Some Aspects of Agricultural Development on Steep Slopes in South Korea

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Abstract: Methods of agricultural development on steep slopes in Korea (contour farming, bench terracing and semi-bench terracing) are evaluated. Runoff and erosion plot results are discussed and a design criteria proposed for relating slope length to gradient so that annual soil loss will not be excessive.

Introduction

South Korea, situated between 34°N and 39°N latitudes (Fig 1), has a population of about 36 million people and a land area of about 98,000 km². 45% of the population is rural. Two and a half million farm households cultivate 2.2 million ha resulting in an extremely high population density of 1500 people per cropped square kilometer 1).

Annual rainfall varies from 800 to 1400 mm (Fig 1), with 60% falling during summer monsoons. Average monthly temperatures range from -5°C in January to +25°C in July — and only about 200 frost free days are available for agricultural production of susceptible crops. Rice and barley are the principal grain crops, accounting for two thirds of the total cropped area. Double cropping of rice is not possible in Korea and a rice-barley rotation is practised on about half the paddy land. Although rice yields have steadily increased and are now equivalent to those of Japan, South Korea is not self sufficient in grain production. During the sixties and early seventies there was a massive increase in grain imports. In 1974, 3.3 million tons were imported at a foreign currency cost of $327 million. At the same time productive land was being converted to urban use at an average rate of 20,000 ha per year and the demand for food crops rising at about 4% per year. In order to meet some of the food demands, the Government of Korea decided as one of its food production strategies to allocate for agricultural development about 250,000 ha of steep sloping forest land which at that time served as valuable sources of fuelwood for villages.

Korean farmers, because of the critical shortage of level land, have traditionally farmed hillslope slopes with gradients up to about 10%, but the new areas proposed for development were substantially steeper — between 15% and 35%. Since the experience of large scale upland development on steep slopes was minimal in Korea, the Government together with the World Bank who was partly funding some of the projects, established general guidelines for the design of the upland schemes. These guidelines took into account a wide range of factors affecting upland development in South Korea — administrative, financial and institutional problems, traditional practices, and design standards for specific physiographic site conditions. This article focuses on proposed design concepts which may be applicable also for countries other than Korea.

Physiographic Constraints to Upland Development

a) Soils and Fertility

The soils allocated for the upland development 2) are orthic acrisols and dystric regosols commonly found on pediplanes (underlain — mainly by granite and gneiss) and on sloping pediments at mountain foot slopes. The rolling topography is generally undulating with slopes ranging from 5% — 35%. The narrow valleys whose dendritic pattern inter-

1) Compared with population densities (people per cropped square kilometer) of say, India with 1000; Egypt with 1300; Israel with 700; Java with 600; and the USA with 80.
2) Most of the proposed upland development areas are situated below the 600 m contour interval shown in Fig 1.
fingers with the steep mountain areas, have level or gently sloping floors where agriculture has traditionally been developed using contour bunding farming methods.

Since the soils were formed under high temperatures and heavy rainfall, they are characterized by a rapid rate of mineral decay. The soluble products have been leached out, and the soils are noted for their low organic matter content, low cation exchange capacity, and a usually less than 40% base saturation value. Low cation exchange capacity is a result of a combination of a low clay content and a low proportion of exchange minerals in the clay fraction and the soils are therefore highly acid. On 83% of the uplands, soils have a pH below 6.0, and on 57% the pH is less than 5.5. This soil condition imposes a fundamental restriction for most upland crop productivity since soil fertility can only be improved by heavy applications of lime — 4.5 ton/ha in the first year, followed by maintenance dosages of 2–3 ton/ha every five years. Recommended fertilizer application rates are 260 kg/ha for wheat and barley and 360 kg/ha for maize. Phosphate levels are low in virgin soils (5–10 ppm) and applications of up to 1 ton/ha are recommended. Borax is also added. However, recommended lime and fertilizer application rates are difficult to achieve on an extensive scale due to poor transportation facilities to the new upland areas, unwillingness of farmers to take investment risks under erratic rainfall conditions and poor distribution facilities at the village level.

b) Slopes
According to a survey carried out in 1965 (Jin Hwan Park, 1969), 50% of upland farming was then on gradients less than 8%, and 85% below an 18% gradient. Upland projects constructed after 1965, however, were on much steeper gradients — only 15% had gradients below 10% and 40% below 18%. The gradients of the areas proposed for development after 1975, were generally even steeper than in previous reclamation projects. Productivity of the steep gradients can be expected to be less than of the lower gradients because of two inherent site factors:
- soil depth decreases as hillside gradient increases; and
- steeper hillside gradients are generally associated with coarser textured soils.

These two physiographic conditions, operating in combination, substantially limit the available moisture-holding capacity of the soils in new upland areas. A 90 cm loam profile, for example may be able to store up to 150 mm of available moisture, whereas a 60 cm sandy loam profile will have a storage capacity of about 70 mm. Assuming that water use by upland crops is about 4.0 - 4.5 mm/day in the months of July and August, the 90 cm loam profile will have a storage capacity of about 70 mm. Assuming that water use by upland crops is about 4.0 - 4.5 mm/day in the months of July and August, the 90 cm loam profile stores about 33 days of soil moisture for plant growth without rain falling, while the 60 cm sandy loam profile has a moisture reserve for only 15 days under the same meteorological conditions. On steep slopes, available moisture in the root zone limits crop growth — particularly in low rainfall years.

c) Climate
In the three main upland development regions (Central Western, Southern and South Eastern) annual rainfall is about 1100 — 1400 mm, and there are wide variations in seasonal distribution in the regions. Rainfall is much heavier in the summer season (April — June) in the Southern region than in the Central Western (Tab 1), while in July — August, the reserve is true and average rainfall in Central-West may be 100 mm higher (i.e. 50%) than in the Southern region. When autumn comes, rain is again more plentiful in the Southern regions. The frequency of rain days follows a similar pattern in the three regions.

Daily evaporation also shows seasonal and regional variations. The number of days with greater than 4 mm of