LETTER

Reply to Maes et al.: A global estimate of the water footprint of *Jatropha curcas* under limited data availability

In response to our article on the water footprint (WF) of bioenergy (1), Maes et al. (2) argue that we overestimated the WF of jatropha oil, used data from a limited number of plantations, and made methodological errors. We did use little data, because hardly any data on jatropha production are available. Although we took data from various plantations from different countries, Maes et al. state—based on data from one Egyptian plantation—that we overestimated the WF of jatropha. We cannot see how one can justify such a claim. The WF method is well-established and well-used (1). In contrast, it remains unclear how the low estimate for Egypt is computed because documentation is not available (2).

Because little is known on jatropha production (3, 4), we acknowledge that our results may need revision in the future. We compared WFs of bioenergy from different crops, using best estimates of actual yields under actual water use, rather than potential yields under optimized water use. It is easy to find examples for WFs of jatropha smaller than our estimates. But this is true for all crops we considered, so, in comparing average values for different crops it, would not be fair to take better-than-average examples for jatropha. Besides, one should not take the highest yield after some initial years, because the WF should refer to the average over the full plantation life cycle.

We included five plantations in different countries in the *Jatropha curcas* belt (3), excluding immature plantations. For Nicaragua and Indonesia we used wet-mass seed yields of 4.5 ton/ha per year (4). For Brazil and Guatemala we applied similar yields, assuming that reported low yields (4) would increase to that level and gave expectations the benefit of the doubt. For India, we calculated with a wet-mass seed yield of 0.85 ton/ha per year, as reported in ref. 5. We assumed dry matter contents of 93% (3) and dry seed oil contents of 34% (5). In literature, oil contents are between 33% and 39% (3). For oil energy we assumed a higher heating value (HHV) of 37.7 MJ/kg, similar to the HHV of other oil types, where literature gives a range of 30.1–45.8 MJ/kg (3). We assumed all oil can be extracted, an overestimation, and arrived at results given in Table 1.

WFs are influenced by actual evapotranspiration and yield. The sensitivity is reduced because there is a positive correlation between the two. Higher yields do not reduce the WF when evapotranspiration increases accordingly, e.g., by irrigation. Some experts expect yields (dry mass) of 5–7 ton/ha per year under optimal water and nutrient conditions, others report 0.3 ton/ha per year under poor conditions (4). Theoretically, yields of 1.5–7.8 ton/ha per year are possible with good conditions (3). Many projects have irrigation (6). Except for India, four of the five cases we considered represent data under good conditions. We conclude that the WF of jatropha oil ranges between 250 and 1700 m^3/GJ. Where the world average currently lies remains unknown until more comprehensive datasets become available.

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Table 1. Crop water requirement, irrigation requirement, and water footprint (WF) of jatropha oil for five different locations

	Crop water requirement, mm/yr	Irrigation requirement, mm/yr	Green WF, m^3/GJ oil	Blue WF, m^3/GJ oil	Total WF, m^3/GJ oil
Bangalore	1,986	1,311	575	1,116	1,691
Jakarta	1,821	6,75	184	109	293
Managua	1,908	1,163	120	187	307
Tres Lagoas	1,559	566	160	91	251
San Salvador	2,046	1,079	156	174	329
Average			239	335	574