

Research Application Summary

Improving smallholder irrigation performance in Malawi

Mloza-Banda, H.R.¹, Makwiza, C.¹ & Kadyampakeni, D.¹

¹Bunda College of Agriculture, University of Malawi, P. O. Box 219, Lilongwe, Malawi

Corresponding author: mlozab@yahoo.co.uk

Abstract

The paper reports work aimed at improving livelihoods of smallholders by providing investors, policymakers and implementers with concrete knowledge and tools to make informed investment decisions on small-scale irrigation water management interventions. The projects reported assessed promising irrigation interventions and their 'market potential', analyzed which technologies 'fit' in major agroecological environments, gauged potential trade-offs, and recommended out-scaling strategies.

Key words: Breakeven yields, irrigation technologies, scheduling, water management

Résumé

L'article signale le travail visé pour l'amélioration des revenus des petits fermiers en dotant les investisseurs, les décideurs et les gestionnaires, des connaissances concrètes et les moyens pour prendre des décisions muries sur les investissements concernant les interventions sur la gestion de l'eau de l'irrigation à faible échelle. Les projets ont rapporté les interventions d'irrigation prometteuses et évaluées ainsi que leur pouvoir du marché; ils ont analysé quelles technologies peuvent concorder avec les environnements agro-écologiques importants; ils ont mesuré les compromis possibles et ont recommandé des stratégies en dehors toute mesure.

Mots clés: Rendements nuls, technologies d'irrigation, prévisions, gestion de l'eau

Background

A key to promoting agricultural productivity of small-scale farmers is to increase access to affordable and efficient irrigation technologies (FAO, 1997). Low-cost technologies adopted on a wide scale have the potential to expand agricultural production. Farmers are able to apply water when and where they need it employing local labour and skills. Equally, good water management practices can raise productivity, equitable access to water and also conserve the water resource base (Cai *et al.*, 2001).

However, irrigation takes place in flood plains, dambos and river basins that comprise 12% of land surface in Malawi (Malawi Government, 2000). Despite being attractive land systems for agriculture, dambos and river basins are hydrologically sensitive environments, exposed to the risk of soil degradation, over-abstraction and declining water tables and downstream-upstream effects. Second, it is already estimated that 60-70% of water used for irrigation does not actually reach the crop, implying the need for improved irrigation systems, better water harvesting techniques and the growing of suitable crops (FAO, 1997). Because irrigation is costly per unit of water (compared with natural precipitation), a thorough knowledge of how irrigation water is measured and how it can be applied most effectively for efficient irrigation management is required.

In Malawi, few studies have evaluated the agronomic, technical, socio-economic and technical aspects of the different irrigation systems currently in use among smallholder farmers in the country. The focus in this paper is a comparison of the benefits of motorized pumps, treadle pumps, hand dug wells, gravity and residual moisture as irrigation and water management practices applied to dry season crop production while taking into account an inventory of technical, socio-economic, bio-physical and eco-agronomic aspects within the production environment.

Literature Summary

Different practitioners measure water productivity differently. Agronomists measure the relationship between yield and evapotranspiration. Irrigation engineers are concerned with overall water-use efficiency in irrigation systems. Farmers are interested in yield obtained per gross water quantity applied to the field. It is difficult to reach a common agreement because the purpose and use of the values obtained is different (Feddes, 2007). Invariably, with increasing competition across water-using sectors, there is a greater need for more efficient water use.

Irrigation aims at supplying enough water to meet the crop water requirement. The FAO developed methodologies for computation of crop water requirement (FAO, 2002). The methods rely on estimating reference evapotranspiration from which is derived the crop evapotranspiration. The Penman-Monteith method was recommended as the best performing method for estimating crop water requirement. The total amount of water required depends on the soil type. Different soil types have different water holding capacities as influenced by soil texture and structure. Irrigation scheduling is the process of

determining when to irrigate and how much water to apply per irrigation. It is an important key to irrigation water management while ensuring optimum crop growth. It is based on daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil (FAO, 2002).

This study considered that an effective approach to water management and indeed technology dissemination is to follow a performance oriented approach (Kedir, 2004). Data collected to quantify performance indicators at a detailed scale as the farmers' fields are essential for subsequent interventions. While such data is rarely available, it permits retrofitting new techniques and practices to the existing ones. A knowledge base of prevalent water management practices among farmers cultivating using the common smallholder irrigation technologies is important for interventions that can promote water savings and improve water productivity.

Study Description

The first study was conducted in Chingale (15°32' South and longitude 35°11' East) Zomba District, in Southern Malawi. Data collected were on climatic, irrigation, socio-economic, financial and agronomic aspects, and were analyzed using a GENSTAT (6th edition) computer package. Gross margins were established and used to estimate the breakeven yield and breakeven price.

The second study was carried out in Motola (15°54' and 15°59' S; 35°46' and 35°49' E), Mulanje District in the Shire Highlands of Southern Malawi. The study used a sample of 24 winter cropped farmer field plots (130 m²) with 6 plots for each of the irrigation technologies: watering can, treadle pump and communal gravity canal. Another set of 6 plots supported crop growth exclusively by residual moisture. Farmers watered the bean crops according to their normal practice without predetermined irrigation schedules. The time spent on irrigation and other farming activities was recorded as were the volumes of water and irrigation depths attained. The crop water requirement for beans, used as model crop in the study, was calculated using CROPWAT Model based on the modified FAO Penman-Monteith equation and where soil properties and rainfall data for the site were incorporated.

Research Application

Irrigation technologies and yield. The study in Zomba showed that there were highly significant differences ($P < 0.01$) in grain yields at technology level (i.e. motorized pump, treadle pump, water can, gravity irrigation and non-irrigated treatment).

This justified that each technology had its own unique characteristics which could not be captured in the treatment effects in spite of the technical variations in abstraction, conveyance and application of the water.

Because of its highest irrigation frequency, use of watering can had the highest total requirements of 38,231 labour-hours in Type II bean production. The second highest was gravity irrigation that had total labour requirements of 24,169 labour-hours where farmers using this method spent more of the time in the field monitoring water flow. Treadle pumps had the third highest labour requirement because of water extraction through pumping, application and priming procedures. However, the study in Mulanje showed further that farmers using watering cans applied the least depth of water at each irrigation. Gravity canal farmers applied the largest depth of water whenever sufficient quantities were available. The farmers using treadle pumps applied slightly less water than those using gravity canals. Though the watering can farmers irrigated most frequently, they still applied the least total depth of water.

Farmer organisation. Farmers using watering cans were able to make independent water management decisions. They were able to choose when to irrigate their fields without much influence from other farmers. On the contrary, farmers using treadle pumps and gravity canals in the study made their water management decisions as a group. This precept was pivotal to the success of the club and the continued use of the technology and resulted in reduced irrigation depths. It is concluded that proper choice of technology is also vital for increased irrigated crop production. Watering cans are suitable on small gardens close to streams or rivers. Where increase in land under irrigation necessitates change of irrigation technology to mechanical or motorised pumps, a good organisational set up is necessary for good water management.

Irrigation scheduling. It was observed in the study that farmers applied less water over the growing season than required (Fig. 1). The mean depths of water applied for all the irrigation technologies were lower than the irrigation requirement. The farmers over-irrigated the bean crop at the early growth stage but under-irrigated at the mid growth stage when the crop water requirement was highest. Though farmers inherently increased the volume applied, the actual depth of irrigation was less than the crop water requirement.

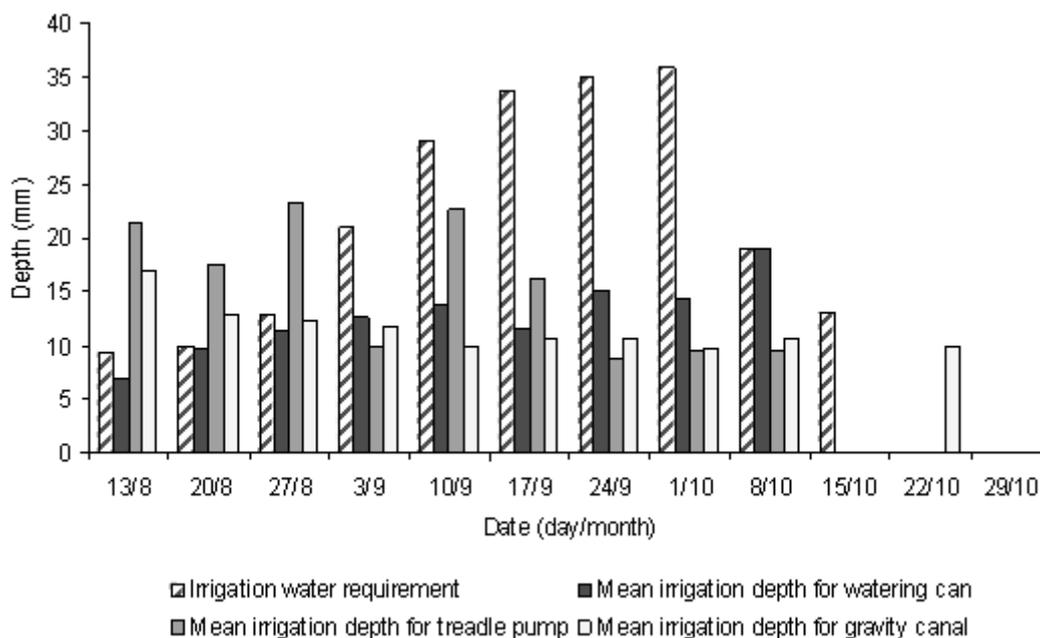


Figure 1. Irrigation requirement and actual application depth averaged for farmers using each irrigation technology in Mulanje

Knowledge of irrigation water management and practical irrigation scheduling was noted to be weak. There is a need to make farmers aware that water needs as the crop develops through the different stages of growth vary. Simplified aids for estimating water requirements for different crops in areas where irrigation is practised are recommended. Farmers practicing irrigation need strong technical support and training in water management to improve their yields.

Economics of production. The study in Zomba showed that treadle pump irrigation, use of watering cans and gravity irrigation had positive gross margins (US\$69 ha⁻¹ to US\$1330 ha⁻¹) (Table 1). Negative gross margins in Type II beans were obtained in motorized pump treatments. According to Nyirenda *et al.* (2001) negative gross margins imply a higher break-even point for farmers using the technology and test crop in question. Break-even yields (BEYs) indicate the safety margin in irrigated agriculture. Bean yields in motorized pump treatments were below BEYs while yields in treadle pump treatments, use of water can and gravity irrigation were above the BEYs. This also explains why these treatments were profitable.

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Table 1. Economics of type II bean production in Chingale, Zomba, Malawi.

Treatment	Total variable cost (US\$ ha ⁻¹)	Yield (kg ha ⁻¹)	Total revenue (US\$ ha ⁻¹)	Break-even yield	Break-even price (US\$ kg ⁻¹)	Gross margin (US\$ ha ⁻¹)
Motorised pump	748	876	478	1370	0.85	-270
Motorised pump	781	1,249	681	1431	0.62	-99
Motorised pump	832	1,000	545	1525	0.83	-287
Treadle pump	196	1,181	644	359	0.17	448
Treadle pump	244	1,806	985	447	0.14	741
Treadle pump	386	833	454	707	0.46	69
Use of water can	233	880	480	427	0.26	247
Gravity irrigation	221	2,843	1551	405	0.08	1330
Non-irrigated	290	694	379	532	0.42	88

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