Forages for agricultural production and catchment protection in Eritrea

EC Wolfe[1], Tzeggai Tesfai[2], Bruce Cook[3], Eskender Tesfay[2] and Alison Bowman[1]

[1] EH Graham Centre for Agricultural Innovation (Charles Sturt University and NSW Department of Primary Industries), PMB, Pine Gully Rd, Wagga Wagga NSW 2650. Email twolfe@csu.edu.au, alison.bowman@dpi.nsw.gov.au
[2] National Agricultural Research Institute, PO Box 4627, Asmara, Eritrea. Email tzeggaites@yahoo.com
[3]23 Callabonna Street, Westlake Q 4074. Email brucecook@aapt.net.au

Abstract

This paper describes a collaborative project between Eritrean and Australian scientists to improve the forage base in Eritrea. An initial agroecosystem analysis, based on 2 short visits and a review of literature, focussed on how the Australian Government could assist the National Agricultural Research Institute (NARI) in Eritrea undertake a capacity-building project relevant to the local livestock industries. After taking account of the unique context of land use, land tenure and livestock management in Eritrea, a 'Forage Options' project was recommended and approved. In an attempt to accommodate the wide range of environments in Eritrea, a list of mainly leguminous germplasm of temperate/Mediterranean and tropical/subtropical origins was compiled using expert knowledge and passport data. Seed was acquired from Australian, ILRI and USDA collections. In 2006, at the start of the local wet season (summer), 261 temperate species (mainly legumes and some chenopod shrubs), 51 tropical grasses and 83 tropical legumes plus 6 local genotypes were sown for assessment at 2 sites, Halhale in the Central Highlands and Shambuko in the Western Lowlands. In June 2007, a further 160 tropical genotypes, mostly legumes, were sown in observation rows at Halhale. Project activities have included regular assessments of the genotypes supplemented with bi-annual training/inspection visits from the Australian forage specialist (BC). These assessments and inspections have produced a provisional short-list of 10-15 species for each of 9 potential forage niches in Eritrea.

Introduction

Eritrea (120,000 km^2, 4.9 million people) is situated on the Red Sea, between 12 and 18?N, and shares borders with Sudan, Ethiopia and Djibouti. Altitude varies from -75 m in the Denakil Depression (Eastern Lowlands) to 3018 m in the Central Highlands. Temperature and rainfall vary markedly throughout the country, from hot desert in the east (average annual rainfall <200 mm) to a mild, subhumid climate in the highlands (average annual rainfall >500mm, wet season late May to September). Recognised native forage legumes include *Alysicarpus* spp., *Biserrula pelecinus, Lotus uliginosus, Medicago polymorpha* and *Neonotonia wightii,* and grasses *Bothriochloa insculpta, Cenchrus ciliaris* and *Urochloa* spp*.* Introduced species, including leguminous shrubs (*Leucaena leucocephala*, *Desmanthus leptophyllus*) and grasses (*Panicum coloratum*, *Pennisetum purpureum*) have already demonstrated value in parts of the country.

Agriculture provides 12.4% of gross domestic product. In rural Eritrea, most human activities are based on subsistence agriculture, with 80% of the population involved in farming and herding. Agricultural issues include the low current productivity of livestock and crop production systems, the importance of enhancing food security, and managing land degradation due to overgrazing and deforestation.

In 2005, the Australian Government signed with the State of Eritrea a Memorandum of Understanding on Cooperation in Agriculture Issues. The Australian Department of Agriculture, Fisheries and Forestry (DAFF) engaged consultants to provide advice on two technical cooperation projects in Eritrea, targeted towards improving agricultural capacity and productivity. One project was allied with the development of a new Agricultural College near Keren (110 km W of Asmara, the capital). The other project, which is the topic of this paper, was undertaken with the Livestock Research Division of the National Agricultural Research Institute, 32 km S of Asmara. The role of NARI, which also includes research teams in Natural Resource Management, Crop Improvement and Agricultural Engineering, is to support the sustainable

utilisation of Eritrea's natural resources and to increase the capacity and productivity of Eritrean agriculture.

This paper describes an initial analysis (in 2005) of opportunities for the application of specific areas of Australian expertise, research and/or experience to enhance Eritrean technical capacity in agriculture, through collaboration with NARI scientists. The progress during 2006-08 on an ensuing 'Forage Options' project is outlined and recommendations are made on the future direction of plant evaluation in Eritrea.

Materials and methods

The assessment of opportunities for the application of Australian expertise was undertaken in 2 stages. The first stage, in May 2005, involved AB and TW in a preliminary survey of relevant published literature on Eritrean agriculture, a 7-day visit to Eritrea to interview key contacts in agricultural institutions and a helicopter journey over a 500 km transect of the 3 main agroecological zones in Eritrea (Central Highlands, Western Lowlands, Eastern Lowlands). This visit took place at the end of the 8-9 month dry season. The landscape was in a denuded state, with vegetative cover falling well short of the 70% benchmark necessary in Australia to control soil erosion, which was clearly evident. During the Stage 2 visit (July 2005), the consultants discussed their preliminary recommendations, which included forage species to withstand sustained grazing and/or a Landcare approach to land management, with the relevant leaders at NARI. They also assessed the local systems of land tenure, land management and agricultural extension.

In May-June 2006, DAFF signed a contract with the New South Wales Department of Primary Industries (NSW DPI) for a 3-year project to enhance the forage options available for livestock production systems in Eritrea. The activities envisaged were the introduction and testing of forage species; the adaptation of Australian management packages to suit the environment, animal production systems and farmers of Eritrea; and the training of Eritrean scientists in aspects of forage species and forage management. In June-July, NSW DPI contracted specialists in tropical forage (BC) and temperate forage (TW) to compile a list of mainly leguminous germplasm, acquire seed and complete the first project visit (June-July 2006), working with Eritrean scientists belonging to the forage group in the Division of Livestock Research, NARI. The list of tropical germplasm was compiled using passport data and expert knowledge (Cook et al. 2005), and seed was acquired from Australian, ILRI and USDA collections. In a bid to select temperate legumes that might flower and set seed in the mild, rainy summer of the uplands of Eritrea, the simple criteria for potentially useful genotypes were 'collected between the Tropics of Cancer and Capricorn' and 'seed available in the Australian Trifolium and Medicago Genetic Resource Centres'. All species were chosen bearing in mind their weed risk potential, especially low palatability and spininess.

In June-July 2006, at the start of the Eritrean wet season (summer), 261 temperate species (mainly legumes and some chenopod shrubs), 51 tropical grasses and 83 tropical legumes plus 6 local genotypes were sown for assessment at 2 sites, Halhale Research Station in the favourable environment of the Central Highlands and Shambuko Research Station in the Western Lowlands. In June 2007, a further 160 tropical genotypes, most of them legumes, were sown in observation rows at Halhale. Although native rhizobia are prevalent, tropical legumes were inoculated with appropriate strains of rhizobium. Subsequent local assessments of the sown genotypes were supplemented with a training/inspection visit from the tropical forage specialist (BC) in September 2006 and thereafter in June and September of each year. In June 2007, an Australian livestock specialist (Ian Blackwood) developed and presented a training module in livestock nutrition.

Results

For reasons that will be discussed in the next section, the early interviews with stakeholders and the literature searches pointed the way towards a 'forage options' project rather than a landcare-type project. This approach involved the assessment of forage genotypes selected for their potential role in sustainable agricultural productivity, including land management and catchment protection.

The idea of evaluating temperate genotypes in a tropical environment was a scientific 'long-shot' that did produce some useful leads from the first year's results. At Halhale, 2 perennial species (*Medicago sativa* and *Cullen australasicum*) were productive during the first summer (2006) and both survived through to the 2008 wet season. In addition, there were 10-12 annual legumes that flowered profusely and set seed (in both replicates) before the onset of the dry season (September). Although their productivity in hill plots was relatively low during 2006 compared with the tropical species and the plot boundaries subsequently became indefinable, several temperate legumes regenerated successfully in subsequent years. At Shambuko, a hotter and drier environment where the sowing date was later and observations were less frequent, only *Cullen australasicum* could be considered successful.

At Halhale, most of the tropical species sown in observation rows established, grew and persisted successfully. The most promising legumes were *Clitoria ternatea, Desmanthus* spp., *Stylosanthes seabrana, Lablab purpureus, Leucaena leucocephala, Macroptilium atropurpureum, Macrotyloma* spp., *Neonotonia wightii, Vigna oblongifolia* and *V. unguiculata*. *Brachiaria* hybrid cv. Mulato, *Cenchrus ciliaris, Panicum coloratum, Panicum maximum, Setaria incrassate,* and *S. sphacelata* have been the most productive grasses. While most of the tropical species established and grew well at Shambuko during the first wet season, few survived the effects of termites, heavy grazing over the dry season, and the long dry season itself. Notable exceptions were *Clitoria ternatea* among the legumes, and *Cenchrus pennisetiformis* among the grasses.

Although observations on the forages have so far been made at only two sites, other Eritrean locations also were inspected. When the project work is supplemented with knowledge and experience of tropical forages in Queensland (BC) and in adjacent Ethiopia (Jean Hanson, Alan Robertson, personal communications), a preliminary list of forage species for the available forage niches in Eritrea was tabulated (Table 1).

Table 1. A preliminary matching of species to the main niches for forage species in Eritrea

1. Forage legumes for crop rotations	2. Tree legumes and dual-purpose species	3. Forages for permanent, intensive back-yard areas	
		Grasses	**Legumes & others**
Clitoria ternatea	*Albizia lebbek*[+]	*Andropogon gayanus*	*Cajanus cajan*
Lablab purpureus	*Cajanus cajan*	*Brachiaria* spp.	*Chamaecytisus palmensis* *[+]
Macroptilium bracteatum[+]	*Chamaecytisus palmenis**[+]	*Cenchrus ciliaris*	*Desmanthus* spp.
Macrotyloma daltonii	*Gliricidia sepium* [+]	*Panicum maximum*	*Leucaena leucocephala*
Macrotyloma uniflorum	*Leucaena leucocephala*	*Pennisetum purpureum*	*Medicago sativa* *
Medicago spp.	*Moringa oleifera*	*Sorghum* spp.	*Macrotyloma axillare*
Mucuna pruriens[+]			*Moringa oleifera*
Vigna unguiculata			*Stylosanthes seabrana*

4. Forages for spate systems (opportunistic irrigation)		5. Forage species for drawdown areas (dams, lakes)	
Grasses	**Legumes**	**Grasses**	**Legumes**

Sorghum spp.	*Aeschynomene americana* *Centrosema pascuorum* *Lablab purpureus* *Macrotyloma uniflorum* *Vigna trilobata* *Vigna unguiculata*	*Dichanthium aristatum*+ *D. annulatum*+ *Paspalum atratum*+ *Setaria incrassata* *Setaria sphacelata*	*Aeschynomene americana* *Arachis pintoi*+ *Centrosema pascuorum* *Desmanthus* spp. *Vigna oblongifolia*

6. Forages for permanent irrigation

Grasses	Legumes
Brachiaria spp. *Panicum coloratum* *Panicum maximum* *Pennisetum purpureum* *Phalaris aquatica* *+ *Setaria sphacelata*	*Aeschynomene* spp. *Arachis* spp. + *Centrosema pascuorum* *Desmanthus* spp. *Leucaena leucocephala* *Lotus* spp. * *Medicago sativa* * *Neonotonia wightii* *Trifolium balansae* *

7. Forages for rangeland improvement

Grasses	Legumes
Bothriochloa bladhii *Bothriochloa pertusa* *Cenchrus* spp. *Dichanthium* spp. + *Paspalum* spp. + *Urochloa mosambicensis*	*Aeschynomene falcata* *+ *Biserrula pelecinus* *+ *Chamaecrista rotundifolia* *Cullen australasicum* *Desmanthus* spp. *Indigofera schimperi* *Stylosanthes* spp. *Trifolium balansae* * *Vicia villosa* subsp. *varia*

8. Species for catchment protection (stock exclusion)

Grasses	Legumes
Bothriochloa spp. *Cenchrus* spp. *Chloris gayana* *Dichanthium* spp. + *Panicum* spp. *Urochloa* spp.	*Aeschynomene* spp. *Biserrula pelecinus* *+ *Chamaecrista rotundifolia* *Cullen australasicum* *Desmanthus* spp. *Indigofera schimperi* *Stylosanthes* spp. *Trifolium balansae* * *Vigna trilobata*

9. Forages for saline areas

Grasses	Legumes
Cenchrus spp. *Chloris gayana* *Dichanthium* spp. + *Panicum coloratum* *Urochloa* spp.	*Aeschynomene* spp. *Biserrula pelecinus* *+ *Chamaecrista rotundifolia* *Desmanthus* spp. *Indigofera schimperi* *Stylosanthes* spp. *Trifolium balansae* *

* Uplands only + Not yet tried

Discussion

The Stage 1 recommendations dwelt on the potential assistance available from Australian scientists to NARI for forage evaluation, livestock production and land management. These original recommendations, especially those on land management, were re-examined in the light of relevant African literature on

livestock production and landscape management. The evidence for negative environmental impacts from local land-use practices in Africa was objectively presented in a series of essays contained in a book (Leach and Mearns 1996). The main conclusions from these essays were:

1. The environmental consequences of disturbances such as grazing, clearing and burning have often been exaggerated by local and foreign experts. For example, it can be argued that the rate of soil erosion in Eritrea is now declining, simply because there is less soil left to erode.

2. Many of the prescriptive management practices proposed as antidotes to vegetation change, desertification, erosion and famine have led or may lead to even worse environmental consequences, due to the failure of scientists and institutional policy makers to appreciate the unique context of Africa, to evaluate the available evidence on the causes and effects of land degradation and/or to acknowledge the knowledge and understanding of indigenous farmers, hunters and herders.

These insights were supported with other published reports on forage resources and livestock management in Eritrea (Chedly et al. 2002, Tr?dal 2002). Pastoralists implement a number of coping strategies during the normal period of feed shortage before the summer rains and during droughts. These strategies include decisions at the village level on the grazing of croplands, livestock movement and migration to distant rangelands, the utilisation of normally swampy areas during droughts, differential management of herds depending on their composition (e.g., breeding animals v. working animals) and livestock supplementation (Tr?dal 2002). These notions enabled the consultants to recommend that the highest priority for Australian technical assistance to Eritrean agriculture via NARI was for a targeted plan of introducing pasture/forage species and varieties that were potentially suitable for the Eritrean environment. In this case, 'environment' comprised not only the climatic, edaphic and topographic features of the landscape but also the potential of the plant species for a range of roles, such as feed for sustaining livestock and draft animals, soil fertility improvement (nitrogen fixation, return of dung and urine) for croplands, cover for catchment protection, and amenity for humans (firewood, shade, shelter).

The progress achieved with plant introduction thus far has been achieved in spite of limited resources, difficult communications and constraints on in-country travel imposed by Eritrean authorities. Rather than introducing more genotypes, the needs now are to select elite material from the accessions already introduced and start broader-scale seed production. Selection may be complicated by possible genotype x environment (G x E) interactions. Sound performance on the deep, fertile cropping soils at Halhale does not necessarily indicate an ability to persist on over-grazed, eroded rangelands. An idea that is worth exploring is that of creating composites of lines within species with similar growth habit. This strategy has the dual benefit of broadening the genetic base of material taken to the rangelands, and also to provide larger amounts of seed in the short term. This approach to plant introduction in Eritrea is different from that in Australia, but then so are the rangeland, the farming systems, and even the mix of livestock. Hence, a broader genetic base may be very important. Focussed plant introduction may still be worthwhile to overcome some specific weaknesses in the suite of accessions already introduced. However, this is a future activity, and should only follow careful assessment of the current suite over a range of environments and applications.

Acknowledgments

We thank Misses Elilta Tekle, Semira Mohammed, Atsedu Ghebremedhin, Sinit Teaghes, Elsa Abraham and Elsa Gebrezgabiher for technical assistance; Mr Alan Robertson for discussions about Ethiopia; curators of various collections and seed companies (Progressive Seeds, Heritage Seeds) for seed; and DAFF for funding the participation of Australian scientists in the project.

References

Chedly K, Tzeggai T and Assefaw T (2002) Country pasture/forage resource profiles: Eritrea. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPC/doc/Counprof/Eritrea.htm

Cook, B.G., Pengelly, B.C., Brown, S.D., Donnelly, J.L., Eagles, D.A., Franco, M.A., Hanson, J., Mullen, B.F., Partridge, I.J., Peters, M. and Schultze-Kraft, R. (2005). Tropical Forages: an interactive selection tool., [CD-ROM], CSIRO, DPI&F(Qld), CIAT and ILRI, Brisbane, Australia. http://www.tropicalforages.info

Leach M and Mearns R (1996) *African Issues. The lie of the land – challenging received wisdom on the African environment* (Heinemann: Portsmouth, NH, USA)

Tr?dal LF (2002) 'Sustainable livelihoods of farmers and pastoralists in Eritrea.' DCG Proceedings No. 8 (Drylands Coordination Group: Noragric, Norway).
http://www.drylandsgroup.org/Publications/DCG_Proceedings/index.html