Snack bags for cows boost smallholder dairy farms' milk production

RIU

Validated RNRRS Output.

In Zimbabwe, work has identified ways in which smallholder dairy farmers can grow enough feed on farm to ensure that their cows produce as much milk as possible. Intercropping forage sorghum or pennisetums with lablab or cow pea produced up to 8 tons of dry matter per hectare over a three year period—despite at least one severe drought. Intercropping with legumes means that the fodder produced contains good levels of protein. Plus, the feed produced can easily be chopped and stored in plastic bags, providing silage that will help poor producers to get through the dry season.

Project Ref: **LPP03:**
Topic: **2. Better Lives for Livestock Keepers: Improved Livestock & Fodder**
Lead Organisation: **Marion Titterton, Zimbabwe**
Source: **Livestock Production Programme**

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Zimbabwe,

Target Audiences for this content:

Livestock farmers,

Document Contents:

Description

LPP03

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Conserved forage in the form of bagged silage maintains livestock productivity through the dry season in sub-Saharan Africa.

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Livestock Production Research Programme
German-Israeli Foundation for International Development
Food and Agriculture Organisation
Zimbabwe Grasslands Association.

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

R7010

University of Zimbabwe :
Marion Titterton, Barbara Maasdorp, Basil Mugweni, Lovemore Nyoni, Humphrey Hamidukwanda, Charles Mutisi

Matopos Research Station:
Owen Mhere

*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

The project purpose was to determine the feasibility of producing and conserving sufficient biomass of high quality forage on a small holding to maintain good productivity in small holder dairy cows in the semi-arid region of Southern Africa during the dry season. The outputs of this project were produced in the period 1998 to 2000.

Outputs were the following:

- **Forage sorghum (*S. vulgare*) and Pennisetums (*P.purpureum* and hybrids) can be intercropped with lablab (dolichos bean, *L.purpureus*) or cow pea (*Vigna unguiculata*) to produce up to 8 tons dry matter per hectare on sandy soil under formal experimental conditions and up to 4 tons dry matter per**

hectare under farming conditions.This is an average yield over three seasons, which included a severe drought.

- **Maize and forage legume tree leaf were successfully ensiled to produce a high quality silage with 11% crude protein.**
- **With the inclusion of legume, the protein content of the harvested forage averages 11.5% crude protein with a metabolisable energy (ME) value of 9.2MJ/kg dry matter.**
- **The forage can be successfully ensiled in quantities of up to 15 kg in reject fertiliser bags or recycled plastic garbage bags using a hand or petrol driven chopper with manual compression of the forage in the bags.**
- **Over two good seasons it was found that enough bags were produced on farm (ranging from 130 to 400 bags over forty farms) to feed two cows one bag a day each for the last two months of the dry season , i.e. two months before calving. This allowed the cows to calve in good condition (average body condition score [BCS] 2.5) which was shown to be important for normal conception but there was no significant effect on lactation yields in indigenous and cross bred cows. In the drought year, the equivalent of half a bag a day was fed to two cows for one month before calving and this allowed body condition maintenance of 1.75 BCS which kept the cows alive, while control cows on no supplement were emaciated or died.**

See papers in Annex 1: Research Outputs

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	*Technology*	*Service*	*Process or Methodology*	*Policy*	*Other Please specify*
X	X		X		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options.
Leave blank if not applicable

Semi-Arid	*High potential*	*Hillsides*	*Forest-Agriculture*	*Peri-urban*	*Land water*	*Tropical moist forest*	*Cross-cutting*
X	X			X			

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	*Irrigated*	*Wetland rice based*	*Smallholder rainfed highland*	*Smallholder rainfed dry/cold*	*Dualistic*	*Coastal artisanal fishing*
	X			X		

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

There are two ways which we propose will add value to the output of our research. They are:

- **Demonstration centres, which are model small holder farms established strategically to be accessible to a large surrounding community. They are each operated by a technician employed by the project who is able to produce, conserve and feed forages using our technologies and who is able to demonstrate and advise visiting groups or individual farmers at any time. Each centre has a nursery which supplies forage material to farmers and which operates a forage chopping chaffer for lease to farmers.**
- **Mhere (2005) reported that farmers were growing bana grass and forage legume tree for harvesting for silage in Matabeleland North. This is a further step in the use of forage tree legume in silage from the research we carried out on maize and forage tree legume, since bana grass is better suited to the environment than maize.**
- **Feed and forage centres which are under the management of a technician employed initially by the project but ultimately by a business structure owned by farmers. These centres produce bags or bales of forage for sale to the community.**

The forage technologies which can be utilised here are (by number and brief description):

- **R7010 Silage**
- **R8339;R7346;R8296 Crop residues**
- **R7351 Cheap protein**
- **ZC 0261 Tool box**
- **R6153; R5732 Forages for dairying**
- **R6619 Box baling**
- **R5188 Stover and straw**
- **R6610 Urea Molasses blocks**
- **R7376 OXFEED**
- **Tropical forages CDRom**

Validation

B. Validation of the research output(s)

*10. **How** were the output(s) validated and **who** validated them?*

*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

Interactive discussions during the on-farm trials.

Following formal trials on intercropping forage sorghum and pennisetums with legumes and their ensilage with bags, on-farm trials were held in the Gulathi communal area during the 1997-2000 seasons. During this period, consultative meetings discussed the impact of the project which have led to wider awareness within the community and beyond.

Outreach from the project :

Many enquiries on how to either join, get involved with, or start a similar project in the East, South and South –West of Gulathi have been received and those making enquiries seem to be conversant with what is taking place at Gulathi. These activities have raised awareness and changed the general perception towards dairy production by other stakeholders in Matabeleland . Examples of these activities for the 1999/2000 season are:

Farmer training and information dissemination workshop 15th April 2000
A farmer –led workshop was held to extend findings, share experience and build interaction and communication techniques of information exchange from farmer-to- farmer. Five groups were represented and a total of 75 participants attended.

Farmer to farmer visits
Gulathi farmers hosted farmer groups from Wenlock (Gwanda), Irisvale, Esigodini and Natisa.

Farmer to station
A field day jointly organized by the project and the National Association of Dairy Farmers was attended by 26 producers on 28 April, 2000.

New initiatives
Four new projects were initiated within the Matobo district influenced by the project at Gulathi. These are Gulathi (Lukadzi x 2), Vulindlela Ward (Lushumbi), Dema Ward (Natisa). In addition 3 wards in the Gwanda district are mobilizing to initiate similar ventures.

Strengthening the linkages

Among the original collaborators, AREX (Extension Branch of Matopos Research Station), Veterinary Department, Department of Health and the District Council and DDP continue to be involved. New linkages have been established with three NGO's: Masiye training camp in Silozwi, ENDA Zimbabwe in the Dema and Vulindlela Wards and Ethandweni children's home in the Whitewaters/Natisa area.

The National Dairy Development Programme (DDP) together with an NGO (Africa Now) has taken up the project for further funding and development. This has allowed the construction of a milk collection centre (MCC), employment of a resident project officer and purchase of improved animals and other activities.

Linkages among the main collaborators (Matopos Research Station, AGRITEX, Veterinary Department, University of Zimbabwe and the Department of Environmental Health) have been strengthened considerably.

Evidence that the outputs have continued to be validated comes from a report on a six-month FAO project in 2005 (Mhere, 2005) where a detailed account was given on the training provided to leading farmers and extensionists on forage production and conservation in Matabeleland North and Matabeleland South. Following the training phase, farmers were given bana grass and legume trees to intercrop and ensile.

While the project lasted six months, NGO promotion is still continuing:
World Vision in Gwanda has achieved expansion (uptake by more farmers) in the same wards as 2004/2005.

Plan International and Orap have increased uptake in both the original and additional wards of Tsholotsho and have requested further training.
The Desert Margins Programme, funded by the Global Development Facility is similarly promoting our forage and silage technology.

Refereed research papers were published (Annex 1), a farmer's manual was produced (Annex 3) and papers were presented to conferences (Annex 3) by the project researchers and leader.

11. ***Where and when*** *have the output(s) been validated?*

Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above ***(max 300 words)****.*

The outputs have been validated in smallholder rainfed semi-arid systems in:

Zimbabwe:
Matebeleland North, Matebeland South and Midlands Provinces. Validation was done through various developmental projects (Farmer Field Schools- FFS) funded by FAO from 2002-2004 in Tsholotsho, Gwanda and Zvishavane Districts. This involved an initial 500 farmers per district and ended up directly

benefiting more than 5000 farmers. Training was also done, in 2002 and 2003, of 57 extension staff in the FFS extension methodology used in validation.

South Africa, Namibia, Zambia and Mozambique (LPP Dissemination Tour).
See: Annex 3. Dissemination papers.

Current Situation

C. Current situation

12. ***How and by whom*** *are the outputs currently being used? Please give a brief description* ***(max. 250 words****).*

Dairy Development Projects:

Although most of the projects are struggling to significantly contribute milk to to DZL (Dairiboard Zimbabwe Ltd), they are nevertheless making use of their outputs from the project. Gokwe in Midlands Province, Hama Mavhaire in Masvingo Province and Irisvale and Gulathi groups in Matebeleland South are located in semi-arid areas of Zimbabwe.

Rural communities in Tsholotsho, Gwanda and Zvishavane Districts:

FAO in their FFS projects, (2002-2004) spearheaded the wide-scale use of outputs from this project in 18 wards (all wards in Tsholotsho) and involving +3000 farmers. Later in 2004, ORAP (an NGO) took up the initiative and concentrated efforts in 5 wards. World Vision in Gwanda and Matobo districts continue to use the outputs in these two districts, albeit on a small scale due to recurrent droughts (smallholder milk production schemes and draft oxen feeding programmes).

Large scale dairy farmers:

Those farmers still operating in Matebeleland and peri-urban dairy schemes (Bulawayo and Gweru) continue to grow these forages and ensiling for their livestock. This is being championed by NADF (the National Dairy Farmers Association).

13. ***Where*** *are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used* ***(max. 250 words).***

Zimbabwe:

-Most of the 32 DDP schemes across the country
-Large scale milk producers
-Numerous enquiries from South Africa and Namibia

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

- **Smallholder milk producers – milking less than 10 animals**
- **Supplementation of draft animals in Tsholotsho and Gwanda- feeding less than 5 oxen**
- **For NADF membes- limited to 20-25 animals. This is both locally and regionally.**

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

- **The most likely successful uptake of research output is that where the research objectives are generated by farmer demand. In this case, farmers approached Matopos Research Station with the request that the research station investigate ways in which their livestock could be fed for maximum productivity throughout the dry season. This interactive approach to a research project ensured high interest in the formal experimentation and following that, excellent cooperation and involvement in the on-farm trials.**
- **Dissemination activities attempted in this project showed the importance of farmer involvement in the whole process. It also showed the compatibility of the technology with the individual farmer problems, with local ecological, socio-cultural and economic conditions of these communities who view milk production as a vehicle for change.**
- **Open communication and strong multidisciplinary teams are essential for appropriate technology development and testing.**
- **The project requires a strong team leader who is available continuously throughout the time span of the project and beyond and who leads a team entirely on an interactive basis with frequent meetings and consultations.**
- **The project requires strong cooperation and collaboration between stakeholders. It is one of the primary functions of the team leader to ensure this is established early and is maintained throughout.**
- **An outreach programme which is conducted simultaneously with on-farm trials is very effective in promoting the technology developed in a project. The overwhelming response by different communities to the farmer-centred strategies used in our project showed the relevance of the project.**

Current Promotion

D. Current promotion/uptake pathways

16. ***Where*** *is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion* ***(max 200 words)***

Currently, several NGOs are promoting forage production and conservation:

World Vision in Gwanda has achieved expansion (uptake by more farmers) in the same wards as 2004/2005.
Plan International and Orap have increased uptake in both the original and additional wards of Tsholotsho and have requested further training.
The Desert Margins Programme, funded by the Global Development Facility is similarly promoting our forage and silage technology.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

- **Limited resources for dissemination and extension services**
- **Limited resources for training**
- **Limited availability of plant material for forages**
- **Limited resources for the Dairy Development Programme to provide field technicians and machinery for the ensilage of forages.**

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

- **Training courses in forage management (such as the one recently offered by FAO in Zimbabwe) for extension personnel and leading farmers**
- **Demonstration centres (as described above). Demonstrations centres would serve not only to provide accessible tools for learning by farmers but for providing essential services such as forage choppers, silage bags and resources such as the Forage Manual produced by our team. These centres not only serve to provide resources for forage production and conservation but also for crop residue (stover) up-grading treatment and storage, grass baleage and urea-molasses block-making. Demonstration centres can also serve as meeting places for farmers to hold discussions with extension staff, Dairy Development Programme staff, project staff and other stakeholders.**
- **Nurseries with plant material, attached to the demonstration centres. Our research has shown that bana grass, forage sorghum, spineless cactus, forage tree legumes, cowpea and dolichos bean are all suitable as forages and can be grown from cuttings and seed grown and stored at a nursery. Initially, nurseries are sources of plant material but will develop into resource centres where farmers can be shown how to plant their own cuttings and to store seed.**
- **Feed and forage centres. An innovative approach but we can provide full details of their establishment and operation, if requested, as proposed for a project which had to be shelved due to withdrawal of funds.**

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

- **If poor people are shown an affordable method of making money, of improving the quality of their life, they will be as quick to grasp the opportunity as any business executive looking for investments that provide a good return. However, like any farmer, be they subsistence or commercial, they are conservative and are cautious about investing their time, labour and money. On the other hand, being**

poor, they have more risk management factors to consider than large scale farmers who have more than one source of income and hence have spread their risks. Therefore, poor people have to be given not only clear evidence of the benefits of the output but resources for uptake and adoption of that output.

- **Outputs should derive from research which is demand driven and which is participatory by farmers and researchers together.**
- **For dissemination of output, farmer to farmer interaction or farmer to directly approached demonstrator is more likely to result in uptake of output than top-down dissemination. Arrangements of field days, visits to sites, availability of resources and training are productive only when followed up by accessibility to interactive demonstrations on demand. Hence our proposals for demonstration centres. This suggests the following format for dissemination:**

1. **Provide training and arrange field days to initially attract as large a number of farmers in the community as possible.**
2. **Encourage leading farmers to extend invitations to large-scale event attendees to visit them and see for themselves how the technologies are carried out**
3. **Invite farmers to visit the demonstration centres either individually or in groups by request to learn not just by viewing procedures but participating and by interaction with the demonstrators.**
4. **Encourage farmers to use services provided by the centres and to attend interactive meetings with stakeholders.**
5. **The demonstration centres have to be sustainable, so charges for services and resources will at some point need to be implemented in order to make the centres self sufficient.**

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*

The positive impacts over three years recorded were:

- **The establishment of forage banks in areas where grazing is unable to sustain livestock through the dry season;**
- **An improved understanding of feeding management by farmers of their livestock to achieve productivity in milk and calves;**
- **An improvement in body condition of milking and breeding cows which led to continuity of milk supply and a significant reduction in delay to conception after calving.**
- **An increase in income from milk sold and from cattle sold.**
- **Maintenance of draught animals enabling timely land preparation from the first rains and hence an increased crop production especially in normal rainfall years.**

Women farmers have been the largest group to realise the impacts since they are the primary group responsible in the family for tending livestock and milking cows. The silage bag technology was designed with women and children in mind, since it allowed a woman or child to easily transport the silage to the feeding area for their livestock. One bag of silage is sufficient to feed two cows per day enough for their nutritional requirements .

So far, it is estimated that six hundred farmers have realised this impact.

- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

During the tive years of the project, the following was recorded on –farm and on-station in the smallholder dairy unit:

- **Body condition of cows increased from an average of 1.5 in October to 2.75 on the Mulvaney scale, an average percent increase;**
- **Production of milk for sale increased for each livestock owner per annum from an average of 600 litres to 1575 litres, an increase of 260%.**
- **Average number of calves per livestock owner increased from five calves in three years to eight calves in three years, an increase of 160%.**

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or

multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

This technology, if adopted widely in the semi – arid region will be a major benefit to the environment by providing relief from the heavy grazing burden placed on the natural pastures over the dry season. This will allow more grass to be re-established and provide more competition to shrubs and small trees, which are a sure sign of poor grazing management. With better quality grazing, livestock can improve their condition in the rainy seasons so that it becomes easier to maintain condition over the dry season. At the same time, soil erosion, of critical importance in Sub-Saharan Africa, will be reduced.
Another important benefit lies in the amount of water held by silage. Silage contains about 70% water and when fed to livestock, reduces the need for water and hence the time and resources spent in finding adequate water for their requirements. It also reduces the pressure placed on limited water resources and environs.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

The only adverse environmental impacts can be perceived as risks. There is the risk that farmers may be encouraged to increase their herd sizes because they believe they can sustain them on the silage they've made when in fact their forage bank may not be adequate. In that case, there would be further denudation of natural pasture.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

This technology, if adopted widely in the semi – arid region will be a major benefit to the environment by providing relief from the heavy grazing burden placed on the natural pastures over the dry season. This will allow more grass to be re-established and provide more competition to shrubs and small trees, which are a sure sign of poor grazing management. With better quality grazing, livestock can improve their condition in the rainy seasons so that it becomes easier to maintain condition over the dry season. The use of dryland and drought resistant forages will become more important as climate change and global warming brings, in all likelihood, more drought and drier years to some regions. Improved condition of natural pastures (see 24) will increase the resilience of the natural grazing.

Annex

Annex 1. Research output papers

Garwe, E., Ball, P. J. H., Hamudikuwanda, H., and Mutisi, C. (1999). Reproductive performance of crossbred cattle developed for milk production in the semi arid tropics and the effect of feed supplementation. *Proceedings of the second DFID workshop on livestock production programme projects in Zimbabwe held at Ingwe Lodge, Matobo, Zimbabwe. 22-23 February 1999.*

Nyoni, L. (2000). The effects of breed and prepartum supplementation with Sorghum-Lablab silage on production and metabolic profiles in cows in a semi-arid area of Zimbabwe. pp 33. *MSc. Thesis.* University of Zmbabwe. Harare. Zimbabwe.

Mhere, O. 1999. Intercropping forage and legume crops. *In* (Titterton *et al*.) Forage Production and Conservation for Dry Season Feeding of Dairy Cows in the Semi-Arid Regions of Zimbabwe. *In* (Ed. T. Smith) Proc. DFID Workshop on Livestock Production in the Semi-Arid Regions of Zimbabwe. Matopos, Zimbabwe. Feb.1999 pp 53-74.

Mhere, O., Maasdorp, B.V. and Titterton, M. 1999. The effect of intercropping on production and ensilage of sweet forage sorghum and pennisetum with cowpea and dolichos bean. In (Eds T. Smith and W. Richards) Proc. Livestock Production Programme Workshop on Livestock Research in Zimbabwe. Department for International Development, Matopos, Zimbabwe.

Nyoni, L., Titterton, M., Hamudikiwanda, H. and Mutisi, C. 2000. Body condition score and lactation responses in indigenous and cross-bred cows in smallholder dairying systems in a semi arid area of Zimbabwe. In (Eds.T. Smith and S.H. Godfrey) Sustaining Livestock in Challenging Dry Season Environments. Proceedings of the third workshop on Livestock Production Programme Projects. Matobo, Zimbabwe. 26-28 September, 2000. pp

Ashbell, G., Kipnis, T., Weinberg, Z.G., Hen, Y., Azriell, A., Kaller, S. and Titterton, M. 1999. Developing a technology for ensiling forage crops for smallholder cattle owners in developing countries. *In* Proc. XIIth Int. Silage Conference on Silage Production in Relation to Animal Performance, Animal Health, Meat and Milk Quality. Uppsala, Sweden. July 5. 1999.

Mugweni, B.Z. 2000. The effect of feeding mixed maize-forage tree legume silages on milk production from lactating Holstein dairy cows. M.Sc. Animal Science. Thesis. University of Zimbabwe, Harare.

Mugweni, B.Z., Titterton, M., Maasdorp, B.V. and Gandiya, F. 2000 . Effect of mixed-cereal-legume silages on milk production from lactating Holstein dairy cows. In (Eds. T. Smith and S.H. Godfrey) Sustaining Livestock in Challenging Dry Season Environments: Strategies for Smallscale Livestock Farmers. Proceedings of 3rd workshop on Livestock Production Programme

Mhere, O., Maasdorp. B.V., Titterton, M., Dube, S.M. and Heindrich, G. 2000. On farm assessment of forage yields and silage quality of intercropped drought tolerant cereal and legume forages crops. In (Eds. T. Smith and S.H. Godfrey) Sustaining Livestock in Challenging Dry Season Environments: Strategies for Smallscale Livestock Farmers. Proceedings of 3rd workshop on Livestock Production Programme Projects. Matobo, Zimbabwe. 26-28 September, pp 76-81

Garwe, E.C., Ball, P.H., Hamudikiwanda, H. and Mutisi, C. 2000. Reproductive performance of indigenous and cross-bred cows developed for milk production in semi-arid regions and the effect of food supplementation. In In (Eds. T. Smith and S.H. Godfrey) Sustaining

Livestock in Challenging Dry Season Environments: Strategies for Smallscale Livestock Farmers. Proceedings of 3rd workshop on Livestock Production Programme Projects. Matobo, Zimbabwe. 26-28 September, pp 82-89

Kipnis, T., Titterton, M., Ashbell, G., Weinberg, Z., Hen, Y., Azriell, A, Maasdorp, B. and Mhere,

2001. Development of ensiling technology and its use by small holder cattle owners in the semi-arid region of Zimbabwe. Final report submitted to the German-Israel Fund for Research and International Development (GIFRID). February. Pp.3-12.

Annex 2. Overview papers

FAO (Food and Agriculture Organisation). (1994). Farming systems development. A participatory approach to helping small-scale farmers. Rome, Italy.

DDP (Dairy Development Programme), (1999). A report given at the Annual Smallholder Dairy Producer of the Year at Rusitu, Chipinge on July 30 1999. Zimbabwe.

Machaya, A. C. (1994). some factors affecting smallholder dairy production in Zimbabwe*. Journal of the Zimbabwean Society for Animal Production* VI: 61-67.

Chimonyo, M. (1998). The effect of work and nutrition on reproductive performance in Mashona cows in a semi-arid smallholder area of Zimbabwe*. MSc. Thesis*. University of Zimbabwe. Harare.

Titterton, M., Mhere, O., Maasdorp, B., Kipnis, T., Ashbell, G., Smith, T. and Weinberg, Z. (2002). Ensiling of tropical forages with Particular Reference to African Livestock Systems:. Forage production and conservation for dry season feeding of smallholder dairy cattle in the semi-arid region of Southern Africa*. In* Proc. XIIIth International Silage Conference . Auchincruive, Scotland. September 11,2002

Gandiya, F. 1999. Smallholder dairying in Zimbabwe- problems and opportunities. *In* (Eds. S. Dickin and D. Dickin) Zimbabwe Society of Animal Production Annual Journal. (Published in Farming World).Projects. Matobo, Zimbabwe. 26-28 September, pp 82-89

Annex 3. Dissemination papers

Titterton, M. and Bareeba, G.B. 1999. Grass and legume silages in the tropics. Paper presented to

Electronic conference on Tropical Silage held by Food and Agriculture Organisation. September 15-30. Website: http://www.fao.org./WAICENT/FAOINFO/AGRICULT/AGP/AGPC/doc/pasture/pasture.ht.

Nengomasha, E.M., Sikosana, J. and Titterton, M. 2004. Report on regional dissemination tour of South

Africa, Namibia, Zambia and Mozambique: Dissemination and Promotion of Livestock Production Programme Research Outputs. . Livestock Production Research Programme, Natural Resources International. July 11-24.

Mhere, O. Maasdorp, B. and Titterton, M. 2002. Forage Production and Conservation Manual.: Growing and ensiling annual and perennial forage crops suited to marginal and semi-arid areas of Southern Africa. Ed. T. Smith. Livestock Production Programme.. Natural Resources International.

Mhere, O. 2005. Live fences and Forage production project in Matabeleland North and South provinces, Zimbabwe. End of project report. FAO Emergency Unit in collaboration with AREX Matopos Research Station and ICRAF. Harare, Zimbabwe.