EXECUTIVE SUMMARY

WATER USE EFFICIENCY OF MULTICROP AGROFORESTRY SYSTEMS, WITH PARTICULAR REFERENCE TO SMALL-SCALE FARMERS IN SEMI-ARID AREAS

This project commenced in 1999. It was conducted in several phases, namely:

(a) "On-station" on the Hatfield Experimental Farm of the University of Pretoria in which pure stands of sorghum, cowpeas, sweet potatoes and *Leucaena leucocephala* were compared with intercropping of Leucaena hedgerows with the same crops in the alleys for three seasons.

(b) "On-station" at the University of Pretoria, in which pure stands of sorghum, maize and Leucaena were compared with intercropping of Leucaena hedgerows with the same crops in the alleys for the two seasons.

(c) "On-farm" sylvopastoral system in Venda to produce forage and fodder for a small scale communal dairy project.

(d) "On-farm" alley cropping systems (with maize and Leucaena), at Sekakane and Chuene Maja, compared with mono-culture maize.

(e) Community development in the Sekakane and Chuene Maja areas.

As this project developed it became evident that this effort to expand the use of alley cropping / agroforestry away from the humid and sub-humid tropics, where it has yielded excellent results, to the semi-arid regions, and in particular with reference to small scale farmers, was faced with specific problems. While the "on-station" work was conducted in Pretoria, which internationally would be classified as semi-arid, in South African terms this area receives a relatively good rainfall and the site was characterised by good physical and chemical soil conditions.

As a result, the extrapolation of results to "drier" conditions, because of rainfall, temperature, evaporation and soil conditions, is open to question. In the context of relative aridity, if Hatfield was classified as semi-arid, then the "on-farm" sites could be classified as arid with certain seasons qualifying as semi-arid, and certain seasons as hyper-arid. The implications for crop selection are very important in this project, especially in the context of sustainability. Of the species used, Leucaena, although at its best in humid to sub-humid tropical conditions, can survive fairly dry conditions. Cold might place limitations on the growing season, the availability of leaf in winter, and the incidence of top kill and consequent coppicing. Sweet potatoes were a poor choice as intercrop as it does better in warmer and wetter environments and in rotations rather than in a mono-culture.

Cowpeas were probably a good choice in terms of being indigenous and hardy, but in terms of community preference this crop would not be preferred. Moreover the advantages of being leguminous would be negated to some extent by combining it with a leguminous tree crop. It would also probably perform better in a rotation where considerations of fertility, weed control and pest control would be better managed. Cereal or grain crops would, therefore, be the preferred intercrops with Leucaena.

Maize is an exotic species which dominates the diet preferences of many rural communities in Africa. In semi-arid conditions, good management practices can ensure sustainable maize production. Where, however, the rainfall and soil conditions are unfavourable, and maize is not a sustainable option, more drought-tolerant (sorghums and millets) grain crops should be considered, despite the priorities of the farming communities.

Sorghum in the above-mentioned conditions would be a viable alternative crop. Where, however, growing conditions are better maize would remain the first choice grain crop. The grain millets should also be considered in future work even though there is a stated

preference for maize. The farming community needs to be made aware of the relative risk of different grain crops in areas where the rainfall indicates greater aridity.

The need is for mixed farming systems, which meet the diverse needs of the community. As a "needs-driven" project the emphasis on the system would concentrate on one or more needs, for grain, bulk roughage, high protein fodder and/or fuel wood.

It is in the context of needs (and hence relative value of the different products from multi-crop systems) that the production data from both "on-station" and 'on-farm" trials should be interpreted. Assuming a need for a diversity of products for both man and beast, the decision which needs to be made is – do we recommend an alley cropping system or do we recommend separate blocks of the different crops?

Under marginal climatic and soil conditions, and the latter may be affected by financial ability of small scale farmers to ameliorate (rip, deep plough, drain, lime, fertilize) the soil, the results from this project would appear to indicate the avoidance of competition between different crops in alley systems and the optimization of mono-culture agronomic practices would be the route to go. With better growing conditions the choice between alley systems and monocultures, would depend on the needs for different components and the relative values allocated to these products. For example, a small scale farmer producing maize grain for use within the community, would probably attach a value comparable to what that community would have to pay the local trading store, while a producer marketing to millers would have a value determined by national supply and demand and the global market. Similarly fuel wood prices/values would be determined by the availability and prices of alternative sources of energy, and this would vary tremendously from area to area. The demand for (and value of) livestock feed would also vary from area to area, depending on such factors as the availability and quality of veld and the nutritive needs of different classes of stock. Feeding for survival or for production, for beef or mutton or milk are all very different scenarios, each of which can justify certain inputs into feed. Under good climatic and soil conditions (prime land capability with minimal erosion hazard) the choice of land use system would be governed by economic considerations, although certain land users may persist with less profitable enterprises because of personal preferences, irrespective of which was the most profitable enterprise. Under South African conditions, which are so often typified by high variability (even in high potential areas), there is probably a valid argument in favour of diversification, mixed farming or spreading the risk. Where this is practiced, annual crops, perennial crops and fodder trees could be combined in a range of alternative land use scenarios. Apart from mono-cultures, crop rotations, intercropping, etc., this might include different forms of agro-forestry.

Monitoring of competition for light and water in this project has indicated that:

(a) row orientation of trees in alley cropping (this changes constantly in conditions where most plantings are on the contour) at these latitudes do not have a major effect on light interception during the summer months, but might have negative impacts on the southern side of rows in the winter months, or depending on the pruning/hedge row policy for the trees. The effect will also vary tremendously depending on the intercrop. Temperate species generally have lower threshold values than tropical species at which they can still photosynthesize effectively, but even within each of these groups there is considerable variation in shade tolerance. Hence, complementary work, conducted at Hatfield, has demonstrated that while virtually all the intercrop annual row crops did extremely poorly in the rows adjacent to the trees, *Panicum maximum* (a tropical C4 perennial grass species) was at its best virtually under the canopy of Leucaena coppice. This observation might be confounded by the high fertility under the canopy of the leguminous tree crop. However, the annual row crops did not benefit from this situation.

(b) While the favourable soil conditions and better rainfall conditions at Hatfield would hypothetically reduce negative competition for water because of the deeper rooting habit of the trees, in practice competition for water in the upper soil layers was very strong in the rows closest to the trees (probably because under the experimental conditions there was little or no recharge of subsoil moisture and trees competed in the

shallower horizons for moisture). On the "on-farm" site at Sekakane, which was the only co-operative site to yield production data, it appeared that in the poorest season maize survival and productivity was severely impaired up to 5 m from the trees, while in the best season (with ±360 mm of rain this was by no means a good season) maize rows 3 m from the trees had the best yielding plants. Such results should be interpreted in the context of two factors:

1. In other work conducted on Leucaena by the University of Pretoria, it was found that the lateral spread of tree roots was much greater where unfavorable sub-soil conditions impeded root penetration;

2. Simulations of the water balance (using the SWB model) in a range of soils under a range of rainfall conditions indicate that under unfavourable rainfall conditions there is no water recharge of the deeper soil layers in 6 of the 9 scenarios examined. As a result there would be strong competition for water between different plant species in the upper soil layers as opposed to complementarity under better growing conditions.

Finally, considerable inputs into the functionality of different agro-forestry models and their uses, has demonstrated that some of these could find application in developing systems or "what if-scenarios" incorporating trees, which could improve crop productivity and sustainability. At the same time, however, it must be emphasized that considerable research must still be conducted to provide a sound basis for predicting crop and tree productivity.

With respect to community development, it must be recognized that while the technology of implementing alley cropping systems in harsh environments is still in its infancy, it will be difficult to gain acceptance by land-users who operate under difficult socio-economic pressures. Agro-forestry/alley cropping should clearly be an integral part of extension programmes designed to provide alternatives for land users to improve the productivity of their land (whether for crops or livestock). It should not be seen as an objective in itself but rather as one of numerous means to the realization of objections.

In future, such projects should therefore be years in the planning, based on comprehensive surveys of natural, human and financial resources and not months as is currently often the case. In this project the human factor often proved to be the biggest limitation. On the other hand, the progress that was made was ascribed to the inputs of staff, students, government officers and, most importantly, members of the communities.