April 2008

POLICY BRIEF

BIOFUEL PRODUCTION

The potential of the impact of large-scale planting of the biofuel crop *Jatropha curcas* was investigated.

Jatropha curcas: Measuring the Impact of Large-scale Planting on Water Resources

Jatropha curcas – A threat to South Africa's water resources?

New crop species introduced on a large scale have the potential of impacting on South Africa's water resources. International interest in one of a number of so-called "miracle" crops, ***Jatropha curcas***, has grown significantly in recent years.

J. curcas, a drought-tolerant, fast-growing crop suitable for bio-energy production, has also been seen as a possible contributor to poverty alleviation and job creation. For these reasons, large-scale schemes for planting ***J. curcas*** have been proposed in South Africa.

The effective management of commercially planted species in terms of possible water resource impacts requires accurate information on generalised water use and bio-physical production characteristics relevant to areas having planting potential. With such information largely lacking in the case of ***J. curcas***, the Department of Water Affairs and Forestry (DWAF) has been forced to adopt a cautious approach and to propose that, until necessary information becomes available, the large-scale cultivation of ***J. curcas***, as with other new species having similarly uncertain water requirements, be declared a Stream Flow Reduction Activity (SFRA).

Uncertainty surrounding the effective use of water by ***J. curcas*** dictated that research be undertaken to develop a capability for predicting impacts of large-scale planting of ***J. curcas*** on water resources in South Africa. This research has entailed the acquisition of available information on the bio-physical requirements of ***J. curcas*** to enable mapping of areas suitable for planting, the provision of crop yield information for gauging production potential and the provision of water-use data as a basis for SFRA recommendations relating to large-scale cultivation of ***J. curcas***.

Furthermore, since the soundness of policy decisions are dependent on perceptions and understanding various stakeholders have around ***J. curcas*** cultivation, and also around related SFRA and water-use licensing issues, gauging of such perceptions and levels of understanding were included in the research process.

Review of world knowledge

An international review of available knowledge on the cultivation, hydrology and production of ***J. curcas*** yielded some useful biophysical data, but also confirmed that relatively little is known about the ecological and hydrological impacts of ***J. curcas***. In addition, remarkably little information could be found anywhere in world literature on crop yields of ***J. curcas*** in relation to biophysical and prevailing climatic conditions, thus presenting an obstacle to reliable crop-yield prediction for potential production areas in South Africa.

Estimating yield and water use

A crop modelling approach in three phases had to be employed to obtain crop productivity estimates of ***J. curcas*** for different areas in South Africa. The first phase simply used biophysical cut-off limits, derived from the knowledge review, to eliminate all areas where ***J. curcas*** will not grow due to climatic and physical constraints.

The second and third phases approached the estimation of crop yield in two different ways with different levels of complexity, but with similar results. The more complex method entailed deriving crop-yield equations for ***J. curcas*** from existing equations for crops (banana, eucalyptus and sunflower) with properties encompassing the oil-producing and tree-like growth properties of ***J. curcas***, taking into consideration the known tolerance limits of ***J. curcas*** itself. Whilst the derived equations do not pretend to be precise, they are able to provide good indications of expected yields of ***J. curcas*** for a range of potential production areas.

The crop-yield equations predict that the highest potential yields of *J. curcas* in South Africa are likely to be obtained in the coastal areas of KwaZulu-Natal and the Eastern Cape, as well as inland, along the eastern slopes

of the Drakensberg Mountains in Mpumalanga, where yields of over 8 t of seed/ha may be achieved. At the other extreme, low yields of less than 2 t of seed/ha can be expected in the northern parts of the country and along the south-eastern seaboard. The central interior is not at all suitable for *J. curcas* due to low rainfall and frost.

Hydrological (water-use) characteristics of ***J. curcas*** were inferred from field measurements of crop transpiration at selected test sites representing optimal growing conditions in two different areas (Empangeni and Makhathini Flats). Over a period of almost 2 years, transpiration of ***J. curcas*** plants was continuously monitored through the measurement of sap flow using the Heat Pulse Velocity (HPV) technique. In addition, selected weather variables and, and, where possible, soil-water dynamics were monitored to provide the basis for the subsequent application of modelling as a means of simulating water use of ***J. curcas*** throughout potential production areas.

By scaling up from transpiration measurements made for individual trees, to transpiration estimates at plantation level, total transpiration quantities could be reliably obtained for ***J. curcas*** stands of different ages at Empangeni and Makhathini.

These quantities could then be used to derive parameter values for models that would enable transpiration of ***J. curcas*** to be estimated at places elsewhere in South Africa. Two models were considered appropriate for such use: the FAO 56 model based on the use of empirically determined crop coefficients and an empirical relationship between observed transpiration and measurements of leaf area index (LAI) obtained at both the Empangeni and Makhathini sites.

By using these models in a GIS environment, transpiration estimates for ***J. curcas*** could be mapped on a national scale. Transpiration estimates obtained by using the FAO 56 model, because of crop coefficient sensitivity to the dry conditions under which values of this parameter were derived, were considerably lower than those provided by the more robust LAI model. **Both modelling approaches, however, suggested strongly that *J. curcas* uses less water than original natural vegetation would be expected to use. On this basis, there would be no justification for *J. curcas* being declared a SFRA.**

Stakeholder concerns, perceptions and understanding

Key issues highlighted by a group of stakeholders comprising employees from government departments were the potential invasiveness of ***J. curcas***, its water-use potential, food-security issues and the economic viability of planting ***J. curcas***, particularly with regard to the rural poor. DWAF is primarily concerned with stream flow reduction and the wider issues of catchment degradation and management, particularly where plantings are unwisely effected. The Department of Agriculture (DoA) sees food security and possible invasiveness as major issues, while the Department of Minerals and Energy (DME/National Energy Regulator) aims to maximise the production of bio-diesel as a replacement fuel. These varying concerns do have the effect of creating some tension among the departments.

In essence, it emerged there is a **critical lack of knowledge** regarding ***J. curcas*** and the implications of potential large-scale planting in South Africa. It is evident that the key government departments, particularly the Department of Environmental Affairs and Tourism (DEAT), DoA and DWAF, should adopt a consensus around ***J. curcas*** and communicate their position to other government departments and the general public.

It further emerged that the stakeholder group comprising potential producers and processors of ***J. curcas*** are not well informed regarding the establishment, survival and yield of the crop, the areas which show growth potential, water-use implications, and government's position on ***J. curcas*** as a potential SFRA and alien invasive plant.

Policy recommendations

- *Jatropha curcas* has been presented as a "wonder" plant when, in reality, very little is known about it and actual success stories cannot be found. Care should be taken in promoting its wide-scale cultivation.
- *Jatropha curcas* can be grown successfully in South Africa along the Eastern Escarpment and along the coast. Areas of low and variable rainfall, and areas susceptible to frost, should be avoided. Production in marginal areas should not be considered unless there is an exceptional reason, such as a very high poverty index, for such investment.
- *J. curcas* appears unlikely to have a negative impact on stream flow and, on this basis, cannot justifiably be declared a SFRA.
- The outcomes of local research should be widely disseminated amongst both potential growers and regulators. It is particularly important for government to engage with stakeholders and disseminate correct information so that educated decisions relating to cultivation of *J. curcas* can be made.
- Further research, related to water use and other issues, such as economics and invasiveness, is advisable.

Further reading:
Jatropha curcas in South Africa: An Assessment of Its Water Use and Bio-physical Potential (**Report No: 1497/1/07**). To order this report contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565 or E-mail: orders@wrc.org.za