Utilisation of nutrient-enriched waste water from aquaculture in the production of selected agricultural crops

JF Prinsloo*, HJ Schoonbee and J Theron
Aquaculture Research Unit (ARU), University of the North, P/Bag X1106, Sovenga 0727, South Africa

Abstract

A comparison is made of the water efficiency of two types of drip-irrigation systems and one micro- and one flood irrigation system, using nutrient-enriched water, in the production of selected vegetable and maize crops. Results showed the micro- and drip-irrigation systems to be the most economical in terms of water usage. Of these, the drum-drip-irrigation system was the most efficient and probably the system of choice to be developed further for community-based sustainable food production systems in predominantly rural areas of South Africa.

Introduction

Calculations of South Africa's potential surface and underground water resources revealed that this country can only support 80 m. people, and that large-scale shortages of food can be expected under such conditions. This may then lead to the outbreak of serious nutritional diseases, especially amongst the country's rural communities (Frankish, 1978; Kirsten, 1974; Steyn et al., 1995).

Although the agricultural output of South Africa can potentially increase much more to meet the demand for food for the immediate future, the ultimate constraint in the long term will remain the availability of water and its optimal use. With an average annual precipitation of approximately 497 mm (which is well below the world average of 860 mm), storage dams are continuously being constructed to retain some of the surface runoff water to meet the increasing demand for domestic, industrial and agricultural use. Although it has already become necessary to recycle water for industrial purposes in some parts of the country because of the shortage of water, there still remains considerable scope for extending the food production potential of water available to agriculture. One way to achieve this is to integrate aquaculture with traditional agricultural practices, where the same water can first be used to grow fish before being used to irrigate crops. The contribution of aquaculture towards food production in South Africa, however, is at this stage still insignificantly small, with an estimated income of about R18 m. per year (DWAF, 1996).

One of the first serious attempts in South Africa at the development of a community-scale poultry-fish-vegetable integrated aquaculture-agriculture system aimed at sustainable food production in rural areas, was that of Prinsloo and Schoonbee (1987). Nutrient-enriched wastewater from duck-fish ponds was used to successfully produce a variety of vegetable crops. Yields were significantly higher using this water compared to those of the same type of vegetables irrigated with freshwater. Since then, a number of similar vegetable production trials were undertaken using wastewater from water-recirculating intensive fish production systems which, in some cases, was again reused for integrated poultry-fish production prior to its utilisation as irrigation water for vegetable production (Prinsloo et al., 1999 a,b,c,d). The same water was then used to evaluate the efficiency of four different methods of irrigation in the production of selected agricultural crops.

In this paper the efficiency of drip, drum-drip, micro- and flood irrigation systems, using nutrient-enriched water in the production of cabbage, spinach, lettuce, beetroot, carrots, green beans and maize is compared.

Materials and methods

Irrigation water used

Two types of nutrient-enriched irrigation water were used for the drip, drum-drip and micro-irrigation systems and for flood irrigation, respectively. In the first case, nutrient-enriched wastewater was obtained from a recirculating intensive fish production unit stocked with tilapia *Oreochromis mossambicus* (Peters) and the sharptooth catfish *Clarias gariepinus* (Burchell) at densities which ranged between 200 and 400 fish/m^3 of water (unpublished data).

This same water was also pumped into integrated fish-poultry ponds where chicken sheds were suspended over the fish ponds which then received a further enrichment of the water as a result of the nutrients emanating from chicken droppings and waste chicken food (Prinsloo et al., 1999d). This water was used in the flood irrigation programme. Physical and chemical analyses were undertaken on both types of water during both the summer and winter crop production cycles.

Physical and chemical conditions of waste water

As mentioned, routine physical and chemical analyses were undertaken on the two types of wastewater used for irrigation purposes during both the summer and winter crop production periods. Analyses were performed according to standard international procedures (*Standard Methods*, 1995). Water temperatures (°C) were measured using Thies hydro-thermographs. Dissolved oxygen concentrations (mg/ℓ) of the wastewater were determined using an oxy 92 meter. pH values were determined with a portable Hanna 8244 pH meter. The electrical conductivity (µS/cm) was recorded with a Hanna HI 8633 conductivity meter. Ammonia (NH_3-mg/ℓ), nitrite (NO_2-mg/ℓ), nitrate (NO_3-mg/ℓ), orthophosphate (PO_4-mg/ℓ), as well as turbidity (NTU) were all determined using a Hach spectrophotometer. Mean values, as well as ranges for each parameter, were determined and tabulated.

* To whom all correspondence should be addressed.
☎(015) 2682294; fax (015)2682294; e-mail: koosp@unin.unorth.ac.za
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