Title: Bio-Physical Requirements and Socio-Economic Acceptance of Infield Rainwater Harvesting and Conservation in the Semi-Arid Central Region of South Africa


Proposed Statements

1. On-station and on-farm research led to development of appropriate techniques and practices of in-field rainwater harvesting and conservation (IRWH&C) which improves water use efficiency, increases yields and choice of crop combinations with low, erratic rainfall on low potential soils.

2. Chances of acceptance of new technologies are much greater if new production techniques are developed with adequate involvement of resource users, and when a context is created in which the level of skills of community members and the organizational capacity of communities can be improved.

3. Through technology transfer, training and extension it was demonstrated that IRWH&C improves livelihoods, i.e. food security, income, social and cultural well-being of households in rural communities where the majority of members live below the poverty line.

4. The acceptance of IRWH&C for food production in homestead backyard gardens has generated interest to expand activities by up scaling to communal croplands, which has to be undertaken within existing institutional arrangements, available markets, mechanization services and management capabilities.

Context and primary issues and problems that are being addressed

A large number of smallholder farmers in South Africa are operating in remote areas and ecologically variable conditions, with poor soils, low and erratic rainfall. The development and transfer to farmers of production practices and techniques that encourage water and soil conservation, and increased water use efficiency can provide these farmers with an opportunity to increase agricultural production.

The innovative approach / good practice developed

Using the Thaba Nchu area in the Free State Province as a case study, the hypothesis was that a production technique combining the water conservation benefits of water harvesting, no-till, basin tillage, mulching and long-fallow would make sustainable crop production possible at a reasonable level for selected crops. Field experiments were conducted over three growing seasons on four ecotopes with maize, sunflower, sorghum and wheat to test the hypothesis. They consisted of statistically designed experiments on two ecotopes at the Glen Research Station and semi-statistical demonstration trials on two ecotopes on smallholder farmer’s lands near Thaba Nchu. Detailed soil water content measurements were made on all four ecotopes, and runoff measurements were also made with automatic runoff measuring devices on the Glen ecotopes. These measurements made it possible to quantify the water balance and determine precipitation use efficiency to test the long-term validity of the short-term results from the field experiments. Both sets of tests showed that the water harvesting and basin tillage (WHB) part of the hypothesis is correct. Indications are that in the long-term, average yield increases compared to conventional tillage, of around 50% can be expected from maize and sunflower using the technique on the ecotopes tested. Although long-fallow has proved its value for very dry seasons, long-term yield predictions indicate that this strategy will be uneconomical. Mulch in the basins has been shown to be beneficial under certain circumstances. Additional research was needed for clarification in this regard.

In follow-up research four different in-field rain water harvesting (IRWH) systems and conventional tillage (CON) were compared in field experiments at Glen and on farmers’ fields near Thaba Nchu. The four IRWH treatments were: organic mulch in the basins with a bare runoff area (ObBr); organic mulch in the basins with organic mulch on the runoff area (ObOr); organic mulch in the basins with
stones on the runoff area \((ObSr)\); stones in the basins with organic mulch on the runoff area \((ShOr)\). The crops grown were maize, sunflower and dry beans. An empirical stress model termed “Crop Yield Prediction for Semi-Arid Areas” (CYP-SA) was developed to enable long-term yield predictions to be made. Measured yields over three seasons in the field experiments, and predicted long-term yields using the model, showed the following: For all the crops on all the ecotopes the \(ObSr\) treatment was the best IRWH treatment, generally only statistically significantly better than \(ObBr\). The clearly defined superiority of IRWH over \(CON\), already shown in the 1996-1999 WRC project, was confirmed (Hensley et al., 2000). These results are strongly supported and eloquently described by the long-term, yield cumulative probability functions (CPFs) obtained with CYP-SA. Measurements on the experimental plots showed that water losses by deep drainage were negligible during the three growing seasons. Since runoff losses were also zero on all the IRWH plots, the only cause of water loss was evaporation from the soil surface \((Es)\). This was shown on the maize plots to be highest on the \(ObBr\) treatment, and similar on the other three treatments, amounting to 79% and 74% of the annual rainfall, respectively. The equivalent value for the sunflower plots was approximately 70% for all the treatments. It is clear that in order to further improve precipitation use efficiency (PUE) above the current best values of 7.4 and 4.8 Kg ha\(^{-1}\) mm\(^{-1}\) for maize and sunflower respectively, it will be necessary to find ways of suppressing \(Es\) still further (Botha et al., 2003).

### Challenges in implementation of IRWH

Many water conservation projects have failed, despite good techniques and design, because of the failure to investigate their social and economic aspects. In other cases where improved water management and conservation techniques have been introduced, their sustainability and environmental impacts have been overlooked. New technologies (tangible creations as part of material culture) not only present opportunities for communities to improve their material well-being, they also influence the non-material culture (intangible creations such as beliefs, norms and values) of a community. One of the most urgent challenges facing a community is the need to adapt its non-material culture to material innovations. Such adjustments and acceptance are not always immediate. Sometimes they take decades; sometimes they never occur. Changes in the material culture take place at a faster pace than the non-material aspects of a community’s culture. It is important to be aware of this difference when assessing the social acceptability of new technologies. When considering this case study, one of the conditions for the success of water conservation techniques is the acceptance by resource users – the farmers. Among other issues, chances of acceptance of new technologies are much greater if new production techniques are developed with adequate involvement of resource users, and when a context is created in which the level of skills of community members and the organizational capacity of communities can be improved to allow their effective management of the techniques. Furthermore, profitable technologies that are thought to result in socio-economic inequities and disruptions to the social organization may be resisted by communities.

Smallholder farmers already operate in an environment fraught with high levels of risk due to climatic and price variability. The risk levels and income potential for investment of labor and other inputs must be acceptable, if the new techniques are to find use among farmers. The benefits generated by the new production technologies must be apparent to farmers as early as possible in the technology development or on-farm adaptation and adoption phase.

The new technologies should provide significant economic returns if farmers are to be persuaded to undertake the required investments. Profitability analyses using enterprise budgets show that there is a significant increase in farm income when farmers adopt rainwater harvesting compared to the income levels achieved under conventional crop cultivation. By adopting the simplest form of in-field rainwater harvesting – without the use of mulches in the basins and the runoff area, farmers can increase their income by about USD130.00 per hectare in the case of maize production. Analyses of on-station production data suggest that farm income can be increased further with the use of organic or stone mulches.

In addition, investment analyses were carried out to assess whether it was worthwhile for farmers to invest in creating the basins and micro-catchments required for collecting rainwater in their fields.
The results of the analyses suggest that farmers can increase their income by undertaking IRWH, and that the investment will payoff over time. Farmers also need to be compensated for the risk that they take by changing from the conventional ways of producing to the new techniques. The results of the stochastic dominance analyses show that farmers will receive more profit with a lower risk of failure when using the IRWH techniques, which contributes to economic sustainability.

The improvement of rural households’ food security situation is central to the National Department of Agriculture’s policy. In this study estimations of the required farm size to produce enough food or income to meet the requirements of an average household in Thaba Nchu using IRWH techniques were made. It was found that about 8 hectares of land are required to produce enough food (income) to last a family of 5 from one harvest to the next. With rainwater harvesting, these areas are substantially lower at about 3 to 5 hectares. Results from the field survey carried out in the study area showed households’ expenditures levels were below the nationally determined poverty line. Improving agricultural production using IRWH techniques thus provides potential for directly and immediately improving food security for households in Thaba Nchu (Kundhlande et al., 2004).

**Background information**
