POLICY BRIEF

June 2020
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Investigating the water use of agroforestry

A recently completed Water Research Commission (WRC) project investigated the water use of agroforestry systems for food, forage and/or biofuel production.

Background

Agroforestry is the intentional introduction or retention of woody species, especially nitrogen-fixing species, within crop and fodder production systems. The integration may be simultaneous or sequential, such that the different species are not grown at the same time within a given area of land.

Agroforestry can provide a range of benefits, including improved diets and income generation, reduced environmental degradation, improved soil fertility and structure, and climate resilience. In many agroforestry systems there is competition that exists between the woody species and the understorey crop for water, light or nutrients.

Therefore, one of the main challenges of these systems is to determine a hedgerow pruning frequency that reduces the competition and maximises the amount of biomass for feeding livestock fodder and replenishing soil fertility. Previous work investigating the influence of different agroforestry systems and species on soil water, water use efficiency and yields of the different components of the system has been funded by the Water Research Commission (WRC).

The current study sought to broaden understanding of the opportunities that agroforestry provide to strengthen smallholder agricultural systems. Factors that other studies have identified as hindrances to the adoption of agroforestry, such as the high labour requirements and the lack of available of planting material were considered. The research was conducted at a research facility of the Department of Agriculture and Rural Development, Owen Sithole College of Agriculture (OSCA), and the privately-owned Fountainhill Estate at Wartburg, KwaZulu-Natal. On-farm sites were also identified for participatory action research with smallholder farmers.

This study focused on multi-purpose, short-lived woody legumes. ***Sesbania sesban*** (referred to here as Sesbania) – an indigenous species – and pigeon pea (***Cajanus cajan***) – an agronomic crop – were selected as the woody species for the trials.

Agroforestry systems investigated

Three systems, namely improved fallow, alley cropping and silvopastoral systems were tested.

Improved fallow

The improved fallow is a sequential system because land is planted with woody legumes for a period of time (generally two years as a minimum) to improve the soil fertility, after which the trees are removed and replaced with a crop (e.g. maize, sorghum or millet). In the current improved fallow trials, combinations of pigeon pea and Sesbania were established as the fallow tree crop with ***Panicum maximum*** (a pasture grass) or maize planted as the 'follower' crops.

Since many farmers do not have enough land to take the full area out of production for two years, a system that included a maize crop in the first year while the trees were still small was tested. The trials showed that the grass (***P. maximum)*** yields were greater when it was intercropped with pigeon pea than with Sesbania because the latter competed more strongly for sunlight and water.

When grown in combination with Sesbania, the grass ***(P. maximum)*** component only established properly in the second season. Similarly, maize grown in combination with pigeon pea performed better than maize grown with Sesbania.

The biomass production of the tree species and the two systems was also compared when the fallows were cleared or cut back. The Sesbania outperformed the pigeon pea for both systems.

The effect of the fallow on soil properties was studied, and results showed that the improved fallows recorded lower bulk density and higher infiltration rates. The effect of improved fallows on soil macrofauna (species diversity and richness) was also investigated.

In comparison with continuous maize and a two-year natural fallow, the improved fallow plots had significantly greater species richness. There was a significant correlation between the amount of leaf litter and the diversity and richness indices for the plots.

There were also positive correlations between infiltration rate and amount of leaf litter. It is suggested that the leaf litter provided by the woody legumes was a substrate for microbial activity, which also improved the infiltration rates.

The effect of a two-year improved fallow on maize yields was compared against continuous maize. There was a positive correlation between maize yields (and soil macrofauna species richness. In the first season post fallow, the maize yields (both grain and stover) were superior to those of the continuous maize, as was the infiltration rate.

Figure 1: Sole maize plot in the improved fallow trial at OSCA.

Figure 2: *Sesbania sesban / Panicum maximum* plot in the improved fallow trial at OSCA.

Alley cropping

Alley cropping is an agroforestry system where woody plants are grown in hedgerows that are some distance apart and an understorey crop such as maize is grown in the alleys between the hedgerows. Alley cropping trials comprised Sesbania and pigeon pea hedgerows grown in combination with maize in alleys that were 3 m wide.

Hedgerows are generally pruned to reduce competition with the crop grown in the alley and to provide a source of material for green manure or fodder. The effect of hedgerow cutting height on the system was investigated.

Two cutting heights (50 cm and 75 cm) were compared with sole maize and with an alley system where the trees were only cut back once at the start of the season to allow for establishment of the maize crop. It was found that when hedgerows were pruned at a lower height this reduced hedgerow biomass production but did not have a positive effect on the production of the maize growing in the alley, probably due to the alley width.

In another trial where woody species were compared, it was found that pigeon pea competed much less with the maize crop than did Sesbania.

Figure 3: One of the maize – pigeon pea alley cropping plots at Fountainhill.

Silvopastoral systems

Silvopastoral systems are those that include an intercropping of woody species and pasture species aimed at supporting livestock production. In the current trial *P. maximum* was grown in alleys formed by hedgerows of periodically pruned pigeon pea. *P. maximum* was selected because it is fairly shade tolerant, growing naturally under tree canopies.

Two pigeon pea cutting heights (60 and 90 cm) were compared with sole *P. maximum* and with a treatment where the pigeon pea was left uncut. The lower cutting height produced less pruned tree biomass. The silvopastoral systems, regardless of the cutting height, provided more – and better quality – fodder than did the systems that only provided grass.

Figure 4: *Panicum maximum / pigeon pea silvopastoral system at Fountainhill Estate, Wartburg.*

Water use of selected agroforestry systems

Water use of the different agroforestry systems was investigated using Watermark sensors at three depths (200, 500 and 1200 mm). The pigeon pea was found to have less effect on the soil water content than the Sesbania, which is in agreement with the observed rooting patterns when trees were excavated – the tap roots of the Sesbania plants were deeper and their lateral roots spread further than those of the pigeon pea plants.

The inclusion of a woody component increased the water productivity of the system in terms of both total dry matter (DM) production and crude protein yield per unit of water used, with the Sesbania being more water productive than the pigeon pea.

A loss of many Sesbania and pigeon pea plants as a result of a heavy frost in June 2018 at Wartburg highlights the importance of good hedgerow management so as to extend the longevity of the hedgerows as well as the amount of material produced. A late pruning before winter meant that regrowth required the use of carbohydrates stored in the roots.

This meant there were insufficient carbohydrates available to recover from the defoliation caused by the frost. Thus, in areas where frost occurs, it may be better to make use of improved fallows as the trees are better able to recover from frost if they are left unpruned.

An experiment conducted with smallholder farmers using different systems with pigeon pea and Sesbania. The farmers generally found that the trees competed too severely with the maize to allow alley cropping but saw value in growing them on their farms as a source of fodder – either fresh or dried. Rabbit production was also introduced to farmers as a means of adding value to agroforestry systems as they can be supplemented with leaves, twigs and seedpods of both Sesbania and pigeon pea.

Cost-benefit analyses

Cost-benefit analyses undertaken for the three systems indicated that, while the Sesbania / maize system did not look promising due to the cost associated with propagating and transplanting the seedlings, the other two systems – especially the silvopastoral system, looked reasonable except for the high cost of labour for managing the woody component.

The viability of the systems improved substantially when the labour rate was calculated based on those used locally within communities (below minimum wage).The decisions of farmers to engage in agroforestry are unlikely to be made based only on the financial viability of the systems, but may be attractive from the perspective of diversifying their systems and providing multiple benefits.

Conclusions and recommendations

The choice of species and the spatial arrangement is very important if competition for light and water is to be minimised – the choice of species depends on the climatic conditions of the area (for example many of the commonly used species are not frost tolerant) as well as the farmers' priorities.

Temporal arrangements may be useful in avoiding competition but require access to sufficient land for cultivation.

Agroforestry practices diversify farming systems and increase agro-biodiversity.

The inclusion of drought tolerant woody species such as pigeon pea can make farming systems more resilient and better suited to the anticipated effects of climate change (specifically erratic rainfall and higher temperatures).

The inclusion of new woody species with which people are unfamiliar may also require changes in their eating habits or will require efforts to access new markets (e.g. pigeon pea grain).

Related report:

Water use of agroforestry systems for food and forage production (**WRC Project no. K5/2492**). For more information, contact WRC Executive Manager, Dr Sylvester Mpandeli at Email: sylvesterm@wrc.org.za