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SELECTION OF VETCH GENOTYPES UNDER RAINFED CONDITIONS IN HIGHLAND BALOCHISTAN

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SELECTION OF VETCH GENOTYPES UNDER RAINFED CONDITIONS IN HIGHLAND BALOCHISTAN

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ABSTRACT: Feed deficits are a major limitation on animal productivity in the arid highlands of Balochistan and no adapted forage legume species are available locally for the cold and dry conditions experienced in these areas. An unconventional selection program to select and improve forage legumes species was the first step to overcome the feed deficits. This paper describes the results of evaluation and selection trials comparing Vicia sativa genotypes with Vicia villosa ssp. dasycarpa Acc 683 and with a local lentil species as an experimental control. The trials were conducted at multiple sites and seasons with winter and spring planting. V. dasycarpa was more productive both in total dry matter production and seed yield. In favourable environments V. sativa genotypes were equal in production to V. dasycarpa. V. sativa Acc. 713 has been selected for winter planting due to its better productivity across trial locations, yield stability under different environments and adequate level of winter hardiness. These newly selected forage legumes species have a high tolerance to the prevailing environmental stresses and if introduced, could have a positive impact on the dryland crop-livestock farming system in highland Balochistan.

Key Words: V. sativa; V. villosa ssp. dasycarpa; Unconventional germplasm selection: Highland Balochistan: drought and cold stresses.

INTRODUCTION

Sheep and goats are the major income-earning resource for most farmers in highland Balochistan, supplemented by an additional small amount of income from rainfed agriculture. The total population of small ruminants in Balochistan is around 18.4 million, of which 11.1 million are sheep and 7.3 million are goats (Government of Pakistan, 1986). The population growth rate of small ruminants in this area exceeds 7% per year (Masood et al., 1988). Due to this rapidly increasing and large animal population, and the consequent overgrazing of palatable rangeland species which have a slow regrowth capacity, an increasing feed deficit exists in this area. This feed deficit is very acute in the winter months when most of the range species are dormant. In winter female ruminants are usually pregnant or lactating, and their feed requirements are high. Therefore, poor nutrition is a major constraint to the productivity of these animals (ICARDA 1989).

The main source of supplementary feed is wheat which is a valuable dual purpose crop. It is grown to produce grain for humans, but an important secondary objective is to provide some forage for ruminants. The wheat may be grazed or cut in early spring when green, and after harvest the straw is also valued and widely used. At present, forage legumes are not grown for livestock under dryland conditions, although lucerne is grown under irrigation on a small scale. Aware of the importance in Balochistan of small ruminant production and rainfed agriculture, the Arid Zone Research Institute (AZRI) has been collaborating for several years with the International Center for Agricultural Research in the Dry Areas (ICARDA) in a selection program to develop suitable forage legumes for these harsh, dry highland conditions.

After surveying available legume species which had performed well under similar rainfed conditions elsewhere (Moneim et al., 1988), from 1985 onwards, a range of species was introduced for testing. The species included woolly pod vetch, (*V. villosa* ssp. *dasycarpa*), narbon vetch, (*V. narbonensis*), common vetch (*V. sativa*) and common chickling (*Lathyrus sativus*). The performance of these legumes in highland Balochistan has been reported by Keatinge et al., 1989 and Ali et al., 1989a. In this paper, the evaluation and selection results of only the *V. sativa* genotypes are presented; the trials were conducted at mutiple sites.

MATERIALS AND METHODS

In the 1987/88 season, 20 *V. sativa* genotypes obtained from ICARDA's head office in Syria were planted in winter and spring at three sites in highland Balochistan for initial observation and selection of desirable genotypes. The site details are given in Table 1. *V. villosa* ssp. *dasycarpa* Acc. 683 and the local lentil (*Lens culinaris*) were included as check entries. At each site trials were planted with a single row hand drill in a randomized complete block design with three replications. The plot size was 1.5 X 5 m with 25 cm row spacing. Triple superphosphate (46 % P_2O_5) was applied at sowing at a rate of 60 kg P_2O_5/ha. Seeds were inoculated prior to sowing with suitable

Rhizobia supplied by the Pakistan National Agricultural Research Center at Islamabad. In the absence of adequate rainfall, some supplemental irrigation water was used to ensure uniform crop establishment and to ensure sufficient seed stock subsequently (Table 1). Winter planting was done in late September or early October, and spring planting in late January or early February, according to the practices of local farmers. The four middle rows of each plot were harvested by hand in order to record the total dry matter (TDM) production and seed yield.

Eight V. sativa genotypes were selected from the 1987/88 trial on the basis of cold and drought tolerance, maturity length, disease resistance and yield potential and planted in the following two years. In the 1988/89 season the sites and planting times were the same as in the previous year, but in the 1989/90 season, the trials were planted only in winter with one additional site at Loralai. Agronomic and cultural practices were the same as those used in the first year.

The desirable characters needed in V. sativa genotypes for this target environment appear to be:

1. Cold tolerance
2. Rapid emergence and the ability to make good early growth.
3. Regrowth ability after cutting, grazing or frost damage.
4. Early maturity.
5. Drought resistance/tolerance.
6. Disease resistance.
7. High forage production.
8. Non-shattering genotypes.
9. Good palatability and high nutritive value.

RESULTS AND DISCUSSION

The performances of V. sativa genotypes during the 1987/88 season with winter and spring planting are presented in Tables 2 and 3. Winter plantings gave better results than the spring ones in the 1987/88 season which was very dry; little cold damage was experienced that winter. No rainfall was received from September to December at all the sites, causing reduced vegetative growth of most entries. Absolute minimum air temperatures during the winter months were -7, -5 and -12 ^{0}C at Quetta, Khuzdar and Kan Mehtarzai, respectively (Table 1). V. sativa Acc. 1335, 1293 and 708 were completely killed by frost at Quetta and did not recover after the winter, but most of the other entries started regrowth in early spring. V. dasycarpa Acc. 683 and the local lentil was found to be very cold-hardy and no frost damage to these lines occurred.

In the winter plantings, V. sativa Acc. 713 produced the highest total dry matter (TDM) at all the sites, and was significantly ($P<0.05$) better at Kan Mehtarzai than the local lentil check. The seed production of this line was also significantly ($P<0.05$) higher than the local check at Quetta and Kan Mehtarzai (Table 2). V. sativa Acc. 1459 was significantly ($P<0.05$) better in seed production than the local check at Kan Mehtarzai. However, most of

the genotypes failed to produce seed at Quetta and Khuzdar due to drought and heat stresses which came at the grain formation stage. In general, V. sativa lines produced greater TDM than the local check.

In contrast to the 1987/88 season, the 1988/89 season was favourable for crop production. More than 200 mm of well distributed rains were received at Quetta and Kan Mehtarzai. The winter rains at Khuzdar were very low, but substantial summer rains had previously provided enough stored moisture for the crop to reach maturity. Minimum air temperatures during early crop growth were not low enough to damage the crop. However, during the grain formation stage in May the minimum air temperature suddenly dropped below zero for about one week at all sites. This badly affected the grain formation process, causing lower numbers of pods per plant, seeds per pod and seed weights. This sudden drop of temperature in May was a very rare event according to analyses of previous temperature records in this area (Rees et al., 1990a).

In the relatively favourable year of 1988/89, V. dasycarpa Acc. 683 was again the outstanding genotype in the winter plantings at all the locations, producing the highest TDMs and seed yields at both Khuzdar and Kan Mehtarzai (Table 4). Spring planted V. sativa genotypes were more productive than the local lentil, but the yields in general were much lower and more variable (Table 5).

The 1989/90 cropping season was a good year with more than 300 mm of well distributed rains being received during the crop growth period at Quetta and Kan Mehtarzai. At Kan Mehtarzai heavy snow occurred during the winter months. This retarded vegetative growth and delayed the maturation period of the crop. No severe cold damage was experienced at Quetta, but desiccating winds during the grain formation stage severely affected grain setting, thus seeds were shrivelled and yields were low.

In the favourable season of 1989/90, V. sativa genotypes produced higher TDM at Quetta and Kan Mehtarzai than the local lentil. At Quetta, V. sativa Acc. 713 produced slightly more TDM than V. dasycarpa Acc. 683, but significantly more than the local lentil (Table 6). At Loralai, no V. sativa genotypes could compete with the local lentil and V. dasycarpa Acc. 683 in TDM production. At Kan Mehtarzai, although the differences in TDM production between the genotypes were not significant, V. dasycarpa Acc. 683 produced the highest TDM of 2433 kg/ha, compared to 767 kg/ha from the local lentil.

Seed production of V. sativa genotypes was adversely affected at Loralai by a severe attack of army-worm Spodoptera spp., near crop maturity. Such severe pest damage is experienced only rarely in highland Balochistan, as the climatic conditions are usually not favourable for these pests (Ahmad et al., 1990a). The local lentil gave significantly ($P<0.05$) higher seed yields than all the other entries at Quetta and Kan Mehtarzai, due to its early maturity compared with other genotypes; this character helped the local lentil to escape from the effects of the desiccating winds and the army-worm attack.

Averaged over all the 15 trials in 3 years, V. dasycarpa Acc. 683 was significantly ($P<0.05$) better in TDM production and seed yield than the local check. Although V. sativa Acc. 713, 715 and 490 also produced higher seed yields than the local check, the differences were not significant (Table 7). V. dasycarpa Acc. 683 showed a better tolerance to environmental stresses than the V. sativa genotypes and was an outstanding performer in the high elevation dryland areas of Balochistan (Keatinge et al., 1989, Ali et al., 1989a and Rees et al., 1989b).

The results of the first three years of germplasm evaluation of V. sativa genotypes in highland Balochistan indicated that this species can grow quite well in the arid highlands of Balochistan. The desirable characters needed in these genotypes are cold and drought tolerance, also wide genetic adaptability and stability of yields in poor environments. V. dasycarpa Acc. 683 was found to be more cold tolerant than all the V. sativa genotypes. V. sativa Acc. 713 exhibited a satisfactory level of winter hardiness, and was also more productive than the local lentil. Frost damage is an important yield limiting factor in this area (Ahmad et al., 1989 and Ali et al., 1990b). Therefore, the lack of good cold tolerance in most of the V. sativa genotypes is a major disadvantage when considering them for potential release in highland Balochistan (Keatinge et al., 1989).

Seed shattering was another important factor which reduced yields of these V. sativa genotypes, and obviously non-shattering genotypes are more desirable. V. sativa genotypes exhibited better growth vigour early in spring than the V. dasycarpa, a character which is desirable in this area, provided it is associated with cold tolerance. Early growing genotypes utilize the available moisture more effectively and can produce more green forage. As far as drought tolerance is considered, V. sativa genotypes have the same level of drought tolerance as V. dasycarpa, but V. dasycarpa produces more vegetative growth than V. sativa, and thus is superior in TDM production and seed yield than the local lentil and V. sativa lines. Most of the V. sativa lines were earlier in maturity than V. dasycarpa and this character is advantageous in dry seasons, helping the crop to escape from terminal drought at the grain filling period (Ahmad et al., 1990b, Fischer and Maurer 1987).

At present, wheat monoculture is predominant in dryland farming in this area; only a little barley is grown. Both these crops are used in a dual purpose capacity. The introduction of new leguminous forage crops could provide farmers with an alternative to wheat or barley monocropping. V. sativa and V. dasycarpa could be used in different ways in this area, for green grazing at the flowering stage, for hay, or for straw and seed production. Rees et al., 1989b pointed out that grazing at the flowering stage would not be very worthwhile in this area because at this time most of the range vegetation is also suitable for grazing. The other important advantage of forage feed is that its straw has a higher nutritive value than wheat and barley straw (Thomson et al., 1990).

Most of these V. sativa genotypes were of longer maturity period, and no success has been achieved so far in the evaluation and selection of shorter maturity genotypes. Therefore, more V. sativa genotypes will be screened in this environment to find more appropriate genotypes for spring planting. However, V. dasycarpa Acc. 683 and V. sativa Acc. 713 are at present the most promising genotypes for winter planting. The farmers of this area should benefit by growing these promising forage legume species which would improve the nutrition and health of their livestock. Evaluation and selection for these desirable characters were found to be difficult in this area, owing to the erratic, low rainfall and physical harshness of the environmental conditions. However, exposure of the material to the prevailing environmental stresses and use of multi-location testing appeared to provide a reliable strategy for identifying genotypes resistant to biotic and abiotic stresses.

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Table 1. Site details and meteorological data for the four sites in highland Balochistan.

Location	Elevation (m)	Latitude	Longitude
Quetta	1690	30° 07'N	66° 58'E
Khuzdar	1250	27° 46'N	66° 39'E
Kan Mehtarzai	2250	31° 00'N	67° 45'E
Loralai	1340	30° 24'N	68° 36'E

Location	Rainfall+Supplemental Irrigation (mm) 1987/88	1988/89	1989/90*	Abs. Min. Temp. in the season (°C) 1987/88	1988/89	1989/90*
Que.	113+50	239+50	301+50	-7	-8	-7
Khu.	32+150	219+30		-5	-8	
K.M.	66+150	222+30	491+30	-12	-13	-10

Que.= Quetta. Khu.= Khuzdar. K.M. = Kan Mehtarzai.

* Meteorological data not available for the Loralai triai site.

Table 2. Total dry matter (TDM) and seed yield (kg/ha) of 20 *V. sativa* lines during 1987/88 season with winter planting.

Ent. No.	Name	Acc.No.	TDM Yield			Seed Yield		
			Que.	Khu.	K.M.	Qu.	K.hu.	K.M.
1	*V. sativa*	713	1482	553	957	83	121	333
2	*V. sativa*	715	673	643	727	18	177	202
3	*V. sativa*	308	892	527	622	9	71	223
4	*V. sativa*	1293	135	97	365	0	12	133
5	*V. sativa*	1520	486	332	198	3	40	47
6	*V. sativa*	1335	17	35	357	0	5	79
7	*V. sativa*	1293	81	149	139	0	16	43
8	*V. sativa*	1458	91	95	239	0	12	73
9	*V. sativa*	1293	64	61	189	0	2	71
10	*V. sativa*	490	581	569	553	1	43	185
11	*V. sativa*	709	1007	519	358	7	48	86
12	*V. sativa*	1315	677	486	552	0	54	108
13	*V. sativa*	505	267	144	491	2	6	140
14	*V. sativa*	1335	0	107	209	0	7	81
15	*V. sativa*	1293	0	26	292	0	2	105
16	*V. sativa*	7	385	251	580	7	43	85
17	*V. sativa*	708	0	111	192	0	4	53
18	*V. sativa*	1459	1175	267	929	34	26	235
19	*V. sativa*	1485	530	621	587	0	38	197
20	*V. sativa*	2	318	515	374	0	79	94
21	*V. dasycarpa*	683	1444	358	685	12	53	235
22.	*L. culinaris*	Local	1153	477	467	12	86	40
Mean			521	316	457	9	43	129
LSD (5%)			445	-	410	24	-	141

Table 3. Total dry matter (TDM) and seed yield (kg/ha) of 20 *V. sativa* lines during 1987/88 season with spring planting.

Ent. No.	Name	Acc.No.	TDM Yield			Seed Yield		
			Que.	Khu.	K.M.	Que.	Khu.	K.M.
1	*V. sativa*	713	497	933	650	33	0	187
2	*V. sativa*	715	347	853	717	6	0	218
3	*V. sativa*	308	227	833	667	5	0	185
4	*V. sativa*	1293	126	300	350	1	0	48
5	*V. sativa*	1520	258	440	400	7	0	21
6	*V. sativa*	1335	164	233	467	5	0	66
7	*V. sativa*	1293	101	233	433	1	0	54
8	*V. sativa*	1458	161	227	417	14	0	37
9	*V. sativa*	1293	111	287	433	0	0	55
10	*V. sativa*	490	345	767	800	2	0	227
11	*V. sativa*	709	337	460	617	17	0	85
12	*V. sativa*	1315	315	420	450	5	0	17
13	*V. sativa*	505	371	467	483	14	0	32
14	*V. sativa*	1335	61	227	583	0	0	94
15	*V. sativa*	1293	156	487	450	3	0	45
16	*V. sativa*	7	307	553	567	9	0	43
17	*V. sativa*	708	234	460	633	6	0	84
18	*V. sativa*	1459	263	467	767	2	0	258
19	*V. sativa*	1485	173	400	850	0	0	240
20	*V. sativa*	2	296	447	733	3	0	92
21	*V. dasycarpa*	683	222	647	733	28	11	207
22.	*L. culinaris*	Local	93	367	600	0	15	90
Mean			235	478	582	7	1	108
LSD (5%)			159	443	208	17	2	62

Table 4. Total dry matter (TDM) and seed yield (kg/ha) of selected V. sativa lines during 1988/89 season with winter planting.

Ent. No.	Name	Acc.No.	TDM Yield			Seed Yield		
			Que.	Khu.	K.M.	Qu.	Khu.	K.M.
1	V. sativa	713	7458	758	1000	146	68	221
2	V. sativa	715	6333	450	750	81	35	258
3	V. sativa	308	6625	383	1167	55	15	227
4	V. sativa	490	7438	721	1042	70	21	284
5	V. sativa	709	6521	388	917	36	25	159
6	V. sativa	1459	5479	492	958	13	14	292
7	V. sativa	1485	6104	358	917	27	15	327
8	V. sativa	2	5021	858	708	23	64	76
9	V. dasycarpa	683	7417	4421	2250	14	1165	509
10.	L. culinaris	Local	3500	396	1042	31	54	29
Mean			6190	923	1075	50	148	238
LSD (5%)			-	1443	453	-	1017	129

Table 5. Total dry matter (TDM) and seed yield (kg/ha) of selected V. sativa lines during 1988/89 season with spring planting.

Ent. No.	Name	Acc.No.	TDM Yield			Seed Yield		
			Que.	Khu.	K.M.	Qu.	Khu.	K.M.
1	V. sativa	713	417	201	667	61	5	180
2	V. sativa	715	500	151	542	84	1	181
3	V. sativa	308	458	199	625	95	3	127
4	V. sativa	490	542	251	583	170	1	123
5	V. sativa	709	375	112	458	89	3	50
6	V. sativa	1459	250	200	667	40	2	161
7	V. sativa	1485	417	144	542	27	1	103
8	V. sativa	2	250	204	458	12	12	47
9	V. dasycarpa	683	458	344	667	95	45	160
10.	L. culinaris	Local	292	124	667	2	6	24
Mean			396	193	588	68	8	116
LSD (5%)			-	-	-	66	-	92

Table 6. Total dry matter (TDM) and seed yield (kg/ha) of eight selected V. sativa lines during 1989/90 season with winter planting.

Ent. No.	Name	Acc.No.	TDM Yield			Seed Yield		
			Que.	Lor.	K.M.	Qu.	Lor.	K.M.
1	V. sativa	713	8700	300	1167	322	1	222
2	V. sativa	715	7833	383	933	385	0	212
3	V. sativa	308	5433	250	1167	200	1	271
4	V. sativa	490	8467	383	1867	188	0	525
5	V. sativa	709	6600	333	1167	262	5	260
6	V. sativa	1459	6200	350	1767	59	1	329
7	V. sativa	1485	6267	467	1167	20	0	219
8	V. sativa	2	6933	483	567	83	0	59
9	V. dasycarpa	683	7600	1667	2433	173	19	445
10.	L. culinaris	Local	4533	1800	767	673	476	86
Mean			6857	642	1300	237	50	233
LSD (5%)			2406	530	-	79	156	-

Table 7. Overall mean total dry matter (TDM) and seed yield (kg/ha) of eight selected V. sativa lines tested at different sites in highland Balochistan (Average of 15 environments).

Ent. No.	Name	Acc.No.	TDM Yield	Seed Yield
1	V. sativa	713	1715	132
2	V. sativa	715	1456	124
3	V. sativa	308	1338	99
4	V. sativa	490	1661	123
5	V. sativa	709	1345	75
6	V. sativa	1459	1349	97
7	V. sativa	1485	1303	81
8	V. sativa	2	1211	43
9	V. dasycarpa	683	2089	211
10.	L. culinaris	Local	1085	108
Mean			1455	109
LSD (5%)			470	90