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RAIN-FED CROP PRODUCTION SYSTEMS OF UPLAND BALOCHISTAN 3. FORAGE LEGUMES (VICIA SPECIES)

by

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Short title: Rain-fed forage legumes in upland Balochistan

Rain-fed crop production systems of upland Balochistan

3. Forage legumes (*Vicia* species).

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SUMMARY

This is the third in a series evaluating the potential for improved crop production under rain-fed conditions in upland Balochistan, in which the possibility of introducing forage legumes is examined. Seasonal feed shortages have been identified as a major constraint to livestock production in upland Balochistan and the introduction of dryland forage legumes capable of producing relatively high protein content straw presents one possible solution to this problem. The growth and yield potential of three new introductions of *Vicia* species were observed on farmers' fields from 1985 to 1988, and these were compared with the local lentil (*Lens culinaris*) land-race as a control treatment.

In 1985/86 and 1987/88 lack of rain delayed emergence until February, with the result that the crops were subject to considerable water stress, but only mild levels of cold

stress in these years. In these conditions there was little difference between the *Vicia* species. In 1986/87 rainfall was much higher, permitting autumn sowing, and the crops were subject to considerable cold stress during the winter, and to moderate levels of water stress. *V. narbonensis* was severely damaged by cold and *V. sativa* somewhat less so, whilst *V. villosa* ssp. *dasycarpa* and the local lentil showed negligible amounts of cold damage. *V. villosa* ssp. *dasycarpa* produced higher straw and seed yields (2780 and 600 kg ha^{-1}, respectively) than the lentil (1280 and 490 kg ha^{-1}, respectively) or the other *Vicia* species in these conditions. Inoculation with *Rhizobium leguminosarum* produced large yield increases in three of the four trials in this year (22 to 120 per cent).

Averaged over all trials *V. villosa* ssp. *dasycarpa* produced higher herbage and straw yields, and similar seed yields to the lentil control (1410, 1160 and 230 kg ha^{-1}, respectively; compared to 920, 650 and 240 kg ha^{-1}). The water use efficiencies of the lentil and *V. villosa* ssp. *dasycarpa* were similar: 4.9 and 5.1 kg ha^{-1} mm^{-1}, respectively. The crude protein content of *V. villosa* ssp. *dasycarpa*, fifteen and seven percent, respectively; and its good yield potential in the arid conditions of upland Balochistan suggest that this species would be a useful introduction into the rain-fed farming system of upland Balochistan as part of a sustainable crop-livestock production system.

INTRODUCTION

Seasonal feed shortages, particularly during winter, as a result of low rangeland productivity and large increases in animal numbers, have been identified as a major constraint to livestock production in upland Balochistan, (Iqbal *et al*., 1981). Some barley is grown as fodder, but the principal crop product fed to sheep and goats is wheat straw (Nagy and Sabir, 1987). Fallow replacement with forage legumes, providing high protein content forage for animal feed, has shown great potential for increasing livestock productivity and farm profitability in Syria and Turkey (Cocks & Thomson, 1988; Acikgoz, 1988). The dryland farmers of upland Balochistan do not practice any crop-fallow system as usually recognized; instead fields are left fallow when rainfall receipt is low, and are planted to cereals if sufficient rainfall occurs (Nagy and Sabir 1987). However, the introduction of forage legumes, grown on unutilized land, or as a replacement for some of the cereal crop area, or as part of a rotation, offers a potential strategy for improving animal feed supplies and livestock production in upland Balochistan. The purpose of this paper is to report on the performance of selected *Vicia* species grown on farmers' fields in upland Balochistan from 1985 to 1988.

MATERIALS AND METHODS

Details of trial locations, trial management measurement of rainfall, temperature and soil water at planting are given in Part 1 (Rees *et al*., 19XX). Seed of *Vicia sativa*, *V. narbonensis* and *V. villosa* ssp. *dasycarpa* were provided by ICARDA, Syria. The local variety of lentil, which is a minor crop in upland Balochistan (less than five percent of rain-fed cropped land is planted to lentil, Buzdar *et al*., 1989) and is commonly used as a dual purpose crop, providing high quality straw for animal feed, as well as seed for human consumption, was used as a control treatment. In 1985 when only a little seed was available three simple crop comparison trials were planted in a randomised complete block design with three replicates. In 1986/87 and 1987/88 the trials were expanded to include the four species factorially combined with +/- *Rhizobium leguminosarum* inoculum and +/- 60 kg ha^{-1} phosphate fertilizer in a randomized complete block design with three replicates.

The row spacing was 40 cm (the row spacing used by the farmers for lentil), and the seed rate was 90 kg ha^{-1}. The inoculum was mixed with the seed just prior to planting, with a little sugar solution to act as a sticking agent. The phosphate fertilizer was applied as triple super-phosphate sown into the seed bed with the seed. Herbage yields were determined from two 1 m samples of row per plot at 100% flowering. Straw and seed yields were determined from the entire center two rows of each plot.

RESULTS

Details of the rainfall patterns and temperatures recorded during crop growth are given in Part 1 (Rees *et al*., 19XX). In all trials at all locations crop responses to application of phosphate fertiliser were small and not statistically significant.

1985/86

In 1985/86 the crops emerged at the end of January and the ten frost days (air temperatures of 0 °C or less) recorded (Table 1) occurred immediately after emergence and did not appear to damage the seedlings. Soil water at sowing and rainfall during crop growth were low and yields were accordingly low also (Table 1). Under these conditions of considerable water stress but little cold stress, all three *Vicia* species produced yields similar to, or greater than, that of the lentil control, with little difference between the *Vicia* species. In two of the three trials crop failure occurred, i.e. seed yields were less than the seed sown.

1986/87

In 1986/87 monsoon rains provided sufficient soil water for September/October planting and good crop establishment. Moderate levels of water stress were observed from flowering onwards. 96 days with minimum temperatures below 0 C were recorded at the three trials at Dasht and Kovak (1750 - 2000 m elevation), but there were only 5 such days at Khuzdar (1200 m elevation). At Khuzdar little cold damage was observed, but in the other three trials, V. narbonensis and V. sativa showed considerable cold damage, and at the DashtR site V. narbonensis was completely killed by the cold. V. villosa ssp. dasycarpa produced considerably higher herbage and straw yields than the other Vicia species in all four trials (Table 2). In three of the four trials seed inoculation with R. leguminosarum resulted in considerable yield increases, but at the Dasht R site, straw and seed yields were apparently reduced by seed inoculation.

1987/88

In 1987/88 rains did not occur until the end of January and sowing was delayed until mid-February, resulting in a shortened season for crop growth. Frosts occurred during the latter part of February, before emergence, and so the crops were not subject to cold stress in this season. Rainfall was extremely low at all sites, as was soil water at planting (except at Khuzdar and Kalat where pre-planting irrigation was applied), resulting in severe water stress and extremely low yields, with crop failure in four of the five trails (Table 3). V. villosa ssp. dasycarpa produced at least as much herbage and straw as the other three species in these conditions. Responses to inoculum were small and not statistically significant.

The crude protein percentages of the herbage, straw and seed of V. illosa ssp. dasycarpa were 15, 7 and 20, respectively.

Crop comparisons over years.

The data indicate that in nearly all the trials V. villosa ssp. dasycarpa yielded more than, or as much as, the lentil control, and frequently out-yielded the other Vicia species. This was tested by analyzing the data for each crop from all twelve trials, using the data from the treatments without fertilizer or inoculum (Table 3). Orthogonal comparisons indicated statistically significant differences between V. villosa ssp. dasycarpa and the other three species grouped together at P < 0.1%, 0.1% and 5% for herbage, straw and seed, respectively.

Figure 1 shows linear relationships between total dry weight at maturity and soil water at planting to 1 m depth plus rainfall during crop growth, for the lentil and V. illosa ssp. dasycarpa crops. The slopes, and intercepts of the two lines are not significantly different from each other, indicating that these two crops had similar water use efficiencies.

DISCUSSION

Both water stress and cold stress are potentially serious limiting factors for forage production in upland Balochistan. In northern and western Balochistan sufficient rain for autumn sowing can be expected in only four years out of ten (Kidd et al., 1988) and so in these areas crops are generally sown in spring, frequently, but not always, avoiding most cold stresses. In the two years reported here in which the crops emerged in February and so avoided cold stress, the differences between the crops were small, probably due to the severe water stresses experienced in these years. In 1986/87 when water receipt was much higher the crops were planted in September/October and were subject to considerable cold stress during winter, V. villosa ssp. dasycarpa gave considerably higher yields than the other Vicia species and the lentil control, showing little cold damage and the ability to produce high straw and herbage yields in favorable moisture conditions. V. villosa ssp. dasycarpa is thus the obvious choice of forage legume for upland Balochistan for autumn sowing. The choice for spring sowing is not so clear-cut: there was little difference overall between V. villosa ssp. dasycarpa and V. sativa in the spring-sown trials and the palatability of the herbage of V. illosa ssp. dasycarpa is somewhat less than that of V. sativa (ICARDA, 1986; Thomson et al., 1990). V. sativa is thus also a potential candidate for spring sowing areas of upland Balochistan. Ali et al. (1989) suggest two other forage species, V. ervilia and Lathyrus sativus for spring sowing in upland Balochistan, and concur with the proposal of V. villosa ssp. dasycarpa for autumn sowing.

Inoculation with Rhizobium leguminosarum increased straw and herbage yields of all the crops in three of the four trials in 1986/87 when water stress was less severe, suggesting that considerable yield increases in both food and forage legume production could be achieved by development and extension of this technology, restricting inoculum use to years when soil water availability at planting is high.

The lack of response to phosphate fertilizer is in agreement with the results with wheat and barley reported in Parts 1 and 2 (Rees et al., 19XXa, 19XXb), and does not support the use of phosphate fertilizer in dryland agriculture in upland Balochistan.

Farmers of upland Balochistan currently produce only barley or wheat straw as supplementary feed for their animals. The crude protein content of the herbage and straw of V. illosa ssp. dasycarpa is considerably higher than that of wheat and barley (Part 2, Rees et al., 19XXb) and in agreement with other published values, eg. Thomson et al. (1990), who also demonstrated that voluntary intake of V. villosa ssp. dasycarpa and V. sativa straw was higher than that of barley, suggesting that livestock production could be considerably improved by utilisation of Vicia crop products. These forage crops could be used in one of three ways: as green grazing at flowering (the time of maximum dry weight); cut at flowering and stored as hay; or harvested as mature seed and straw. The option of green grazing does not seem appropriate for upland Balochistan, where herbage production coincides with the time of maximum range productivity. Herbage production was generally ten to twenty percent higher than mature crop production, (a result of the water stress during the post-flowering period common in mediterranean-type rainfall climates) which, with the higher crude protein content of herbage than of mature straw makes the option of hay production from *Vicia* crops in upland Balochistan relatively attractive. Rihawi *et al*. (1987) questioned the utility of *Vicia* hay production in Syria because of unacceptably high mechanized harvest losses, but in Balochistan such harvesting would be by hand, which should reduce such losses. The option of growing fodder crops for straw production, for use at times of feed shortage, also seems appropriate, and the high protein content and voluntary intake of *V. villosa* ssp. *dasycarpa* straw suggests that this crop could play a useful role in the crop-livestock system of upland Balochistan. Clearly more work is required, to develop appropriate feeding strategies for livestock, and to develop cropping strategies that produce both sufficient food crops for the farmers and feed crops for their animals, but the work presented here suggests that forage crops, particularly *V. villosa* ssp. *dasycarpa*, could play an important role in improving the productivity of the crop-livestock system of upland Balochistan.

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Table 1. 1985/86 trials: Soil water at planting to 1 m depth (mm), rainfall (mm) and number of frost days during crop growth, and crop yields (kg ha^{-1}).

Trial	Dasht	DashtR1	DashtR2	Mean
Soil water	34	60	77	
Rainfall	137	220	137	
Frost days	31	31	31	
Herbage yields:				
Lentil	178	1131	395	568
V. sativa	316	2033	285	878
V. narbonensis	198	1742	307	749
V. villosa	184	850	437	490
$S.E._{crop}$	84	245*	41	88*
$S.E._{location}$				121*
Straw yields:				
Lentil	160	492	303	318
V. sativa	198	1106	224	509
V. narbonensis	151	789	190	377
V. villosa	246	353	369	323
$S.E._{crop}$	28	134*	25*	46*
$S.E._{location}$				60*
[illegible]				
V. sativa	67	19[illegible]	29	98
V. narbonensis	30	283	96	136
V. villosa	34	130	88	84
$S.E._{crop}$	16	54	13	19
$S.E._{location}$				25*

* Treatment means significantly different at $P < 5\%$.

Table 2. 1986/87 trials: Soil water at planting to 1 m depth (mm), rainfall (mm) and number of frost days during crop growth, and crop yields (kg ha^{-1}).

Trial	Khuzdar	Kovak	DashtR	Dasht	Mean
Soil water	116	53	180	96	
Rainfall	162	194	221	221	
Frost days	5	97	96	96	
Herbage yields:					
Lentil	735	443	5702	1160	2010
V. sativa	695	221	2551	804	1068
V. narbonensis	744	301	0	867	478
V. villosa	1527	527	10665	1561	3567
-Inoculum	581	248	4196	773	1450
+Inoculum	1269	498	5258	1422	2112
$S.E._{crop}$	327	123	765*	186*	215*
$S.E._{inoculum}$	231*	87*	541	131*	152*
$S.E._{location}$					243*
Straw yields:					
Lentil	355	459	3338	964	1279
V. sativa	349	195	3826	749	1280
V. narbonensis	303	214	0	570	272
V. villosa	1459	974	7542	1157	2783
-Inoculum	491	297	4165	711	1416
+Inoculum	742	624	3188	1009	1391
$S.E._{crop}$	199*	102*	546*	158	153*
$S.E._{inoculum}$	141	72*	386	112	108
$S.E._{location}$					225*
Seed yields:					
Lentil	165	312	890	591	490
V. sativa	72	203	1026	367	416
V. narbonensis	101	333	0	273	177
V. villosa	165	592	1280	341	594
-Inoculum	112	143	975	384	392
+Inoculum	139	576	623	402	447
$S.E._{crop}$	25*	99*	147*	60*	47*
$S.E._{inoculum}$	18	70*	104*	42*	33
$S.E._{location}$					

* Treatment means significantly different at $P < 5\%$.

Table 3. 1987/88 trials: Soil water at planting to 1 m depth (mm), rainfall (mm) and number of frost days during crop growth, and crop yields (kg ha^{-1}).

Trial	Khuzdar	Kalat	Kovak	Dasht	DashtR	Mean
Soil water	133	87	41	45	26	
Rainfall	32	51	107	147	102	
Frost days	1	-	15	4	4	
Herbage yields:						
Lentil	299	772	71	31	351	305
V. sativa	425	1080	72	33	406	403
V. narbonensis	508	1384	87	45	215	448
V. villosa	651	1126	82	37	481	475
-Inoculum	485	1032	75	37	357	397
+Inoculum	456	1148	82	36	369	418
$S.E._{crop}$	91	103*	10	5	94	33*
$S.E._{inoculum}$	65	73	7	4	66	24
$S.E._{location}$						54*
Straw yields:						
Lentil	495	161	22	53	152	176
V. sativa	504	226	28	66	93	184
V. narbonensis	303	228	52	68	50	140
V. villosa	503	293	37	69	133	207
-Inoculum	407	243	30	65	111	171
+Inoculum	496	211	39	63	104	182
$S.E._{crop}$	74	34	6	5	20	17*
$S.E._{inoculum}$	53	24	4	4	14	12
$S.E._{location}$						17*
Seed yields:						
Lentil	77	87	0	0	4	34
V. sativa	106	146	0	0	26	56
V. narbonensis	73	197	0	0	30	60
V. villosa	90	76	0	0	31	39
-Inoculum	77	125	0	0	23	45
+Inoculum	96	127	0	0	24	49
$S.E._{crop}$	15	12	-	-	6	4*
$S.E._{inoculum}$	11	8	-	-	5	3
$S.E._{location}$						5*

* Treatment means significantly different at $P < 5\%$.

Table 4. Lentil and *Vicia* yields (kg ha^{-1}) analyzed over all twelve experiments (without inoculum or phosphate fertiliser).

	Herbage	Straw	Seed
Lentil	925	653	238
V. sativa	540	639	200
V. narbonensis	450	219	77
V. villosa	1416	1158	234
$S.E._{site}$	144*	257*	98*
$S.E._{crop}$	147*	85*	30*
$S.E._{sc}$	508*	295*	105*

* Treatment means significantly different at P < 0.1%.

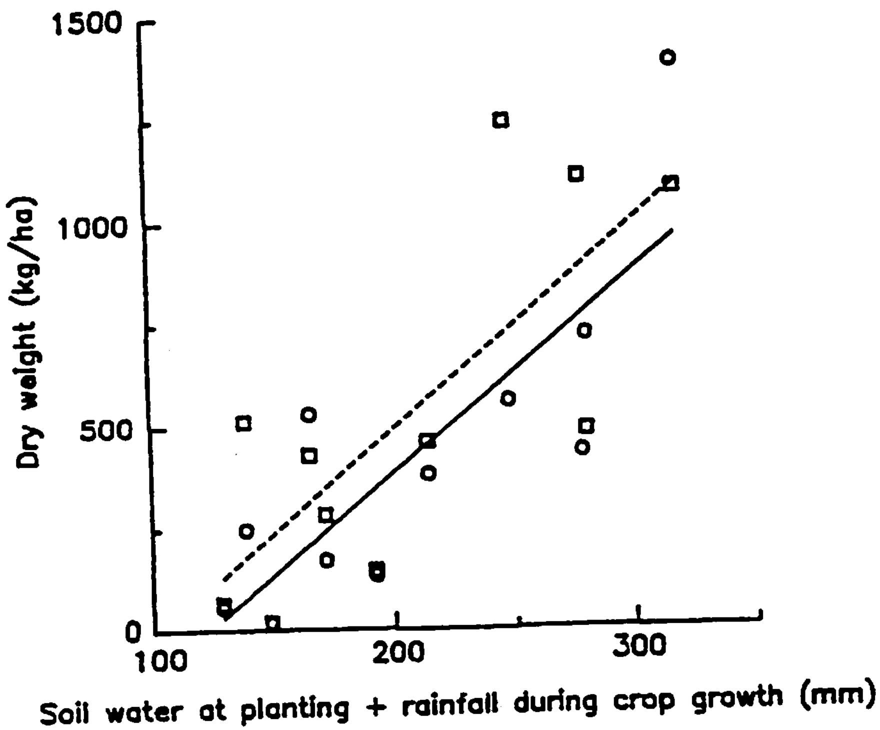

Figure 1. Relations between total above-ground dry weight at maturity and (soil water at planting + rainfall during crop growth).
o, —— lentil: $y = 4.93(x - 122)$ $r = 0.82$
□, --- _V. villosa_ ssp. _dasycarpa_: $y = 5.06(x - 103)$ $r = 0.77$