# WATER HARVESTING ON A YELLOW-GREY EARTH

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THE unequal distribution of rainfall in both time and space is a characteristic of the New Zealand climate. Two farming seasons rarely have the same amount of rain and notable differences can occur between closely located areas. Rainfall intensity and incidence vary greatly from one place to another so that, of all the elements significantly distinguishing climate, it is the one least amenable to generalization,

Soil moisture deficiencies in summer are commonly associated in the same year with water surpluses in late winter and early spring, when the waterlogging of soils is widespread, especially those soils classed as either "poorly drained" or "imperfectly drained".

Water harvesting is simply an attempt to rationalize natural water supplies by transferring the surpluses of the wet season into a storage dam and redistributing them by irrigation to selected crops in the dry season. It is a practice which can be adopted in a situation where water from perennial streams or groundwater wells is either unavailable or too costly to recover, but it is not commonly an alternative to these sources of supply.

Water for farm dams usually comes from surface runoff. In water harvesting, however, the water comes from subsurface drainage systems whose primary purpose is to remove surplus water from the soil which would otherwise adversely affect plant growth. It is this water that is directed into storage dams for summer use and offers the most efficient use of rainwater that could be devised in a humid or sub-humid climate.

From local rainfall records it is clear that rainfall deficits are common events as Table 1 shows.

Elsewhere in New Zealand, particularly on the more intensively used ploughable land below about 200 m altitude, the same kind of analysis is likely to show recurring deficits affecting plant production.

Water harvesting is defined as the process of collecting, conveying and storing water from an area that has been treated to

TABLE 1: NUMBER OF YEARS WITH RAINFALL DEFICITS IN SIZE RANGE
1946-1975 (December-March), Palmerston North, DSIR Station
Penman P.E.T.*

| Size range (mm) | O-50 | 50-100 | 100-150 | 150-200 | 200-250 | 250-300 | 300 |
|---|---|---|---|---|---|---|---|
| | 6 | 4 | 6 | 4 | 7 | 2 | 1 |
| | | | | | | Total = 30 | |

*Potential evapotranspiration calculations according to Coulter (1 973). The distribution of these deficits coincides with the critical growing months of the year shown in Fig. 1.

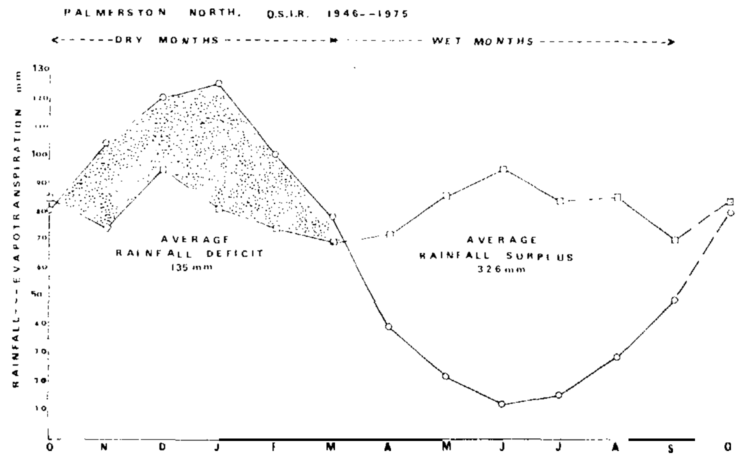


FIG. 1: *The balance of rainfall (circles) and potential evapotrampiration (squares) at Palmerston North. The period of rainfall deficit is indicated by the stippling.*

increase the runoff of rainwater (Myers. 1963) and the manner of achieving this on a yellow-grey earth can most conveniently be discussed as follows.

## COLLECTING AND CONVEYING THE WATER

On intensively used land composed of heavy textured clay soils, the need for drainage in wet seasons is usually more urgent than irrigation in dry seasons. Accordingly, the most efficient subsurface drainage, consistent with economic considerations, will be justified; coincidentally, this is likely to result in the maximum yield of water for storage.

In the context of water harvesting, the treatment of the land and the collection of rainwater will be through an appropriate mole drainage system and, assuming proper design, conveying the water to storage will be through intercepting pipelines located according to certain standards.

In soils of suitable consistence and plasticity for mole drainage, parallel systems spaced 2 m apart and drawn 0.45 m deep will be found most satisfactory (Hudson *et al.,* 1962). This moling intensity results in some 5000 m of channel to each hectare which will indicate the intensive nature of the treatment.

Field drainage standards are commonly measured by the frequency of mole interception by pipelines on a given surface gradient and the kind of backfill used; gravel backfill consisting of screened stone of particle sizes 12-25 mm diameter will be found most satisfactory.

It is likely that intensively used land, usually found in a water harvesting situation, will be dominated by surface gradients ranging from flat to about 2%. In these circumstances, pipeline spacing on pasture land will be in simple grids placed 40 m apart. An area used for horticultural purposes, however, may warrant even more intensive pipe installations.

## WATER YIELD

Research data from the water harvesting research at Massey University confirm that, on that site, average annual rainfall 990 mm, not less than 25% of total annual rainfall will flow to storage (Turner *et al.,* 1976). This represents about 2500 $m^3$ of water per hectare gross each year, a convenient figure to relate to storage capacity and crop irrigation requirements.

While rainfall variations can also result in the occasional "below average" event, research has shown that winter drainage is sufficiently reliable, on the Massey site, to fill the dams in 9 out of every 10 years.

Losses of stored water through evaporation and seepage will vary with both site and season and an allowance of about 30% can be recommended for this wastage.

## WATER STORAGE

A variety of types of earth dams are used for storage, and these include gully, hillside, ring dams, and Turkey nests; in New Zealand the first two of these are the most common.

Landforms in the North Island offer an abundance of watercourses for gully dam storage. There are, however, three points about their use that need attention. First, the New Zealand landscape is typified by fairly deeply incised watercourses which contrast markedly with more geologically mature surfaces in, say, New South Wales, which offer wide channels. Therefore, a balance is needed between depth of water and the surface area flooded. Land covered with shallow water will usually be more productive in pasture in a humid climate and watercourse capacity is better used with a series of dams built in staircase fashion. The second point refers to channel gradient: the flatter the gradient the greater the water storage for each cubic metre of soil moved into the embankment. The third point concerns the quality of soil material used for the embankment. Very commonly, gully sites contain strata of coarse-textured soil, sometimes intermixed with gravel. The most satisfactory sealing clay should be identified by a suitable grid of auger holes; where good clay material is in short supply, it should be stockpiled and used as an embankment core and finally as a sealing bianket on the inside of the bank.

The techniques of dam building and appropriate proportions are a separate consideration beyond the scope of this paper.

## WATER USE

Harvested water is usually intended for irrigation and in many cases it will be scarce water. It is therefore important to match the crop to the water available. High value crops such as fruit, market garden vegetables, amenity horticultural uses such as the irrigation of golf greens, as well as the strategic watering of special crops like maize for dairy cows, are examples of attractive uses of harvested water.

Pasture response to irrigation water is, of course, well documented and significant increases in production have been recorded both seasonally and in total annual yields (Rickard, 1972). However, there is unlikely to be any general relationship between the amount of irrigation water applied and pasture obtained owing to variations in drought severity. The circumstances in which the water deficit occurs in a particular season will strongly influence response. Thus, on the Massey research plots on Tokomaru silt loam, a yield increase of 4860 kg DM/ha was recorded in the 1974-5 season using 250 mm of water in addition to 329 mm of rainfall; this represents 19 kg DM/ha/mm of irrigation water applied. However, for the 1975-S season the response to irrigation was only 6 kg DM/ha/mm applied, indicating a much reduced water demand owing to summer rainfall. In 1976-7 the response was 23 kg DM/ha/mm of irrigation water.

It is worth noting that these plant production increases represent the effect of water alone. Since the pasture involved had not been improved by renewal, renovation or fertilizer, these treatments could be expected to significantly increase pasture yields.

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