Livestock production and economic implications from augmenting degraded rangeland with *Atriplex halimus* and *Salsola vermiculata* in northwest Syria

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Abstract
Three stocking rates (low: one sheep 2.25 ha^{-1}, medium: one sheep 1.5 ha^{-1} year^{-1} and high: one sheep 0.75 ha^{-1} year^{-1}) were studied for 7 seasons (1990/91-1996/97) on native range and on pasture over sown with fodder shrubs at Maragha, northwest Syria. There were 8 Awassi sheep in each stocking rate treatment, and the treatments were replicated 3 times in fenced paddocks. Milk yield, lamb production, live weight and supplementary feeding of the sheep were monitored. The results showed significantly higher forage availability on the range over-sown with fodder shrubs by 82% and 41% in the medium and high rainfall seasons, respectively and by 142% and 379% in the average and low rainfall seasons, compared with the native pasture. The total energy used in the supplementary feed was greater under the native pasture than that in the shrub-sown pasture in 5 out of 7 seasons, while crude protein consumption was greater in the native pasture than on the shrub-sown pasture in all 7 seasons. Milk production and lamb body mass were higher on shrub-sown pasture than those in native pasture in 4 and 6 out the 7 seasons, respectively. Benefits obtained from reduced feed costs, extra milk and lamb sales were higher on shrub-sown pasture than those in the native pasture in 5 out of the 7 seasons. Total benefits measured over the entire study period were highest under the high stocking rate, reaching about 77 US $ ha^{-1}. We concluded that shrub plantation in west Asia could safely be utilized at stocking rate of one sheep 0.75 ha^{-1} year^{-1} for the benefits of the pasture and users.

Introduction

For decades, rangelands in North Africa, West and Central Asia have suffered from overgrazing and many areas are severely degraded. Out of 18.5 million ha (the total area of Syria) 10.2 million are considered rangeland, which receives no more than 200 mm of rainfall and is unsuitable for cultivation but supports native pasture which is utilized by increasing numbers of sheep. Rangelands in Syria, originally supporting woodland and shrub vegetation now comprise annuals, mainly small growing grasses and herbs, and occasionally small populations of legumes. It produces an average of 400 kg ha^{-1} per year in contrast to the expected yield of 1-2 t ha^{-1} per year of Mediterranean rangelands in general (Le Houerou & Hoste, 1977, Gintzburger, 1986). Degradation of vegetation is accompanied by severe soil erosion by wind. It was also reflected in an increased use of concentrates to feed animals for 3-12 months year^{-1} by cooperative members in Syria (Razzouk, 1998).

Planting of shrubs is known to reverse the degradation of rangeland. These shrubs can also play an important role in animal production: being a source of protein and nutrients, provide green feed for animals at times of low nutritional value of grass and forbs, provide drought reserve when other forage sources are in short supply. Over three hundred thousand hectares of rangeland in Syria have been improved by growing shrubs over the past two decades, mostly by direct seeding. However, the biggest challenge was how to manage these plantations in a sustainable way. This paper reports on livestock production in relation to pasture type.

Materials and methods

The experiment was conducted for seven seasons (1990/91-1996/97) at Maragha Station (37º 40′N, 35º 33′E, altitude 370 m) of the Steppe Directorate, Ministry of Agriculture, 120 km east of Aleppo in the northwest Syria. The experimental sites consist of undisturbed native pasture (not previously cultivated to grow barley) and the shrub-seeded pastures located nearby each other. The native pasture predominately annual grasses: *Bromus tectorum* L., *B. danthoniae* Trin., *B. sterilis* L., *Hordeum glaucum* L., *Poa bulbosa* L., *Malva aegyptia* L., and *Plantago ovata* Forssk. The shrub-sown pasture contained, in addition to the above species, parallel rows (5 m apart) of *Atriplex halimus* L. and *Salsola vermiculata* L. directly sown into the pasture in 1986.

Treatments

The study was carried out on 108 ha of rangeland improved by growing shrubs and a 108 ha of native pasture. Three stocking rates: one sheep 2.25 ha^{-1} $year^{-1}$, one sheep ha^{-1} $year^{-1}$ and one sheep 0.75 ha^{-1} per $year^{-1}$, referred to as low, medium, and high stocking rates, respectively. The 3 stocking rates were accommodated in randomized complete bock designs with three replications in each of the two sites. One hundred and forty-four Awassi ewes divided into groups of eight: two animals each of: 3, 4, 5, and 6 years old). Each group was permanently assigned to large (18 ha); medium (12 ha) or small (6 ha) plots, representing the low, medium, and high stocking rates on both pastures. The paddocks were fenced.

Flock management

Animals were introduced into the experimental plots on February 1, 1990. Thereafter, they grazed the plots for the whole year, from early morning to sunset, and were sheltered at night. Each year the oldest two ewes in each plot were replaced; also replaced were any (sick and barren ewes). The ewes were vaccinated at different times of the year against Anthrax, Sheep pox, Foot and mouth, Enterotoxaemia. Lambs were given injections of Selenium/Vitamin E deficiency immediately after been born to cater for mineral and vitamin deficiencies. Water was provided in the pasture and in the pens at all times. Live weight of ewes was recorded once every week, throughout the year during all seasons. Mating is performed the first week of July, during which time ewes from replications of the same treatment in each pasture were grouped together and one ram was kept with the group for 6-8 weeks. Lambs in excess of one per ewe were removed at birth and managed separately. The lambs were running with their mothers for 63 days then weaned, weighed and sold.

Supplementary feeding

Sheep grazing natural pasture were offered basal diet of cereal straw and a ration composed of wheat bran 20%, cotton seed cake (CSC) 20% and barley grain 60%. Sheep grazing the shrub-sown pasture were offered basal diet of cereal straw and a ration composed of wheat bran 20% and barley grain 80%, according to their energy and protein requirements. The supplementary feed was formulated to supply the nutritional requirement for energy and protein for ewes over the year as affected by body weight and production phase (i.e. pregnancy, lactation, dry ewes or mating as described by A. Goodchild and quoted by Nordblom et al., 1992.

Available feed on pasture

Total feed production on native and on shrub-seeded pastures was measured twice: in spring (March – April) and in autumn (September) inside and outside exclusion cages every season (1989-97). There were 20 cages (0.6m x 0.6m x 0.6m) for measuring ephemerals, which were distributed along 2-transects across each plot. Yields of shrubs were measured inside and outside 20 protective cages (1 x 2 x 1 m each) distributed along two transects across the plots, using the reference unit method (Andrew *et al*., 1979). The number of unit-equivalents is converted to

forage yield (dry weight) via calibration curves. The cages on both pastures were relocated in January every year of the study.

Results and Discussion

Out of the four seasons presented in Table 1, 1996/97 is considered high rainfall season (254 mm) compared with the annual average of 196 mm at Maragha Station. While 1993/94 is considered low rainfall season (134 mm). The other 2 seasons 1990/91 and 1992/93 are medium rainfall with 215 and 210 mm, respectively. However the rainfall distribution in those two seasons was very much different, resulting in the different forage production. Season 1992/93 is considered average season (185 mm).

Table 1 Total forage production (kg ha^{-1}) of herbaceous[a] plus grazable portions of shrubs[b] inside (in parenthesis) and outside exclusion cages during the spring of four seasons as affected by pasture type and stocking rate at Maragha, northern Syria

Season	Pasture type	Stocking rate			mean	item	SE[c]
		Low	Medium	High			
1990/91	Native	(501) 61	(358) 62	(252) 88	(370) 70	Pasture type	(55.8) 100.8
	Shrub-sown	(660) 305	(697) 363	(661) 207	(673) 292	Stocking rate	(60.4) 123.4
	Mean	(581) 183	(457) 148	(457) 148		Pasture x stocking rate	(96.7) 174.6
1992/93	Native	(253) 186	(147) 131	(162) 133	(187) 150	Pasture type	(46.8) 38.8
	Shrub-sown	(554) 515	(551) 483	(253) 210	(453) 403	Stocking rate	(57.3) 47.5
	Mean	(404) 351	(349) 307	(207) 171		Pasture x stocking rate	(81.0) 67.2
1993/94	Native	(119) 82	(121) 76	(68) 49	(103) 69	Pasture type	(70.8) 61.7
	Shrub-sown	(563) 514	(571) 563	(347) 273	(494) 450	Stocking rate	(86.7) 75.6
	Mean	(341) 298	(346) 307	(208) 161		Pasture x stocking rate	(122.6) 106.8
1996/97	Native	(1163) 988	(957) 730	(787) 513	(966) 744	Pasture type	(178.2) 128.2
	Shrub-sown	(1107) 967	(1470) 1245	(1529) 1120	(1369) 1110	Stocking rate	(218.3) 157.1
	Mean	(1135) 977	(1214) 988	(1158) 816		Pasture x stocking rate	(308.7) 222.1

[a]Consist mainly of *Poa bulbosa*, *Hordeum glaucum*, *Bromus* spp. and *Plantago ovata*.

[b]Leaves and twigs.

[c]Error D.F. equals 8 for all seasons.

The shrub-sown pasture exceeded the native pasture in total forage production (inside cages) by 82% and 41% in the medium and high rainfall seasons and by 142% and 379% in the average and low rainfall seasons (1992/93 and 1993/94, respectively). Table 1 shows that the shrub component of the feed inside and outside the protective cages was always higher than the native pasture. The highest total forage production during the study (1.4 t ha^{-1}) was recorded in 1996/97 under the shrub-sown pasture and the lowest (130 kg ha^{-1}) in 1993/94 under the native pasture. Mean energy consumption was greater with native range than with shrub-sown pasture in 5 out of the 7 seasons, ranging from 743 to 1833 MJ ha^{-1} on native pasture and 708-1230 MJ ha^{-1} on shrub-sown pasture. Similarly the crude protein consumption was consistently greater with native pasture in all 7 seasons.

Table 2 summarizes the benefits of shrub-sown pasture over the native pasture in terms of income. These were calculated from the savings obtained from reduced feed costs and sales of

extra milk and extra lamb production. The average cost of establishing the shrubs averaged over the study period (seven seasons) is deducted from the benefit in each season. Prices quoted for establishing shrubs by direct seeding in 1985 (government records) were 3-4 US$ ha^{-1}. These costs included cultivation, seed collection, seed transport and sowing (Osman & Shalla, 1994). There were little fluctuations in the prices of commodities in Syria during the 7 years of the study. Therefore, fixed market prices were used to calculate the economic benefits. The average net benefits in the present study were positive for the shrub-sown pasture during 5 out of the 7 seasons with the biggest incomes being generated in the first 2 years of the study (18 and 21 US $ ha^{-1}). The total net benefits increased with stocking rate. The accumulated total benefits during the study period were about 16, 50 and 77 US $ ha^{-1}at low, medium and high stocking rates, respectively.

Table 2 The net benefits[a] in US $ ha^{-1}[b] of the shrub-sown pasture over native pasture at three stocking rates during seven seasons.

Seasons	**Stocking rate**			
	Low	**Medium**	**High**	**Average**
1990/91	9.05	20.29	25.27	18.20
1991/92	16.07	15.31	31.47	20.95
1992/93	-2.91	2.95	-7.51	-2.49
1993/94	-5.51	8.15	16.15	6.26
1994/95	-2.33	2.03	1.85	0.52
1995/96	0.53	-1.55	-2.67	-1.23
1996/97	0.75	2.89	12.11	5.25
Total	15.65	50.07	76.67	47.46

[a]Total benefit minus the cost of establishing shrubs (4 US $ ha^{-1}[b] average over the seven seasons).
[b]The benefits were calculate from the savings obtained from reduced feed costs and from extra milk and lamb sales at weaning (negative values indicate better performance on native pasture)

Conclusions

Planting of shrubs in Maragha have significantly improved productivity of the native pasture, reduced the need for supplementary feeding and maximized the economic benefits.

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