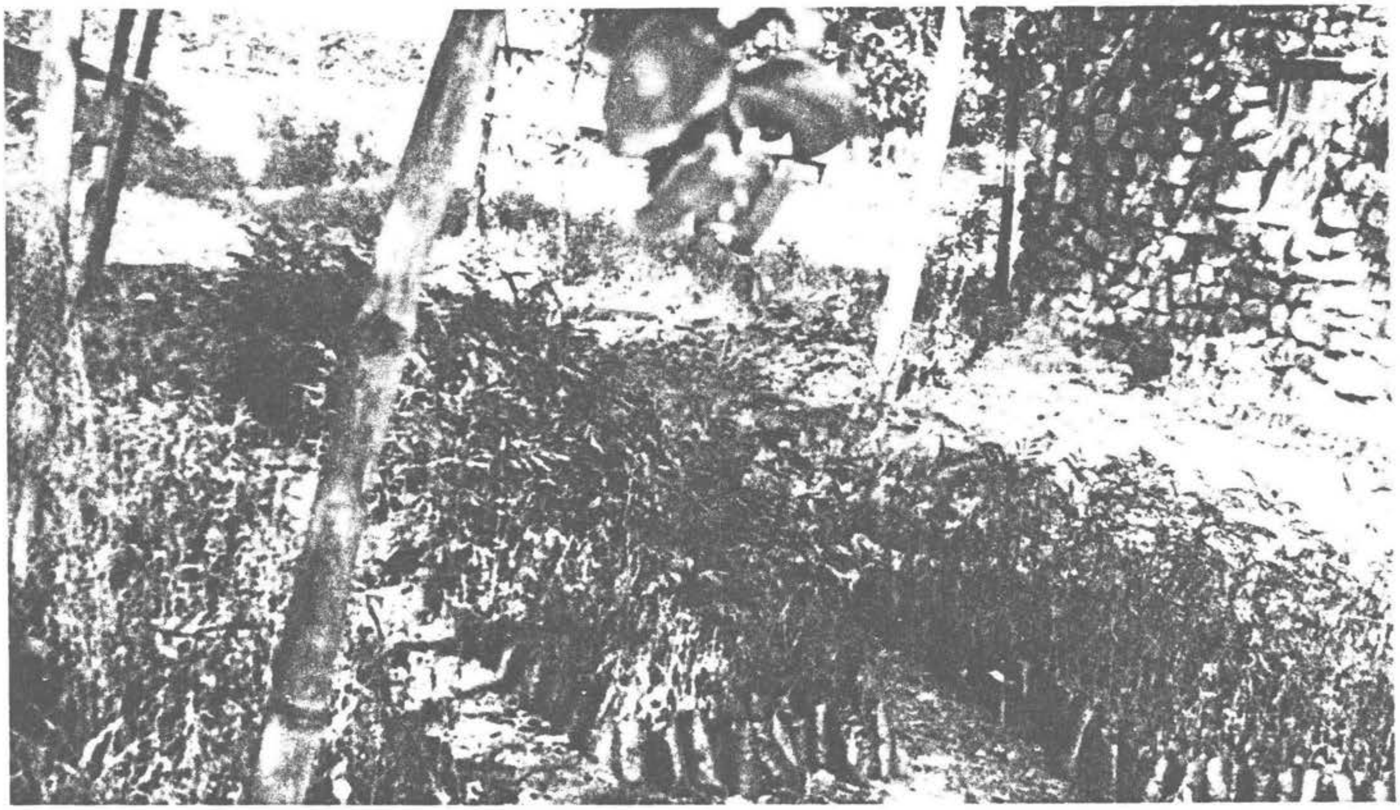
* Reaching all the persons concerned was rendered easier because of a motorcycle placed at my disposal for that purpose by the East Africa Centre of Friends World College. — R.M.K.



Tree Nursery started by the author as a cooperative project in Kenya

Two Main Problems — and What To Do About Them

The survey made it clear that there were two main problems: (1) the need for better water supply; and (2) the need for *rapid* reforestation to meet the continuing demand for firewood — the only kind of fuel being used for cooking and heating. Although conditions at Avdat, Israel, had been quite different, my experience there led me to think that it might be possible to find solutions to both problems in Kenya, too. First of all, I could try to set up an agroforestry tree nursery. At the same time it suddenly occurred to me that *the tin roofs of our society members' houses could be regarded as being — in fact — potential catchment areas which — as such — might well serve to harvest,* in specially constructed tanks, *the abundant quantities of rain water running wastefully away in each periodic downpour!*

But how to go about this? I felt that the first step should be to establish at Katheka-Kai a community development office where I would be able to talk to fellow-members of the Society, to explain to them the importance of what we could actually do. Next, I set about gathering funds to support both projects. The effort was successful, and we obtained a modest but adequate sum of money from several international organisations supporting rural development in Africa.

Kenyan Government Helps

For the agroforestry tree nursery, tools and fencing wire were provided by the Kenyan Ministry of Agriculture in Machakos District; some of the seeds were contributed by other sources. The plants to be grown included several species of fruit trees, e.g. avocado, papaya and custard apple; but most were forest trees, e.g. eucalyptus, pine and leucina. Cultivation of the latter in particular is now being boosted to help solve forestation problems because of its many positive features: it grows rapidly even in relatively arid areas; its roots not only hold the soil together, preventing erosion, but are nitrogen-fixing; its leaves and young branches as well as the seed pods can all be fed as fodder to livestock; and its larger branches and trunk constitute a good potential source of wood for both fuel and building.

Once our seedlings were well established and ready to be transplanted, we found ourselves faced with a number of other problems. People tended to ask for fruit trees, showing a reluctance to plant anything which would be "unproductive", and being unwilling to accept the importance of planting forest trees *as such*. Eventually, however, our campaign to plant such trees, too, was quite successful, and we were able to persuade them to purchase almost 5,000 seedlings for transplantation in individual plots. Another difficulty was economic: the inability of most of our members to pay on the spot for the seedlings received.

Roofs as Microcatchments for Rain

During the months in which our tree nursery was itself being nursed along, we also vigorously attacked the problem of water harvesting. My calculations based on rainfall data from previous years convinced me that most *roofs were large enough in area to harvest more water than the family would*

Specially developed brick tank reservoir to collect rainwater from tin-roof acting as micro-catchment area (see text)

need for its domestic consumption! I realised that what we would need for the success of the project would be large enough tanks to serve as reservoirs. Actually, mine was not an entirely new idea: the British had long ago introduced concrete water tanks, but these were far too expensive to be practical. Tanks made of corrugated iron had also proved impractical since they lasted only for a short time before rusting away. It seemed to me that the answer lay in *brick tanks* constructed not of conventional fired bricks (which use up significant quantities of precious firewood in their manufacture) but of compressed soil, sand and cement blocks produced with a Cinva-ram (see below) compressing machine. This device had first been introduced to Kenya (from Asia) a decade earlier but — as far as I know — had never been used properly; as a consequence, it had been largely neglected. My first step was to carry out a series of experiments in which we determined the optimal proportions of soil, sand, and cement to yield the greatest possible strength. In the process we also succeeded in making a number of modifications in the machine itself to increase its efficiency.

Brick-making Machine

The Cinva-ram machine is a simple, manually-operated device designed to exert a pressure of about 25 kg per 1000 cm^2 on the mixture of soil, sand and cement placed within a rectangular metal compartment. The upper and lower sides of this compartment are forced inwards, compacting the mixture into brick, by the action of a lever system consisting of two short parallel bars connected to a long piece of pipe. Basically, the machine is made to produce brick blocks measuring 30 cm × 15 cm × 10 cm, but modifications can be made to change the size in accordance with requirements. For constructing the water reservoirs we found that a more suitable brick was obtained by the insertion of a disc resulting in a wedge-shaped block. This type of brick involved the use of less mortar at a saving in cement while at the same time making for a stronger joint.

Experiments showed us that a good proportion to be used when making blocks for houses is 65% soil, 30% sand and 5% cement. We used a 50 kg bag of cement, mixed with seven wheelbarrows of red soil and four wheelbarrows of sand, with the addition of about 18 litres of water. For the water tank we used six wheelbarrows of soil, and three-and-a-half wheelbarrows of sand with the 50 kg bag of cement. A single bag of cement yielded 80 blocks for the water tank or 100 building blocks for the house. (The manner in which water is added is very important: it should be poured in very slowly, to avoid too-soggy a mixture: when pressed in your hand, it should hold together and not show any drops of water.)

How to Build a Watertank

Following are the details of the procedure we used in the successful construction of a community water supply tank: Most important is the proper *calculation of the materials required*. For example, let's say that we want to build a tank measuring 240 cm high with a diameter of likewise 240 cm.

Circumference = $2r\pi$ or 3.14×240, i.e. 753.6 cm^2. That means 25 blocks will be needed for each course (layer). Since a tank 240 cm high *(including the mortar)* will have 15 courses (layers), we need $15 \times 25 = 375$ blocks. After placing our order for that quantity with the block makers, we begin to prepare the site, removing all the soft loose soil until we reach the hard subsoil. Next, we dig a foundation ditch 60 cm deep and 45 cm wide which is then filled with hard rocks. A single layer of rocks is also placed down over the remainder of the exposed subsoil. Next, all the stones are pounded with heavy instruments to compact them and to level them down. Mesh wire is now placed over the entire surface and a mixture of concrete in a ratio of 1:3:4 is poured over the whole, being smoothed lightly and left to dry for a day or two, with occasional wetting as is usual for concrete. We are now ready to start laying the bricks. A 1.9 cm iron bar is positioned around the outer edge of the foundation, and well-mixed mortar (1:3) (three wheelbarrows of sand to one bag of cement) is applied. Bricks are put down at a distance of 1.25 cm from one another. Careful calculations should be made to ensure that only whole bricks are used in each course, the edges of the bricks in each succeeding course to be placed exactly above the centre line of the underlying bricks. An important part of this stage of construction is the insertion within the mortar under each brick of a U-shaped piece of baling wire (about 7.5 cm in length), the ends of which should project about 2.5 cm towards the centre of the tank. These ends will later be used to secure the wire mesh which will cover the entire inner surface of the tank, the purpose being that of strengthening the finishing layer of plaster, and of preventing cracks. The plaster itself should contain waterproof cement and should be applied within a single day. At all stages of construction daily wetting should be done to cure the mortar properly. When the tank has been completed, it is to be wetted daily for another 10 days, at which stage it should be filled with water — slowly so as to permit checking for any leaks. The cover of the tank may vary according to needs and personal preferences. Openings will be left to permit connection to the source of collected rainwater and also to afford access to the tank when necessary for cleaning and repairs.

How to Make Bricks to Order

As we completed the first water tank, the potential usefulness of the Cinva-ram bricks was readily apparent, and we immediately set about the establishment of a small brick-producing industry. We first produced about 1,500 bricks to construct a building shed. Next, we put up another water tank, which, now that we had the benefit of our earlier experience, took only two weeks to complete. People showed great enthusiasm for the new bricks and began to place orders, including one large enough to build an entire house. The brick block-making process may be summed up as follows:

1. single layers of newly-made brick blocks are placed within the shed, where they are wetted daily for three days;
2. next, they are stacked up in the shed, to remain there for another three days, during which time they are still wetted daily;
3. they are then brought out into the sun to cure thoroughly for another three weeks or so, when they will be found ready for use.

The Cinva-ram bricks proved to have many advantages:

1. They are as strong as, if not stronger than, the traditional fired bricks.
2. They are *consistently* identical in size and shape, making construction much easier than with traditional bricks which tend to be somewhat irregular and to contain pockets of air (leading to a wastage of mortar).
3. Absolutely all of the bricks made are usable, in contrast to the traditional bricks for which wastage sometimes may run as high as 50%.
4. They are easily and quickly manufactured. Once a person places an order, he knows exactly when they will be ready. Traditional bricks, in contrast, can be made only during the summer season, when there is no danger of damage because of rain.
5. The cost is considerably less than that of the traditional bricks and there is no need for firing, which means a real saving of precious fuel.

Benefits and Costs

The water tanks we constructed had a capacity of some 7,000 litres. They rapidly filled during the first rains from October to December. In fact, we found ourselves faced with a small problem of *overflow* for which we had failed to make advance provision. We eventually solved that problem by making a run-off channel (resembling those I had come to know at Avdat!) which would water a row of *leucina* trees as well as a small plot of vegetables planted nearby.

True, that is not enough to meet the year-round daily need of water for domestic purposes. However, there are two seasons of rainfall in Kenya — one from March to June, the other from October to December. During these two seasons there are many days when no water need be taken from the tank. All in all, the tanks were found to be more than adequate for the 3-month intervals when there were no rains.

True, also, that even these relatively inexpensive water tanks — they cost about $400 each — are beyond the reach of many families in our cooperative settlement: for families with no outside source of income, average yearly earnings may be as low as $500. There are, however, a number of self-help groups in Katheka-Kai. These could pool their small monthly contributions towards a tank-building project which would aim at supplying tanks to every family within a number of years. They could also encourage volunteer participation in the block-making industry and in the actual construction of the tanks, and thus reduce costs.

In Retrospect...

The distance from Avdat to Katheka-Kai is many thousands of kilometres, across mountains and seas and vast deserts. The heritage left by the ancients in the bleak hills of the Negev desert in the remote past and its revival and improvement by modern Israel has served as an inspiration for techniques which will make it possible for our cooperative community in Katheka-Kai to harvest the bountiful rains. And it may very well help us to meet our need for greater domestic water supply, reforestation and improved agricultural practices. ●