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Kohak-96, first cold and drought tolerant vetch variety for the arid uplands of Balochistan, Pakistan

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bstract

provide an alternative feed source for animals in winter, the study was conducted to develop a suitable, annually sown, ol season, forage legume variety for the arid uplands (≥1000m altitude) of Balochistan. Out of 36 experiments, Kohak-96 nificantly ($P<0.05$) out-performed the check in 29 and 23 experiments in TDM (total dry matter) and seed yield, spectively, whereas it remained non-significant ($P>0.5$) in rest of the experiments. It gave 25-67 per cent TDM and 0-100 r cent seed increase over the check. It gave maximum average TDM (total dry matter) of 6083 kg ha^{-1} and seed yield 981 ha^{-1} during 1986/87 as compared to 2510 kg ha^{-1} TDM and 445 kg ha^{-1} seed yield by the check (local lentil) during 95/96. The minimum average TDM of 149 and 104 kg ha^{-1} was given by Kohak-96 and check, respectively, during 87/88 with spring-planting. At the same time, the minimum seed yield was also obtained from both in the same season d the check could not produce any seed at all indicating the in-appropriateness of planting Kohak-96 in spring in the most years. Application of *Rhizobium* inoculum and 60 kg ha^{-1} phosphate fertilizer at the time of sowing of Kohak-96 gave nificantly ($P<0.05$) higher TDM and seed yield than non-application of these two agronomic inputs. A seed rate of 60 ha^{-1} gave significantly ($P<0.05$) higher TDM and seed yield than other seed rates. Forage production gradually increased m pre-flowering to maturity in Kohak-96 and the check (local barley, used only for grazing studies). Kohak-96 significantly <0.05) out-performed the local barley in forage production at all phenological stages. The forage intake by sheep was nificantly ($P<0.05$) higher for Kohak-96 at the first two stages of growth but less than the check at maturity. The sheep zing Kohak-96 gained significantly ($P<0.05$) more weight than the sheep grazing barley consistently at all phenological ges. This indicates that sheep could be maintained successfully on Kohak-96, cultivated under rainfed conditions in nter, during forage deficit period without any loss in their body weight and it can also act as winter forage reserve.

troduction

e to rapid increases in population, increasingly large ficits in the production of crops and livestock are forecast the Asian and African regions (Dyson, 1996). To meet e present and future demands for increased agricultural tput, not only productivity needs to be enhanced from e current status by using conventional farmland but also rginal lands will have to be utilized as a supplementary ntributor to the agricultural sector for the betterment of e national economy. A large area of highland (≥1000m itude) Balochistan (approximately 20 million hectares) is sently the most under-utilized agricultural resource in the untry which with careful management could assist in hieving sustainable agricultural productivity (Qamar *et al.*, 999).

e dryland farming systems of highland Balochistan are minated by the production of small ruminants raised on proximately 18 M ha of rangeland (Nagy *et al.*, 1989) h a secondary component of subsistence wheat duction on 750,000 ha (Rees *et al.*, 1988) and the soil generally poor in fertility. This land is located at an tude of 1000-3000m and experiences a mixed arid tinental mediterranean and arid sub-tropical monsoonal ate. Rainfall is highly erratic and seldom exceeds 250 and winters can be exceedingly cold (Kidd *et al.*, 8). Thus the entire area can only be regarded as mely marginal for cropping. In consequence of these marginal and highly variable climatic conditions, considerable forethought and breeding strategy is required while attempting to select appropriate germplasm for developing improved varieties to suit rainfed cultivation and to help in improving soil fertility in upland Balochistan. Hence an aggressive research strategy should be designed to identify crop cultivars which can permit both more consistent and rewarding agricultural productivity in this harsh environment. Moreover, the feed demand for small ruminant production in such areas is another important factor, which should determine the cropping strategies of the area. The number of sheep and goats in Balochistan has increased from 1.7 to approximately 19 million head since 1955 (GOP, 1998) and livestock owners are reporting severe feed shortages (Nagy *et al.*, 1989). The local livestock-raising community is forced to migrate in winter to other areas to graze their animals. This migration can be minimized if the people are provided with adequate forage resources (Nagy *et al.*, 1987). The overall research policy is therefore, strongly biased towards improving all sources of animal feed availability from cropping land to reduce pressure on the severely over-grazed rangelands. In this situation, the introduction of forage legume species in the present farming system of highland Balochistan looks promising (Keatinge *et al.*, 1991) with additional benefits to be gained from symbiotic nitrogen fixation and soil rehabilitation (Qamar *et al.*, 1999).

Materials and Methods

In 1985, the Pakistan Agricultural Research Council's Arid Zone Research Centre (AZRC), Quetta, in partnership with the international Center for Agricultural Research in the Dry Areas (ICARDA), Syria, started its germplasm evaluation programme for annual forage legumes (mainly Vetches) in upland Balochistan. The variety of choice was the selection *Vicia villosa* ssp. *dasycarpa* Acc. 683 (Syrian origin). The genetic material was first selected under natural stresses at the research station, Quetta and then advanced to multi-locational preliminary testing and then to on-farm trials. To test the genetic material under farmer's conditions, sites other than Quetta employed farmer's fields throughout the study.

The experimental sites were Quetta (altitude 1750 m), Sariab (altitude 1700 m), Dasht (altitude 1725 m), Khuzdar (altitude 1250 m), Loralai (altitude 1340 m), Kan Mehtarzai (altitude 2250 m), Kovak (altitude 1760 m) and Kalat (altitude 1800 m) covering a range environments typical of upland Balochistan. Meteorological data were recorded at each site. A minimum daily air temperature of -19 °C (Kan Mehtarzai in 1986/87) and a minimum annual rainfall of 60 mm (Khuzdar in 1987/88) were recorded during the course of study. Two planting times, winter (September-October) and spring (January-February), were used. To expose the genetic material to low air temperatures, it was essential to have emergence before freezing temperatures in the field are experienced. Therefore, wherever rainfall or residual moisture was not available for early (winter) planting, irrigation water equal to 20-50 mm rainfall was used and later the experiments received only natural precipitation. The advanced experiments were planted in 6-row plots with 5 m row length and 25 cm row spacing in a Randomized Complete Block Design (RCBD). Local lentil (*Lens culinaris* M.) was used as a check because of the non-availability of any cool season annual forage legume for dryland cultivation. Fertilizer 20:60 NP (kg ha^{-1}) was applied at the time of planting. The seeds were inoculated with *Rhizobium* inoculum before sowing for germplasm evaluation trials. The central 4 rows of each plot were harvested for yield data. The experiments were harvested in the months of May, June and early July depending upon different locations.

For on-farm experiments, farmer's practices were followed and the experiments were planted on conserved moisture received from rainfall which was very erratic and mostly the planting time varied from September to March. To determine the effects of *Rhizobium* inoculum and phosphate fertilizer on the productivity of the genotypes, agronomic trials were also conducted. To determine the forage production and palatability, the plots were sampled before grazing studies at different phenological stages of the varieties at Quetta station. Crude protein contents were determined at the National Agricultural Research Centre (NARC), Islamabad using the micro-Kjeldahl method (AOAC, 1975). Local barley was used as a check in these studies because barley, a dual purpose crop, is mainly grown for grazing in the upland Balochistan. Weight gain/loss of each animal was calculated by recording weight of each animal before and after the grazing of each forage. Forage intake by each animal was calculated as: Total forage available (kg) divided by No. of animals x No. of days grazed (Rafique *et al.*, 1993). The variety was approved for release by the Balochistan Seed Council in December, 1996 and registered with the Department of Seed Certification and Registration, Islamabad in March, 1997 (Gazette of Pakistan, 1998).

Results

The Kohak-96 gave maximum average TDM (total dry matter) of 6083 kg ha^{-1} and seed yield 981 kg ha^{-1} during 1986/87 as compared to 2510 kg ha^{-1} TDM and 445 kg ha^{-1} seed yield by the check (local lentil) during 1995/96. The minimum average TDM of 149 and 104 kg ha^{-1} was given by Kohak-96 and the check, respectively, during 1987/88 with spring-planting. At the same time, the minimum seed yield was also obtained from both species in the same season and the check could not produce any seed at all indicating the in-appropriateness of planting Kohak-96 in spring in the most dry years. Out of 36 experiments conducted during 1985/86 to 1995/96 across the locations, Kohak-96 significantly ($P<0.05$) out-performed the check in 29 experiments in TDM and in 23 in seed yield whereas it remained non-significant ($P>0.5$) in the rest of the experiments. Kohak-96 gave 25-67 per cent TDM and a 0-100 per cent seed increase over the check during the course of study (Tables 1 and 2).

Application of *Rhizobium* inoculum and 60 kg ha phosphate fertilizer at the time of sowing of Kohak-96 gave significantly ($P<0.05$) higher TDM and seed yield than no application of these two agronomic inputs (Table 3). The seed rate of 60 kg ha^{-1} gave significantly ($P<0.05$) higher TDM and seed yield than other seed rates (Table 4).

Forage production gradually increased from pre-flowering to maturity in Kohak-96 and the check (local barley). Kohak-96 significantly ($P<0.05$) out-performed the local barley in forage production at all phenological stages and protein contents (Table 5). The forage intake by sheep was significantly ($P<0.05$) higher for Kohak-96 at the first two stages of growth but less than the check at maturity (Table 6). The sheep grazing Kohak-96 gained significantly ($P<0.05$) greater weight than the sheep grazing barley consistently at all phenological stages of the variety (Table 7).

Discussion

The environmental conditions in upland Balochistan are highly variable and marginal for crop growth. The variation in plant productivity is expected in these kinds of situations and even the survival of the plant can be at stake. All kinds of representative years were available during the eight years of study and Kohak-96 was robustly productive in environments. It indicates that it can be grown success

Table 1: Total dry matter (TDM) of Kohak-96 in comparison with heck(local lentil) in different experimental tests under rainfed conditions of upland Balochistan during 1985/86 to 1995/96.

Trial Type and Locations	No. of Locations	Year	Avg. TDM (kg ha^{-1})		% Increase	Site Sig. (P<0.05)	
			Kohak-96	Check		Sig.	NS
Winter-planting							
Preliminary: Qta*	1	1985/86	467	188	60	1	0
A: Qta, Khu, K.Meh	3	1986/87	6083	2378	61	3	0
B: Qta, Sar, Khu, K.Meh	4	1987/88	981	732	25	3	1
C: Qta, Khu, K.Meh	3	1988/89	4696	1696	64	3	0
Adapt: Qta, Lor, K.Meh	3	1989/90	3900	2367	39	2	1
Adapt: Qta, K.Meh	2	1995/96	5867	2510	57	2	0
On-farm							
Khu, Kov, Das1, Das2	4	1986/87	3377	1769	48	4	0
Khu, Kov, Das1, Das2	12	1985-88	1392	891	36	8	4
Spring-planting							
A: Qta, Khu, K.Meh	3	1986/87	2505	820	67	3	0
B: Qta 1 1987/88	149	104	30	0	1		

* Qta: Quetta; Sar: Sariab (Quetta); Khu: Khuzdar; K.Meh: Kan Mehtarzai; Lor: Loralai; Kov: Kovak; Das1 & 2: Dasht sites 1 & 2; Sig.: Significant; NS: Non-significant; P: Phosphate; Avg.: Average.

Table 2: Seed yield of Kohak-96 in comparison with check (local lentil) in different experimental tests under rainfed conditions of upland Balochistan during 1985/86 to 1995/96.

Trial Type and Locations	No. of Locations	Year	Avg. Seed Yield (kg ha^{-1})		% Increase	Site Sig. (P<0.05)	
			Kohak-96	Check		Sig.	NS
Winter-planting							
Preliminary: Qta*	1	1985/86	119	28	76	1	0
A: Qta, Khu, K.Meh	3	1986/87	981	291	70	3	0
B: Qta, Sar, Khu, K.Meh	4	1987/88	274	37	87	2	2
C: Qta, Khu, K.Meh	3	1988/89	563	38	93	2	1
Adapt: Qta, Lor, K.Meh	3	1989/90	212	412	0	3	0
Adapt: Qta, K.Meh	2	1995/96	668	445	33	2	0
On-farm							
Khu, Kov, Das1, Das2	4	1986/87	594	490	18	2	2
Khu, Kal, Kov, Das1, Das2	5	1987/88	39	34	13	1	4
Without inoculum & P	12	1985-88	234	238	0	6	6
Spring-planting							
A: Qta, Khu, K.Meh	3	1986/87	433	191	56	2	1
B: Qta	1	1987/88	9	0	100	0	1

* Qta: Quetta; Sariab (Quetta); Khu: Khuzdar; K.Meh: Kan Mehtarzai; Lor: Loralai; Kov: Kovak; Das1 & 2: Dasht sites 1 & 2; Sig.: Significant; NS: Non-significant; P: Phosphate; Avg: Average.

Table 3: Effect of Rhizobium inoculum and phosphate application on total dry matter (TDM) and seed yield (kg ha^{-1}) of Kohak-96 under rainfed conditions in upland Balochistan. The values within each main effect in the same column are significantly (P<0.05) different. ± S.E.

Main Effect		TDM (± 194)	Seed Yield (± 53)
Inoculum:	None	3886	488
	Applied	4451	601
Phosphate:	None	4039	514
	Applied (60 kg ha^{-1})	4298	575

Table 4: Effect of different seed rates (kg ha^{-1}) on total dry matter (TDM) and seed yield (kg ha^{-1}) of Kohak-96 under rainfed conditions in upland Balochistan ± S.E.

Seed Rate (± 110)	TDM (± 185)	Seed Yield (± 53)
30	4034	607
60	4952	705
90	4504	531
120	4022	467
150	3328	412

Table 5: Comparison of Kohak-96 with Local Barley in forage production (kg ha^{-1}) and protein content at three different phenological stag of pre-flowering (PF), flowering (F) and maturity (M) under rainfed conditions at Quetta during 1988/89. + S.E.

Forage Variety	Forage production			Protein (%)		
	Phenological Stage					
	PF(+ 140)	F(+ 318)	M(+ 249)	PF(+3.7)	F(+4.0)	M(+2.
Kohak-96	1529	2604	2656	23.7	23.2	15.1
Barley (Local)	733	993	1638	10.2	4.9	5.1

Table 6: Forage intake (g h^{-1} d^{-1}) by sheep grazing pastures of Kohak-96 and Local Barley at different phenological stages under rainf conditions at Quetta during 1988/89. + S.E.

Forage Variety	Phenological Stage		
	Pre-flowering (+ 32)	Flowering(+ 36)	Maturity (+ 41)
Kohak-96	265	437	353
Barley (Local)	250	308	491

Table 7: Weight gain or loss (g h^{-1} d^{-1}) by sheep grazing pastures of Kohak-96 and Local Barley at different phenological stages un rainfed conditions at Quetta during 1988/89. + S.E.

Forage Variety	Phenological Stage		
	Pre-flowering (+ 40)	Flowering (+ 26)	Maturity (+
Kohak-96	8	67	65
Barley (Local)	-150	-9	13

under rainfed conditions in highland Balochistan and it can provide forage for animals even in the most dry conditions. The variety has a low harvest index owing to excessive flower drop and is generally not high yielding but it is highly encouraging that it produced seed even in the most dry seasons (Saxena *et al.*, 1993). Though it is a forage variety, farmers do need to keep some seed back for regrowing it in the next season and Kohak-96 does provide some security for seed return in the prevailing conditions of highland Balochistan. It requires long duration for its growth with substantial cold and drought tolerance and gives reasonable forage production with winter-planting (Siddique and Loss, 1996). Since no vetch variety was available for its comparison in Balochistan, it was compared with Balochistan local lentil and many other exotic vetch genotypes. It produced substantially higher biomass and straw than all other vetches and lentil.

Inoculation with *Rhizobium leguminosarum* increased straw and seed yield because *Rhizobium* for this species does not seem to be sufficiently present in Balochistan soils and it becomes essential to inoculate the seeds with appropriate strain of the bacterium before sowing to have the nitrogen fixation process started and to get maximum crop productivity. In this way, the variety may help in rehabilitating the nitrogen depleted soils of the farmlands of upland Balochistan (Ali *et al.*, 1988; Aydin and Acar, 1995; Qamar *et al.*, 1999).

For grazing studies, local barley was used as a check variety because it is a dual purpose crop and early planted barley is generally grazed in upland Balochistan (Nagy *et al.*, 1989). Lentil is not grazed and therefore was not used in the palatability studies. The intake of local barley by the sheep was low and they lost weight at the pre-flowering and flowering stages. It indicates that sheep preferred Kohak-96 over the local barley and the loss of weight in animals grazing barley may be the result of the p nutritive value of the forage as compared to Kohak which was highly nutritive. Van Soest (1966) stated t legumes are eaten in larger amounts than grasses beca they are digested more quickly as they contain less cell constituents, less crude fibre, more nitrogen and m soluble carbohydrates. Sheep could be maintai successfully on Kohak-96 cultivated under rai conditions in winter during forage deficit period without loss in their body weight. However, feeding woolypod v as a sole diet should be avoided because a distinctive t syndrome in cattle resulting in death has been relate intensive grazing of pure stands of woolypod vetch a flowering and podding stages (Peet and Gardner, 1 Harper *et al.*, 1993). Instead, it can act as a winter fo reserve and the rangelands could be provided with s rest with this manipulation of feeding regime. Approp grazing management may include a light grazing at a early stage, legume/cereal intercropping and preservati hay.

Kohak-96 is suitable variety for winter cultivation, minimum inputs, under the rainfed conditions of hig Balochistan. This variety can be used in one of the ways; i) as green grazing at flowering (the tim maximum weight-gain by sheep); ii) cut at flowerin stored as hay (with a plot for seed production spare harvested at maturity for seed and straw where stra be used in winter and the seed used for planting th crop.

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