EXECUTIVE SUMMARY

1. MOTIVATION

Rural farming systems in the Upper Thukela region of the KwaZulu-Natal Drakensberg operate under communal tenure. The major constraints of these farming systems are the low quality and shortage of fodder during the dry winter season, shortage of land and shortage of water. Fodder trees with a high nutrient content have been used in other parts of Africa to increase animal production. Growing trees together with crops can greatly enhance productivity of rural farming systems, since tree roots can exploit water and nutrients below the shallow roots of crops. Trees can also increase productivity through soil nitrogen fixation and the provision of fodder. While the benefits of the intensive use of fodder trees to supplement forage production have been well documented (Jabbar, Reynolds, Larbi & Smith 1997; Roothaert 2000), there has been virtually no research on agroforestry systems in the temperate, frost-prone areas of the KwaZulu-Natal Drakensberg.

2. PROJECT OBJECTIVES

Main objective:

To examine agroforestry systems in terms of competition for water between trees and crops.

Secondary objectives:

(a) To monitor soil moisture profiles in agroforestry systems to determine the effects of below ground moisture competition between roots of trees and crops.

(b) To determine the comparative water use of multi-purpose trees in agroforestry systems in the Upper Thukela region for recommendation on appropriate species.

In addition, the project team carried out a study on the economics of the agroforestry system, which was not part of the original objectives.

3. BACKGROUND

In response to a request from a local farmers' association, a project was initiated in 1997 to examine the potential of an agroforestry system to increase fodder production. In 1994 the National Plant Conference was held to address the current wood fuel crisis in South Africa. One recommendation was for the State to incorporate agroforestry into the Reconstruction and Development Programme to increase animal fodder provision and provide fuel wood. In the past, efforts to introduce agroforestry systems to small-scale farmers in the Upper Thukela region have largely been a failure. The main reasons for this are:

(I) There is a general belief that agroforestry species will reduce the water supply and cause low crop yield. Community members have a strong perception that during the recent drought trees were responsible for the drying up of streams.

(ii) There has been a lack of farmer participation in planning research trials and adapting them to people's needs.

In 1994 the CSIR took part in a participatory rural appraisal workshop in the Upper Thukela to give under-serviced communities an opportunity to participate in the planning of their development programmes. One of the main needs identified by the community was to improve the productivity of their cattle. Follow-up workshops have investigated the option of planting fodder trees and addressing the community's needs with respect to trees and water. The current project is part of the implementation phase of these exercises in which farmers are involved in research trials addressing their needs.

The aim of this study was to determine the optimum combination of fodder trees and maize to increase production and minimize soil water competition.

4. METHODS

An on-farm trial was conducted to determine dry matter production of four fodder tree species and their effect on soil water and maize production. The trees were planted in an alley-cropping system and intercropped with maize in a randomised block design. The trees were planted at two row spacings (0.5 and 1 m) with an inter-row spacing of 5.25 m. The four tree species selected were an indigenous fodder tree species (*Acacia karroo*), a nitrogen fixing species (*Leucaena leucocephala*), a fruit bearing species (*Morus alba*) and a multi-purpose species (*Gleditsia triacanthos*). The trees were harvested 0.75m above the ground at least twice during the growing season.

In order to increase the chance of adoption of this new technology, the trial was carried out in a participatory way, involving farmers' in all steps (e.g. location of site, management of trees and maize, monitoring biomass production, evaluating tree species etc.). A fodder flow analysis was carried out to determine the farmers' practices and develop an understanding of his farming system and constraints. Regular farmers days were held to provide feedback to the farmers and discuss the benefits and constraints of the agroforestry system.

Volumetric soil moisture was measured in the upper 0.3 m of soil in each row of the trial using the Time Domain Reflectometry technique (Topp, Davis & Annan 1980). One probe was installed in every tree and maize row; a total of one hundred and sixty eight probes throughout the study site. The Neutron probe technique was used for monitoring the water content of the deeper soil in the trial. Twelve aluminium access tubes up to 5 m deep, were placed in each of the plot replicates.

Biomass (fodder and fuelwood) of the trees and maize yield were recorded at regular intervals throughout the study. The effect of shading of the trees on the maize was recorded with a line quantum sensor and seven single quantum sensors. Nutrient analyses were conducted on the four plant species and soil.

5. RESULTS AND DISCUSSION

Fodder yield in all species decreased with the wider intra-row spacing of trees (1 m). It is, therefore, recommended that agroforestry species should be planted 0.5 m apart to maximize fodder production. The most productive tree species throughout the three-year study period was the indigenous species, *Acacia karroo* (1600–3000 kg ha-^{1}). Fodder yield in *L. leucocephala* increased significantly from 1999 (500 kg ha^{-1}) to 2001 (3800 kg ha^{-1}). Although this species was slow in establishing, it is apparent that once established it is a productive species. The *Morus alba* tree had the highest fuel wood production (8300 kg ha^{-1} in 2001) and was favoured by the farmer because of its fruit production.

There were no significant differences in tree height between the wide and narrow intra-row spacing within species. By March 2000 the greatest height was exhibited by *M. alba* (3.8 m) followed by *G. triacanthos* (3.5 m) and *L. leucocephala* (2.8 m). The maize rows next to the *M. alba* trees showed a high percentage of shading (>80%) across all rows. This species should be pruned regularly to minimize the shading effect on adjacent maize rows. By contrast, with the other tree species, the rows furthest from the trees intercepted 50-80% of the available PAR. The least growth in terms of height was exhibited by *A. karroo* (1.5 m). This was due to the relatively slow recovery after the trees were harvested in January 2000. This species should not be pruned severely (>0.75 m) and can be maintained as a hedge.

Shortage of crude protein in diets of cattle has been recognized as a constraint to milk production (CARNET 1996). All four species selected in this trial had high protein contents. *Acacia karroo* and *L. leucocephala* had the highest protein values (23.2 and 25.1 % respectively) of all the tree species. These species can be used as a protein supplement and will increase milk production if they are incorporated into the dairy farming system.

One of the disadvantages of growing fodder trees next to maize is that the trees may compete with the maize for light, nutrients and water. In 1999, the second year of establishment of the trees, the average maize yield in all the plots (5 014 kg ha^{-1}) was higher than the control (4100 kg ha^{-1}). The highest maize yields were recorded in the *A. karroo* and *L. leucocephala* plots (6600 ha^{-1}), and tree spacing did not have a significant effect on maize yield. The maize yield in 2000 was generally lower than the control (3900 kg ha^{-1}) with an average of approximately 3700 kg ha^{-1}. The yield of maize rows closest to the row of each tree species was reduced when compared to the most distant row. This impact was greatest in *G. triacanthos* and *M. alba* where yields decreased from 1190 kg ha^{-1} to 420 kg ha^{-1} and from 1590 kg ha^{-1} to 560 kg ha^{-1}, respectively. The maize yield reduction next to *L. leucocephala* was 100 kg ha^{-1} while that of *A. karroo* was 700 kg ha^{-1}. The results, therefore, show that the trees do impact negatively on maize production of rows closest to the trees, but there are considerable differences between species in this respect.

There was little difference between the soil water content of the tree line and the various maize lines (inner, middle and outer) indicating that competition for water is unlikely to be the reason for lower maize yields. The surface soil water content did not differ significantly between the maize and tree rows. However, at greater soil depths (75-125 cm) the trees in the wide spacing used less water than those in narrow spacing. The high soil water values recorded in this study indicate that in the current cycle of good rainfall the plants in the agroforestry trial were not stressed. Thus the trees did not compete with the crops for soil moisture in good rainfall seasons. Since the trees have access to water at greater soil depths they are likely to be more productive into the dry season than shallow rooted crops.

During dry periods in 2000 the soil water ranged between 19-27%, with no differences recorded between the tree and maize rows. This indicates that the trees exerted no influence on the soil moisture across the trial. The analysis of the wet period showed that values were much higher (28-33%), reflecting the good rainfall over this period. The variability of soil water was much less during the wet periods, and differences due to tree and maize competition would be unlikely during these high moisture conditions.

A comparison of soil water in the profile throughout the study period shows that the trial appeared much drier in 2001 than in 2000, which was in turn drier than 1999. This suggests that there may be drying of the trial profile from year to year as the trees mature.

In order for agroforestry to become widely accepted socially it needs to exhibit clear financial benefits to local communities. Two economic models were applied to the data to determine the financial viability of the agroforestry system compared with a mono-cropped maize system. The results show that agroforestry is economically viable where there is low maize production and high tree production. The relative profitability of agroforestry drops off as maize production increases. Agroforestry systems with a high fodder production by the tree component are, therefore, recommended if agroforestry is to be economically viable.

If the farmer plants one hectare to *A. karroo* intercropped with maize he will save R4500 on dry matter supplements. In addition, the farmer can save costs on fuel wood (R2770) if he intercrops one hectare with *M.alba*. Agroforestry not only benefits the farmer financially but also reduces the pressure on the grassland and indigenous forests.

6. CONCLUSIONS

High soil water values recorded during summer indicated that in the current cycle of good rainfall the plants in the agroforestry trial were not stressed. Thus the trees do not compete with the crops for soil moisture in good rainfall seasons. Light interception was an important factor in reducing maize yields in the row nearest to the trees. Since the trees have access to water at greater depths, they are likely to be more productive into the dry season than shallow rooted crops.

The most productive tree species throughout the three-year study period was the indigenous species, *Acacia karroo* (1600 – 3000 kg ha^{-1}). In spite of decreased maize yields in the trial, this study showed that increased fodder and fuel wood production could result in considerable savings to the farmer. Intercropping trees and maize could result in savings of up to R4 500 on dry maize supplements and R2 700 on fuel wood.

7. EXTENT TO WHICH THE CONTRACT OBJECTIVES HAVE BEEN MET

Main objective:

To examine agroforestry systems in terms of competition for water between trees and crops.

The study indicated that all four fodder trees did not compete with the maize crop for water. However, competition for light had a negative impact on yield of maize rows adjacent to the trees.

Secondary objectives:

(a) *To monitor soil moisture profiles in agroforestry systems to determine the effects of moisture competition between roots of trees and crops.*

The TDR and neutron probe techniques showed that there was little difference in water content between treatments in the surface from 25 to 75 cm where values ranged between 0.16 and 0.18. At 100 cm the less densely spaced trees in both the *A. karroo* and *M. alba* wide treatments appeared to be using less water than the narrow spacing. From 125 to 175 cm the *Acacia* trees in the narrow treatment appeared to be using more water than any other species. From a depth of 200 cm to 400 cm there was little influence of the trees on the water in the profile.

(b) *To determine the comparative water use of multi-purpose trees in agroforestry systems in the Upper Thukela region for recommendation on appropriate species.*

The results of analysis of variance on the TDR soil water data indicated that there were significant differences at the 5% level between the water use of the different tree species. From neutron probe data, the driest profiles were associated with *A. karroo* and the wettest with *M. alba* wide treatment. At 100 cm soil depth the less densely spaced trees in both the *A. karroo* and *M. alba* wide treatments appeared to be using less water than the narrow spacing. From 125 to 175 cm the *Acacia* trees in the narrow treatment appeared to be using more water than any other species.

8. CAPACITY BUILDING & TECHNOLOGY EXCHANGE

The agroforestry trial is an important demonstration of a quantitative on-farm agroforestry experimental trial in KwaZulu-Natal. The trial plays an essential role as a demonstration of the potential of agroforestry in supplementing fodder shortages in rural farming systems. In order to build the capacity of the community, cross visits to the agroforestry trial were held by members of the neighbouring Okhombe community. They had the opportunity to talk to members of Mr Mahlobo's work team and discuss the use of trees in providing fodder to improve productivity. The trial enabled community members to plan their tree planting programmes.

Visits to the trial by rural resource management students, Landcare facilitators and grassland science students at the University of Natal contributed to the learning experience and capacity building of these groups.

The project forms the core of a PhD study for Mr van Niekerk.

Mr. G. Ramuthivheli, a student from RAU, carried out the economics survey on the value of fodder and supplements for cattle in the Upper Thukela district as part of his MSc study.

The on-farm trial was used as a demonstration in a pilot study for rural resource management students at the University of Natal. This proved to be so successful that it is now included in the Participatory Development Certificate in Education. This will be upgraded to 32 credits in 2003. Fifteen students doing the Land Care course have visited the trial and gained valuable experience on solving problems co-operatively with farmers.

Mahlodi Tau, a student at the University of Natal, is currently using the trial in his Masters study on improving rural livelihoods through natural resource management.

The trial is also a valuable demonstration to local and overseas students as it shows the importance of on-farm trials in rural areas. Numerous students have been taken to the trial including students from other countries such as Zimbabwe, Eritrea, and Kenya.

This project increased the viability of rural farming systems in the Upper Thukela through the training of small-scale commercial farmers in the application of agroforestry principles.

9. RECOMMENDATIONS

This study indicated that the introduction of fodder trees as an alley cropping system into maize fields increased fodder production. However, one of the problems of alley cropping is that it is difficult for the farmer to harvest the fodder and weed the cropland. Two systems suggested by the farmer are the planting of trees within the fence along the farm boundary, or along contour bunds in the maize fields. Further research is required to examine alternative agroforestry systems that will optimize management of crops and fodder trees in temperate, frost-prone areas of KwaZulu-Natal.

In recent years there has been a move by farmers away from the accepted annual ploughing and cropping system to "no till" systems. The impact of these techniques on agroforestry systems requires further investigation.

The broader dissemination of the results of this study to other communities, extension officers, students and researchers, can be achieved through producing a popular article in the form of a leaflet.

10. DATA

All processed data have been catalogued and stored at Environmentek, CSIR, c/o Department of Agrometeorology, UNP, P/Bag X01, Scottsville, 3209.

Contact person: Dr. C.S. Everson.

These data are held on non-flexible diskette. All data can be supplied to researchers and managers on CD-R diskettes.