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LIVESTOCK AND VEGETAL PRODUCTION IN DESERTS USING RUNOFF WATER

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Executive Summary

The overall purposes of the project is 1) to demonstrate the water use efficiency of fast-growing *Acacia saligna* and *A. salicina* trees using runoff water in arid and semi-arid regions, and 2) to evaluate these two species as protein-rich fodder for small ruminants.

Preparation of runoff and microcatchment plots

In Israel, five different sized watersheds were identified and their corresponding limans (dike surrounded plots) were built. *Acacia saligna* seedlings were planted in the limans at a density of 12,500 per hectare. In addition, nine microcatchments were established; three controls and, prior to the rainy season, three were surface treated with poliacryamid and three with siliconite. Rainfall and runoff water were monitored to calculate runoff efficiency. Preliminary results showed that runoff efficiency was not constant with rainfall intensity.

In Kazakhstan, nine microcatchments, with three different sized collecting areas, were established prior to the winter of 1993/94. In spring 1994, soil samples were taken every 30 cm to a depth of 180 cm in both microcatchments and collecting areas to estimate runoff efficiency. Another 16 plots were established in which four treatments were applied; four plots irrigated with water equivalent to 300, 500 and 700 mm of rainfall per year, and a non-limiting water control. *Acacia saligna* seedlings will be planted in all plots in spring 1995.

Nutritive value of phylodes from mature and young *Acacia saligna* and *A. salicina* trees fed to sheep and goats

In Israel. On a dry matter basis, Acacia phyllodes (leaves without sepioles) had 11-13% crude protein; mature and young trees contained 11-13% and 22-23% ash and 9-10% and 15-19% condensed tannins, respectively. Daily dry matter intakes ranged from 146 to 230 g and 77 to 127 g for mature and young trees, respectively. These intakes did not meet maintenance requirements and animals lost body mass. Dry-matter digestibilities for both tree species were low, 30-40% and 27-38% for goats and sheep, respectively. The low phyllode intakes and low digestibility, due to high tannin content, resulted in all animals having negative nitrogen and energy balances. These results show that while Acacia are fast growing and efficient in water use with foliage of a relatively high crude protein content, their high tannin content (both total and condensed tannins) limit their use as a sole feed to

small ruminants. Further investigations are being conducted to study their use as a supplementary feed when animals are treated with substances to neutralize the negative effects of tannins.

In Kazakhstan, duplicate Acacia samples, sent from Israel, were analyzed for chemical composition and the ash fraction was analyzed for macro and micro elements. This was done in order to confirm the Israeli results and to have the laboratory methodology prepared for the studies to be carried out in Kazakhstan during 1995.

These findings and our subsequent investigations will contribute to a better understanding of how these two Acacia species can be utilized as multi-purpose trees for both energy and animal nutrition purposes for potential international development projects.

Collaboration between scientists of the two countries consisted of reciprocal visits with on-site participation in experiments. In addition, a trainee scientist has been active in all studies conducted in Israel.

Research Objectives

The specific objectives are:

1. To develop an accurate and practical technique for measuring runoff water.
2. To establish whether *Acacia saligna* or *A. salicina* can be grown in semi-arid south Kazakhstan using runoff water.
3. To quantify above ground biomass production and water use efficiency of these species in south Kazakhstan.
4. To evaluate the nutritive value of these species as either a sole feed or as a supplementary feed for small ruminants.
5. To quantify the rainfall/runoff characteristics of soils in southern Kazakhstan for catchments with different collecting areas.
6. To establish water management techniques that will allow the use of runoff water for the production of fodder in areas which lack conventional water resources, without endangering the environment.

Research Accomplishments

In Israel, rainfall/runoff relationships

Instrument development

A tipping bucket device for the measurement of runoff with a resolution of 1 liter was developed, tested and installed in each of nine microcatchments. The device has a magnetic relay device which gives a five volt pulse per tip. The nine instruments, together with a tipping bucket rain gauge, were connected to a Campbell CR10 data logger. Thus, rainfall and runoff could be simultaneously monitored under field conditions. A typical output, in this case a control plot, is presented in Fig. 1.

Runoff efficiency

Rain storms were analysed individually and the peak and average rainfall intensity computed for each rainfall event. Results for control and poliacrylamid (PAM) surface treated microcatchment plots are presented in Fig 2. It is clear that the runoff efficiency (total collected runoff water per unit of producing area divided by rainfall) was not constant with intensity. For a first approximation the data can be divided into two groups: below and above an average intensity of 6 mm hr^{-1}. This is in sharp contrast with the previously held viewpoint that a single value for rainfall/runoff relations was thought to be constant. The implications of these findings for microcatchment design are important for future development planning.

Tree planting

Seedlings (saplings) of *Acacia saligna* and *A. salicina* were prepared and planted in each liman at a density of 12,500 seedlings ha^{-1} in 1993. The saplings are now well established, developed and are growing satisfactorily. Physiological measurements were and are being carried out this year on imposed runoff and runoff plus irrigation treatments within the limans.

Nutritive value of *Acacia saligna* and *A. salicina* phyllodes from mature and young trees

Acacia saligna and *A. salicina* phyllodes were fed asa sole feed to 16 goats and 16 sheep in four replicates for a experimental period of ten days after a ten adjustment period. The chemical and energy content of the phyllodes are presented in Table 1. Of particular interest are the relatively high crude protein content of phyllodes from both mature and young of both tree species, the high ash

and very high condensed tannins contents of young trees relative to mature trees, and the relatively low metabolizable energy content of all types of phyllodes.

Energy intake and body mass change of goats and sheep fed phyllodes are given in Table 2. Both goats and sheep lost body mass at a rate of approximately 1% d^{-1} of their initial body mass caused by their low metabolizable energy intakes of up to 84 $kJ^{-0.75}$ d^{-1}. These energy intakes were low due to low feed intakes and digestibilities (25 to 40%). There was a trend for goats to have a higher digestive capacity than sheep but differences were not significant.

Fiber and lignin balances of goats and sheep fed phyllodes are shown in Table 3 and their nitrogen balances are shown in Table 4. The striking negative balances for acid detergent fiber (ADF), acid detergent lignin (ADL) and nitrogen are caused by the strong affinity of condensed tannins for these two fiber fractions and protein. The resulting tannin complexes are indigestible and are excreted in the feces. Further analyses showed that the tannins bind to both feed and endogenous proteins and are excreted via the feces in the ADF and ADL fractions as "artifact ADF" and artifact ADL". In addition, it was found that the fiber measured in the feed is not the same as that measured in the feces. These results indicate that the detergent extraction techniques for fiber fractions should not be used for tannin-rich feeds.

Scientific Impact of Collaboration

Israel scientists were in Kazakhstan in October-November 1993 to participate in the selection of suitable sites and to plan and prepare microcatchments and the experimental plots for the irrigated study. In April-May 1994, a second visit was made to help in water runoff measurements.

The collaborating Kazakh principal investigator was in Israel in summer of 1994 to visit the experimental site, to discuss results obtained to date and to plan the studies to be carried out in 1994/95.

Description of Project Impact

The technique developed to improve the measurement of runoff water will be used in both countries during the next rainy season. In addition, treating the surfaces of the microcatchment

water-collecting areas in Kazakhstan with poliacrylamid should improve the runoff and subsequent water collection and storage for maximum efficiency.

The results from the evaluation of the nutritive value of the phyllodes show that the foliage of mature trees are preferable to young trees. Furthermore, it was clearly demonstrated that phyllodes can not be fed to small ruminants as a sole feed and so it is planned to examine their use as a supplementary feed for grazing animals.

Strengthening of Developing Country Institutions

A Kazakh trainee, from the Kazakh Institute of Sheep Breeding, has been in Israel from February 1994 and has participated in all aspects of the project, including experimental planning, the use of state of the art equipment, methodology and on-line recording and analysis of data.

Future Work

In Israel, it is planned to continue the effect of catchment area and the water use efficiency of Acacia trees. In view of the low nutritive value recorded to date, we have decided to add to the original work plan the use of Acacia foliage as a supplementary feed. Feeding of fresh as compared with stored dry foliage (used so far) will be first examined and subsequently the small ruminants wiil be treated with a tannin neutralizing substance to improve animal performance.

In Kazakhstan, Runoff/rainfall relationships in the nine established microcatchments for the winter of 1994/95 will be studied. In addition, seedlings will be planted out during April-May 1995 and their development and growth will be monitored. Depending on their development, water use efficiency studies will be initiated and foliage nutritive value will be evaluated.

Managerial Issues, Budget, Special Concerns

No problems have been experienced to date with these issues.

Collaboration, Travel, Training and Publications

Collaboration between participating scientists has already been mentioned, to this end Professor A. A. Degen, Mr. R. W. Benjamin and Dr. P.R. Berlinger had a two week visit to the Buchtulan Dryland Experimental Station in Kazakhstan during October-November 1993. Professor A. A.

Degen, Mr. R.W. Benjamin and Dr. G. Alkaparov were in Kazakhstan for two weeks at the Buchtulan Dryland Experimental Station during April-May 1994. Professor T. Sarbosov was in Israel at the Ben Gurion University facilities at Wadi Mashash Runoff Farm and at the Isan Center for one week during June 1994. Mr. G. Sarbosov has been a trainee scientist at the above University facilities since February 1994 and will continue to participate in all the Israel studies.

Professor A. A. Degen, Mr. R.W. Benjamin and Dr. G. Alkaparov will be again in Kazakhstan in April May 1995 to participate in measurements at the experimental sites that will be made there during that time.

In the next six months, a continuation of the runoff/rainfall relationships studied during 1993/94 will be carried out in Israel and Kazakhstan according to the project work plan and as stated previously in this report. In addition, further experiments will be carried to evaluate the use of Acacia foliage as a supplementary feed for grazing goats and sheep as already stated in this report.

Request for A.I.D. Actions

The Kazakh principal investigator, following his visit to Israel, wrote a report in which he stressed the favorable Acacia characteristics of being fast growing, water use efficient and its potential use as an energy and fodder source. These characteristics would have would have great potential in Kazakhstan for soil conservation, as well as relieving energy and fodder shortages in the farming communities in the arid regions. However, as seedlings, sown from seed in June 1994, will not be ready for planting out before April-May 1995, it will be impossible to evaluate their value within the present duration of the project unless a third year can be added for carrying out the project's objectives in Kazakhstan. To this end, he insisted that a third year be requested from A.I.D with the collaboration of Israel with their expertise in measuring runoff/rainfall relationships, water use efficiency and the analysis of Acacia for ant-nutritive factors together with the examination of substances to neutralize them. To budget for this, he requested that funds ear-marked in the Kazakhstan for the purchase of equipment be used for a third year's running expenses. While Israel fully agrees with this request, the Israel budget does not low any such flexibility. To collaborate in a third year Israel would need an additional $ 15,000.

Table 1

Chemical composition and energy content of phyllodes from mature and young *Acacia saligna* and *Acacia salicina* trees
(Values are means ± SD; n=4)

	Acacia saligna		*Acacia salicina*	
	Mature trees	Young trees	Mature trees	Young trees
DM (% in air-dry leaves)	87.3 ± 0.76	87.7 ± 1.12	87.6 ± 1.91	87.8 ± 1.58
Ash (% DM)	12.9 ± 0.57	22.4 ± 0.44	11.5 ± 0.30	21.8 ± 0.53
OM (% DM)	87.1 ± 0.57	77.6 ± 0.44	88.5 ± 0.30	78.2 ± 0.53
Crude protein (% DM)	11.1 ± 0.34	13.2 ± 0.32	11.1 ± 0.19	12.1 ± 0.30
NDF (% DM)	49.0 ± 1.64	45.7 ± 3.31	51.7 ± 1.67	44.3 ± 2.64
ADF (% DM)	26.6 ± 2.93	22.1± 3.97	27.9 ± 3.20	21.2 ± 3.71
ADL (% DM)	14.4± 2.21	10.7 ±2.48	14.8 ± 1.99	9.9 ± 2.42
Hemicellulose (% DM)	22.5 ± 2.05	23.6 ± 1.34	23.7 ± 1.95	23.0 ± 1.88
Cellulose (% DM)	12.2 ± 0.86	11.4 ± 1.51	13.1 ± 1.55	11.4 ± 1.33
Total phenolics (% DM)	15.0 ± 1.65	10.3 ± 0.56	14.5 ± 0.94	11.9 ± 0.39
Total tannins (% DM)	12.5 ± 0.86	9.5 ± 0.42	12.1 ± 1.78	9.9 ± 0.48
Condensed tannins (% DM)	8.8 ± 1.18	15.6 ± 1.22	9.8 ± 1.19	19.6 ± 1.03
Gross energy (kJ kg^{-1} DM)	19.4 ± 0.45	16.0 ± 0.34	20.0 ± 0.43	15.9 ± 0.15
Metabolizable energy (kJ kg^{-1} DM)				
In vitro	5.3 ± 0.32	6.0 ± 0.46	5.3 ± 0.22	5.8 ± 0.29
In vivo goats	4.6 ± 0.42	5.0 ± 0.37	5.7 ± 0.22	3.9 ± 1.18
In vivo sheep	5.1 ± 0.56	4.6 ± 0.43	4.21 ± 0.50	3.2 ± 1.34

DM = dry matter; OM = organic matter; NDF = neutral detergent fiber; ADF = acid detergent fiber;

ADL = acid detergent lignin

Table 2

Energy intake and body mass change of goats and sheep fed phyllodes from mature and young *Acacia saligna* and *Acacia salicina* trees

(Values are means ± SD; n=4)

	Acacia saligna		*Acacia salicina*	
Goats	Mature trees	Young trees	Mature trees	Young trees
Mean body mass (kg)	16.1 ± 2.72	15.5 ± 3.17	12.6 ± 1.92	15.7 ± 1.35
Body mass change (% d^{-1})	-1.31 ± 1.131	-0.70 ± 0.538	-0.97 ± 0.163	-1.37 ± 0.550
DMI (g d^{-1})	215 ± 44.2	108 ± 31.0	146 ± 36.00	105 ± 20.6
Apparent DM digestibility (%)	29.9 ± 3.84	40.2 ± 5.04	34.1 ± 6.97	34.0 ± 7.07
GEI (kJ d^{-1})	4161 ± 828.1	1716 ± 483.3	2916 ± 662.1	1656 ± 310.6
Apparent DE (% GE)	28.8 ± 2.74	38.2 ± 3.37	34.8 ± 7.48	29.9 ± 8.80
Apparent ME (% GE)	23.6 ± 2.25	31.3 ± 2.76	28.5 ± 6.13	24.5 ± 7.22
MEI (kJ d^{-1})	971 ± 129.2	535 ± 138.8	820 ± 220.9	399 ± 97.9
(kJ $kg^{-0.75}$ d^{-1})	122 ± 19.8	69 ± 18.9	125 ± 41.2	51 ± 13.6
Sheep				
Mean body mass (kg)	26.5 ± 1.89	26.9 ± 4.50	25.9 ± 2.62	25.8 ± 6.66
Body mass change (% d^{-1})	-1.00 ± 0.258	-1.26 ± 0.357	-0.68 ± 0.314	-1.11 ± 0.575
DMI (g d^{-1})	230 ± 83.9	77 ± 23.5	230 ± 11.9	187 ± 83.9
Apparent DM digestibility (%)	25.1 ± 6.32	38.3 ± 2.09	27.6 ± 2.57	27.0 ± 8.41
GEI (kJ d^{-1})	4316 ± 1546	1239 ± 375	4560 ± 258	2975 ± 1335
Apparent DE (% GE)	24.3± 3.85	34.6 ± 3.67	25.6 ± 3.06	24.4 ± 10.31
Apparent ME (% GE)	20.0 ± 3.16	28.4 ± 3.01	21.0 ± 2.51	20.0 ± 8.45
MEI (kJ d^{-1})	878 ± 356.4	357 ± 141.7	970 ± 163.5	661 ± 493.9
(kJ $kg^{-0.75}$ d^{-1})	76.5 ± 33.10	30.1 ± 9.98	84.4 ± 10.69	55.9 ± 40.32

DMI = dry matter intake; MEI = metabolizable energy intake; GEI = gross energy intake; DE = digestible energy:

MEI = metabolizable energy intake

Table 3

Fiber and lignin balances of goats and sheep fed phyllodes from mature and young *Acacia saligna* and *Acacia salicina* trees
(Values are means (g d^{-1}) ± SD; n=4)

	Acacia saligna		*Acacia salicina*	
Goats	Mature trees	Young trees	Mature trees	Young trees
Neutral detergent fiber	9.2 ± 4.21	30.0 ± 8.85	13.8 ± 9.67	15.6 ± 14.26
Acid detergent fiber	-51.1 ± 13.02	- 21.2 ± 24.99	-36.5 ± 29.63	-47.6 ± 19.44
Hemicellulose	80.6 ± 5.73	75.8 ± 9.93	72.7 ± 11.69	73.1 ± 8.99
Cellulose	15.9 ± 16.65	41.2 ± 7.45	35.0 ± 3.34	33.4 ± 16.92
Acid detergent lignin	-110 ± 20.4	-90 ± 50.4	-105 ± 64.2	-145 ± 38.0
Sheep				
Neutral detergent fiber	14.2 ± 11.13	27.7 ± 6.44	6.1 ± 6.76	2.9 ± 14.90
Acid detergent fiber	-47.3 ± 16.23	-38.4 ± 17.23	-52.4 ± 8.00	-68.9± 33.58
Hemicellulose	86.2 ± 9.03	83.9 ± 4.72	74.7 ± 13.40	66.4 ± 7.31
Cellulose	19.4 ± 11.31	29.7 ± 14.25	20.0 ± 8.64	30.0 ± 5.29
Acid detergent lignin	-105 ± 25.0	-115 ± 27.0	-118 ± 23.6	-187 ± 79.4

Table 4

Nitrogen (N) balances of goats and sheep fed phyllodes from mature and young *Acacia saligna* and *Acacia salicina* trees
(Values are means ± SD; n=4)

	Acacia saligna		*Acacia salicina*	
Goats	Mature trees	Young trees	Mature trees	Young trees
N intake (g d^{-1})	4.25 ± 1.39	1.52 ± 0.50	4.13 ± 0.35	3.71 ± 1.46
Faeces N (g d^{-1})	5.33 ± 1.71	1.38 ± 0.43	5.51 ± 0.36	4.23 ± 1.94
Apparent digestible N (%)	-25.4 ± 6.71	8.5 ± 13.48	-33.8 ± 9.14	-12.8 ± 10.53
Urine N (g d^{-1})	1.90 ± 0.14	5.03 ± 1.94	2.56 ± 0.50	3.30 ± 0.46
N balance (g d^{-1})	-2.98 ± 0.0.48	-4.89 ± 1.77	-3.94 ± 0.57	-3.83 ± 0.84
(g $kg^{-0.75}$ d^{-1})	-0.26 ± 0.05	-0.42 ± 0.10	-0.33 ± 0.05	-0.33 ± 0.09
Sheep				
N intake (g d^{-1})	4.01 ± 0.88	1.97 ± 0.44	2.70 ± 0.66	1.96 ± 0.38
Faeces N (g d^{-1})	4.68 ± 1.06	1.57 ± 0.38	3.20 ± 0.92	2.17 ± 0.63
Apparent digestible N (%)	-16.7 ± 3.79	18.9 ± 16.30	-17.5 ± 13.93	-10.1 ± 15.90
Urine N (g d^{-1})	1.26 ± 0.33	2.93 ± 0.85	0.97 ± 0.63	1.96 ± 0.45
N balance (g d^{-1})	-1.93 ± 0.40	-2.53 ± 0.82	-1.46± 0.58	-2.18 ± 0.75
(g $kg^{-0.75}$ d^{-1})	-0.25 ± 0.05	-0.30 ± 0.10	-0.22 ± 0.08	-0.28 ± 0.09