

## CHAPTER 9

### SUMMARY

Ruminant animal production enterprises rely heavily on planted pastures and natural veld for production. To make a profit from these enterprises, input costs must be optimized. One way of achieving this is to select grass species adapted to the specific production environment (mainly climatic conditions), which can not only produce high yields but also feed of a high quality.

With the implementation of a government initiative, in which a shift from annual monocropping systems to more sustainable perennial grass and legume systems, from which animals can be produced, was encouraged, the opportunity to intensify the knowledge on some annual and perennial fodder species arose. The aims of these studies were to produce the different species under different levels of water availability, to evaluate the water use efficiency of the different species and the ability of such species to adapt to different scenarios.

1. *C. ciliaris*, a notable drought tolerant species, produced yields (11.7-20.0 t ha<sup>-1</sup>) under non-control conditions (W1, W2 and W3) which were comparable to yields obtained under control conditions (W4) for traditionally irrigated grasses such as the *Cynodon* hybrid (12.0-15.8 t ha<sup>-1</sup>) and *P. clandestinum* (5.6-11.8 t ha<sup>-1</sup>).

These results also indicated that a traditionally drought tolerant grass species,

such as *C. ciliaris*, should not be overlooked when identifying species for use under irrigation.

In both seasons *C. ciliaris* was one of the more efficient water users with water use efficiencies ranging from 12.7 - 24.9 kg DM ha<sup>-1</sup> mm<sup>-1</sup>; 6.9 - 14.4 kg DDM ha<sup>-1</sup> mm<sup>-1</sup> and 0.9 - 2.2 kg CP ha<sup>-1</sup> mm<sup>-1</sup> for W4 and Control (W1) conditions respectively.

The relatively good yields and water use efficiencies of *C. ciliaris* could be attributed to having a large number of trichomes on the leaf surfaces while the stomata were well protected from the environment by the veins. In this way excessive water loss from the leaf surfaces could be limited.

The dry matter digestibility of *C. ciliaris* ranged from 50.44 to 60.66 from W1 to W3 conditions while the crude protein content ranged from 4.09 to 8.43 from W2 to W4 conditions.

In a growth analysis, *C. ciliaris* grew at a rate of 100 to 140 kg ha<sup>-1</sup> day<sup>-1</sup> at the end of two consecutive growth cycles during the summer growing period.

In a trial with only *C. ciliaris*, the *Cynodon* hybrid and *P. clandestinum*, the yield and dry matter water use efficiency as affected by different levels of water and nitrogen were evaluated. This was done after yields in the rainshelter trial were sometimes higher at W2 than control conditions, and it was speculated that a nitrogen deficiency could have caused this. At high levels of nitrogen, the level of water available became less important as the yield at W2 and W3 levels did not differ significantly.

2. The *Cynodon* hybrid initially produced relatively poor yields in the 1996/97

season, but produced similar yields to *C. ciliaris* in the 1997/98 season. A few researchers have argued that some perennial grass species take one to two growing seasons to become well established. In this time the true yield potential of the species is not realized. The water use efficiencies varied from 12.4 to 20.0 kg DM ha<sup>-1</sup> mm<sup>-1</sup>, 6.7 to 11.0 kg DDM ha<sup>-1</sup> mm<sup>-1</sup> and 1.3 to 2.7 kg CP ha<sup>-1</sup> mm<sup>-1</sup> for W4 and W1 conditions respectively.

The relatively good yields and water use efficiencies of the *Cynodon* hybrid, as in the case with *C. ciliaris*, could be attributed to having a large number of trichomes on the leaf surfaces while the stomata were well protected from the environment by the veins. In this way excessive water loss from the leaf surfaces could be limited.

The dry matter digestibility of the *Cynodon* hybrid ranged from 54.0 to 60.2% and the crude protein content from 8.98 to 10.74% for W1 and W4 conditions respectively. The crude protein content of the *Cynodon* hybrid was the highest of the five grass species. Combined with good yields, this is a grass species with a lot of different potential applications.

The growth rate of the *Cynodon* hybrid was, however, far lower than that of the tufted species reaching a maximum of 40 to 70 kg ha<sup>-1</sup> day<sup>-1</sup> for two growth cycles.

3. *D. eriantha* tended to be better adapted to wetter conditions. Despite this tendency, it still produced yields of 6.9 and 13.2 t ha<sup>-1</sup> under W1 and W4 conditions respectively which is in the same yield order recorded by other South

African researchers. In terms of dry matter and digestible dry matter water use efficiency, *D. eriantha* were also good, ranging from 7.9 to 19.4 kg DM ha<sup>-1</sup> mm<sup>-1</sup> and 4.6 to 14.5 kg DDM ha<sup>-1</sup> mm<sup>-1</sup>, while the crude protein water use efficiency was rather low (0.4 to 1.1 kg CP ha<sup>-1</sup> mm<sup>-1</sup>) due to the low crude protein content of the plants.

*D. eriantha* had more stomata on the abaxial than adaxial leaf surface and the epidermis was covered by large wax crystals, it was however not enough to ensure the yields and water use efficiency of *C. ciliaris* and the *Cynodon* hybrid, but it was better than both *P. maximum* and *P. clandestinum*.

The dry matter digestibility ranged from 56 to 62.75% and the crude protein content ranged from 4.15 to 6.11%.

The growth rate of *D. eriantha* at the end of two growth cycles were about 5 kg ha<sup>-1</sup> day<sup>-1</sup> less than that of *C. ciliaris*.

4. *P. maximum* also tended to be better adapted to wetter conditions. The yields over the two summer growing seasons were disappointingly low ranging from 6.2 to 10.4 kg ha<sup>-1</sup> at the W1 and W4 water availability levels respectively. The water use efficiencies in terms of dry matter yield and digestible dry matter were, therefore, also low at 6.4 and 14.9 kg DM ha<sup>-1</sup> mm<sup>-1</sup> and 3.5 to 9.1 kg DDM ha<sup>-1</sup> mm<sup>-1</sup> at the W1 and W4 levels respectively, while the crude protein water use efficiencies were not as bad at 0.3 to 1.4 kg CP ha<sup>-1</sup> mm<sup>-1</sup> for levels W1 and W4, respectively.

Digestible dry matter content at W1 and W4 were 50. and 68.71% respectively ,

while the crude protein contents for the same treatments were 4.18 to 7.7%.

As in *D. eriantha*, the stomata border the veins and are seldom, if ever, found in the middle of the intercostal zone. The leaf surface is once again covered by a wax deposit, but it does not cover the guard cells as was the case for *D. eriantha*.

Although the leaf surfaces of *P. maximum* thus possess some of the characteristics to prevent excessive water loss, these were not as extensive as those found in *C. ciliaris*, for example. This might explain why *P. maximum* was not able to produce yields and use water as efficiently as those grass species with the better water loss prevention from the leaves.

The maximum growth rate of *P. maximum* at the end of two growth cycles were 60 and 110 kg ha<sup>-1</sup> day<sup>-1</sup> respectively, placing it's growth rate between that of *C. ciliaris* and *D. eriantha* on the one end and the *Cynodon* hybrid and *P. clandestinum* on the other end. Despite the growth rate of *P. maximum* being lower than that of *C. ciliaris* and *D. eriantha*, it was much higher than that of the *Cynodon* hybrid and *P. clandestinum*.

5. *P. clandestinum* also tended to be better adapted to wetter conditions. As with the *Cynodon* hybrid, it produced much better yields in the 1997/98 (7.7 and 11.8 t ha<sup>-1</sup> at W1 and W4) than 1996/97 (4.0 and 5.6 t ha<sup>-1</sup> at W1 and W4) season. This resulted in rather low water use efficiencies in the 1996/97 season of 5.2 and 8.6 kg DM ha<sup>-1</sup> mm<sup>-1</sup>, 3.4 and 5.3 kg DDM ha<sup>-1</sup> mm<sup>-1</sup> and 0.5 and 0.8 kg CP ha<sup>-1</sup> mm<sup>-1</sup>, while the water use efficiencies in 1997/98 were 10.4 and 14.2 kg DM ha<sup>-1</sup> mm<sup>-1</sup>, 5.0 to 6.0 kg DDM ha<sup>-1</sup> mm<sup>-1</sup> and 0.9 and 1.4 kg CP ha<sup>-1</sup> mm<sup>-1</sup>,

respectively.

Dry matter digestibility for the 1996/97 season was 60.77 and 65.61% while it was quite low in the following season at only 28.5 and 48.66%. *P. clandestinum* plants, however, contained a much higher crude protein content (7.19 and 10.11%) in both seasons than *C. ciliaris*, *D. eriantha* and *P. maximum*, but not the *Cynodon* hybrid.

The leaf surfaces of *P. clandestinum* were characterised by big but few stomata. These stomata was also not protected in the same way as any of the other grass species, while the epidermis was protected by a smooth waxy layer. This was, however, not enough to prevent excessive water loss from the leaf surfaces and might explain the low water use efficiencies for this species.

The growth rate of *P. clandestinum* were the lowest for the five grass species tested, reaching a maximum of 25 and 45 kg ha<sup>-1</sup> day<sup>-1</sup> at the end of the two growth cycles.

6. As water became less available, less photosynthesis could take place resulting in lower yields. Although there was a significant reduction in yields between the highest and lowest levels of water availability, the yields in between these extremes were not significantly different. This absence of significance can be explained by the plant's ability to use water stored in the soil profile. If the soil profiles were not filled to field capacity at the beginning of the season, significant differences could have been expected.

The water use efficiency at lower levels of water availability (17.0 kg ha<sup>-1</sup> mm<sup>-1</sup>)

were often better than under control (non-water limiting) conditions ( $10.7 \text{ kg ha}^{-1} \text{ mm}^{-1}$ ). This means that plants were able to adapt to the lower levels of water available by using less water to produce the same amount of dry matter than would have been the case under control conditions. This would imply that less water could be used per unit area or that more hectares of a certain crop can be produced, with the assumption that the soil profiles were at field capacity at the start of the season.

Dry matter digestibility was not as affected by the level of water availability as was crude protein content. Whereas dry matter digestibility was improved by higher levels of water available in some cases, it was often the case for crude protein content. This better crude protein content could have been the result of higher levels of nitrogen applied at higher levels of water availability. This was done to prevent nitrogen deficiencies at the higher levels of water availability.

In a morphological study on the grass leaves, few differences could be found in terms of level of water availability. The most clear cut effect of the level of water was on the number of stoma per area. For *C. ciliaris*, the *Cynodon* hybrid and *P. clandestinum* there was a tendency of fewer stoma per area, with less water available, on the adaxial leaf surfaces, while the abaxial leaf surfaces of *C. ciliaris*, the *Cynodon* hybrid and *D. eriantha* also tended to have fewer stoma with less water available. The level of water availability did not alter the number of stoma per leaf surface.

7. In a glasshouse trial where the effect of different levels of water and nitrogen

availability were tested for *C. ciliaris*, the *Cynodon* hybrid and *P. maximum* the following results were obtained. The *Cynodon* hybrid used significantly less water than *C. ciliaris*, but produced significantly the highest yields in this trial. As was expected, the grasses tended to use more water and also produce higher yields as the level of nitrogen applied was increased.

All three grasses tend to produce higher yields at the N3 level, compared with the N0 level of nitrogen, despite receiving less water. Where water availability is thus restricted, one should still apply nitrogen. The amount of nitrogen will, however, be determined by how much the economic return is increased. The economics are emphasized when comparing the yields at W2 and W3, regardless of the amount of nitrogen applied. The yields at these two levels of water availability were similar and diminishing increases in yield may lead to a drop in profit, if this is not taken into consideration.

Water use efficiencies were increased by increased amounts of nitrogen applied, but were not significantly different from each other at the N2 - N3 level of nitrogen. Even a little bit of nitrogen increased the WUE, while not maintaining a high level of nitrogen, it might not have a negative effect on WUE.

The root systems of all three grass species tended to be poorer at W1 than W2 and W3 conditions, with that of the *Cynodon* hybrid being the poorest. The root systems also tend to be better with N2 and N3 than with N0 and N1 levels of nitrogen, regardless of the amount of water applied.