Lathyrus Genetic Resources in Asia

Proceedings of a Regional Workshop

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R.K. Arora, P.N. Mathur, K.W. Riley and Y. Adham, *editors*

International Plant Genetic Resources Institute
Office for South Asia
New Delhi 110 012, India

IPGRI

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Cover : *Lathyrus* crop field view and diversity : Photos courtesy S.S. Baghel, S.L. Mehta

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International Plant Genetic Resources Institute
Office for South Asia c/o NBPGR, Pusa Campus
New Delhi 110 012, India

IPGRI Regional Office for Asia, the Pacific and Oceania
c/o Stesen Kuarantin Lepas Masuk
Jabatan Pertanian, Bangunan JKR(P) 1746
43400 Serdang, Selangor Darul Ehsan, Malaysia

International Plant Genetic Resources Institute
Via delle Sette Chiese 142
00145 Rome, Italy

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Foreword

It gives me great pleasure to prepare a foreword to these proceedings of the Regional Workshop on *Lathyrus* Genetic Resources in Asia. The proceedings contain the recommendations of the participants from the major *Lathyrus* growing countries in Asia to form a small network aimed at effectively conserving, sharing, documenting and using the available diversity of this hardy legume crop. The proceedings also contain information on the status of *Lathyrus* genetic resources, utilization and research in the participating countries.

For the past decade, this hitherto neglected crop has received intense international attention. It is well recognized that farmers' varieties of this crop can tolerate flooded conditions after sowing and drought conditions later in growth. The species possesses unique adaptation as a post-rice crop across much of South Asia. Variants have been found with high quality and yields of grain and fodder. Nevertheless, these advatanges were overshadowed by the presence of a crippling neurotoxin known as ODAP found in the seed of *L. sativus*. History records a number of epidemics of Lathyrism when groups of people have been permanently crippled by over-consumption of *Lathyrus*.

A colloquium held in Pau, France in 1985, workshops in London in 1988 and in Dhaka in 1993 as well as the present workshop on genetic resources have produced proceedings that record rapid scientific progress in addressing the neurotoxicological, biochemical and genetic questions regarding lathyrism and *Lathyrus*. Genetic stocks with very low levels of neurotoxin have now been identified both through conventional breeding and through somatic mutation. Attempts to rapid methods of analysis of neurotoxin levels in plant tissue have been developed and rapid progress in breeding these lines reported. Such progress makes the aims of the present workshop even more pertinent. There is now the opportunity to incorporate the low neurotoxin trait into a broad range of genetic diversity possessing local adaptation, pest and disease resistance, and high yield and quality of grain and fodder, while maintaining the essential resistance to stress conditions that give *Lathyrus* its unique advantage.

The preparation for this workshop has involved close collaboration and linkages with many other groups and individuals who were not able to attend the Workshop itself. Financial support for this workshop came from a project 'Genetic Resources of Neglected Crops' which is financed by Federal Ministry of Economic Cooperation and Development (BMZ), Germany and executed by IPGRI Headquarters in Rome. Dr Joachim Heller, the coordinator of this project has provided strong encouragement and funding for this workshop which is highly appreciated, but unfortunately he was not able to attend. A monograph of *Lathyrus sativus* is presently under preparation as one component of the BMZ-supported project. Dr Yawooz Adham, the IPGRI Regional Director of West Asia and North Africa region was also unable to attend, but we are very grateful for his support in sending participants from Turkey and Jordan at this meeting. Finally, a meeting held in Ethiopia just prior to this workshop recommended the formation of the International *Lathyrus* and Lathyrism Research Association (ILLRA). We have established good linkages with this association through Mr. Ferdinand Lambien of Belgium, who pointed out that ILLRA will carry out biochemical, genetic studies to investigate the pathway and control of ODAP, and start work on genetic transformation. The aims and activities of the proposed *Lathyrus* Genetic Resources Network should be highly complementary to those of ILLRA.

Finally, I would like to thank Dr R.K. Arora and his staff at the Delhi office of IPGRI for their untiring efforts in organizing the Workshop, preparing these proceedings and their active role in carring out the recommendations of this workshop. A *Lathyrus* directory is under preparation and the Descriptor list for *Lathyrus* is being considered by IPGRI. We hope to convene a small group to carry forward the ideas on the enhanced networking to conserve and use *Lathyrus* resources.

Kenneth W. Riley
Regional Director
IPGRI-APO

Welcome Address

A. Alam

Lathyrus sativus locally called '*Khesari*', '*Teora*', '*Lakh*'/'*Lakhdi*' is an important post-monsoon crop of the Chhattisgarh region of Madhya Pradesh, relay cropped by broadcasting seeds 15-20 days prior to harvest of rice crop at seed rates of 80-100 kg/ha, while about 40 kg/ha would suffice by drilling. Broadcasting is done when the surface is wet or still some water standing. About a day or more after broadcasting seeds, the standing water is drained off. Such a relay cropping is locally called *Utera*. *Utera* practice is endemic to the Chhattisgarh region. Crops taken by *Utera* are *Lathyrus*, linseed, lentil and gram, *Lathyrus* being the most common. In the absence of irrigation and difficulty in preparing conventional seedbed and drilling before moisture recedes to too low levels, the practice has continued. The scientists at Indira Gandhi Agricultural University, Raipur have evolved improved *Utera* practice. They have achieved encouraging results, doubling crop yield, by ploughing and cross-ploughing and drilling same day as soon as soil reaches to friable range, soon after harvest of paddy.

Of the 0.89 million ha *Lathyrus* grown in India, about 88% is in the state of Madhya Pradesh and of this, 86% in the Chhattisgarh region. Thus, you can see how much an important crop it is for us. It is next only to rice. But, the productivity is extremely low with very high cost benefit ratio. Yet we can not derive comfort with the situation. The average productivity is extremely low at 0.38 t/ha. Under favourable condition, 0.5-0.6 t/ha is obtained. Some farmers, specially in deep vertisols or verticsols, are switching over to chickpea. Researches have led to postulate on-farm water harvesting tank devoting about 10% of the watershed which allows assured crop of rice and protective irrigation to the crop after rice with good results. Yet all these are still at experimental and pilot field trial stage. *Utera* crop of *Lathyrus* continues to be the most popular post-monsoon crop in this region.

This is a traditional crop of long standing known for it ability to withstand moisture stress and other productivity constraints, high in protein and with no major (other than thrips) pest problem. It is used as traditional *dal*, bread and *besan* (decuticled *Lathyrus* flour) for human consumption as well as livestock feed concentrate.

Association of neurotoxin causing of Lathyrism in mid-seventies, created lot of hue and cry, and brought the crop under discard. Even legislative measures were passed to stop its cultivation. But it has successfully withstood the pressures. After a dip in its production, it has come up again. However, in certain parts, area under *Lathyrus* is showing negative growth rate owing to emergence of better options like chickpea where protective irrigation is there. Emergence of low toxin varieties augurs bright future for *Lathyrus*.

I feel delighted that this important Regional Workshop on *Lathyrus* is being held at Indira Gandhi Agricultural University, Raipur and the experts who have made significant contributions in India and abroad are participating in it. On behalf of the University and on my personal behalf, I extend a very warm welcome. With your presence, we are honoured.

We look forward for very successful deliberations and your inputs of thoughts and comments on our on-going programmes on *Lathyrus* breeding and cultivation. I have requested my colleagues Dr. S.S. Baghel, Director, Research Services and Dr. R.L. Pandey, Senior Scientist, to arrange a proper field visit to show our work, to seek your comments and suggestions.

Before I close, I would like to say that though we have tried to do our best but please forgive us for any lapses or shortcomings.

Thank you.

Inaugural Address

E.A. SIDDIQ

This is the second IPGRI-ICAR sponsored regional workshop after the first one on sesame held some time back at Akola. The present workshop on *Lathyrus sativus* assumes importance in many ways. Possibly for the first time, importance and urgency of collection, conservation and utilization of this under-utilized crop are being addressed at a regional level involving countries, where it is grown as a grain/fodder or grain-cum-fodder crop. This is one crop wherein controversy over the rationale of its growing as a food crop remains still unresolved in South Asia in general, India in particular. The relationship between consumption of *Lathyrus* and incidence of lathyrism is still being debated. Nevertheless, being the most hardiest crop, cheapest source of protein to poor people and a good fodder, it is still grown over a large area in India. I am happy that this workshop is being held in Chattisgarh region of Madhya Pradesh, where *Lathyrus* is an important crop in rice fallows. Whereas, it is a fodder crop in the West and North African (Turkey, Morocco, Algeria and Syria) countries, it is a dual purpose crop in South Asian (India, Bangladesh and Nepal) countries. Breeding objectives, therefore, differ according to the end use of the crop and all breeding efforts to evolve desired varieties have been relying on the variability available in the region. But for isolated efforts, very little progress has been made till now to assess the extent of genetic diversity available in different countries/regions and to share knowledge and germplasm vis-a-vis each others' needs for effective utilization. In the South Asian countries the need is for varieties with low neurotoxin (BOAA), which is believed to be the cause of lathyrism.

Ever since BOAA content was related to the incidence of lathyrism, and a ban was imposed on the sale of grains of *Lathyrus*, India initiated research in all seriousness to develop varieties with low (<0.2%) BOAA content through conventional recombination breeding as well as induced mutagenesis and somacloning. As a result, low neurotoxin varieties/lines combining high grain and fodder yield, and desired promising agrobotanic traits including resistance to pests and diseases have been developed; But still the country has to go a longway in meeting the varietal need with stability for low neurotoxin content.

I am happy that IPGRI is promoting through regional workshops of this kind involving countries sharing commonality in crop specific diversity, exchange of knowledge and germplasm for more focussed breeding research so as to cater to the varietal needs of the participant countries. We gained by actively involving ourselves in the IPGRI-sponsored regional collaborative programme on sesame improvement. I am hopeful that the outcome of the present dialogue would lead to launching of a similar regional research programme leading to enrichment of collection, effective conservation and optimal utilization of *Lathyrus* genetic resources at regional and global levels. Constitution of Regional Steering Committee to give a practical shape to the idea of sharing information and genetic resources of *Lathyrus* is worth considering by this group.

As some of you are aware, India places considerable emphasis to the conservation and utilization of under-utilized and still un-exploited plant species of economic significance as reflected from the establishment of an exclusive All India Co-ordinated Research Project on under-utilized and under-exploited plants. Food crops such as buckwheat, amaranth, chenopods and coix and industrial crops like jatropha are some of the crops that receive importance under this project. There are many more crops such as fibre yielding, crops like ramie, kenaf, sisal; oil yielding crops like safflower and niger, and fodder/forage crops like *Stylosanthes,* wherein building database on genetic diversity and collection/conservation drives should be one of the priority areas among the future PGR activities.

Restricting my views to the present workshop on *Lathyrus,* I suggest the following for your consideration and deliberation:

(i) Regional efforts for enrichment of *Lathyrus* genetic resources by augmenting collection of cultivars and wild species in countries of rich genetic diversity as well as in areas that remain still under-explored.

(ii) Characterization using conventional descriptros and DNA finger printing of *Lathyrus* genetic resources, evaluation of their economic traits and documentation of the same for easy access to information for all interested/engaged in *Lathyrus* crop improvement research.

(iii) Exploring the possibilities of organizing through IPGRI, regional varietal trials of promising low toxin varieties of *Lathyrus* as being done through FAO for maize etc.

(iv) Launching of a network on *Lathyrus* genetic resources collection, conservation and their utilization for overall improvement of the crop in the desired direction with IPGRI as the facilitator.

To sum up, in my view, high priority be given for establishing a regional database, undertaking of need-base collection of *Lathyrus* genetic resources from potential pockets of diversity, characterization and evaluation, establishing core collections, locating and assessing diversity, regeneration and conservation of germplasm in duplicate sets in more than one genebank for safe maintenance. Programmes with such constructive objectives, I am sure, would motivate many donors to extend support.

In the end, let me compliment IPGRI and NBPGR for their timely decision to hold this regional workshop. I am confident that the deliberations of the workshop would lead to constructive recommendations, which would facilitate increase flow of germplasm and their utilization in the region. I wish you all professionally rewarding and personally enjoyable stay over here.

Recommendations

The following recommendations have emanated from the discussions and delebrations of the Workshop sessions covering different aspects of *Lathyrus* genetic resources in Asia.

* It was felt desirable to establish a network on *Lathyrus* genetic resources.

* The proposed network will include countries from South Asia and WANA region including Ethiopia. CLIMA and other research organizations interested in *Lathyrus* may also be associated as research interest groups.

* The network activities will be coordinated by IPGRI Coordinator for South Asia located at NBPGR, Pusa Campus, New Delhi 110 012, India.

* There will be a representative from each country to act as a country coordinator in the network.

The activities suggested for the network are as follows :

* Emphasis on two other species of economic importance i.e. *L. cicera* and *L. ochrus* besides *L. sativus.* Wild species gene pool may also be given adequate attention.

* Current status of germplasm collection needs to be assessed by each country. Documentation of existing genetic resources held by different national programmes needs priority. ICARDA may take up creation of database for germplasm from WANA region and Ethiopia while IPGRI can take up preparation of database for South Asia.

* A list of minimum descriptors as discussed may be made available by IPGRI to cooperators. A booklet on the list of descriptors for the *Lathyrus* gene pool (including wild species) may be prepared and published by IPGRI involving WANA and South Asia region.

* Once the databases are prepared, these will be supplied to member countries for sharing information.

* IPGRI Coordinator at South Asia office, New Delhi may develop a Directory of *Lathyrus* genetic resources and expertise from network countries.

Priorities for Networking

* The major objective of the networking would be germplasm exchange, collection, evaluation, characterization, conservation, and utilization.

* It was agreed to assess the status of existing germplasm available with different member countries.

* Depending on the outcome of critical evaluation of above information, the gaps for further collecting can be identified.

Collaborative Studies

Adaptive studies

* Adaptive studies need to be carried out by countries in the South Asia and WANA region with emphasis on both grain and forage purposes. Mechanism for coordination/country contacts need to be identified.

Breeding

* It was agreed to have collaborative breeding approach to quicken the process of developing lines with low ODAP, high yield (biomass/seed yield), and resistance to diseases and pests/abiotic stresses.

Basic studies

* Basic studies on genetic control of different traits such as flower colour, ODAP content etc.; outcrossing mechanisms; preparation of linkage maps and studies on reproductive biology in different *Lathyrus* species; inter-relations between different *Lathyrus* species using genetical and cytogenetical techniques, molecular markers and other biotechnological approaches; and Inter-specific hybridization, needs to be undertaken. It was suggested that such work may be carried out in India through collaboration.

* The network should have a close link with other groups concerned with establishment of safe ODAP threshold limit, survey on Lathyrism, public awareness, microbiological studies on nodulation/nitrogen fixation, and preparation of agronomic packages.

* Development of low ODAP lines should be coupled with development of appropriate strategies for maintenance of genetic purity through proper isolation mechanisms.

* Some pilot studies may be carried out for *in situ* (on farm) conservation of germplasm in the farmers field.

* It may be desirable for network functioning to approach the national systems to identify/nominate country coordinator and the expert scientists/institutes.

Core Collection

* The importance and need for core collection was stressed. It was suggested that it should be possible to define the core collection with the available data.

Safety Duplicate Collection

* It was suggested to duplicate the germplasm accessions at two places in India, base collection at NBPGR, New Delhi and active germplasm collection may be maintained at IGAU, Raipur and IIPR, Kanpur.

* It was suggested that other participating countries may, if they desire, deposit their germplasm either with NBPGR, New Delhi or at ICARDA.

Genetic Diversity

* Collection of genetic diversity in hot spots and its study may be given due emphasis.

* The active and working collections are being maintained in a number of countries. Such procedure need to be followed by each country. Complementary conservation strategies need to be developed based on experience from pilot studies.

Funding for the Proposed Network

* IPGRI may explore the possibilities of obtaining funds. Need based proposals are to be developed by network participating countries for support. The potential donors such as ACIAR, Asian Development Bank, BMZ Germany, FAO, UNDP and EU etc., may be approached.

Other Follow-up Action

* It was felt that expertise within the region may be fully utilized for various PGR related activities.

* To promote concern on conservation and use of *Lathyrus*, information on work being carried out in the region may regularly be published in IPGRI-APO Newsletter.

* Proceedings of the Workshop may be brought out by IPGRI, New Delhi office.

* The Network Coordinator will have the country coordinator nominated by the nodal agencies in the participating countries.

* It was agreed that the Network Coordinator will indicate steps to have a Steering Committee constituted in consultation with the country coordinators.

Status of Grasspea Research and Future Strategy in Bangladesh

M.A. Malek, C.D.M. Sarwar, A. Sarker and M.S. Hassan

Introduction

Grasspea (*Lathyrus sativus* L.) locally known as 'Khesari' is widely cultivated as a relay crop in the amon rice fields. In Bangladesh, among pulses it ranks first in terms of both acreage (33%) and production (34%) (Table 1). The major growing areas are greater districts of Barisal, Faridpur, Patuakhali, Dhaka, Noakhali, Jessore, Rajshahi and Comilla. In the rural areas it is consumed as 'dal' (a soup type preparation) with rice and is the cheapest source of protein. Though it contains a neurotoxic compound ODAP (b-N-Oxalyl-diaminopropionic acid) causing lathyrism in human beings, it is still cultivated because of its wider adaptability and low inputs. Moreover, it provides cheap and quality fodder to cattle. Research has indicated that it is possible to breed zero or low toxin varieties which are relatively safe for human consumption.

Area and Production

In Bangladesh, grasspea is grown in an area of 239 343 hectare with a production of 174 245 tonne of grains (Table 1). The productivity is low, the mean being 728 kg/ha because it is cultivated without any care and input.

Table 1. Area, production and yield of different pulses (5 years average from 1987-88 to 1991-92)

Pulse crop	Area (ha)	Production (tonne)	Yield kg/ha	% of total area	% of total production
Grasspea	239 343	174 245	728	32.6	33.6
Lentil	211 927	156 334	738	28.9	30.2
Chickpea	99 543	69 308	696	13.6	13.4
Black gram	69 202	50 521	736	9.4	9.8
Mung bean	58 388	31 542	540	8.0	6.1
Field pea	18 860	13 351	708	2.6	2.6
Pigeon pea	5 584	3 248	582	0.8	0.6
Other pulses	30 202	18 765	621	4.1	3.6
Total	**733 049**	**517 714**		**100**	**100**

Lathyrus and Lathyrism

A neurotoxic compound called ODAP has been found in the seed of grasspea which causes lathyrism, a serious neurologic disease in human beings on continuous consumption of grasspea seed for 3-4 months as a staple food. However, data from interviews conducted with the growers and consumers during the collection of local germplasm samples indicated that the disease is not common, a few suspect cases have so far been reported. A majority of those interviewed reported about the gastric problem associated with the consumption of grasspea 'dal' rather than lathyrism.

Research Progress

Until 1976, there was no systematic research on grasspea. Under the Coordinated Pulses Research Programme funded by Bangladesh Agricultural Research Council (BARC), the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Institute of Nuclear Agriculture (BINA) initiated the grasspea collection programme along with other pulse crops. Later on, Bangladesh Agricultural University (BAU) and Rajshahi University (RU) were also involved in this programme. Samples of local and exotic germplasm were collected and evaluated for variation in yield and morpho-agronomic characters. In general, the local germplasm lines appeared well adapted, early in maturity with high harvest index and having high ODAP content.

Later on in 1979, the Pulses Section of Plant Breeding Division at BARI initiated the Grasspea Research Programme along with six other pulses under the financial assistance of International Development Research Centre (IDRC) of Canada. At a later date in 1988 a separate centre for Pulses Research under BARI was established with CIDA assistance in the name of Crop Diversification Programme (CDP); linking research (BARI), extension (DAE), marketing (DAM) and seed production (BADC). The CDP continued upto June, 1995. The second phase of CDP for a period of another five years is likely to operate very soon.

Varietal Development

The main breeding objective of grasspea is to develop varieties with high seed and high biomass yield having low ODAP content. The crosses were made between early high yielding local cultivars and those having early maturity, larger seed size and low neurotoxin content. From these segregants and segregants received from IARI (Quader 1985) two varieties namely BARI-Khesari-1 and BARI-Khesari-2 have been released in 1995. The performance of the two released varieties are shown in Tables 2 and 3. In another crossing series a number of low ODAP, high yielding lines have been identified. Yield potential alongwith other agronomic performance are presented in Table 4. The promising lines are being evaluated over years across locations. Besides, 55 line have been selected from 900 local germplasm, that are now in preliminary and observation trials. In addition, 159 single plants were selected from 8 F_5 populations and will be evaluated in plant progeny rows. In crossing programme, F_1, F_2 or F_4 generations have been developed and those are being advanced following SSD method.

Table 2. Average performance and ODAP content of the released varieties compared to the check

Line / varieties	Days to maturity	Plant height (cm)	1000 seed weight (g)	ODAP content (mg/g)
8603 (Barikhesari-2)	115	70	68	0.0 137
8612 (Barikhesari-1)	115	70	64	0.006
Jamalpur (Check)	112	60	40	0.0 528

Table 3. Average yield (kg/ha) performance of the released varieties over years across locations

Line/varieties	1986-87 (1 location)	1987-88 (3 locations)	1988-89 (2 locations)	1989-90 (4 locations)	1990-91 (3 locations)	Over all Mean
8602 (Barikhesari-2)	1350	1333	2960	1299	1692	1727
8612 (Barikhesari-1)	1836	1167	2828	1205	1571	1720
Jamalpur (Check)	1198	900	1520	1248	1616	1296

Table 4. Performance of the promising lines in preliminary yield trial (1994-95)

Lines	Days to maturity	Yield (kg/ha)					ODAP (%)
		Joy	Jes	Ish	Rah	Mean	
112/14-1	110	1156	2226	1087	1486	1489	0.272
104/11-1	112	1417	1800	1379	913	1377	0.100
114/26-1	110	1297	2691	1285	1447	1670	0.178
108/11-1	114	1323	1615	1024	755	1179	0.261
114/6-1	112	906	2312	1302	992	1378	0.275
110/8-1	116	755	2456	1359	863	1358	0.233
112/15-3	112	1724	2211	1017	889	1460	0.280
107/10-4	114	745	2199	1337	854	1284	0.178
112/7-2	113	1161	2719	1365	1126	1593	0.285
Jamalpur (Check)	108	1671	-	1139	1300	1370	0.806

Screening for Low ODAP Lines

A number of germplasm lines and segregants have been tested for their ODAP content at the Department of Biochemistry, Dhaka University. A good number of very low ODAP content lines have been identified. However, different environments and storage period appear to influence the toxin content.

Cropping System and Agronomic Practices

Grasspea is grown mostly as a relay crop in low lying areas in amon rice fields. Broadcast sowing is done in rice field with heavy moisture 4-5 weeks before harvest of paddy following a seed rate of 30-40 kg/ha. Generally, last week of October till second week of November is the suitable time for grasspea sowing. A small area is grown as an intercrop with a row of grasspea between two rows of sugarcane. Chemical fertilizers and pesticides are not used in its cultivation. Some rhizobial strains compatible with grasspea nodule formation and high yield have recently been identified by BARI (Bangladesh Agricultural Research Institute), BINA (Bangladesh Institute of Nuclear Agriculture) and BAU (Bangladesh Agriculture University).

Consumption

Grasspea is used mainly as split ‘dal’ in making a soup-like preparation which is eaten with rice. The khesari powder (*besan*) is used in making *pakoras* or *boras, chapatis* or *dal puri*. Boiled pods and roasted seed mixed with rice are also consumed by the villagers. *Khichuri*, which includes mixture of rice, khesari dal and spices boiled into a porrage is a poorman's meal. Soaking overnight and decanting water has been found to be completely safe for comsumption. This method needs to be popularized.

Seed Production

BARI is responsible for production and supply of breeders seed and pre-foundation seed of the released varieties. Bangladesh Agricultural Development Corporation (BADC) produces foundation and certified seed. Since BADC has limited capabilities, NGO's and private seed companies should be involved in quality seed production and supply to the growers.

Marketing

During March, farmers harvest grasspea from the field. Majority of the marginal farmers sell grasspea just after harvest. Usually they keep a portion of their harvest for their own consumption and seeds for next year cultivation. So during this time there is more supply of grasspea in the market. Consequently the price becomes low which ultimately discourage farmers to cultivate this crop. Table 5 shows the distribution pattern in profit out of pulse trading.

Constraints

Virtually we could not start characterization of the germplasm. We have only evaluated the germplasm for limited agronomic characters. Moreover, for ODAP analysis, we are following S.L.N. Rao's colorimetric method, which is slow in analyzing large number of samples. Laboratory facilities and overall infrastructure for HPLC which accelerates ODAP analysis need more support.

Table 5. Price of pulses in 1985

Cost of production (Tk kg^{-1})	3.00
Marketing cost at growers' level (Tk kg^{-1})	0.09
Marketing cost at traders' level (Tk kg^{-1})	1.01
Total investment (Tk kg^{-1})	4.10
Price received by growers (Tk kg^{-1})	5.75
Price paid by consumer (Tk kg^{-1})	11.27
Absolute profit (Tk kg^{-1})	7.17
Profit share of growers (Tk kg^{-1})	26%
Profit share of traders	74%

Source: Elias (1991)

Research Priorities

More emphasis needs to be given to :

1. Collection of germplasm, its evaluation and utilization in breeding superior cultivars.
2. Breeding for multiple disease resistance like downy mildew and powdery mildew.
3. Breeding salinity tolerant varieties for southern belt.
4. Short duration varieties suitable for relay and intercropping.
5. Breeding dual purpose varieties for grain and fodder.
6. Breeding low-toxin varieties with better nutritional qualities for consumer acceptance (safe level of toxicity should be determined).
7. Strengthening linkages with national and international agencies working on grasspea.

References/Literature consulted

Bangladesh Bureau of Statistics. Statistical Yearbook of Bangladesh, 1980.

Bangladesh Bureau of Statistics. Statistical Yearbook of Bangladesh, 1992.

Bangladesh Bureau of Statistics. Yearbook of Agricultural Statistics of Bangladesh, 1992.

Bangladesh Bureau of Statistics. Statistical Pocket book of Bangladesh, 1993.

Bangladesh Bureau of Statistics. Monthly Statistical Bulletin of Bangladesh, March 1993.

Bangladesh Agricultural Research Institute. Annual Reports on Pulses Breeding. Pulses Research Centre, 1987-88 to 1992-93.

Elias, S.M. 1991. Socioeconomic Constraints Limiting Pulses Production. Pp. 169-175 *In* Advances in pulses research in Bangladesh: Proceeding of the Second National Workshop on Pulses, 6-8 June 1989, Joydebpur, Bangladesh and International Crops Research Institute for the Semi-arid Tropics, Patancheru, A.P. 502 324, India.

Quader, M. 1985. Genetic Analysis of Neurotoxin Content and some Aspects of Reproductive Biology in *Lathyrus sativus* L. Ph. D thesis submitted to the Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012, India.

Genetic Resources of Grasspea (*Lathyrus sativus* L.) in Bangladesh

C.D.M. SARWAR, M.A. MALEK, A. SARKER AND M.S. HASSAN

Introduction

Grasspea (*Lathyrus sativus* L.) is cultivated in Bangladesh since times immemorial. It grows all over Bangladesh with an acreage of 239.343 hectare, production of 174 245 tonne and the productivity of 728 kg per hectare. Among the pulses, grasspea occupies the highest acreage (33%) and production (34%). This crop is generally sown in October/November and harvested during March.

Bangladesh is situated between 20°34' - 26°38' N latitude and 88°01' - 92°41' E longitude and is divided into thirty agro-ecological zones. Out of these thirty, farmers of four agro-ecological zones do not cultivate grasspea. A drought situation prevails in the Barind area of greater Rajshahi district while salinity is common in some of the areas in southern part of Bangladesh which are at low altitude. This indicates that a wide range of environmental diversity is present in grasspea cultivation area. Grasspea contains ODAP (β-N-Oxalyl-diaminopropionic acid) a neurotoxin, which could increase in drought and decrease in saline condition (Haque *et al.* 1993).

Uses

The main use of grasspea is its seed. It is the principal source of protein to the poor. The split seeds are used as soup and as component of daily diet of the villagers. Besides, the flour/powder of grasspea seeds called *besan* is used for preparing different food items e.g. *pakoras, chapati, dalpuri* etc. During Ramdan, majority of the *ifter* items are prepared by Grasspea seed or *besan*. Moreover, in some parts of Bangladesh, the young tendrils of grasspea plant are consumed as leafy vegetable.

In some areas grasspea is grown for fodder purpose. Cattle are allowed to graze in the field during vegetative stage. Bundles of grasspea plant are sold in market as fodder. After threshing, the dried hay and after milling the bran of grasspea seed are also used for cattle food. Thus the grasspea has diversified uses in Bangladesh both as a food cum fooder crop.

Cropping patterns

The major cropping patterns that includes grasspea in Bangladesh are as follows:

July/Aug. - Oct./Nov.	Oct./Nov. - March	March - July/Aug.
Transplanted amon	Grasspea	Fallow
Broadcast amon	Grasspea	Fallow
Transplanted amon	Grasspea	Broadcast Aus/jute

Generally grasspea is cultivated as a relay sole crop in transplanted amon rice/ broadcast amon rice field. Farmers broadcast over night soaked or unsoaked grasspea seed in the rice field 3-4 weeks before harvest. The usual time of sowing ranges from last week of October to middle of November. At the time of sowing, there should be abundant moisture in the field. By the time, the rice is harvested, the grasspea plant attains almost 3 weeks growth. Gradually the crop canopy covers the land which limits the evaporation loss of residual moisture ensuring judicial use of residual moisture.

In some places grasspea is cultivated as sole crop following usual land preparation. Grasspea mixed with mustard, linseed and safflower and relayed in transplanted among rice field are also common in some areas. Farmers generally use tall type mustard i.e *Brassica juncea* as a mixed crop with grasspea. Use of tall type compound crop with grasspea has two advantages. First, it gives additional crop from the same piece of land without loss of yield of main crop. Secondly, it provides support to the crop canopy of grasspea for better utilization of solar energy. Grasspea inter-cropping with gourd and sugarcane is also practiced by the farmers in some areas. So, traditionally grasspea is being grown following diversified methods of cultivation.

Germplasm Collection

Upto 1980, there were few collections of grasspea, along with other pulses, and agronomic evaluation of those collections were made. First systematic collection was made by Dr. Van der Maesen (then at ICRISAT) in 1979. During 1980 and 1981, Dr. Nazmul Haque of Southampton University, U.K. and Scientists from Bangladesh Agricultural Research Institute (BARI) made systematic collection of different pulses from Rajshahi and Khulna Divisions of Bangladesh. These germplasm collecting missions were financed by the Food and Agriculture Organization (FAO). Major part of these collections were either damaged or lost due to lack of proper storage facilities. Particularly the passport data of the accessions collected are not available. Subsequently, in 1992 and 1994, Pulses Research Centre, BARI made four collecting missions to collect landraces of different legumes. Besides, a separate collection programme in collaboration with the Department of Agriculture Extension on grasspea were made in 1992, 1993 and 1994. (Sarwar and Malek 1995). A total of 2078 germplasm of grasspea were collected from 55 districts of Bangladesh (Table 1). The area covered are shown in Fig.1 and Table 1. The germplasm are available at Pulses Research Centre (PRC) and Genetic Resources Centre (GRC) of BARI for research purpose. In 1995, in collaboration with International Centre for Agricultural Research in the Dry Areas (ICARDA) and Centre for Legumes in Mediterranean Agriculture (CLIMA) collection trip was made under "Collection and conservation of Bangladeshi landraces of Lentil and *Lathyrus*" project. Sixty two grasspea accessions were collected.

Table 1. Grasspea germplasm collected from different districts of Bangladesh

Districts	No. of accessions	Districts	No. of accessions	Districts	No. of accessions
Pabna	68	Jhalokati	45	Tangail	17
Sirajganj	30	Barguna	4	Majikgonj	28
Bogra	34	Patuakhali	71	Dhaka	13
Joypurhat	14	Barisal	113	Narayanganj	13
Rajshahi	116	Bhola	56	Munshiganj	1
Chapai Nawabganj	44	Laximpur	73	Shariyatpur	25
Natore	24	Noakhali	40	Madaripur	60
Nowgaon	46	Feni	25	Gopalganj	28
Gaibandha	20	Chittagong	27	Faridpur	58
Rangpur	42	Comilla	29	Rajbari	25
Kurigram	11	Chanpur	32	Kusthtia	35
Lalmonirhat	19	Bramanbaria	39	Meherpur	14
Nilphamari	39	Narshindhi	5	Chauadanga	23
Dinsjpur	63	Gazipur	12	Jhenaidah	41
Tahaurgaon	8	Kishoregonj	33	Mgaura	16
Satkhir	67	Netrakona	31	Narail	38
Khulna	40	Mymensingh	58	Jessore	97
Bagerhat	57	Sherpur	13		
Pirojpur	55	Jamalpur	39	**Total**	**2 078**

Database Management

The passport data sheets of the collected grasspea germplasm accessions have been kept in the field books and are available with the Pulses Research Centre, Genetic Resources Centre and the Central Library of BARI and CDP. However for ease of information handling and transfer, a database management called Grass-BDB has been developed at Pulses Research Centre. About one thousand five hundred entries have already been entered into the database. The rest of the entries are also being documented. The database covers only the passport information of the germplasm. It is planned to incorporate the evaluation data also to this database.

Evaluation

In 1993-94, the materials collected from Rajshahi Division (Northern part) and coastal area (Southern part) of Bangladesh were evaluated at BARI. Each entry was grown in 1.5

Fig. 1. Map showing different districts of Bangladesh (The shaded ares are not included in the grasspea collection programme)

Table 2. Range, mean, standard deviation and co-efficient of variation of local germplasm

Characters	**Range**	**Mean**	**SD**	**CV(%)**
Days to 50% flowering	57.00 - 91.00	79.00	5.10	6.5
Days to maturity	117.00 - 128.00	125.00	2.70	2.2
Pod length (cm)	2.70 - 3.50	2.91	0.12	4.2
Seeds/pod	3.00 - 5.30	3.90	0.42	10.8
Yield (kg/ha)	960.00 - 2 502.00	1 577.00	44.30	21.4

m row plot at a distance of 50 cm between rows. Days to 1st and 50 percent flowering, days to maturity, pod length, seed per pod and 1000-seed weight were recorded (Table 2). Table 3 shows summary statistics of two populations on days to 1st and 50% flowering. The germplasm from Rajshahi Division and coastal area are designated as population 1 and population 2, respectively. The ODAP content of these germplasm were partially analysed. The ODAP content ranged from 0.04 - 0.75% with a mean of 0.32% and coefficient of variation 31.8%. Around 788 germplasm collected during 1994 from major grasspea growing area have been evaluated, and the data are being analyzed.

Table 3. Statistical analysis of germplasm for flowering duration

Population	Mean	Minimum value	Maximum value	Range	Skewness	Kurtosis	SD
Days to 1st flowering							
Population 1	64	48	78	30	-0.406**	-0.201	5.5
Population 2	61	41	73	32	-1.037**	-0.400	9.4
Days to 50% flowering							
Population 1	71	55	88	33	-0.534**	0.707	5.0
Population 2	69	43	82	39	-1.362**	0.427	10.1

International Linkages

Free exchange of germplasm among grasspea growing countries would ensure better utilization of grasspea genetic resources to improve the crop through different national programmes. The germplasm collected by the Pulses Research Centre of Bangladesh Agricultural Research Institute has been sent to ICARDA and CLIMA. One thousand one hundred and fifty three (1153) and two hundred (200) accessions have been sent to ICARDA and CLIMA, respectively. The present *Lathyrus* diversity could be helpful not only to the breeding programme of BARI but also to other countries, national programmes concerned with grasspea improvement.

There had been a joint collection programme between PRC (BARI), Bangladesh, CLIMA, Australia and ICARDA, Syria during 1995. Sixty two grasspea germplasm were collected from 16 districts of Bangladesh. About 50 percent seed of each accession was kept at PRC, BARI and another half was sent to ICARDA. A number of low-toxin, early maturing and high yielding lines (biomass) have been selected from the Bangladesh germplasm by CLIMA, Australia.

Future Emphasis

Though grasspea is an underutilized legume, however, its cultivation has gradully increased over years (Fig. 2) in Bangladesh. These areas are specific for grasspea cultivation and no other crops can replace this crop. Farmers always prefer to grow this crop because of its hardiness, minimum labour and low inputs. For the improvement of grasspea and its better utilization, besides enriching collections, more emphasis need to be given on characterization, evaluation, documentation and conservation of availble genetic resources. In overall perspective the following points should be taken into consideration.

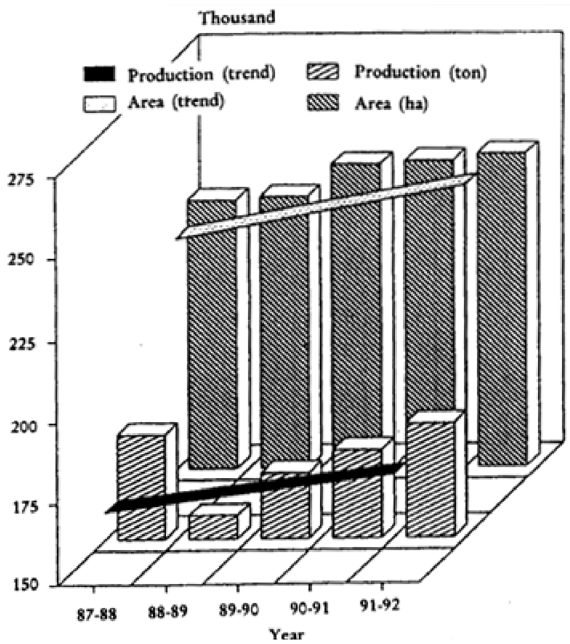

Fig. 2. Trend in area and production of grasspea in Bangladesh

1. Free exchange of grasspea germplasm among the grasspea growing countries

2. Collection efforts should be prioritized at national level for undertaking collections from unexplored areas.

3. A global database network should be established under the control of IPGRI, so that grasspea growing countries could get information regarding germplasm as well as literature on grasspea. The database management also helps to identify any duplication of the germplasm collected.

4. A central genebank should be established at ICARDA where a set of germplasm from each country should be stored for future use.

References/Literature consulted

Bangladesh Bureau of Statistics. Statistical Yearbook of Bangladesh, 1992.

Bangladesh Bureau of Statistics. Yearbook of Agricultural Statistics of Bangladesh, 1992.

Bangladesh Bureau of Statistics. Statistical Pocket book of Bangladesh, 1993.

Bangladesh Agricultural Research Institute. Annual Reports on Pulses Breeding. Pulses Research Centre. 1987-88 to 1992-93.

Haque, R.M. Hussain and L. Labein. 1993. Effect of salinity on β-ODAP and other free amino acids in *Lathyrus sativus*. Lathyrus Newsletter. Third World Medical Research Foundation, New York, USA and London, U.K.

Sarwar, C.D.M and M.A. Malek. 1995. Collecting Grasspea Germplasm in Bangladesh. (Submitted for publication in IPGRI Newsletter for Asia, The Pacific and Oceania).

Appendix 1. Passport data sheet used by BARI for recording information from collecting sites

BARI ACC.NO	: CGI-08931654	DONOR'S NAME	: Mr.Nizam Uddin
CROP SPECIES	: *Lathyrus sativus* L.	COMMON NAME	: Khesari
ENGLISH NAME	: Grasspea	COLLECTION'S NAME	: MS-1083
COLLECTOR (S)	: CDMS	DATE	: 10.06.93
VILLAGE	: Bakkhli	UNION	: Syedpur
THANA	: Sitakunda	DISTRICT	: Chittagong
LATITUDE		LONGITUDE	
ALTITUDE			

SOIL TEXTURE	**TOPOGRAPHY**	**STATUS**	**SAMPLE SOURCE**
Sandy	Swamp	Wild	Filed
Sandy loam	Flood plain	Weed	Threshing floor
Loam	Level	Landrace	Market
Silt loam	Undulating	Primitive cultivar	Institute
Clay		Breeder line	Others
Silt			

HABITAT	**FREQUENCY**	**MATERIAL**	**SAMPLE TYPE**	**SAMPLING METHOD**
Cultivated	Abundant	Seed	Population	Bulk
Natural wild	Frequent	Vegetative	Pure line	Random
Disturbed wild	Occasional	Both	Individual plant	Selective
Others	Rare			

ORGAN USED AS PRIMARY PRODUCT : Seed, Green fodder, Dry fodder

CULTIVATION PRACTICES

a)	Sowing date	:
b)	Harvesting date	:
c)	Season	: Kharif I, Kharif II, Rabi
d)	Monoculture	: Mixed
e)	Relay	:
f)	Mixed with	:
g)	Method of farming	: Rainfed, Irrigated

ADDITIONAL NOTES :

Genetic Evaluation and Varietal Improvement of Grasspea in Nepal

C.R. YADAV

Introduction

A large number of summer and winter grain legumes are grown in varied agro-climatic conditions in Nepal. In aggregate, grain legumes occupy 13% of the total cultivated area and rank fourth in terms of area and production after rice, maize and wheat (CBS 1994). Grasspea is the second important legume after lentil in terms of area and production. Though the area and production of grasspea have indicated declining trends from 1985/86 to 1993/94, the productivity is almost similar. The area under cultivation, production and productivity for total grain legume and for grasspea in Nepal is presented in Table 1a and b, respectively.

Cropping System and Sowing Practices

The cropping intensity of Nepal is generally high and ranges between 100 to 300 percent. However, the average is 180 percent. The adaptation of grasspea in marginal areas like water logged lowland rice areas, plays an important role in increasing the cropping intensity. In such areas, farmers can not take a good winter crop of wheat, oilseeds or other winter legumes. It is mostly relay sown in late maturing rice fields during November when field moisture is at saturated condition. A seed rate of 30-40 kg/ha is used. Usually the seeds are soaked overnight and mixed with the fresh

Table 1. (a) Area, production and productivity of grain legumes in Nepal

Year	Area('000 ha)	Production ('000 MT)	Productivity(kg/ha)
1985/86	253.66	146.16	576
1986/87	262.94	166.09	632
1987/88	254.57	139.49	527
1988/89	265.73	156.68	590
1989/90	268.54	163.23	608
1990/91	267.72	161.32	603
1991/92	261.86	154.54	590
1992/93	319.78	191.14	598
1993/94	321.90	195.48	607

Table 1. (b) Area, production and producitivty of grasspea in Nepal

Year	Area ('000 ha)	Production ('000 mt)	Productivity (kg/ha)
1985/86	53.33	28.12	521
1986/87	53.98	28.92	536
1987/88	44.02	19.51	443
1988/89	38.58	19.81	513
1989/90	38.13	21.19	556
1990/91	40.86	22.99	563
1991/92	38.72	20.70	535
1992/93	40.06	20.04	500
1993/94	40.88	21.00	514

cowdung before sowing. It is believed that mixing of cowdung with seed helps and protects the seed from birds, insects and also enhances the germination.

Normally no additional chemical fertilizer is used for grasspea cultivation, at the same time, farmers also do not use any insecticides to protect the crop against pests. Grasspea is commonly mixed with linseed during relaying in standing crop of rice before 15-20 days of harvest.

Utilization

Grasspea is used in many ways for human and cattle consumption in Nepal. Some of the major uses are :

i) During the month of February, the young vegetative parts are plucked (4-6 cm length) and cooked as green vegetables. Also they are rolled and dried for off-season use as vegetable.

ii) Green pods and seeds are eaten as snacks directly or whole pods are cooked and eaten as vegetable.

iii) Dried Grains

(a) Split '*dal*' - Dried grains are splitted to make '*dal*' and consumed with rice.

(b) Flour - Flour is used for pancake like preparation (*badi* or *pakoda*). Increasingly grasspea flour is being used to adulterate the high price flour like chickpea and mung bean flour.

(c) Feed - Ground splitted grain or flour are used as feed for lactating cattle or for bullock at the time of heavy field use like land preparation.

iv) Fodder - Grasspea is used as forage from the young vegetative stage to maturity. The threshed dried crop residue commonly finds its use as food.

v) Soil health - Although no systematic study has been made to demonstrate the contribution of grasspea soil improvement, however, farmers strongly feel that grasspea cultivation maintains the soil fertility level of their poorly drained land better than any cereals or oilseeds.

Lathyrism

Observation based upon systematic survey on lathyrism in Nepal is not available since no study has been done so far to find out the extent of lathyrism problem in Nepal. Preliminary interviews conducted during the collection of germplasm indicated that the problem is not common and wide spread due to lower consumption level. However, a few suspected cases observed and majority of persons interviewed were found to be aware of the problem both in human and livestock population. There was indication of shifting to other crops because of lathyrism problem and thus area has decreased over years.

Germplasm Collection and Evaluation

Until 1986, grasspea did not receive any research attention from National Grain Legumes Research Programme (NGLRP). It was realized that grasspea improvement needs to be given emphasis considering its hardy nature and continued important role, it has played in cropping system. Therefore, some improvement works were initiated since 1986. Some collection of local germplasm was made and a collaborative working relationship was established with Agriculture Canada Research Station, Morden Manitoba, Canada through International Development Research Centre (IDRC). Seventeen local germplasm were sent to Dr. C.G. Campbell for the determination of the low ODAP content and to initiate the hybridization for the incorporation of low ODAP character in local germplasm.

In the mean time, twenty accessions of diverse origin having low ODAP were acquired from Canada and these were evaluated in observation nursery at Parwanipur. Seven local germplasm accessions were also included in the nursery. These entries in the nursery were evaluated for various morpho-agronomical characters. Summary of the observations are presented in Table 2.

Considerable variability for grain yield has been recorded. In general local germplasm lines were found to be more adapted, higher yielding, early maturing, shorter in plant height, had more number of seeds per pod but with small seed size than the introduced/exotic lines. For the first time, it was found that local germplasm lines grown in Nepal contain higher levels of neurotoxin (ODAP).

Ten local and exotic lines were selected from the germplasm nursery during 1986-87. Based upon their adaptation and yield the selected lines were tested in replicated trials (4 replication). Initial Evaluation Trial were conducted at two locations viz., Rampur (inner *terai*) and Parwanipur (*terai*) in rainfed condition. The results from Rampur are presented in Table 3.

Table 2. Comparative summary of observations on different characters of local (L) and exotic (E) germplasm lines at Parwanipur, Nepal, 1987/88.

Characters	Mean		Range		Standared Deviation		CV(%)	
	L	E	L	E	L	E	L	E
Days to flower	73	83	72 - 74	69 - 99	0.75	9.96	1	12
Days to maturity	129	139	-	134 - 138	-	2.78	-	2
Plant height(cm)	40	97	26 - 51	44 - 138	0.96	2.00	2.4	2
No. of pods/plant	42	44	26 - 71	26 - 70	16.00	13.64	38	31
No. of seeds/pod	4	3	-	2 - 4	-	0.6	-	20
100 seed wt (g)	4	12	3 - 5	3 - 17	0.76	3.96	19	28
Grain yield (kg/ha)	844	469	669 - 1133	200- 807	194.00	216.00	23	46
ODAP (%)	0.2	994	0.2 720	0.3 345	-	1.80	-	-

Results revealed that the top yielders were all local germplasm lines. The Dhanush local 21 produced highest grain yield (1565 kg/ha). The lowest grain yield was produced by Indian exotic line NC 8A-74. The variability in grain yield was very high in introduced line which might have resulted in high coefficient of variation. Early and final plant stands were found better in local lines than exotic. On an average, local lines were also early in maturity, had higher number of pods per plant and seeds per pod than the exotic lines. This may explain the higher yielding ability of the local lines. Large seed size was observed in some of the exotic lines. In general this trial also revealed that local lines are very well adapted in Nepalese conditions.

Table 3. Performance of grasspea lines in Rampur, Nepal (1987-88)

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pods/ plant	Seeds/ pod	100 seed wt. (g)	Grain yield (kg/ha)	Ranks
Local 26(Siraha)	81	139	61	39	3.0	5.2	1 192	4
Local 23(Siraha)	73	125	56	28	3.3	5.2	1 197	2
NC 8B-2	92	145	59	12	3.0	6.3	101	8
NC 8A-74(India)	95	145	50	15	3.6	10.2	74	9
NC 8A-97 (Bangladesh)	84	130	40	39	2.8	5.3	718	6
Local 21(Dhanush)	83	132	61	29	3.5	4.7	1 565	1
Local 20(Parsa)	82	134	49	39	3.4	4.5	1 147	5
NC 8A-76(India)	85	142	66	25	2.9	8.9	287	7
Local 24(Parsa)	71	125	51	19	4.1	4.5	1 193	3
NC 8A-84(France)	96	144	55	18	2.7	11.0	-	
Mean	84	136	55	26	3.2	6.6	830	
F Test							NS	
CV (%)							32.6	

A systematic collection of grasspea local germplasm was carried out during 1987 with the financial assistance from IDRC. The survey and collection were made mostly in the *terai* and inner *terai* regions and some parts of sub-tropical basins. A total collection of 76 samples were split into two lots. One lot was sent to Dr. C.G. Campbell in Morden, Manitoba, Canada and the other lot was sown at Rampur, Nepal to multiply the seeds and for preliminary characterization.

A total of 88 samples which include 76 new samples collected during 1987, five local germplasm collected earlier and seven introduced lines, were sown in germplasm observation nursery. Only seventy two samples from 1987 collection germinated and three of the introduced lines failed to produce any yield. Various observations taken during crop season have been summarized for local germplasm in Table 4.

Table 4. Comparative summary of observation on different characters of local germplasm at Rampur, Nepal (1987-88)

Characters	Mean	Range	Standard Deviation	CV(%)
Days to flower	85	68 - 94	5.1	6
Days to maturity	135	125 - 139	5.4	4
Plant height (cm)	71	46 - 106	3.1	4
No. of pods/plant	36	13 - 59	8.7	24
No. of seeds/pod	4	2 - 5	0.6	15
1000 seed wt (g)	42	30 - 60	6.7	16
Grain yield (kg/ha)	987	134 - 1697	37.5	4

Considerable variability was observed in yield, number of pods per plant, seed size and days to flowering. The exotic germplasm had mostly white colour flower whereas, no white coloured flower was observed in local germplasm. Other interesting differences observed were that, the local germplasm lines had mostly four leaflets and generally five or six seeds per pod, while the exotic lines had only two leaflets and generally less than four seeds per pod. Hence, it can be deduced that the local germplasm lines had characters which can be advantageous for higher yield.

Coordinated Varietal Trial

Statistically, locations were found highly significant. During 1989-90, grain yield was found highly significant among genotypes. Mean grain yield was 675 kg/ha over four locations (Table 5). However, highest grain yield was produced by LS 26 (855 kg/ha), followed by LS 25 (851 kg/ha) and Parsa local 23 (765 kg/ha).

In Coordinated varietal trial conducted in 1990-91, LS 32 produced highest mean grain yield (1633 kg/ha) at Parwanipur and Parsa local 23 (1814 kg/ha) at Rampur. The mean grain yield was 930 kg/ha over three locations (Table 5). However, Parsa local 23 was found top yielder (1180 kg/ha) followed by LS 26 (1096 kg/ha) and LS 57

Table 5. Mean grain yield of genotypes in grasspea coordinated varietal trial over years and locations

Genotypes	1989-90 (4 locations)	1990-91 (3 locations)	Grand mean
Parsa Local 23	765	1 180	973
NC 8A-76	550	733	642
Parsa Local 20	753	1 001	877
LS 26	855	1 096	977
NC 8A-97	528	926	727
LS 25	851	1 065	958
LS 58	746	639	693
LS 32	698	1 096	857
LS 09	583	811	697
LS 01	-	525	525
LS 57	-	1 077	1 077
Siraha local 23	-	1 013	1 013
Mean	675	930	835
F. test	**	**	
CV (%)	36	32	
	Pooled Analysis		
Location	**	**	
Genotype × Location	NS	*	

*,** significant at 5 and 1% level of probability.

(1077 kg/ha). The genotypes differ from location to location in terms of grain yield. Genotypes × location interaction was also found significant.

The grasspea genotypes tested from 1986-87 to 1990-91 revealed that local landraces performed better in grain yield and are more adapted in *terai*/inner *terai* environments in Nepal than the exotic lines. Therefore, these local landraces can be used in hybridization programme with exotic lines having low ODAP content for the development of grasspea genotypes having high yield and low ODAP content.

A socio-economic study is urgently needed to determine the extent of lathyrism in Nepal. In general grasspea would continue to be an important source of plant protein in the dietary needs of Nepalese and concentrated efforts are required to increase its productivity.

References/Literature Consulted

Adhikari, B.R., M.P. Bharti, R.P. Sah and R.K. Neupane. 1987. Collection of *Lathyrus sativus* germplasm in Nepal. Nepal Agricultural Association, Kathmandu, Nepal.

Bharti, M.P. 1986. Status of *Lathyrus sativus* among grain legumes in Nepal. Pp. 142-145 *In* Lathyrus and Lathyrism (ed) A.K. Kaul and D. Comber, Third World Medical Research Foundation, New York.

Bharti, M.P. and R.K. Neupane. 1988. Situation of *Lathyrus sativus* cultivation and screening of germplasm in Nepal. INILSEL Workshop, London, 2-6, May 1988.

CBS 1994. Agriculture Statistics of Nepal. ASD, Thapathali, Kathmandu, Nepal.

Rachie, K.D. and M.P. Bharti. 1985. A consultancy report on Pulses Improvement in Nepal. Integrated Cereal Project, Department of Agriculture, Nepal.

Status of *Lathyrus* Research and Production in Nepal

R.K. NEUPANE

Introduction

Grain legumes are important crops in Nepal in many ways. They play an important role in providing the bulk of protein requirement for human and animal population and in restoring the soil fertility. They constitute an integral part of various cropping patterns and have good export potential. More important grain legume crops (given in order of their national importance) are lentil (*Lens culinaris* Medik.), grasspea (*Lathyrus sativus* L.), chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* (L.) Millsp.), soybean (*Glycine max* (L.) Merr.) and black gram (*Vigna mungo* (L.) Hepper).

Grasspea is one of the important grain legume crops of Nepal. The grain is used as human food and cattle feed and the straw as fodder. In terms of area and production it ranks second after lentil. Grasspea cultivation is mostly restricted to water logged lowland areas where farmers usually can not take a good winter crop of wheat, oilseeds or other legumes. The predominant cropping pattern is relay planting of grasspea with late maturing rice during November when the field moisture is at optimum and the crop is grown occasionally mixed with linseed and lentil.

Area, Production and Productivity

Currently grasspea is cultivated in approx 38 000 ha with average productivity of 0.507 t/ha only. This represents 12 percent of area and 9.5 percent of production of all grain legumes. Grasspea is cultivated in all the five regions of Nepal (Table 1). Ecologically 97 percent of area and production are recorded from the *terai*/inner *terai*. Within *terai* and inner *terai* region, cultivation is more concentrated in southern part which is low lying and remains waterlogged for longer period. Regional distribution of the crop indicated that 56 percent of its total cultivation area (and production) is in central and 35 percent in the eastern region (Table 1).

Significant changes in area and production of grasspea have occurred during the past decades. Earlier, grasspea used to cover maximum area among grain legumes. However, lentil has taken the lead. For the period 1983-84 - 1992-93, declining trends in area and production of grasspea were recorded with a marginal increase in productivity (Table 2). Compared to 1971 figures the number of holdings growing grasspea were reduced by 13 percent, and the size by 37 percent in 1991 (Neupane 1995).

Table 1. Area (ha), production (mt) and productivity (mt/ha) of grasspea by ecological zones and regions (1993-94)

Ecological Zones	Area (ha)	Production (mt)	Productivity (mt/ha)
High Hills	-	-	-
Mid Hills	1 260	630	0.500
Terai	37 010	18 770	0.507
Development Regions			
Eastern Region	13 520	6 930	0.513
Central Region	21 400	10 730	0.501
Western Region	2 010	1 040	0.517
Mid-Western Region	1 010	520	0.515
Far-Western Region	330	180	0.545
Total	38 270	19 400	0.507

Table 2. Trends in area, production and productivity 1983-84 - 1992-93

Crops	Change per annum		
	Area ('000 ha)	Production ('000 mt)	Productivity (kg/ha)
Lentil	+ 8.52	+ 5.90	+ 13.63
Chickpea	- 0.42	+ 0.06	+ 8.78
Pigeonpea	+ 1.75	+ 1.45	+ 11.55
Black gram	+ 0.75	+ 0.66	+ 16.08
Lathyrus	+ 1.73	+ 0.47	+ 8.15
Soybean	+ 0.78	+ 5.70	+ 5.06
Horse gram	- 1.03	- 0.44	+ 1.64
Total	+ 8.70	+ 7.90	+ 12.60

Germplasm Collection

The first systematic collection mission for grasspea was organized in April - May 1987 by Nepal Agricultural Association (NAA) in collaboration with International Development and Research Centres (IDRC). Seventy six accessions were collected from 18 districts of Nepal (Adhikary *et al* 1987). Subsequently, a second collecting mission was organized in 1985 jointly by Centre for Legumes in Mediterranean Agriculture (CLIMA) and Nepal Agricultural Research Council (NARC) and 46 accessions were further added to existing germplasm collection.

Characterization and Evaluation

Grasspea germplasm collected during 1987, were grown at Rampur for characterization and evaluation (Furman and Bharati, 1989). Data on 13 agro-morphological characters were recorded as per IBPGR descriptor list. The characterization and evaluation of grasspea germplasm collected during 1995, will be conducted by the Grain Legume Research Programme at Rampur, in collaboration with the Plant Genetic Resources Unit (PGRU), NARC, Khumaltar.

Diversity in germplasm evaluated

A wide range of variability was recorded in plant height, number of pods per plant, seeds per pod, 100 seed weight and grain yield of genotypes (Table 3). Seventeen exotic germplasm lines introduced from Canada were also evaluated at Parwanipur (*terai* location). In general, local germplasm lines were found to be more adopted, higher yielding and early, but were having smaller seed size than the exotic germplasm (Bharati and Neupane 1988).

Table 3. Summary of variability recorded in 86 local germplasm accessions of *Lathyrus* grown at Rampur, Chitwan

Parameters	Mean	Minimum	Maximum	Coefficient of variability (%)
Days to 50% flowering	85.0	17.0	93.0	4.0
Days to maturity	136.0	132.0	139.0	1.4
Plant height (cm)	58.0	41.0	76.0	114.9
Pods/plant	46.0	18.0	143.0	43.7
Seed/pod	3.8	2.9	5.5	14.3
100 seed wt (g)	4.1	2.7	6.5	16.4
Grain yield (kg/ha)	1160.0	343.0	1730.0	25.9

Varietal Improvement

Grain Legume Research Programme (GLRP) at Rampur, Chitwan coordinates research on all legumes including grasspea. Promising local and exotic genotypes were tested for their adaptation under different environmental conditions of *terai* and mid hills. At Khumaltar (1360 m), the genotype NC 8A74 recorded the highest grain yield of 0.74 t/ha with fresh biomass yield of 12 t/ha (GLRP 1987). In mid hills, fodder supply for livestock becomes scarce during winter. Hence, in addition to grain, fodder yield was also taken into consideration. In a replicated trial conducted at Dhankuta (1700 m), grain yields of 1.87 and 1.82 t/ha were recorded with fresh biomass yield of 6.12 and 5.05 t/ha from Parsa Local 20 and LTH 72, respectively (Table 4).

Varietal trials conducted at Parwanipur, Bhairahawa and Rampur over the years have indicated high yielding ability of local landraces compared to the exotic lines (Tables 5 and 6), however, local genotypes of grasspea contain high levels of

Table 4. Performance of grasspea genotypes in varietal trial at Pakhribas, Dhankuta during winter 1989

Genotypes	Plant height (cm)	Days to maturity	Pods/ plant	Grain yield (t/ha)	Fresh biomass yield (t/ha)
Parsa Local 20	32	167	17	1.87	6.12
LTH 72	40	167	40	1.82	5.05
LS 58	41	174	12	1.67	4.24
DL 21	34	166	18	1.56	2.73
Sirha Local 23	25	163	13	1.53	2.76
NC 8A-97	37	168	17	1.25	4.92
LS 01	36	166	23	1.18	2.177
NC 8A 76	34	175	10	1.17	6.69
LS 325	33	162	11	1.07	2.64
LS 57	29	162	20	0.98	3.49
NC 8A-74	35	175	6	0.90	5.67
NC 8B-232	57	176	14	0.84	8.94
Mean	36	168	17	1.32	-
F Test	*	*	ns	*	
LSD (0.05)	15.9	7.7	-	0.095	
C V (%)	36	19.0	2.0	17.6	13.2

(ODAP) toxin (>0.2%). The exotic genotypes introduced from Canada were very late and poor yielders. Selected local genotypes were crossed with genotypes with low ODAP content at Agriculture Canada, Manitoba. The segregating population was grown at Rampur during winter 1990-91. Most of the lines did not set flowers, and the remaining lines did not set fruits.

At present above research activities have been kept for maintenance of germplasm at Rampur and Parwanipur. However, as access to low ODAP content lines becomes easier, the programme will take further momentum, as grasspea is still an important crop for farmers and will continue to be important in future too.

Conservation of Germplasm

One set of active collections (both exotic and local) is maintained at GLRP headquarters at Rampur, using upright freezers. Duplicate set of germplasm collected during 1987 has been sent to Agriculture Canada for long term storage. Germplasm collected during 1995 through CLIMA/NARC collaborative programme has been taken to CLIMA, Australia for long term storage with a duplicate sample being kept at PGRU, Khumaltar for medium term storage.

Table 5. Performance of grasspea genotypes in coordinated varietal trial at Parwanipur during winter 1988

Genotypes	Plant height (cm)	Days to maturity	Pods/plant	Grain yield (t/ha)
Sirha Local 26	47	130	46	2.26
LS 25	46	133	45	2.24
Parsa Local 20	47	130	42	2.23
Parsa Local 24	47	130	55	1.90
Sirha Local 23	44	131	55	1.69
Dhanush Local 21	39	131	40	1.65
NC 8A - 97	41	130	44	1.64
NC 8A - 76	50	135	54	1.64
Mean	45	131	48	1.88
F	ns	ns	ns	**
LSD (0.05)				0.263
C V (%)				9.5

** Significant at 1% level of probability

Table 6. Performance of selected grasspea genotypes at Bhairahawa during winter 1989

Genotypes	Plant height (cm)	Days to maturity	Pods/plant	Grain yield (t/ha)
Siraha Local 26	54	139	29	1.58
LS 25	57	141	28	1.48
Parsa Local 20	60	140	31	1.48
LS 58	52	139	29	1.38
Nc 8A - 76	58	143	31	0.86
NC 8A - 97	49	139	26	1.05
Trial mean	55	140	30	1.21
F	ns	ns	ns	*
LSD	-			0.304
C V (%)	9.5	2.1	17.2	21.000

* Significant at 5% level of probability

Agronomic Research

Agronomical research on grasspea has not been conducted in Nepal so far. It is mostly relay planted in late maturing rice field during November when the field moisture is at saturated condition. A seed rate of 30-40 kg/ha is used. Usually the seeds are soaked over night and mixed with the fresh cowdung before broadcasting. Farmers are under the impression that mixing of cowdung with seed will help to protect the seed from birds and insects, and also enhance germination. Neither chemical fertilizer nor any insecticidal spray is generally used for grasspea cultivation. Grasspea is commonly mixed with linseed during relaying. In recent years it is also gaining popularity in upland areas of inner *terai* and is grown after maize with minimum land preparation and sometimes planted mixed with mustard, barley or other winter legumes.

Uses

Grasspea is used in many diverse ways both as food and fodder crop by man. Some major uses are given in another paper by C.R. Yadav in these proceedings.

Although no systematic study has been made to demonstrate the contribution of grasspea on soil improvement, farmers strongly feel that grasspea cultivation maintains the soil fertility level of their poorly drained land, better than other cereals or oilseeds.

Constraints to Production

1. *Institutional constraints :* Currently *Lathyrus* is not a priority crop for research in Nepal. Research work is only at maintenance level. Inadequate manpower, research and subsequent policy and funds for research is a problem.

2. *Agroecological constraints : Lathyrus* is mostly grown as a rainfed crop in marginal lands under minimum or zero inputs levels. Little agronomic work have been done to optimize seeding date, seed rate, plant establishment and inter/mixed cropping ratios.

3. *Genetic constraints :* Available local genotypes have high ODAP content resulting in lathyrism if consumed in excessive quantity. Besides this, tiny growth and poor harvest index are important draw backs of *Lathyrus.*

4. *Biotic constraints :* Thrips and aphids among insects and powdery mildew, rust, wilt and botrytis diseases are some of the important biotic constraints.

5. *Socioeconomics : Lathyrus* seeds have low market price, and are less preferred by consumers. Extension service for *Lathyrus* is almost nil.

Future Needs, Opportunities for Expansion

After harvesting rainfed lowland rice, a large area remains fallow during winter. Because of the versatility of *Lathryus,* both in waterlogged and drought conditions, the opportunities for area and production expansion are enormous if suitable varieties having low ODAP content along with the package of practices are made available. The adaptability of *Lathyrus* even in mid hills (1000 - 1500 m) has shown the opportunities for its cultivation and use as food, feed and fodder.

References

Adhikary, B.R., M.P. Bharati, R.P. Sah and R.K. Neupane. 1987. Collection of *Lathyrus sativus* germplasm in Nepal. Nepal Agricultural Association, Kathmandu, Nepal.

Bharati, M.P. and R.K. Neupane. 1988. Situation of *Lathyrus sativus* cultivation and screening of germplasm in Nepal. Paper presented to the INILSEL Workshop, 2-6 May 1988, London.

Furman, B.J. and M.P. Bharati. 1989. Collection and characterization of legumes germplasm in Nepal. National Grain Legumes Improvement Programme, Rampur, Chitwan, Nepal.

GLRP 1987. Annual Report - 1986-87, GLRP, Rampur, Chitwan, Nepal.

Neupane, R.K. 1995. Status of Food Legumes Research and Production in Nepal. Proceedings of FAO Regional Workshop on pulses, 1-6 April 1994, New Delhi.

Evaluation and utilization of *Lathyrus sativus* collection in India

R. B. Mehra, D. B. Raju and K. Himabindu

Introduction

Lathyrus sativus commonly known as *khesari* in India is an ancient cultigen . Its cultivation at present is mainly limited to the states of Madhya Pradesh, Bihar, West Bengal and Maharashtra but the crop is also grown in small pockets in other states.

The first ever effort to systematically collect the grasspea germplasm in India was made in 1967 when seven districts of Madhya Pradesh were surveyed jointly by Pulses Improvement Project of USAID, New Delhi; Nutritional Research Laboratory, Hyderabad; and Directorate of Agriculture and Directorate of Health, Government of Madhya Pradesh. About 600 field collections were made and analysed for BOAA at Biochemistry laboratory of USAID, at Indian Agriculture Research Institute (IARI), New Delhi and by National Institute of Nutrition (NIN), Hyderabad. Subsequently, in 1969 under a PL 480 project at IARI, New Delhi, germplasm was also obtained from other states including Bihar, Eastern U.P., West Bengal, Gujarat, and Haryana through the courtesy of the Division of Plant Introduction, IARI, New Delhi . This germplasm was evaluated for agronomc traits and for BOAA (Jain *et al.* 1974). Later during 1975 to 1977, IARI scientists made special efforts to collect germplasm from the tribal districts of Bihar (Sethi *et al.* 1987) and evaluate it for agronomic traits and BOAA. In 1992, all the germplasm at IARI was transferred to Kanpur and later to Raipur where the coodinated Programme now operates.

Under a research project entitled ‘Genetic Improvement of grasspea’ initiated in 1988 at the Division of Genetics, IARI, New Delhi, grasspea germplasm were collected from Raipur district of Madhya Pradesh, Bihar and Maharashtra and were also introduced from outside India [Afghanistan, Bangladesh, Canada, Cyprus, Ethiopia, France, Germany, Syria (ICARDA), and USSR through the courtesy of NBPGR , Pusa Campus, New Delhi].

Germplasm Evaluation

Two hundred and eighty three accessions of *Lathyrus sativus* and five other species of *Lathyrus* (*L. psuedocicera*, *L. inconspicuous*, *L. aphaca*, *L. cicera*, *L. chrysanthus*) were evaluated at the Division of Genetics, IARI, New Delhi during *rabi* 1994-95 in an augmented block design using 3 checks viz., P 24, LSD 3 and LSD 6. Simple statistics for six quantative characters viz., Plant height (cm), number of primary branches, pod length (cm), number of pods per plant, seeds per pod and 100-seed weight(g) were estimated for collections from India, Syria and Canada (Tables 1 and 2). For a limited

Table 1. Estimates of statistics measuring central tendency in grasspea collection at IARI, New Delhi

Character	India (223)*		Syria (48)		Canada (12)	
	Mean	Mode	Mean	Mode	Mean	Mode
PLT HT	83.90	79.00	87.10	79.0	87.30	84.0
PRI BR	6.09	6.00	6.15	6.0	6.50	7.0
POD LTH	2.92	3.05	3.60	4.0	3.08	3.1
POD/PLT	26.80	20.00	21.30	25.0	40.00	38.0
SD/POD	2.96	2.90	3.00	3.0	2.96	3.0
SD WT	8.90	9.00	10.60	10.0	13.16	14.0

*Number of assessions are given in parenthesis.

Table 2. Estimates of statistics measuring dispersion in grasspea collection at IARI, New Delhi

	RANGE			C.V.(%)		
Character	India (223)	Syria (48)	Canada (12)	India (223)	Syria (48)	Canada (12)
PLT HT	57 - 110	70 - 110	59 - 101	11.6	12.7	17.0
PRI BR	3 - 10	4 - 8	4 - 8	21.0	14.4	17.2
POD LTH	2.1 - 4.0	4 - 6	3.0 - 3.4	13.0	24.0	4.2
POD/PLT	10 - 90	15 - 38	22 - 70	49.0	30.1	30.6
SD/POD	2.0 - 2.7	3.0 - 3.5	2.5 - 3.0	9.5	3.3	4.8
SD WT	5.42 - 19.20	5.9 - 20.0	5.8 - 18.0	25.0	33.5	27.0

number of exotic collections from the remaining countries only means were worked out (Table 3).

Indian material was mostly blue flowered with light to dark brown smooth and speckled seeds. However, a white flowered and a red flowered lines with white and reddish brown seed coat were also observed. Flower size was small in these lines. According to Jackson and Yunus (1984) such accessions appeared to be more primitive. The accessions from Canada and Syria and from other countries were generally white flowered with white bold seeds.

Accessions from Cyprus had the maximum plant height while accessions from the USSR and other species group were shorter in plant height. The Indian accessions showed wide range for this trait. The mean number of primary branches was maximum in accessions from Canada, whereas the range for primary branches was maximum in Indian collections.

Table 3. Mean performance for six agronomic traits in other exotic germplasm collection at IARI, New Delhi

Character/ No. of assessions	France (4)	Bangladesh (4)	Ethiopia (2)	Cyprus (2)	Afghanistan (1)	Germany (1)	USSR (1)	*Lathyrus* Species (5)
PLT HT	81.00	90.10	80.50	95.50	85.0	72.0	59.0	47.60
PRI BR	5.20	5.70	5.00	5.50	5.0	5.0	5.5	5.40
POD LTH	3.10	3.03	3.25	3.35	3.3	2.8	2.8	4.80
POD/PLT	32.20	31.30	24.05	50.00	18.0	15.0	27.5	-
SD/POD	3.02	3.00	2.70	3.10	2.7	2.8	2.8	4.20
SD WT	17.09	9.87	9.36	10.96	7.5	24.0	21.0	8.98

* Number of accessions are given in paranthesis.

Pod length was maximum in species group followed by accessions from Syria. These accessions showed a higher estimated value for mode than mean indicating that the accessions having higher pod length were preponderant in Syrian collections. Accessions from Cyprus and Canada had the maximum mean number of pods per plant but the range for this trait was maximum in Indian accessions. Mean number of seeds per pod was maximum for accessions in the other species group. The accessions from Cyprus and France were almost at par with the Syrian accessions for number of seeds per pod. Indian collection had the mean number of seeds per pod similar to Canadian accessions. Accessions from Germany recorded maximum 100-seed weight while accessions from Afganistan had the least 100-seed weight.

Phenotypic coeffiecient of variation (PCV) for plant height was maximum in Canadian accessions. While for number of primary branches , pods per plant and seeds per pod, Indian accessions showed the maximum PCV indicating that little selection pressure has been applied and Indian collection more or less represented the landraces available in different states of India. Syrian accessions showed highest PCV for pod length and 100-seed weight.

Among the collections from different countries, accessions from Syria and Canada showed least variability for number of seeds per pod. This showed that some selection for higher number of seeds per pod has gone into accessions from these two countries.

Canadian and Syrian accessions had higher mean 100-seed weight and coefficient of variation as compared to Indian accessions. Such material may be more appropriate for planting under upland conditions but not suitable for *utera* sowing in Indian conditions where small seeded lines are preferred.

The estimates of correlation coefficient between the different characters (Table 4) showed that pod length and number of seeds per pod were positively associated in all the three collection groups. Plant height and seed weight also showed a positive association in Indian and Canadian collection, indicative of the fact that if environmental conditions permit, the plant height will go on elongating and resulting increased maturity duration will permit more accumulation of dry matter in the seed.

Indian collection also showed significant positive association between pod length and seed weight and between seed weight and seeds per pod, a desirable attribute. However, there is an undesirable negative correlation between seed weight and number of pods per plant.

To further examine if the collections from India, Syria and Canada showed distinctness

Table 4. Correlations between different character pairs in different germplasm groups in grasspea

Characters		Total	India	Syria	Canada
PLT HT	PRI BR	0.059	0.043	0.180	- 0.182
	POD LTH	0.079	0.101	- 0.134	- 0.051
	SD/POD	- 0.011	- 0.021	0.047	0.023
	SD WT	- 0.163*	0.163*	- 0.100	0.687*
	POD/PLT	-	- 0.115	-	0.179
PRI BR	POD LTH	0.104	0.105	0.111	- 0.352
	SD/POD	0.099	0.112	- 0.022	- 0.180
	SD WT	0.144	0.059	0.546	0.124
	POD/PLT	-	0.043	-	0.185
POD LTH	SD/POD	0.203*	0.209*	0.212	0.628*
	SD WT	0.196*	0.212*	- 0.070	- 0.213*
	POD/PLT	-	0.154	-	- 0.262
SD/POD	SD WT	0.134*	0.183*	- 0.221	0.188
	POD/PLT	-	0.095	-	0.272
SD WT	POD/PLT	-	- 0.221	-	- 0.026

* Significant at 5% level as Probability.

Table 5. ANOVA between and within groups for five characters in grasspea

	DF	PLT HT	PRI BR	POD LTH	SD/POD	SD WT
				Mean Squares		
Between	2	265.66*	0.47	0.64*	0.01	141.59*
Within	280	102.57	1.41	0.08	0.07	6.73
C.V (%)		12.10	19.5	9.86	8.85	27.43
Bartlett's value		2.82	3.49	8.85	88.54	18.52
Probability level		0.24	0.17	0.012	-	-

* Significant of 5% level as Probability.

for some of the traits studied, analysis of variance for "Between" and "Within" groups was carried out (Table 5). Plant height, pod length and seed weight were the three traits that characterized the distinctness of the collections.

Utilization of Genetic Variability

Two lines, P 505 and Sel. 1276, purified and selected from germplasm collection from Santhal Pargana region of Bihar were found very promising for uplands of north-eastern plains. Seed BOAA level of P 505 was of the same order whereas, for Sel. 1276 it was lower than that of standard check P 24. At present three low toxin lines viz., P 28, P 94-3 and P 90-2 (ODAP content less than 0.1%) are being tested in national trial.

From a study of sixteen high seed BOAA and sixteen low seed BOAA lines sampled randomly from the germplasm representing Indian landraces (Table 6), it was inferred that seed ODAP was not involved in the genetic diversification of grasspea under natural evolution (Vedna Kumari *et al.* 1991).

Table 6. Cluster composition in *Lathyrus sativus* cultures pooled over low and high ODAP groups

Cluster number	Number of cultures	Cultures included
I	12	P 40A^{L}, P 32B^{L}, P 505B^{L}, P 59^{L}, P 28B^{L}, P 36B^{H}, P 27-1^{H}, P 27-2^{H}, P 27-3^{H}, P 27-4^{H}, P 27-5^{H}, P 46D^{H}
II	8	P 27A^{L}, P 45^{L}, P 33B^{L}, P 1276B^{L}, P 505C^{L}, P 24B^{L}, P 49^{L}, LSD 1^{H}
III	3	LSD 3^{H}, P 27-6^{H}, P41-1^{H}
IV	2	P 33A^{L}, P 41-2^{H}
V	1	P 505A^{L}
VI	1	P 505^{H}
VII	1	P 59A^{L}
VIII	1	P 28A^{L}
IX	1	P 36C^{H}
X	1	P 50B^{H}
XI	1	EC 51^{H}

H= High ODAP L=Low ODAP

To study the inheritance of flower pigment production in grasspea, five lines purified from the germplasm viz., P 27 (white flower), Red (red flower), EC 242692 (white flower with blue keel), P 505 (blue flower) and P 28 (pink flower), developed from the cross Red × P 24 through pedigree method of breeding, were crossed in a half diallel fashion and segregation for flower pigment studied in F_1 and F_2 generations (Table 7). Four genes appear to control flower pigment production (Vedna Kumari *et al.* 1993).

The seed from F_1 of two high yielding lines Red (BOAA =0.35%) and EC 242692 (BOAA = 0.40%) gave very low seed BOAA content (0.04%) (Fig. 1) suggesting inhibitory epistasis giving rise to speculation that more than one metabolic pathway may be active in BOAA synthesis (Mehra *et al.* 1993).

Some of the germplasm lines showed temperature induced male sterility (TGMS). This could be one of the reasons of observing high out crossing in some of the grasspea lines.

Table 7. F_2 segregation of flower colour in three crosses of *Lathyrus sativus*

Cross	Observed frequency		Expected ratio	Chi-square	P-value
P 505 X P 27	295 coloured	: 81 colourless	3:1	2.39	0.10-0.20
	219 Blue	: 53 Pink			
	23 Blue tinged	: 81 White	36:9:3:16	3.33	0.30-0.50
P 505 X P 28	155 Blue	: 100 Pink	9:7	2.29	0.10-0.20
P 27 X EC 242697	67 Blue tinged	: 16 White	3:1	1.59	0.10-0.25

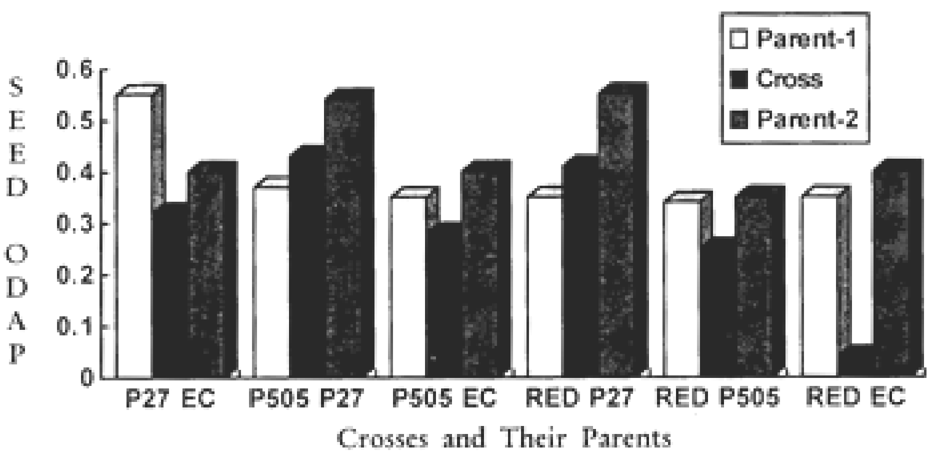

Fig. 1. ODAP(%) in seed of high neurotoxin lines of *Lathyrus sativus* and their crosses

Genetic Control for QTL's

The selection of parents for the diallel set made to study the inheritance of flower colour was considered as a random sample from the population of germplasm and the gene action was studied for the quantitative characters. An estimate of the relative proportion of additive to total genotypic variance (2 σ GCA /2 σ GCA+ σ SCA) indicated that non additive variance was predominant for days to flower, pods per plant, 100-seed weight and seed protien content. Both additive and non-additive variances were equally important for seed yield/plant , while additive genetic variance was predominant for seed ODAP content. For seeds per pod , the estimate of σ GCA was negative which was taken as zero thus, only non additive genetic control was indicated for this character (Table 8).

Table 8. Gene action for seven characters from a 5×5 half-diallel cross in *Lathyrus sativus*

Character	Days to flower	Pods/ plant	Seeds/ pod	100-seed weight	Seed yield	Seed ODAP	Seed protein
$	0.25	0.16	_	0.22	0.55	0.71	0.11

$ = Ratio of additive to total genotypic variance

References

Jackson, M.T. and A.G. Yunus. 1984. Variation in the grasspea (*Lathyrus sativus* L.) and wild species. Euphytica 33: 549-559.

Jain, H.K., P.L.N. Somayajulu and G.K. Barat. 1974. Final Technical Report of PL 480 scheme on “Investigations on *Lathyrus sativus* L.” , Division of Genetics, IARI, New Delhi.

Mehra, R.B., V. Kumari, G.K. Barat, D.B. Raju and K. Himabindu. 1993. Behaviour of neurotoxin content in some crosses of grasspea (*Lathyrus sativus* L.). Lathyrus and Lathyrism : **2** (122), p 8.

Sethi, K.L., R.B. Mehra and B.M. Lal. 1987. Studies on variability and correlation between toxin content and seed weight in *Lathyrus sativus*. L. Science and Culture **47**(7) : 263-64

Vedna Kumari, R.B. Mehra and L.S. Shami. 1991. Genetic diversity in relation to BOAA content in *Lathyrus sativus L*. Abstracts and Souvenir: Symposium on grain legumes. Feb. 9-11,1991, IARI, New Delhi. p 91.

Vedna Kumari, R.B. Mehra, D.B. Raju and K. Himabindu, 1993. Genetic basis of flower colour production in grasspea. Lathyrus and Lathyrism *:* **5** (1); pp 10.

Status of *Lathyrus* Research in India

R.L. Pandey, M.W. Chitale, R.N. Sharma and Nitin Rastogi

Introduction

The centre of origin and distribution of *Lathyrus* species gene pool is mainly in the Mediterranean region, while grasspea is predominant in Asia and Africa. The genus *Lathyrus* comprises of 150 species (Allkin *et al.* 1983). Among these, four species viz., *Lathyrus sativus, Lathyrus odoratus, Lathyrus ochyrous* and *Lathyrus aphaca* are found in India. *Lathyrus sativus* in cultivated for grain and fodder, while others grow in nature as weeds. *Lathyrus aphaca* is a common weed with wheat in north India. Some more species are reported from the Himalayan region.

Grasspea locally known as *Lakh/Lakhadi* or *Teora* is an important grain legume of India. Despite of ban on its cultivation in several parts of the country, it is still cultivated in sizeable area. The major grasspea growing states are Madhya Pradesh, Maharashtra, Bihar, Orissa, West Bengal and Uttar Pradesh. It has an area of 1.5 million hectare with the annual production of 0.8 million tonne. Nearly two third of national acreage under grasspea is in South-eastern Madhya Pradesh and Vidarbha region of Maharashtra.

Growing Practices

Grasspea is considered as hardy crop and therefore, it is still raised under harsh conditions. Generally it is grown under three farming systems.

a) Sole crop in kharif (rainy season) fallow : Rainfed areas where irrigation water is not available for winter crops and soils are vertisols, farmers leave the fields fallow during rainy season and cultivate either chickpea or grasspea during winter.

b) Relay or utera system : This is the most prevalent system in rice growing regions of India, particularly in south-eastern Madhya Pradesh, Vidarbha region of Maharashtra, parts of Orissa and West Bengal. *Utera* cultivation of grasspea has its own advantage as it is easy to cultivate without much efforts but it is very difficult to boost up its productivity under this system. Farmers broadcast the seeds of grasspea in standing crop of paddy, nearly 20-30 days before its harvest and after that they just turn-up for its harvest after three months of sowing. Under these conditions, farmers give more emphasis for its fodder and consider grain yield as bonus .

c) Mixed cropping : In rainfed areas of Rewa, Jabalpur, Hoshangabad, Bhopal and Indore divisions of Madhya Pradesh and in certain areas of Uttar Pradesh, grasspea is grown as mixed crop with wheat, chickpea, barley and linseed.

Major Constraints in Grasspea Cultivation

1. One of the major bottle neck is grasspea cultivation is the presence of neurotoxin principle known as β-N- Oxaly L-α-β–diamino propionic acid (ODAP) in its seeds (Adiga *et al.* 1963) and plant system (Rao *et al.* 1964). It is considered that excessive consumption of grasspea causes lathyrism.

2. Since its maximum area is under *Utera*, inadequate plant population is another major bottleneck in increasing the productivity.

3. Grasspea cultivation under relay cropping faces two different situations viz., excessive moisture at sowing and stress at growth and reproductive stages of the crop, resulting in poor yield.

4. Attempts are being made to increase its *per se* performance atleast at par with lentil but input application especially fertilizer is difficult, rather impossible on standing crop of paddy, when *utera* is sown. So the crop not only faces the moisture stress but also has the nutrient starvation.

5. Lack of suitable varieties : So far not much efforts have been made for its genetic improvement. Only two varieties viz., Pusa 24 and Nirmal have been developed for general cultivation. Pusa 24 is the only cultivar having low ODAP content of 0.2 percent. Nirmal is developed and recommended for West Bengal. Attempts are being made to develop toxin free or low toxin varieties at Indira Gandhi Agricultural University, Raipur and Indian Agriculture Research Institute, New Delhi, but these are still under testing phase. Varieties developed should suit to growing situations of relay cropping.

6. Lack of good quality seed : So far no systematic seed production of any of the released varieties of grasspea has been undertaken.

7. Lack of plant protection measures adopted by the farmers : Pod borer (*Etiala jhinkinella*) and thrips (*Caliothrips indicus*) are the major pest causing nearly 30 percent economic losses. Similarly, powdery mildew (*Erysiphe pisi*) and downy mildew (*Perenosopra* sp.) are the major diseases of this crop causing economic losses.

8. This crop responds to Rhizobium inoculum but there is no efficient strain of Rhizobium available for commercial use.

Research Activities

To overcome these problems a national programme for genetical and technological improvement had been launched in 1976 at Raipur (M.P.). Dholi (Bihar), Kanpur(U.P.), IARI, New Delhi and Sakoli (Maharashtra). *In vitro* technology has successfully been utilized at the Division of Biochemistry, IARI, New Delhi and as a result good somaclones having low toxin content have been developed. These lines are being tested under multilocational programme.

Germplasm collection, evaluation and documentation

Enhancement of genetic resources : Collection and maintenance of grasspea germplasm is being done by NBPGR Regional Station, Akola. Raipur being the ICAR pulse centre is also involved in such activities.

Collection of germplasm at Raipur : In 1976 with the inception of scheme, some of the indigenous accessions were provided by Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur. Later on, Indian Institute of Pulses Research, Kanpur has also supplied some indigenous material. Exotic accessions belonging to Italy, Canada, Germany, Bangladesh, France and USA were received from NBPGR, New Delhi. During 1989-90 and 1990-91 huge number of landraces of grasspea have been collected from Madhya Pradesh. At present nearly 2600 accessions are being maintained at Raipur centre. A set of landraces have been conserved in National Gene bank at NBPGR, New Delhi (IC 142 554 to IC 143 565). Short term storage facilities have also been developed at Indira Gandhi Agricultural University, Raipur.

Evaluation and characterization : Handling of whole germplasm at a time, is somewhat cumbersome due to seed shattering and revivation in next growing season. At first stage 1187 accessions have been evaluated and characterized for phenological, morphological, agronomical and quality characters. For estimation of toxin content (ODAP), a well equipped laboratory has been established in the Department of Plant Breeding and Genetics, I.G.A.U., Raipur. Based on the observations recorded on different morphological traits, the variability observed is briefly illustrated here.

Plant type : Erect, Semierect and spreading

Leaf size : Broad, narrow, long and tiny; bifoliate, tri-foliate and tetrafoliate.

Anthocynin pigmentation on stem and pod : Complete pigmentation, half pigmentation and pigmentation completely absent (green).

Flower colour: Blue (common), white, white blue, red, pink and pinkish blue.

Considerable variability exists for all the characters, which could be utilized for its improvement in relation to quality of seed i.e. low toxin and grain yield.

Documentation : The information generated after evaluation and characterization of germplasm was documented for 1187 accessions in the form of a catalogue and published in December 1995. Evaluation, characterization and documentation of rest of the accessions would be taken in the near future.

Table 1. Descriptive variation for agronomic characters in grasspea germplasm

Descriptors	Mean	Range		C.V.
		Min.	Max.	(%)
Days to 50% flowering	62.209	47.00	94.00	12.108
Days to maturity	107.714	86.00	127.00	4.753
Plant height (cm)	33.933	15.40	68.40	23.172
Branches/plant	9.265	1.80	28.40	33.657
Pods/plant	19.380	2.40	59.00	45.775
Pod length (cm)	2.971	1.88	5.18	11.587
Pod width (cm)	0.883	0.26	1.30	11.013
Seeds/pod	3.271	1.60	4.60	12.756
Seeds/plant	54.703	6.20	200.00	50.159
Seed index (g)	6.270	2.21	19.50	29.676
Biological yield (g)	8.306	0.40	51.00	55.933
Yield/plant (g)	3.779	0.60	19.81	59.832
ODAP (%)	0.438	0.13	0.87	38.527

Development of high yielding low toxin varieties

Pure lines for sole cropping : In certain areas of Madhya Pradesh and Uttar Pradesh grasspea is also cultivated in vertisols under rainfed situation. Different pure lines having high yield and suitability to these situations have been selected from available germplasm. These are RLS 1, RLS 2, JRL 115, JRL 16, JRL 41, JRL 43 from Raipur and selection 505 and selection 1276 from IARI, New Delhi. Their yield performance over three years is given in Table 2.

Table 2. Yield performance of promising pure lines under upland situation with one irrigation

Pure line	Yield (kg/ha)			Average
	1990-91	1991-92	1992-93	
JRL 115	1 657	1 744	1 985	1 795
RLS 1	1 534	1 778	1 913	1 742
JRL 16	1 594	1 539	1 642	1 592
JRL 43	1 510	1 592	1 538	1 547
Pusa 24	1 565	1 582	1 818	1 655
Local	1 255	1 225	1 475	1 318

Pure lines for relay (utera) cropping : Relay cropping of grasspea is very common in Madhya Pradesh, Maharashtra, Orissa, West Bengal and part of Bihar, where protective irrigations are available for rice crop only. Farmers broadcast the grasspea seeds in standing water before the harvest of paddy. It is the opinion of the farmers that small seeded (*Lakhadi* type) sustain much better under this but they are poor yielders. Attempts are being made to develop pure lines adaptable to *utera* situation. Yield performance of bold and small seeded cultivars of grasspea are presented in Table 3.

Table 3. Performance of promising pure lines under *utera*

Genotype	Yield (kg/ha)			
	1988-89	1991-92	1992-93	Average
Lakh (Bold seeded)				
Pusa 24	451	728	845	674
LSD 3	627	539	862	676
JRL 115	429	596	881	635
RLS 1	539	889	921	783
Lakhadi (Small seeded)				
JRL 43	627	380	928	645
JRL 41	605	747	763	705
JRL 16	638	988	638	754
Local	506	456	565	509

Development of low toxin varieties : Neurotoxin principle is the causative factor of neurolathyrism in human beings. Endemic outbreak of lathyrism was reported from Rewa division of Madhya Pradesh by the Indian Council of Medical Research (Ganapathy and Dwivedi 1961). Due to these reasons, cultivation and trade is being discouraged. Though the agricultural situation has drastically changed after green revolution and no one consumes grasspea in pure form and in excessive quantities, research efforts are however, directed to breed varieties having high yields and low toxin compound.

Hybridization : As a result of hybridization between landraces from India and low

Table 4. Performance of new strains of grasspea at Raipur

Genotype	Pedigree	% ODAP			Average yield (kg/ha)
		1988-99	1991-92	1992-93	
LS 155-9	a-67 x 60	0.036	0.060	0.080	1 235
LS 155-10	a-67 x 60	0.061	0.080	0.100	1 030
LS 157-5	LS 8246 x a-68	0.046	0.100	0.090	1 309
LS 157-12	LS 8246 x a-68	0.047	0.090	0.070	1 272
LS 157-14	LS 8246 x a-68	0.032	0.080	0.080	1 165
LS 172-7	a-84 x LS 8545	0.034	0.100	0.090	1 405
LS 220-1	Irradiated	0.044	0.050	0.090	1 488
Pusa 24	State check	0.190	0.270	0.320	1 658

toxin lines from Canada, some promising strains having low toxin content have been developed (Table 4). These are being evaluated in multilocational trials.

New strains developed either through hybridization or through bio-technology have better performance over Pusa 24, but benefit of low toxin content is associated with these strains (Table 5).

Table 5. Performance of new strains of grasspea at Raipur

Genotype	% ODAP			Average yield (kg/ha)
	1992	1993	1994	
Bio R-202	0.048	0.040	0.043	1 207
Bio L-203	0.037	0.036	0.057	1 202
Bio R-231	0.089	0.029	0.118	1 014
Pusa 24	0.220	0.170	0.320	1 247

Genetic Variability Studies

Sufficient information on toxicology and separation of toxin compound is available but little literature is available on its genetic behavior and its relation with other yield attributing traits. The basic genetic information generated by genetic studies are discussed here.

Variability analysis : Estimates of variability at genotypic and phenotypic level revealed that high magnitude of genetic variability for ODAP content and yield contributing parameters do exist in the available germplasm. Sahu and Kashyap (1992), Pandey *et. al.* (1995), Shrivastava and Pandey (1996) analysing the germplasm lines at Raipur found high magnitude of genetic variability for days to 50 percent flowering, days to maturity, plant hight, number of branches/plant, number of pods/plant, pod length, pod width, leaf length and width, seeds per pod and per plant, harvest index, seed index, grain yield and ODAP content in seed. Available variability could successfully be utilized through selection of pure lines and hybridization to combine high grain yield with low toxin content.

Heritability and genetic advance : Shrivastava and Pandey (1996) estimated heritability and genetic advance for fifteen characters including ODAP content in seeds of grasspea germplasm. High heritability coupled with high genetic advance was found for days to maturity, number of branches/plant, number of pods/plant, seed index and ODAP content indicating the importance of additive gene action for these characters.

Grain yield/plant showed moderate heritability with moderate genetic advance indicating the possibility of yield improvement even by selection of superior genotypes. Rest of the characters expressed low heritability with varying magnitude of genetic gain.

Association studies : Grain yield was positively associated with plant height, number of branches/plant pods and seeds/plant, seed index and harvest index (Pandey *et al.* 1995; Shrivastava and Pandey 1996). ODAP content showed independent nature, having no association with any trait under study. It is therefore, possible to combine low ODAP with high grain yield.

Path coefficient analysis : Path coefficient analysis revealed that seeds /plant, seed index, harvest index, branches/plant and leaf width had high positive direct effect on grain yield. Since these traits also had significant positive association with grain yield, emphasis should be given on these traits during selection. Number of seeds/plant had higher direct and also indirect effects via pods and branches/plant on grain yield. Hence, due weightage should be given to higher number of branches and pods per plant.

Divergence analysis : Shrivastava and Pandey (1996) studied genetic diversify in 126 accessions including indigenous and exotic ones. Genotypes were grouped into 10 clusters having maximum distance between cluster 1 and 10. They further, concluded that genetic diversity did not show any relation with geographical distribution of the genotypes.

Future Plan of Work

Collection of germplam from unexplored areas : With the development of irrigation facilities grasspea is being replaced by some other economic crops. This has created severe genetic erosion. Therefore, NBPGR should explore the untouched areas particularly the West Bengal, Bihar and Eastern Uttar Pradesh where irrigation potential is increasing day by day. Secondly, there are possibilities to get some other species of grasspea like *Lathyrus aphaca* and *Lahyrus ochyrous* from Himalayan regions of India.

Conservation and utilization of germplasm : Conservation of available genes for future use is very important aspect of genetic resources. NBPGR has long term storage facilities but medium term storage facilities should also be created in Regional Stations to facilitate the research activities on this crop.

Characterization and documentation : Proper evaluation, characterization and documentation of the available germplam should be carried out at national and global level.

Search for resistant genes against diseases and insect pests : This crop belongs to poor farmers and is grown under poor management. No one adopts chemical control for diseases and insect pests. Therefore, development of varieties having resistance to prevalent pests and diseases have become essential. In the existing genepool resistance against thrips and powdery mildew is not available. Therefore, rigorous screening of the germplam lines from different parts of the world should be done to identify the donors. However, *Lathyrus aphaca* showed resistance against powdery mildew and thrips, hence, it should be incorporated in the programme on interspecific hybridization.

Epidemiological studies : There is need to have an epidemiological survey in grasspea production area of the Indian subcontinent, to know the recent trend on grasspea consumption and its ill effects on human health. There is also need to workout the safe limit of grasspea in daily diet.

International network : International network on grasspea should be strengthened for genetic enhancement / development of suitable varieties. Information on the biosynthesis on priority basis of ODAP content is essential to know the transmission of this compound from seed.

References/Literature Consulted

Adiga, P.R., S.L.N. Rao and P.S. Sharma. 1963. Some structural features and neurotoxic action of compound from *L. sativus* seeds. Curr. Sci. 32 : 153-155.

Allkin, R., T.D. Macfarlane, R.J. White, and M.E. Adey. 1983. Name and synonyms of species and subspecies in the viciae. Issue 2 viciae database project publication, No.2 Southamton.

Ganapathy, K.T. and M.P. Dwivedi. 1961. Studies on clinical epidemiology of lathyrism. Lathyrism enquiry unit, Indian Council of Medical Research, Gandhi Memorial Hospital, Rewa.

Pandey, R.L., M.W. Chitale, R.N. Sharma, O.P. Kashyap, S.K. Agarwal, A.K. Geda, H.K. Chandrakar and K.K. Agrawal. 1995. Catalogue on Grasspea (*Lathyrus sativus* L.) germplasm. Indira Gandhi Agricultural University, Raipur.

Rao, S.L.N., P.R. Adiga and P.S. Sharma. 1964. Isolation and characterization of Beta-N-oxylayl L - apha, Beta-diamino propionic acid, a neurotoxin from seeds of *lathyrus sativus*. Biochem. 3:432-436.

Sahu, S.L. and O.P. Kashyap. 1992. Genetic variability, correlation and path coefficient studies and their implication in selection of high yielding low BOAA content genotypes of grasspea (*L. sativus L.*) MSc Thesis submitted to IGAU, Raipur.

Shrivastava P. and R.L. Pandey. 1966. Studies on genetic variability and diversity in grasspea (*Lathyrus sativus*). MSc Thesis submitted to IGAU, Raipur.

Lathyrus Germplasm Resources at NBPGR, India : Introduction and Evaluation

I.P. SINGH AND K.P.S. CHANDEL

Introduction

Lathyrus (Grasspea) locally known as '*Khesari*', '*Teora*', '*Lakh*' and '*Lakhdi*' is a protein rich legume mainly grown in dryland areas or extreme harsh conditions of relay cropping system. It is mainly grown in India, Bangladesh, Pakistan, Nepal and Ethiopia, in areas where the irrigation facilities are very limited particularly during winter cropping. *Lathyrus* is grown for food, fodder, as straw feed and green manure. *Lathyrus* crop is grown on about 1.5 million ha in India, and its production estimate is nearly about 0.8 millon tonne of grain yield annually. Its cultivation is more concentrated in south eastern Madhya Pradesh and Vidarbha region of Maharashtra, in rice based cropping system having limited irrigation facilities.

Lathyrus germplasm in India has been classified on the basis of colour of flowers, marking on the pods, and size and colour of the seeds. About 56 types (45 cyaneus, 10 roseus and 1 albus) of *Khesari* have been differentiated in the market samples collected. These were small, medium and large seeded in combination with grey, black and mottled seed colour. It was also noticed that the seeds from crop raised in rice fields are usually smaller than those grown in dry soils. The smaller seed form is known as *Lakhadi* (seed wt 77-108g/100 seeds) and the larger seed forms as *Lakh* (seed wt 110-245g/100 seeds) (Howard *et al.* 1928). In the remote past, a landrace T-2-12 was identified which was marked as resistant to early rust with higher yields than other local types.

Species Diversity in India

Some of the *Lathyrus* species which have been reported to occur in India (Hooker 1876-96, Wealth of India 1948-76; Bamber 1916; Duthie with Babu 1977; Tiwari 1979) are as below :

L. aphaca L., Commonly known as *Pili matri,* it is an annual herb with and abortive leaflets yellows flowers. This species is spread through the northern provinces, ascending from the plains of Bengal to the temperate zone in Kashmir and Kumaon upto an altitude of 2100 m. It has been encountered in Dehradun region (Bhatta-Dhobighat, on way to Kamptee), Bihar, Punjab, Bengal and Central India (Janakpur and Panna, Sagar, Khandwa, Gwalior), and South Nilgiri hills. It is used as fodder.

L. sativus L. : Commonly known as *Lakhdi,* it is an annual herb with red, bluish or white flowers; pods oblong, winged on the back. It occasionally occurs as a winter season weed in field crop and kitchen gardens. It is found in the lanes of West Bengal in the northern provinces ascending to 1300 m in Kumaon. It is also distributed in Punjab, Bihar, Orissa, Maharashtra, Central and South India, and also in Rangali-Biratnagar at 200 m, in the Eastern Himalayas.

L. pratensis L. : Perennial pubescent herb with racemes of yellow flowers and 5-10 seeded compressed pods; distributed in Western Himalayas upto an elevation of 1800 m (Mahasu, Fagu, Garhwal extending to Kashmir).

L. sphaericus Retz : It is an annual herb with solitary flowers and linear many seeded wingless pods. It is a common weed found in northwest provinces, ascending from Bundelkhand and Punjab upto 1800 m in Kumaon. It has been encountered in the northern plains and in Western Himalayas (Bhatta, Dhobighat, Kamptee in Dehradun and Shimla) and in West Bengal.

L. inconspicuus L. : It is an annual herb encountered in the plains and upto 2000 m in Western Himalayas.

L. odoratus L. : It occurs in Madhya Pradesh and is grown widely in sub-tropical region as an ornamental.

L. altiacus Led : It is a sub-erect glabrous perennial herb with few reddish flowers in long peduncled racemes. It is distributed in Western Himalayas, temperate region; Baltal and Chenab valley upto an altitude of 2500 m.

L. luteus Baker : It is a sub-erect perennial herb with bright yellow flowers and linear pods. It is distributed in Western Himalayas, ascending from the salt range in the Punjab to 2500 m in Kumaon and 3000 m in Khagan.

Besides, the NBPGR has also introduced *L. tingitanus* L. Tangler pea is a climbing annual with scarlet purple flowers and many seeded pods. It a native of North Africa used as an ornamental and also as fodder/green manure. The seeds are toxic.

Germplasm Status at NBPGR : Introduction and Evaluation

The National Bureau of Plant Genetic Resources (NBPGR) as a nodal organization has assisted in augmentation of *Lathyrus* genepool diversity from exotic and indigenous sources for crop improvement needs vis-a-vis conservation and utilization.

Germplasm augumentation of *Lathyrus* (*L. sativus*) was started in 1976. Presently, a total of 1119 accessions including exotics are being maintained at NBPGR, of which 1061 samples have been conserved as base collection in the genebank, coded as IC142554- 143568 (IC=Indigenous Collection). *Lathyrus* germplasm collections made in the past at NBPGR represented largely spreading, drought tolerant types varying in seed size (small and bold), seed colour (grey, brown, blackish, greenish and creamish white with and without mottling) and pod size in bushy and semi-bushy types. Wide variability also occurred in the collection for the maturity duration. Indian germplasm material is mostly blue flowered with light to dark brown plain and speckled seeds. Indian germplasm is also characterized by small flower size, a primitive character (Jackson and Yunus, 1984). The exotic germplasm from different countries has been introduced (about 1154 accessions) in the past decade and provided to the indentors. International *Lathyrus* adaptation trials for specific objectives are also being received for conducting trials at Raipur and at the Indian Instutite of Pulses Research, Kanpur.

More than 1100 exotic accessions of different *Lathyrus* species have been introduced in India from different countries and the details are presented in Table 1.

Table 1. Lathyrus species introductions in India

Species name & No. of accessions	Country of introduction	Year of introduction
L. articulatus (1), *L. cicera* (1), *L. clymenum* (1), *L. ochrus* (1)	Canada	1987
L. sativus (225), *L. tingitanus* (2), *L. szowitsii L.* (1), *L. tingitanus* (11)	Canada, Italy Canada	1987
L. sativus (2), *L. annuus* (1), *L. aphaca* (1), *L. blepharicarpus* (1), *L. cicera* (1), *L. chrysanthus* (1), *L. gloeospermus* (1), *L. gorgonii* (1), *L. hierosolymitanus* (1), *L. inconspicuus* (1), *L. marmoratus* (1), *L. pseudocicera* (1)	Bangladesh, Syria	1990-91
L. sativus (42), *L. grandiflorus* (1), *L. latifolia* (1), *L. odoratus* (1), *L. clymenum* (1), *L. ciliolatus* (1), *L. ochrus* (1), *L. cicera* (1), *L. tinganensis* (1), *Lathyrus* sp. (2)	Benglades, Syria France, UK, USA, Germany	1991-92
L. sativus (182), *L. aphaca* (3), *L. annuus* (7), *L. basalaticus* (4), *L. blepharicarpus* (4), *L. cicera* (7), *L. ciliolatus* (3), *L. chrysanthus* (1), *L. gorgonii* (5), *L. gloeospermus* (1), *L. hierosolymitanus* (5), *L. inconspicuus* (5), *L. japonicus* (1), *L. hirsutus* (2), *L. latifolius* (2), *L. ochrus* (2), *L. sylvestris* (3), *L. tuberosus* (2), *L. vernus* (1), *L. laevigatus* (1), *L. marmoratus* (3), *L. pseudocicera* (4)	Syria, USA, France, Germany	1992-93
L. latifolius (1), L. hetrophyllus (2), L. aphaca (1), L. laevigatus (1), L. pratensis (5), L. sylvestris (2), L. sativus (314)	France, Germany	1993-94
International Lathyrus adaptation trials: *(LS-94, LO-94, LC-94)* *L. sativus (270)* International Lathyrus adapatation trials including *L. ochrus, L. cicera*	Syria Syria	1994-95

The germplasm maintenance and evaluation work is being done at the NBPGR Regional Station, Akola where a good number of promising/donor lines for various traits have been identified (Table 2).

Table 2. Promising accessions identified at NBPGR, Regional Station, Akola

Early maturing types (114 days)	IC 12 466, IC 120 473, IC 120 490, IC 120 472, IC 120 507, IC 120 420, JC 12 049, IC 120 596
High grain yielding types	IC 120 474, IC 120 512, IC 120 526, IC 120 530, IC 120 531, IC 120 509, NIC 18 768, NIC 18 849, NIC 18 890, S 720, P 72, P176
High pod bearing (>70 pods/plant)	IC 12 507, IC 120 497, IC 120 537, IC 120 422, NIC 18 768, NIC 18 849, NIC 18 851, NIC 18 890
High banch No. (>15 branches/plant)	IC 120 495, IC 120 497, IC 120 507, IC 120 521, NIC 18 773, NIC 18 785
Prolific pod bearer (>110 pods/plant)	IC 120 507, IC 120 511. IC 120 512, IC 120 562, NIC 18 789
Long pods (>3.5 cm)	IC 120 459, IC 120 477, IC 120 496, IC 120 522
High seeds/pos (>4 seeds/pod)	IC 120 471, IC 120 477, IC 120 521, IC 120 536

Herbarium specimen for about 16 species (exotic and indigenous) are being maintained at National Herbarium for cultivated plants and wild relatives at NBPGR.

Table 3. Records of Lathyrus specimens in NBPGR Herbarium

Species name	Source
Lathyrus altiacus	Indigenous
L. aphaca	Exotic
	Indigenous
L. sphaericus	Indigenous
L. blepharicarpus	Exotic
L. chrysanthus	Exotic
L. cicera	Exotic
L. gorgonei	Exotic
L. hierosolymitanus	Exotic
L. conspicuus	Exotic
L. lecteus	Exotic
L. narmoratus	Exotic
L. ochrus	Exotic
L. odoratus	Exotic
L. pratensis	Exotic
L. pseudocicera	Exotic
L. sativus	Exotic

Future Thrust

Efforts should be made to find the gaps for further augmenting the germplasm, landraces/wild species collections from the already known sources. Search for genes for improving quantitatively inherited traits such as yield in the strains of weedy and wild relatives should be intensified. Augmentation of soil microbes germplasm has recently been initiated by the ICAR and the exploitation of the suitable microbe/ bacterial races would further help to improve cultivar production potential as well as it would help to isolate the ODAP degrading gene from the soil microbes. An effort is this direction has already been made and an ODAP degrading gene has been isolated from a soil microbe, sequenced and introduced into *A. tumefaciens*. Methods have already been developed for the development of transgenic *L. sativus* plants using biolisic gene. Information must also be gathered on variability for and exploitability of nitrogen fixing ability of different *Lathyrus* species. Presently, the development of low toxin cultivars with higher yields is going on at various institutes. Special cultivar testing trials on the recommendation of the parliamentary committee are being made with the two extremely low ODAP varieties (BIO L-212 & BIO L-222) developed at IARI, New Delhi. Looking at multipronged constraints, the interdisciplinary research programmes should be further strengthened and constraints, the interdisciplinary research programmes should be further strengthened at different centres with trained specialists, and facilities should be developed to conduct research in close coordination with the breeders on biochemical/physiological, biometrical, disease resistance and quality aspect to produce 'ready to use' information/material for the breeders. There is also a need to promote the use of known and already established biochemical/biometrical techniques in screening and evaluation of germplasm and the materials/genetic stocks generated by employing pre-breeding and germplasm enhancement techniques. Another important aspect would be to study the genetic potential of different species adapted to various ecogeographical areas for their dry matter/biological yield/grain yield in comparison with other legume crops being considered more suitable as replacement on the basis of their promising attributes.

References

Babu, C.R. 1977. Herbaceous Flora of Dehradun, CSIR, New Delhi.

Bamber, C.J. 1916. Plant of the Punjab. Superintendent, Govt. Printing Press, Lahore.

Duthie, J.F. 1902. Flora of the Upper Gangetic Plain, Vol. 1-3. Bishen Singh Mahendra Pal Singh, Dehradun.

Hooker, J.D. 1876-96. The Flora of British India, Vols. I-VII. Bishen Singh Mahendra Pal Singh, Dehradun.

Haward *et al.* 1928. Mem. Dep. Agri. India Botany. 15(2).

Jackson, M.T and A.G. Yunus. 1984. Variation in the grasspea (*L. sativus* L.) and wild species. Euphytica 33, 549-559.

The Wealth of India, 1948-76. Raw material series, Vol.I-XI, CSIR, New Delhi.

Tiwari, S.D.B. 1979. The Phytogeography of legumes of Madhya Pradesh. Bishen Singh Mahendra Pal Singh, Dehradun.

Crop Status and Genetic Diversity of Grasspea in Pakistan

A.M. HAQQANI AND M. ARSHAD

Introduction

Lathyrus sativus (grasspea, vetchling, khesari or chickling vetch) is a winter season crop adapted to subtropical or temperate climate. Other winter food legumes grown in Pakistan are chickpea (*Cicer arietinum*) and lentil (*Lens culinaris*), while summer food legumes are green gram/mungbean (*Vigna radiata*) and black gram (*Vigna mungo*), Faba bean (*Vicia faba*), pigeonpea (*Cajanus cajan*), cowpea (*Vigna unguiculata*), moth bean (*Vigna aconitifolia*) and kidney bean (*Phaseolus vulgaris*) are grown on a very tiny scale. The production of pulse crops accounts for 7-8% of the total cropped area of the country. Among these, chickpea is the major pulse crop while grasspea is next in area and production (Table 1). Grasspea is a poor man's crop and its split grains

Table 1. Area, production and yield of chickpea and grasspea in Pakistan during 1980-81 to 1993-94

Years	Chickpea			Grasspea		
	Area ('000 ha)	Production ('000 mt)	Yield (kg/ha)	Area ('000 ha)	Production ('000 mt)	Yield (kg/ha)
1980-81	843	337	400	165	76	461
1981-82	902	294	326	177	76	429
1982-83	893	491	550	172	81	471
1983-84	920	522	567	145	80	552
1984-85	1 014	524	517	145	69	476
1985-86	1 033	586	567	140	68	486
1986-87	1 082	583	539	143	69	483
1987-88	821	372	453	138	67	486
1988-89	979	456	466	145	71	490
1989-90	1 035	462	543	143	71	497
1990-91	1 092	531	486	143	71	497
1991-92	997	513	514	141	71	501
1992-93	1 008	347	344	141	71	506
1993-94	1 045	411	393	138	74	536

Source : - Agricultural statistics of Pakistan
- All Pakistan Crop Estimate, Planning Unit, Ministry of Food and Agriculture and Cooperation, Government of Pakistan.

form a major and regular part of diet in rice growing districts of Sindh province. It is being grown after rice in rice-based cropping system in Sindh province from centuries due to its agro-climatic adaptability, resistance to insect pests and diseases.

Area and production of grasspea has remained stagnant over years with only minor fluctuation (Table 1), as it is not popular in areas where other pulses can be grown and give more yield. The other reason is that it contains β-N-oxalyl-L-α, β-diamino propionic acid (ODAP) which causes Lathyrism - an irreversible crippling disorder to legs.

The average grain yield in the country is 448 to 486 kg/ha,while experimental yield potential obtained at the Rice Research Institute, Dokri, Larkana is 1200 to 1500 kg/ha, showing three fold increase in production. However, very little attention is being given to its improvement for varietal development. Non-availability of trained man-power and financal support from the government are the major constraints to exploit its yield potential in its production areas.

Grasspea Cultivation in Sindh

Grasspea is cultivated largely in upper part of Sindh province in the districts of Larkana, Shekarpur and Sukkar. Separate statistics of data for grasspea cultivation in other provinces are not available, but more than 80% of grasspea is grown in Sindh. However, its cultivation area has declined by 18% since 1982-83 mainly due to the introduction of high yielding and short duration wheat varieties and improved varieties in chickpea.

Relay cropping system for its cultivation is common and rice-grasspea-rice is the most common rotation in the grasspea growing areas. It is cultivated since long for fodder and grain consumption. Generally 60% of crop is used as green fodder and 40% is used for human consumption and as animal feed.

It is generally recognized as a food crop of exceptional value among the poor farming communities in Sindh province. It is cheapest as compared to other pulses, rich in protein, can grow in poor soils in the absence of added nitrogen and is tolerant to drought and flooding. Keeping in view the importance of grasspea in future, it is imperative to formulate a comprehensive policy to enhance its world production.

Production Constraints

Fear of Lathyrism might be the major production constraint of grasspea. But there are other numerous constraints which hinder the exploitation of grasspea yield potential. Some of these are as follows:

1. Poor productivity of the traditional varieties
2. Non-availability of quality seed to grasspea growers
3. Low income status of farmers in grasspea growing areas
4. Absence of ineffectiveness of *Rhizobium* strains in soils

5. Unawareness of inputs utilization
6. Non-availability of grasspea production technology
7. Poor cultivation practices
8. Pre and post harvest mechanization difficulties
9. Lack of trained manpower in research institutes and extension departments
10. Marketing and storage problems

Lathyrism

Despite its invaluable merits, its major demerit is that it may cause lathyrism if the daily food consumption contains a large proportion of it. Lathyrism is a motor neuron disease affecting population in Indian sub-continet, Africa and China. The seed contains the neaurotoxic amino acid β-N-oxalyl-L, α-β diaminopropionic acid, called ODAP (B-N-oxalylamino-L-alanine BOAA).

There is no documentary record of Lathyrism in Pakistan, but according to a survey conducted in 1988 during crop season, it was known from grasspea growers that disease exists in human beings in traces but is more common in milch buffaloes which are fed on grasspea seed extensively. The less incidence of disease may be due to the soaking of grasspea *dhal* in water several hours before cooking. The water is removed from *dhal* which may decrease the toxin concentration. These two factors, dehusking and soaking in water may be responsible for lowering the disease incidence in human beings.

Genetic Diversity in Grasspea

Grasspea is being grown in upper Sindh for centuries, and the crop diversity occurs here. A new grasspea variety which has been released recently at RRI, Dokri, Larkana and modern cultivation practices may erode this indigenous genetic diversity of grasspea.

Compared to other food legumes, the conservation of grasspea germplasm has received little attention in Pakistan. Specific expedition for collection of grasspea genetic diversity has not been conducted, and the germplasm was collected during other crop collecting missions undertaken by Plant Genetic Resource Institute (PGRI) at National Agricultural Research Centre (NARC), Islamabad. The present status of grasspea germplasm in comparison with major food legumes germplasm collected by PGRI is presented in Table 2. The details of germplasm collection and documentation indicating species collected, date of collection, location of collection etc. are given in Table 3. AT NARC, the Cytogentic Unit under the Grasspea Improvement Project, (Agriculture Canada/ Pakistan 3p-90-1016) supported by International Development Research Centre (IDRC) collected 84 landraces and obtained about 800 lines from Agriculture Canada Research Station, Morden, Manitoba, Canada. However, these introduced germplasm lines could not be conserved in PGRI, NARC, Islamabad. The potential of a large part of collection of grasspea genetic diversity in PGRI is yet to be fully explored.

Table 2. Food legume germplasm preserved at Plant Genetic Resources Institute, NARC, Islamabad

Crop	No. of accessions	Source	Place of collection
Chickpea	928	Pakistan	Hyderabad, Mirpurkhas, Sukkar, Larkana, Dadu and Jaccobada Districts of Sindh Province; D.G. Khan, Muzaffargarh, Layyah, Bhakkhar, Khushad and Mianwali Districts of Punjab and D.I. Khan and Bannu Districts of NWFP
	1 952	ICRISAT	World collection
Lentil	687	Pakistan	All lentil growing areas including grain markets and grain stores
Mungbean/ green gram	454 300	Pakistan AVRDC	Mungbean growing areas World collection
Black gream/ Mashbean	687	Pakistan	Mashbean growing areas
Cowpea	74	Pakistan	NWFP
Grasspea	97	Pakistan	Sindh Province
Faba bean	12	Pakistan	NWFP

Need for Genetic Diversity

The nature and extent of genetic diversity in grasspea is yet to be assessed for its use in breeding programmes. Its exceptional value lies in developing new crop varieties to meet modern agricultural needs. It increases the expression of a desired traits in a plant. This involves a series of breeding procedures to combine desirable genes. The preservation and conservation of genetic diversity from breeding lines, primitive cultivars, indigenous landraces and wild species is needed to :

1. Develop the tolerance to diverse climatic conditions such as drought and flooding by introducing genes tolerant to these stresses.
2. Exploit variability in plants for maximum inert atmospheric nitrogen fixation by rhizobium which is major nutrient for plant growth.
3. Breed more input responsive varieties for greater biomass and grain yield.
4. Change crop maturity and plant canopy architecture to better fit within the overall existing cropping grasspea patterns.
5. Improve the yield potential and stability within a range of environments.

Table 3. Aboriginal and exotic germplasm collection at Plant Genetic Resources Institute, NARC, Islamabad

No. of accesions	Species	Date of collection	Province	Location	Altitude (m)	Sowing month	Har-vesting month
5	*Lathyrus sativus*	3-7/4/82	Sindh	Grain market Mirpur khas	50-75	10,11	3
6	*Lathyrus odoratus*	7-10/4/82	Sindh	Saeedabad Kazi Ahmad wala Sukkar	50-125	10-11	3,4
1	*Lathyrus aphaca*	10/4/82	Sindh	Goth Qusim	145	10-11	4
10	*Lathyrus odoratus*	10-12/4/82	Sindh	Chab, Shibarpur Kand Kot, Nodcro Larkana Mero Khan Warch	100-150	11	3,4
4	*Lathyrus sativus*	13/4/82	Sindh	Dadu grain market Dadu Nareerabad	105-150	11	3
1	*Lathyrus juncea*	13/4/82	Sindh	Narceraboa	150	11	3
2	*Lathyrus sativus*	15-16/4/82	Sindh	Kashmore Rajonpur	175-220	11	4
2	*Lathyrus odoratus*	19-24/4/82	Punjab/ NWFP	Muzafargarh, D.I. Khan	195-260	11	4
8	*Lathyrus* spp.	4-13/4/83	Punjab	Pasroor, Chaawinda Sialkot, Hafizabad, Muzafargarh	100-280	10	4
3	*Lathyrus doratuso*	29-2/7-8/83	Northern Area	Skardu, Hunza	2 150-2 900	2	7,8
2	*Lathyrus* spp.	25/7/86	Northern Area	Sakardu	2 500-2 520	2	7
11	*Lathyrus* spp.	5-13/4/85	Sindh	Sujawal, Tando Bago, Nali Sarkhari Khor, Daulatpur, Norodadu bridge, Indu, Grain market Shikarpur	0.0-100	10	3
4	*Lathyrus* spp.	16/4/85	Punjab	Langar Sarai, Gharib Shah, Muzafargarh	100	10	4
2	*Lathyrus* spp.	29-16/9-10 /85	Baluchistan	Quetta, Dera Murad jamali	1 640-1 670	4	9
1	*Lathyrus sativus*	14/9/91	Punjab	Bahawalpur	120	10	3
12	*Lathyrus sativus*	14/9/91	PGR Canada	—	—	—	—
1	*Lathyrus cicera*	14/9/91	PGR Canada	—	—	—	—
1	*Lathyrus sowitzii*	14/9/91	PGR Canada	—	—	—	—
1	*Lathyrus clymenum*	14/9/91	PGR Canada	—	—	—	—
1	*Lathyrus doratuso*	14/9/91	PGR Canada	—	—	—	—
1	*Lathyrus articulatus*	14/9/91	PGR Canada	—	—	—	—
1	*Lathyrus tirgitorus*	14/9/91	PGR Canada	—	—	—	—
17	*Lathyrus* spp.	14/9/91	PGR Canada	—	—	—	—
6	*Lathyrus sativus*	14/9/91	PGR Canada	—	—	—	—

Germplasm Evaluation

For sustainable development, a sound breeding programme is primarily based on evaluation and exploitation of the collected and preserved genetic diversity. The local landraces which are available at PGRI could not be characterized and evaluated because of budget paucity and lack of trained manpower. About eight hundred lines obtained from Agriculture Canada Research Station, Morden, Canada and 84 landraces collected from Sindh province were evaluated at seven locations in diverse agro-climatic conditions by the Cytogenetic Unit at NARC, Islamabad. These accessions need to be conserved in PGRI.

Evaluation of genetic diversity for ODAP content

The analysis of the indigenous and exotic germplasm was performed at Quality Laboratory, NARC, Islamabad. Eight hundred eighty accessions of *Lathyrus sativus* were available for ODAP analysis and out of these around 590 accessions were tested for agronomic traits at seven different agro-climatic regions of Pakistan. The seed harvested from these trials were also analysed for their ODAP content. In all around 1080 samples were analyzed. In these germplasm accessions about 88% had 0.1-0.4% ODAP content. Around 8% of the germplasm had more than 0.4% ODAP conten. There were only a few lines (less than 0.6%) which were found having 0.0-0.09% ODAP content. The ODAP content was high in local landraces. ODAP content varied in the grasspea seeds obtained from seven different locations. This showed the sensitivity to diverse agro-climatic conditions for gene(s) responsible for the synthesis and storage of ODAP content in seeds at maturity. A few accessions however revealed consistent results with regard to the ODAP content.

Research Status

Generally grasspea is a crop of rice growing areas of the provinces of Sindh and Baluchistan, it is not grown in NWFP and Punjab provinces and has been a negelected crop. A coordinated Research programme was developed in 1980 for improvement of food legumes with IDRC financial support under Pakistan Research Council, Islamabad, but grasspea was not included as the mandatory crop in the Pulse programme. Financial allocation and other resources needed for its improvement remained lacking in the past. In recent years, a little research with meagre funds has been started at Rice Research Institute, Dokri, Larkana. The evaluation of germplasm for desirable characters of economic importance was done and after the selection of promising lines, yield trials were also conducted.

The cytogenetic Unit at NARC attempted interspecific crosses in grasspea. *L cicera* × *L. sativus* and *L. emphicarpus* × *L. saticus* to develop a hybrid under the Grasspea Improvement Project (Agriculture Canada/Pakistan 3p-90-1016). The later hybrid showed a resprouting trait which could be exploited for developing a multi-cut genotype. This research unit has evaluated 800 exotic and 84 indigenous germplasm lines at seven locations having diverse agroclimatic conditions. The project was for three years. The evaluation fo promising lines possessing higher grain yield trait and low ODAP content is incomplete. The further agronomical testing of the advanced lines could not be undertaken for want of financial support. Hence, there is a need to develop a regional project with 5 years duration aiming at strengthening of the ongoing research in national agricultural research stations. The donor need to be identified for funding of this project. The main focus of the project should be :

a. The collection, evaluation, characterization and conservation of local landraces and exotic germplasm in collaboration with PGRI.
b. Grasspea hybridization programme for creation of genetic variability.
c. Evaluation of breeding lines and promising lines selected from grasspea germplasm for high yield, wider adaptation and low ODAP.
d. Testing agronomic performance of advanced grasspea cultivars (future candidate varieties).

Future Thrust

The PGRI can play a vital role to explore the opportunities which do exist for increasing grasspea production in Pakistan in a sustainable fashion by providing genetic diversity to grasspea scientists/breeders with labelled characters for higher productivity under stress conditions. Therefore, it should supplement more genetic variability through collection of germplasm from indigenous and exotic resources and its use in inter and intra-specific hybridization by breeders. Genotypes should be properly characterized, evaluated and documented, using standard methods. More emphasis should be laid on germplasm collection by exploring the grasspea growing areas of the country, as the landraces grown are highly adapted to the local environmental conditions and their grain quality is acceptable by the consumers. In this efforts to strengthen collection of grasspea germplasm, PGRI should also collaborate with existing national, regional and international plant genetic resources centres for seed exchange to consider its existing germplasm holdings, to meet the growing needs of the breeders for crop improvement.

Natural Distribution and Utilization of *Lathyrus* in Jordan

MAHA Q. SYOUF

Introduction

Jordan is a small country (9.0 million hectares) located in the eastern Mediterranean. The climate is characterized by dry hot summer and mild wet winter and extreme variability in rainfall within and among years. Rainfall decreases from west to east and from north to south. The country has a wide variability in climate and topography that has led to a wide diversity in flora. Forage legumes are highly abundant in that country, and collecting missions have reported more than 2000 accessions of forage legume species. All accessions collected are conserved at the International Center for Agricultural Research in Dry Areas (ICARDA) in a comprehensive database including information on their origin, characteristics and uses. These accessions represent significant variation in many morphological traits which reflect the presence of adaptive traits to the particular environmental conditions. In general, forage legumes can play an important role in sustaining the productivity of farming system in Jordan. Their ability to symbiotically fix nitrogen and improve soil structure are key to farming system sustainability.

Species Distribution and Germplasm Collection

The Mediterranean forage legumes and their distribution have been described in some detail by Mathison (1983). They are distributed mainly in the northern hemisphere around the Mediterranean sea and eastwards to central Asia and/or in the temperate climate zone of Europe, and eastern Asia. Zohary (1972) reported that about 170 species of *Lathyrus* are found in the north temperate zone of both hemispheres and in the mountains of tropical east Africa and south America. Fifteen species of *Lathyrus* were reported from Palestine of which 10 species (*Lathyrus digitatus* (M.B) Fiori, *L. hierosolymitanus* Boiss., *L. aphaca* L., *L. gorgonei* Parl., *L. cicera* L., *L. inconspicuus* L., *L. blepharicarpus.* Boiss, *L. ochrus* (L.) DC., *L. gloeospermus* Warb et Eig, and *Lathyrus pseudocicera*) were reported for Jordan. The national herbarium of the National Center for Agricultural Research and Technology Transfer (NCARTT), Jordan contains 2 specimen of *L. gorgonei* collected from fields of Irbid and Jerash in 1911.

El. Oqlah and Lahham (1985) reported 6 species of *Lathyrus* (*L. blepharicarpus* Boiss, *L. cicera* L., *L. gorgonei* Parl., *L. hierosolymitanus* Boiss., *L. inconspicuus* L., and *L. sativus* L.), through a survey conducted at Ajlun mountain in the northern part of the country. Herbarium specimens of this survey are available at the herbaria of the University of Jordan and the Ministry of Agriculture. Collection missions for germplasm conservation and evaluation purposes were activated in Jordan with the establishment of both the International Board for Plant Genetic Resources (IBPGR) in 1974 and The Genetic Resources Unit at ICARDA in 1980. Collection missions in 1981, 1989, 1990 and 1993 reported 36 accessions of 8 species of *Lathyrus* from all over the country (Table1). *Lathyrus* was found in soil texture of clay, clay loam, silty clay or gravel with a pH of 4. The details of site of collection are presented in Table 2. The most abundant species was found to be *L. aphaca* collected from 15 locations. The range of altitude varied from 50 m below sea level at Shuna (Jordan valley) to 1125 m at Ibbin/Irbid location. The rainfall distribution for this species ranged from 150 mm at Shuna to 650 mm at Dair at Birak/Irbid location (Fig.1 and Table 1). *Lathyrus hierosolymitanus* was collected from 8 locations. Altitude varied from 522 m at Tel Ruz/Balqa to 1125 m above seal level at Ibbin/Irbid, soil texture was either silty clay or clay. Rainfall ranged from 300 mm at Biren to 650 mm at Irbid before Ibbin (Table 2 and Fig 2). Al-Eisawi (1983), encountered one species of *Lathyrus* (*Lathyrus hierosolymitanus* Boiss) from the area of Wadi Araba, where the major habitat is tropical vegetation of the Jordan rift valley, with elevations varing from 200 m below sea level upto 100 m above seal level. Annual rainfall ranges from 0-50 mm, characterized by dry, hot summer and a scarce rainfall; thus the wadi

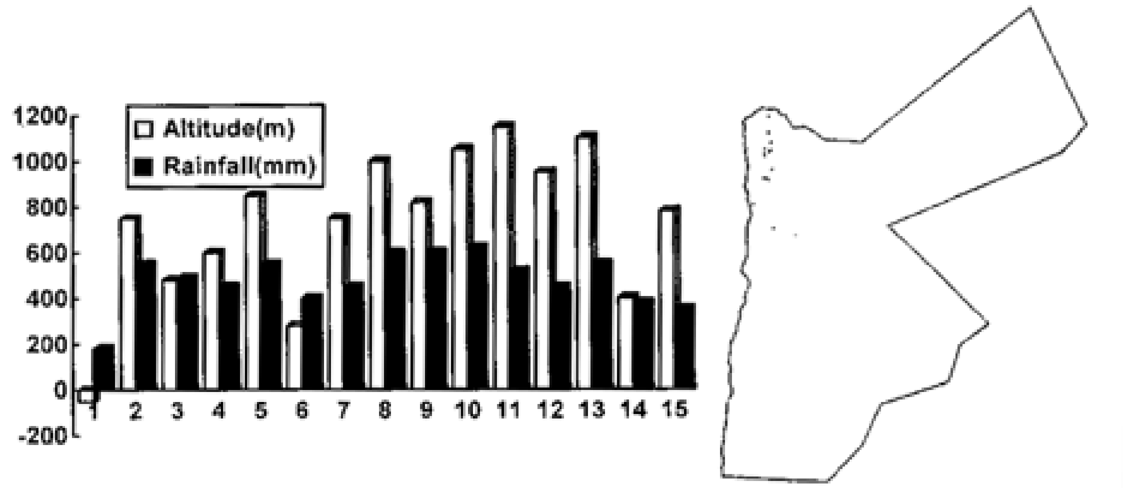

Fig. 1. Altitude, rainfall variation and map showing *Lathyrus aphaca* distribution in Jordan

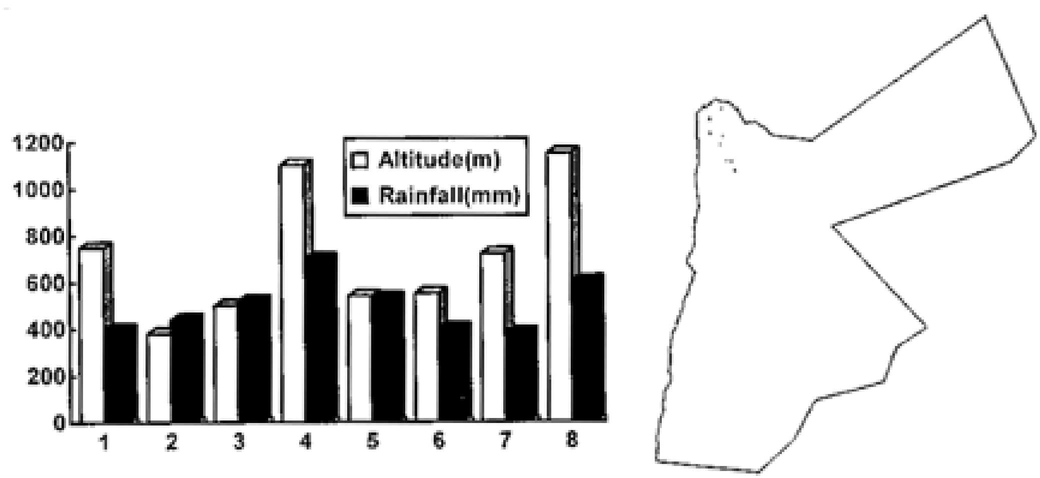

Fig. 2. Altitude, rainfall variation and map showing *Lathyrus hierosolymitanus* distribution in Jordan

Table 1. Total number of *Lathyrus* species collected from Jordan between 1981-1993 and by various collecting missions

Year	Species collected	No.of Accessions	Organizations/reference
1981	*Lathyrus aphaca*	1	ICARDA/JAP*
	Lathyrus gorgonei	1	Syouf (1994)
	Lathyrus pseudocicera	1	
Total	3	3	2
1989	*Lathyrus aphaca*	1	NCARTT/ICARDA
	Lathyrus cicera	1	Syouf (1992)
	Lathyrus pseudocicera	2	
	Lathyrus sativus	1	
Total	4	5	2
1990	*Lathyrus aphaca*	13	NCARTT/ICARDA
	Lathyrus hierosolymitanus	8	Syouf (1992)
	Lathyrus inconspicuus	2	
	Lathyrus pseudocicera	2	
	Lathyrus sp.	1	
	Lathyrus sp.	1	
Total	6	27	
1993	*Lathyrus gloeospermus*	1	NCARTT, Syouf (1994)

* Jordan Australian Project

is classified as a desert (Herbarium specimens are kept at Jordan University; no seeds are stored from this entry).

Lathyrus pseudocicera was collected from 5 locations in the country; altitude ranged from 100 m below sea level at Wadi Shieb to 800 m above sea level at Kamsha/ Amman. Soil texture for the sites was either clay or clay loam (Fig. 3). *Lathyrus inconspicuus* was collected from two sites; Mafraq with 200 mm rainfall and Ajlun with 600 mm rainfall (Fig. 4). *Lathyrus cicera* was collected from Shobak at altitude of 1350 m above seal level and rainfalls of 350 mm. Soil texture was clay. *L. gorgonei* was collected from the Jordan valley at 50 m altitude, and a low rainfall of 150 mm. Soil texture was clay (Fig. 5). *L. sativus* was collected from Tafielah, at an altitude of 1500 m above seal level, in addition to these, two undefined species were also collected during these collecting missions. Syouf (1994) collected *L. gloeospermus* for the first time from a wild habitat at Maro location. The species considered to be very rare was encountered by chance at Maro, 7 km south of Irbid, with a rainfall of 350 mm, a soil pH of 7.9 and a clay soil texture. It is obvious that many species of *Lathyrus* are under severely stressed conditions, little has been found up to date.

Table 2. Species collected and data on site of collection

Year	Species	Province	Site description
1981	*Lathyrus aphaca*	Irbid	North Shuna
1990	*L. aphaca*	Balqa	Dirah 4 km west of Alan
1990	*L. aphaca*	Balqa	Before cross to Dair Trab
1990	*L. aphaca*	Balqa	Al Zahra 3 km after Rumimein
1990	*L. aphaca*	Balqa	Allan, 1 km before the village
1990	*L. aphaca*	Balqa	Rumman 27 km north of Amman
1990	*L. aphaca*	Irbid	10 km south west of Irbid on road to Mazar
1990	*L. aphaca*	Balqa	Anjarah, 25 km west of Jerash
1990	*L. aphaca*	Balqa	Zatara, 3 km northwest of Ajlun
1990	*L. aphaca*	Irbid	Dair al Birak, 7.5 km before Ibbin
1990	*L. aphaca*	Irbid	Ibbin 1 km after the cross to Ajlun
1990	*L. aphaca*	Balqa	Um el Yanabii, 4.5 km west of Ibbin
1990	*L. aphaca*	Irbid	Ibbin 1 km before the village coming from Soof
1990	*L. aphaca*	Irbid	Saham, 6 km after the cross to Kufr Sum
1989	*L. aphaca*	Madaba	Hrethin 15 km from Wadi Wala to Madaba
1989	*L. cicera*	Shobak	Inside Shobak Agricultural Research Station
1981	*L. gorgonei*	Balqa	North Shuna village
1990	*L. hierosolymitanus*	Amman	Shafabadran on Jerash road
1990	*L. hierosolymitanus*	Ajlun	Anjarah near Um Jlude
1990	*L. hierosolymitanus*	Irbid	18 km north of Irbid city
1990	*L. hierosolymitanus*	Irbid	7 km before Ibbin
1990	*L. hierosolymitanus*	Irbid	Kelle 1 km before Kufr Rakeb
1990	*L. hierosolymitanus*	Balqa	Tel el Ruz, 25 km from Seweyleh towards Jeresh
1990	*L. hierosolymitanus*	Amman	Bierin, 3 km towards Jeresh
1990	*L. hierosolymitanus*	Irbid	Ibbin 1 km after the Ajlun cross
1990	*L. inconspicuus*	Mafraq	Rehab
1990	*L. inconspicuus*	Ajlun	Ain Um Jlude, near spring
1981	*L. pseudocicera*	Amman	Wadi sir
1990	*L. pseudocicera*	Irbid	Kufr Assad
1990	*L. pseudocicera*	Amman	Kamsha
1989	*L. pseudocicera*	Karak	Al Ena 30 km from Karak towards Tafilah
1989	*L. pseudocicera*	Balqa	Wadi Shueib
1989	*L. sativus*	Tafila	Al Kadisyah, 20 km towards Shobak
1990	*Lathyrus* sp.	Irbid	Kasfa
1990	*Lathyrus* sp.	Irbid	10 km towards Kasfa
1993	*L. gloeospermus*	Irbid	Maro, 7 km South of Irbid

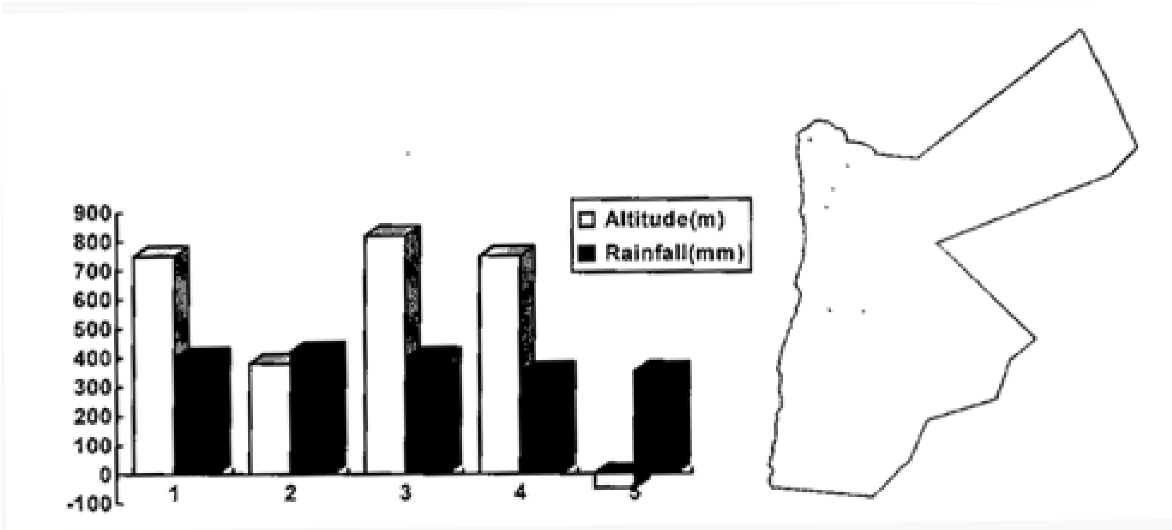

Fig. 3. Altitude, rainfall variation and map showing *Lathyrus pseudocicera* distribution in Jordan

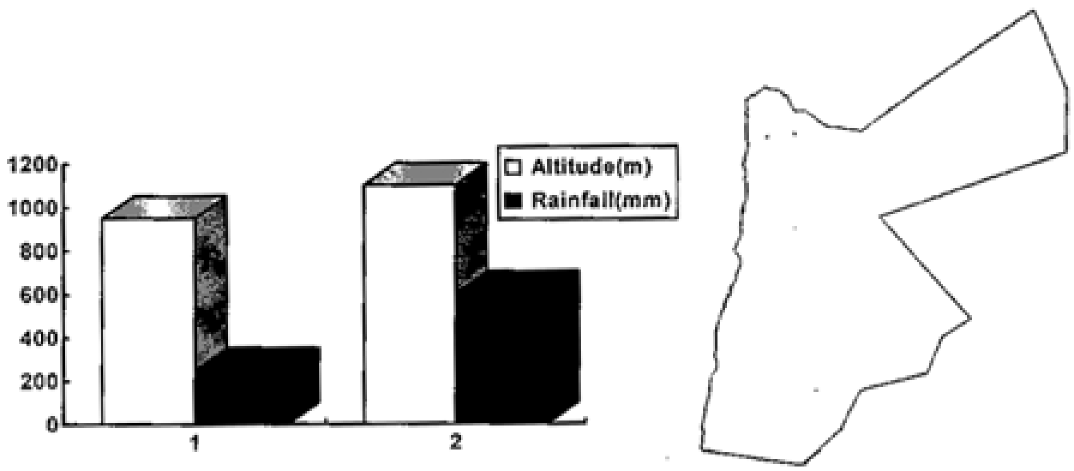

Fig. 4. Altitude, rainfall variation and map showing *Lathyrus inconspicus* distribution in Jordan

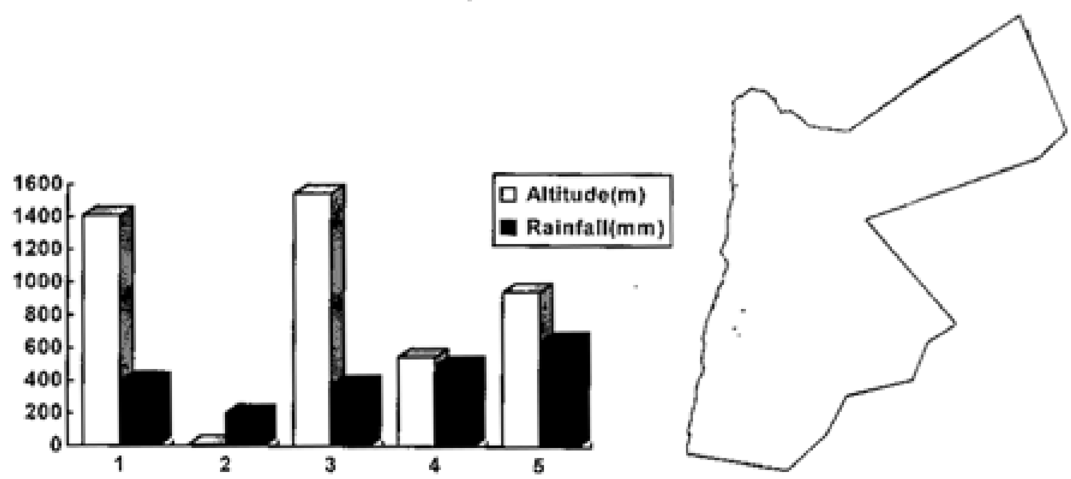

Fig. 5. Altitude, rainfall variation and map showing *Lathyrus species* distribution in Jordan

The recent situation regarding availability of *Lathyrus* species in the country is presented in Table 3.

Table 3. Abundant, rare, very rare and extinct *Lathyrus* species in Jordan as of 1995

Abundant	Rare	Very rare	Extinct
L. aphaca	*L. cicera*	*L. gloeospermus*	*L. ochrus*
L. hierosolymitanus	*L. gorgonei*	*L. blepharicarpus*	*L. digitatus*
L. pseudocicera	*L. inconspicuus*		

Table 4. Frequency distribution for growth habit, Frost tolerance, vigour, and flower colour for 20 accessions of *Lathyrus* at Tel Hadya, Syria

Descriptor/score	Jordanian *Lathyrus*
Growth habit (GRH)	
Spreading	23.8
Semi-spreading	61.9
Erect	14.3
Semi-erect	61.9
Frost tolerance (FROST)	
High tolerant	—
Tolerant	71.4
Moderately tolerant	14.3
Susceptible	9.5
Highly susceptible	4.8
Vigour (VIG)	
Very strong	—
Strong	52.4
Intermediate	33.3
Poor	9.5
Very poor	4.8
Flower colour (FOC)	
White	—
Blue	5.0
Dark pink	60.0
Pink	—
Violet	—
Yellow	35.0

Source: Larry *et al.* (1992)

This genetic erosion is evident especially in species such as *L. ochrus*, *L. gorgonei* and *L. cicera*. No accessions were reported from recent collection for *L. gorgonei* at Jerash or Irbid location. *L. aphaca* is still abundant in the country but often occurs in very small populations, studies on conservation aspects are needed on this species in particular.

Utilization

The scarcity of feed resources, primarily locally produced forages is the major limitation. Over exploitation of rangelands, fallow lands and field crops residues downgrade the importance of cultivated forages for more efficient animal production in Jordan. In areas with annual rainfall of 200-300 mm cereal fallow is a major feature of rainfed agriculture. One of the most promising options for increasing forage production is to replace the fallow with pasture or fodder legumes. These crops can play an important role in sustaining the productivity of farming systems in Jordan. Forage legumes ability to fix atmospheric nitrogen, improve soil structure and provide protein rich food for farm animals. They are currently under-exploited. *Lathyrus* species was one of the forage legume evaluated and tested mainly through the Mashreq Project, the Ministry of Agriculture and the University of Jordan. Ayad (1992) studied four *Vicia* and three *Lathyrus* species (*L. cicera*, *L. ochrus* and *L. sativus*) at Mushager location in 1989 and 1991. He found that as plant growth advanced to full pod formation, digestibility, crude protein, ash content and leaves to branches ratio were decreased, while crude fiber content increased. *L.cicera* and *L. sativus* were found to have the highest crude protein content and the highest seasonal forage yield under different cutting heights over the two seasons tested. Larry *et al.* (1992), characterized 20 accessions of Jordanian *Lathyrus* for twelve descriptors at Tel Hadya, Syria. Most Jordanian *Lathyrus* accessions were semi-erect or erect and had strong or intermediate levels of vigour (Tables 4 and 5), and dark pink or yellow flower colour.

Table 5. Summary of statistics for DFLR, DAP, DMAT, PDPI, PLEN, PWID, SPD, and HSW for 20 accessions of Jordanian *Lathyrus*

Descriptors	Check mean	Accession Mean	Min.	Max.	C.V.(%)
DFLR(days)	114.50	112.40	104.0	120.0	2.9
DAP(days)	129.00	126.90	110.0	132.0	3.7
DMAT(days)	155.00	156.60	151.0	170.0	3.9
PDPI	1.20	1.10	1.0	1.8	20.9
PLEN(cm)	3.53	2.91	1.9	4.7	28.3
PWID(cm)	1.03	0.63	0.3	1.4	52.2
SPD	2.84	3.93	2.4	5.8	24.9
HSW (g)	12.35	3.83	1.3	7.6	45.8

Source: Larry *et al.* (1992)

Days to 50% flowering (DFLR), Days to 90% podding (DAP), Days to 90% maturity (DMAT), Pods per inflorescence (PDPI), Pod length in cm (PLEN), Pod width (PWID), Seeds per pod (SPD) and Hundred seed weight (HSW)

Table 6. Summary of statistics for dry matter and seed yield of eight forage legume selections evaluated during three cropping seasons in Jordan 1990-1992.

Legume species	Dry matter (kg/ha)			Grain yield (kg/ya)		
	Min.	Average	Max.	Min.	Average	Maxi.
Lathyrus ochrus 101	1 165	2 301a	3 760	144	704a	1 480
L. sativus 311	638	1 390b	2 208	83	358c	733
L. sativus 347	425	996c	1 750	81	345c	1 543
Vicia dasycarpa	844	1 185bc	1 692	40	234d	1 450
V. ervilea	734	1 288b	1 574	122	178	238
V. narbonensis	1 249	2 265a	3 300	93	730a	1 230
V. sativa 2541	519	1 403b	2 000	123	163	206
V. sativa 708	1 223	2 097a	3 180	79	512b	1 210

Source : Jaradat and Hadad (1992)
Means within each column followed by the same letter do not differ significantly, Tucky < 0.05

Characterization of *L. gloeospermus* under Baqa local condition in 1994 indicated that this species has a white flower colour, erect growth habit, tolerance to frost and has strong vigor. The other characters recarded were days to flowering (139), average plant height (39.5cm), average seeds per pod (2.5), 100 seed weight (16.4g), seed protein (20.1%), fiber content (0.28%) and fat content (0.9%) (Syouf *et al.* 1994).

Jaradat and Hadad (1992), reported that *Lathyrus* species were among the most promising ones of the ICARDA programmes (Table 6). *Lathyrus ochrus* 101 gave the highest dry matter yields during the 1990, 1991 and 1992 season, when evaluated by the Mashreq project.

Table 7. Average dry matter, biological and grain yields (kg/ha) produced under arid and semi arid environmental condition in Jordan (1989-1991)

Plant species	Dry matter yield	Biological yield	Grain yield
Vicia sativa 2541	2 322	2 629	642
V. sativa 708	1 877	2 426	567
V. sativa 715	1 833	2 385	593
V. narbonensis	2 166	2 168	432
V. dasycarpa	2 184	2 228	804
V. ervilea	2 727	2 946	881
Lathyrus sativus 311	1 882	2 512	811
L. sativus 347	1 679	1 911	520
L. ochrus 101	1 929	2 386	652

Source : Jaradat and Hadad (1992)

When these species were evaluated for low rainfall areas, the most important factor in the production process, *Lathyrus* species differed significantly from the vetches in dry matter and to a lesser extent, in biological and grain yield (Table 7). *Lathyrus* enteries were the lowest in dry matter production and intermediate in biological and seed yield.

Also Jaradat and Hadad (1992) studied the average stress index for nine forage legume genotypes for drought tolerance in Jordan. They found that *L. ochrus* had the lowest stress index for dry matter and biological yield but not for grain yield. *Lathyrus sativus*, selection 311 had the highest stress index estimate for grain yield (Table 8).

Table 8. Average stress index (SI) for nine forage legume genotypes evaluated for drought tolerance in Jordan

Entry	Dry matter yield	Biological yield	Grain yield
Vicia sativa 2541	1.14	1.17	0.87
Vicia sativa 708	2.46	1.13	1.54
Vicia sativa 715	1.60	1.54	1.22
Vicia narbonensis	3.10	1.20	0.62
Vicia dasycarpa	1.83	0.90	1.33
Vicia ervilea	0.36	0.93	1.28
Lathyrus sativus 311	1.18	0.98	2.05
Lathyrus sativus 347	3.50	1.77	1.26
Lathyrus ochrus 101	0.15	0.77	1.04

Source: Jaradat and Hadad (1992)
Note: The lower the SI estimate, the higher the drought tolerance of the entry

Very few farmers grow *L. sativus* in the country, and it is mostly restricted to the northern part. Breeding programmes for *Lathyrus* quality improvement are not being carried out. Nevertheless Mashreq Project through crop rotation of Barley - vetch (*Vicia sativa*, *Vicia ervilea*) and Barley - *Lathyrus sativus*, produced similar yields and did not differ significantly from the former. This is an over whelming hint to include this species in a wider forage programme in the country.

In conclusion, *Lathyrus* species are either threatened now, or will be threatened in the near future by severe genetic erosion or by extinction. Safeguarding their genetic diversity seems possible only through conservation. The most suitable allocation on *Lathyrus* would be a Barley - *Lathyrus* (especially *Lathyrus sativus*) crop rotation.

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References

Ayad, J. 1992. Productivity and quality of some annual forage legumes as influenced by different growth stages and cutting treatments in rain-fed areas. Faculty of Graduate Studies, Graduate Department of Biological and Agricultural Sciences and Natural Resources. University of Jordan, MSc thesis 109 p.

Al Eisawi, D. 1983. Studies on the flora of Jordan. 11. on the flora of Wadi Araba (Araba Valley). Candollea 38 : 365-385.

El Oqlah, A. A. and N. Lahham. 1985. A checklist of vascular plants of Ajlun mountain. Candollea 40: (2) 377.

Jaradat, A. and N. Hadad. 1992. Analysis and Interpretation of Mashreq Project findings (1990-1992). Special report. Mash. Doc. 018.

Syouf, M. 1992. Plant Genetic Resources in Jordan. National Center for Agricultural Research and Technology Transfer. Annual Report, 1992.

Syouf, M. 1994. International Plant Genetic Resources (IPGRI) in West Asia and North Africa: Newsletter No.4(2) 1994.

Syouf, M., S. Saifan and Z. Tehabsam. 1994. Characterization of *Lathyrus gloeospermus*. NCARTT Annual Report, 1994.

Larry, R., A. Shehadeh, and F. Sweid. 1992. Genetic Resources Unit, Annual Report. International Center for Agricultural Research in Dry Areas (ICARDA).

Mathison, M. J. 1983. Mediterranean and temperate forage legumes. Pp. 63-81 *In* Genetic Resources of Forage Plants. (ed.) J. G. McIvor and R. A. Bray. CSIRO, Melbourne

Zohary. M. 1972. Flora Palaestina. The Isreal Academy of Sciences and Humanities. Text II. 498 p.

Lathyrus Genetic Resources in Turkey

CAFER OLCAYTO SABANCI

Introduction

The place of origin of a species was explained by Vavilov as an area that contains a large amount of genetic variability of the species (Zohary 1970). From this point of view, he set up eight geographic centers. Turkey was placed in two of these, The Near East Center and the Mediterranean Center. Turkey is also a secondary center for many crops including some legumes, e.g., sainfoin, originating from another primary center, but have been planted for many years (Harlan 1951). The country has more than 3000 endemic plants (Dokuzoouz 1990), and is rich in plant wealth. Immense diversity occurs in legumes, viz., *Vicia, Medicago, Trifolium, Lathyrus, Onobrychis, Trigonella, Pisum, Cicer* and *Lens,* etc. Pastures and meadows have good amount of genetic variability of many different genera as cited above. However, there has been a significant genetic erosion due to change in cultivation systems, introduction of new varieties, overgrazing, erosion caused by the flood or wind, excessive use of chemicals, conversion of range lands into fields for the other crops. Therefore, plant collecting and conservation assummes national vital importance and priority.

The first activity about genetic resources in Turkey started in 1932 by establishing an institute, and nearly 50 000 accessions were collected in a rather short time. An institute, as an introduction center, was built to conduct these activities in Yimir in 1963. This Institute, which was named as Aegean Agricultural Research Institute, became National Project Center in 1979, and has been conducting plant genetic resources studies, namely, collection, multiplication and regeneration, characterization and evaluation in cooperation with other institutes and universities since then.

Lathyrus Genetic Resources

Davis (1970) reported the existence of about 61 *Lathyrus* species in Turkey, some of them being endemic at local or regional level, such as *L. cilicicus*, *L. elongatus* and *L. undulatus*. Table 1 gives a complete list of genus *Lathyrus* which consists of Mediterranean, East Mediterranean, Euro-Siberian or Irano-Turanian elements. Davis (1970) also mentioned that *Lathyrus sativus* was widely grown in Turkey and *Lathyrus odoratus* was cultivated as an ornamental. *Lathyrus hirsutus* was a cultivated plant before 1970. Also, *L. hirsutus* had been cultivated, especially, in East and Inner Anatolia, during the 1960s (Tosun 1974). *Lathyrus sativus* is still being cultivated, but to a much lesser extent (Acykgoz 1991).

Table 1. *Lathyrus* species found in Turkey (Davis 1970)

Species	Distribution region	Range of altitude
L. amoenus Fenzl.	E. Medit.	s.l. - 1 000 m
L. annuus L.	Medit.	s.l. - 1 000 m
L. aphaca L. var. *aphaca*	—	s.l. - 100 m
var. *affinis* (Guss.) Arc.	E. Medit.	s.l. - 1 700 m
var. *biflorus* Post.	—	s.l. - 1 900 m
var. *floribundus* (Vel.) K. Maly	—	150 - 1 100 m
var. *pseudoaphaca* (Boiss.) Davis	E. Medit.	s.1 - 1 700 m
var. *modestus* P.H. Davis	—	500 - 1 300 m
L. armenus (Boiss. & Huet)Sirj.	Ir.-Tur.(En)	1 270 - 2 800 m
L. aureus (Stev.) Brandza	Euxine	15 - 2 000 m
L. blepharicarpus Boiss.	E. Medit.	100 - 600 m
L. boissieri Sirj.	Ir.-Tur.	1 000 - 2 000 m
L. brachyterus Cel. var. *brachyterus*	IT.-Tur.	1 500 - 2 500 m
var. *haussknectii* (Sirj.) Davis	Ir.-Tur. (En)	—
L. cassius Boiss.	E. Medit.	s.l. - 1 650 m
L. chloranthus Boiss.	Ir.-Tur.	600 - 1 800 m
L. chrysanthus Boiss.	Ir.-Tur.	750 m
L. cicera L.	—	5 - 2 000 m
L. cilicicus Hayek & Siehe	E. Medit. (En)	600 - 1 300 m
L. clymenum L.	Medit.	s.l. - 100 m
L. cyaneus (Stev.) Koch var. *cyaneus*	—	1 670 - 2 800 m
var. *pinnatus* P.H. Davis	Hyr.-Eux. (En)	—
L. czeczottianus Bassler	(En)	1 150 - 2 200 m
L. digitatus(Bieb.) Fiori	E. Medit. (En)	200 - 1 550 m
L. elongatus (Bornm.) Sirj.	—	350 - 1 520 m
L. gorgonii Parl. var. *gorgonii*	E. Medit.	—
var. *pilosus* C.C. Townsend	E. Medit.	s.l. - 1 070 m
L. hierosolyminatus Boiss.	E. Medit.	500 m
L. hirsutus L.	—	s.l. - 1 000 m
L. inconspicuus L.	—	s.l. - 1 500 m
L. incurvus (Roth.) Willd.	—	600 - 2 000 m
L. karsianus P.H. Davis	Euro-Sib. (En)	2 000 - 2 300 m
L. laxiflorus (Desf.) O. Kuntze subsp. *laxiflorus*	—	s.l. - 1 900 m
subsp. *angustifolius* (Post ex Dinsm.) Davis	E. Medit. (En)	1 200 - 1 400 m
L. layardi J. Ball ex Boiss.	Ir. - Tur. (En)	1 575 - 1 800 m
L. libani Fritsch	E. Medit.	750 - 1 650 m
L. lycius Boiss.	E. Medit. (En)	s.l. - 420 m

Contd.

Table 1. *Contd.*

L. marmoratus Boiss. & Bl.	—	75 - 1 700 m
L. montanus Bernh.	—	—
L. niger (L.) Bernh. subsp. *niger*	Euro-Sib.	s.l. - 1 000 m
L. nissolia L.	—	s.l. - 1 900 m
L. nivalis Hand.-Mazz.	Ir. - Tur. (En)	2 400 - 3 200 m
L. ochrus (L.) DC.	Medit.s. l. - 50 m	
L. pallescens (Bieb.) Koch	—	1 800 - 2 200 m
L. palustris L. subsp. palustris	Euro-Sib.	s.l. - 1 000 m
L. pannonicus (Jacq.) Garcke	—	—
L. phaselitanus Hub.-Mor. & Davis	E. Medit. (En)	70 m
L. pratensis L.	Euro-Sib.	s.l. - 2 300 m
L. pseudo-cicera Pamp.	Ir.-Tur.	150 - 750 m
L. roseus Stev.	Hyr.-Eux.	30 - 1 800 m
L. rotundifolius Willd.	—	1 000 - 2 020 m
subsp. *miniatus* (Bieb. ex Stev.) Davis		
L. satdaghensis P.H. Davis	Euro-Sib. (En)	1 900 - 2 150 m
L. sativus L.	—	s.l. - 1 520 m
L. saxatilis (Vent.) Vis.	Medit.	30 - 600 m
L. setifolius L.	Medit.	20 - 800 m
L. spathulatus Cel.	E. Medit.	400 - 1 520 m
L. sphaericus Retz.	—	10 - 2 000 m
L. stenolobus Boiss.	(En.)	—
L. stenophyllus Boiss. & Heldr.	E. Medit.	20 m
L. sylvestris L.	Euro-Sib.	—
L. tauricolla P.H. Davis	E. Medit (En)	800 - 1 300 m
L. trachycarpus (Boiss.) Boiss.	Ir.-Tur. (En)	700 m
L. tuberosus L.	Euro-Sib.	1 000 - 2 150 m
L. tukhtensis Czecz.	(En)	700 - 2 000 m
L. undulatus Boiss.	Euxine (En) s.l. - 600 m	
L. variabilis (Boiss. & Ky.) Maly	E. Medit.	1 000 - 1 700 m
L. venetus (Miller) Wohlf.	Euro-Sib. 600 - 950 m	
L. vernus (L.) Bernh.	Euro-Sib.	60 - 1 400 m
L. vinealis Boiss. & No.	Ir. - Tur.	900 - 1 300 m
L. woronowii Bornm.	(En)	—

Turkey located between 36°- 42'N and 26°- 45'E has nine main agricultural regions with different ecological conditions. The altitude ranges from sea level to 2000 m. Regions, range of altitudes and average annual rainfall are presented in Table 2. The distribution of *Lathyrus* species based on the data gathered by Davis (1970) throughout Turkey as given in Table 2, shows that southern and eastern parts of the country have the majority of the species.

Table 2. Agricultural regions and the number of *Lathyrus* species

Regions	Altitude range (m)	Rainfall (mm)	No of species
Mediterranean (South)	s.l. - 500	970	23
Agean (West)	s.l. - 1 000	750	7
Black Sea (North)	s.l. - 1 500	1 300	14
North west	s.l. - 500	760	16
North east	900 - 2 000	500	3
Central south	1 000 - 2 000	350	16
Central north	800 - 1 000	530	3
Central east	500 - 1 400	470	3
East and South east	500 - 1 000	670	26

Collections

Expeditions have been organized to collect genetic resources including different *Lathyrus* species regularly since the Institute was established. Over 600 accessions comprising 31 *Lathyrus* species have been collected from different regions at different altitudes ranging from sea level to 2000 m (Table 3). Before 1987, expedition missions were interested in collecting forage genetic resources in general and *Lathyrus* species were gathered when encountered. In 1987, 1988 and 1995, expeditions focused on specific germplasm collecting in legume and a total of 449 *Lathyrus* seed samples were collected.

Table 3. *Lathyrus* collections in Turkey

Species	No of Accessions	Altitude (m)	Species	No of Accessions	Altitude(m)
L. amoenus	3	165 - 1 600	*L. laxiflorus*	17	50 - 910
L. annuus	44	s.l. - 2 000	*L. marmoratus*	4	s.l. - 100
L. aphaca	119	s.l. - 2 000	*L. nissolia*	9	100 - 910
L. blepharicarpus	1	100	*L. ochrus*	1	70
L. chloranthus	4	1500 - 1 800	*L. odoratus*	2	1 500
L. chyrsanthus	1	600	*L. pseudoaphaca*	12	100 - 1 650
L. cicera	90	s.l. - 1 660	*L. pseudocicera*	8	100 - 500
L. cilicicus	2	600	*L. rotundifolius*	1	500
L. clymenum	1	s.l.	*L. sativus*	17	20 - 1 100
L. digitatus	9	150 - 1 060	*L. saxatilis*	2	1 650
L. gorgonii	27	s.l. - 1 100	*L. setifolius*	5	60 - 100
L. graminoides	4	100 - 300	*L. sphaericus*	19	125 - 350
L. hierosolyminatus	22	300 - 800	*L. spharucatus*	5	350
L. hirsutus	2	200 - 350	*L. stenophyllus*	2	1 960
L. inconspicus	79	60 - 1 600	*L. tuberosus*	2	1 960
L. lathyroides	1	100	*L. undulatus*	4	200 - 1 060

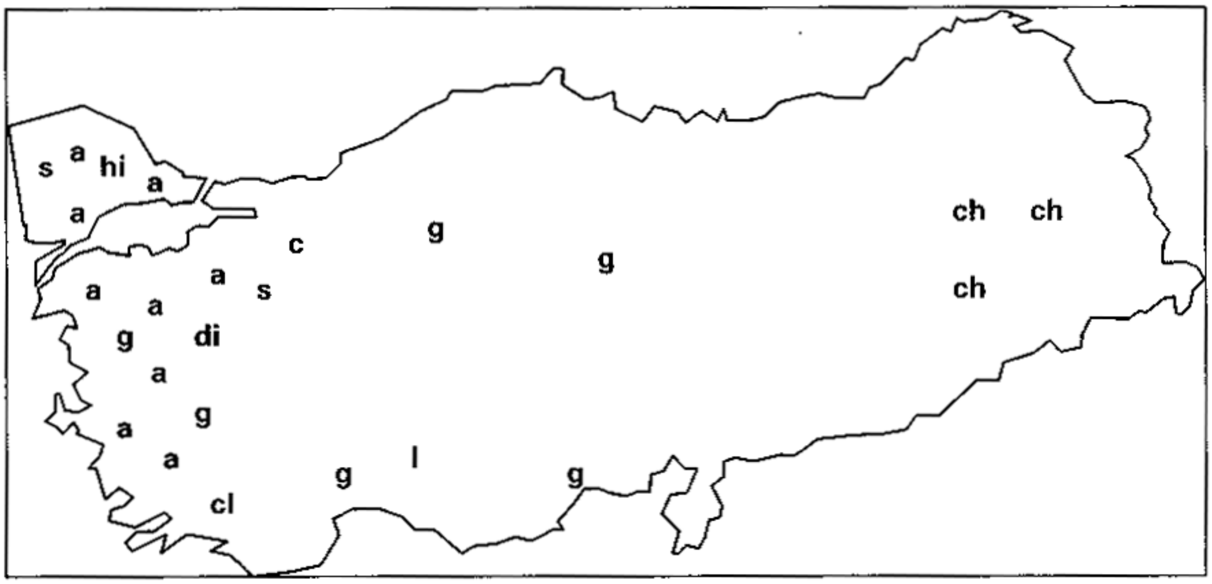


Fig 1. *Lathyrus* species collections in Turkey

a= *L. annuus,* hi= *L. hirsutus,* di= *L. digitatus,* ch= *L. chloranthus,* s= *L. setifolius,*
g= *L. gorgonii,* p= *L. pseudocicera,* ci= *L. cilicicus,* l= *L. lathyroides*

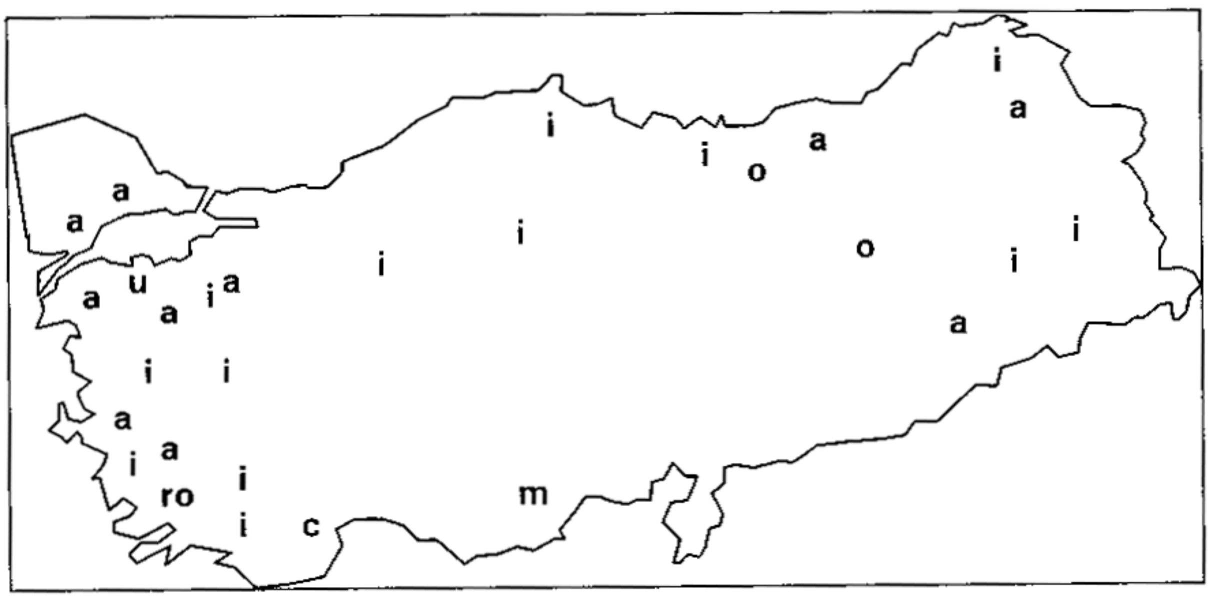


Fig 2. *Lathyrus* species collections in Turkey

a= *L. aphaca,* i= *L. inconspicus,* ro= *L. rotundifolius,* o= *L. odoratus,*
m= *L. marmoratus,* u= *L. undulatus,* c= *L. clymenum*

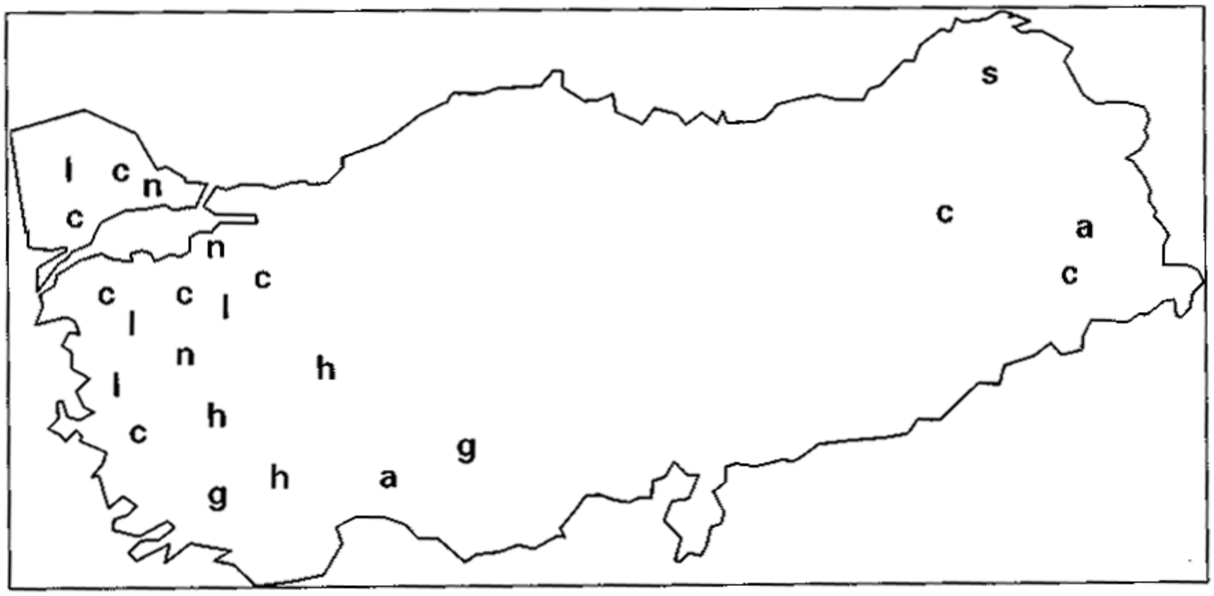


Fig 3. *Lathyrus* species collections in Turkey

a= *L. amoenus*, c= *L. cicera*, l= *L. laxiflorus*, n= *L. nissolia*,
s= *L. saxatilis*, g= *L. graminoides*, h= *L. hierosolyminatus*

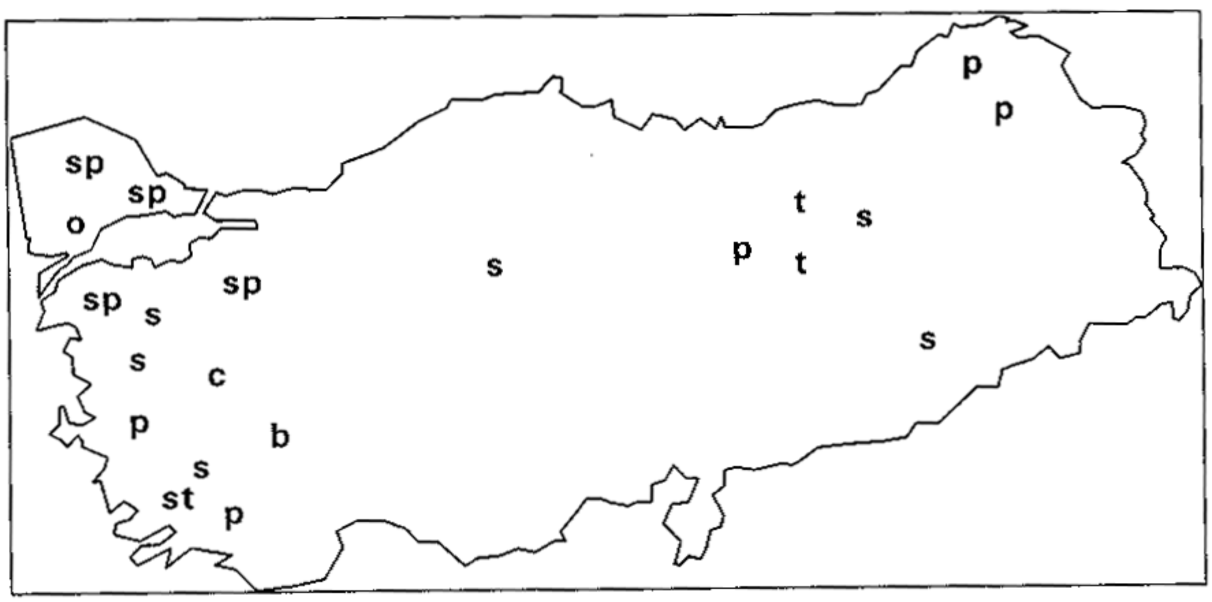


Fig 4. *Lathyrus* species collections in Turkey

s= *L. sativus*, c= *L. chrysanthus*, b= *L. blepharicarpus*, t= *L. tuberosus*,
sp= *L. sphaericus*, st= *L. stenophyllus*, p= *L. pseudoaphaca*, o= *L. odoratus*

Table 4. ***Lathyrus*** **herbarium specimens held in the institute**

Species	No.	Species	No.
L. annuus	29	*L. hirsutus*	2
L. aphaca	46	*L. inconspicus*	59
L. aphaca var. *affinis*	2	*L. laxiflorus*	9
L. aphaca var. *aphaca*	11	*L. layardi*	1
L. aphaca var. *biflorus*	1	*L. marmoratus*	4
L. aphaca var. *floribundus*	8	*L. nissolia*	5
L. aphaca var. *pseudoaphaca*	2	*L. ochrus*	3
L. boissieri	4	*L. pratensis*	6
L. chloranthus	10	*L. pseudocicera*	15
L. chrysanthus	1	*L. roseus*	1
L. cicera	71	*L. rotundifolius*	10
L. clymenum	2	*L. sativus*	24
L. cynaeus-pirinatus	2	*L. sphaericus*	2
L. czeczottianus	1	*L. stenophyllus*	13
L. digitatus	13	*L. sylvestris*	3
L. gorgonii	20	*L. tuberosus*	10
L. graminoides	6	*L. vinealis*	2
L. hierosolyminatus	1		

Table 5. Multiplication and regeneration of ***Lathyrus*** **species**

Species	No. of accessions maintained	No. of accessions available for distribution	Species	No. of accessions maintained	No. of accessions available for distribution
L. annuus	37	18	*L. hierosolyminatus*	17	10
L. aphaca	167	53	*L. inconspicuus*	76	29
L. chrysanthus	1	1	*L. lathyroides*	1	1
L. cicera	71	51	*L. pseudocicera*	6	5
L. digitatus	2	2	*L. sativus*	17	6
L. gorgonii	86	21	*L. seriocarpa*	1	1
L. graminoides	4	1	*L. setifolius*	1	1

The distribution of collected material throughout the country is presented in Figs. 1 to 4. The number of *Lathyrus* species collected is nearly half of that found by Davis (1970). Especially the absence of some endemic species not being encountered during the expeditions shows the genetic erosion caused by many factors as cited above. Moreover, the distribution of these species have changed to a great extent. For example, Davis (1970) reported that some species like *L. annuus, L. aphaca, L. aureus, L. laxiflorus, L. nissolia* and *L. sativus* were widely distributed over the country. Among them, *L. aureus* no longer exists, *L. annuus, L. laxiflorus* and *L. nissolia* can be found only in western part while *L. aphaca* and *L. sativus* in western and eastern parts of Turkey. During explorations, new forage species have also been found such as *Lathyrus belinensis* and *Vicia eristalioides,* during an expedition in Turkey with the association of IBPGR in 1988 (Maxted *et al.* 1989) The *Lathyrus* herbarium specimens maintained by the institute are presented in Table 4.

Multiplication and Regeneration

The multiplication and regeneration of germplasm resources existing in gene bank is an important part of a conservation programme. In the institute, the seeds that reduce in amount due to distribution or decrease in germination percentage for which the tests are made in every five years systematically, are regularly multiplied and regenerated. Table 5 summarizes *Lathyrus* species included in those programmes and also the number of those made available for distribution.

In situ Conservation of Genetic Diversity

The *in situ* project is an important part of the National Plant Genetic Resources Project. Its objects and programme are given in Appendix I.

References

Acykgoz, E. 1991. Yem Bitkileri. Uludao Universitesi Basymevi. pp.96-97.

Davis, P.H. 1970. Flora of Turkey and East Aegean Islands. Vol.3. Edinburgh.

Dokuzoouz, M. 1990. Bitki Genetik Kaynaklarý. *In* Türkiyénin Biyolojik Zenginlikleri. Turkiye Cevre Sorunlarý Vakfý. pp. 25-40.

Harlan, J.R. 1951. Anatomy of Gene Centers of Origins. Amer. Nat. 85 : 97-103.

Maxted, N., H. Obari, A. Tan. Vicieae. 1989. (Leguminosae): New and interesting endemic species from the eastern Mediterranean. Plant Genetic Resources Newsletter, IBPGR. pp. 21-25.

Tosun, F. 1974. Baklagil ve Buodaygil Yem Bitkileri Kültürü. Ankara Üniversitesi Yay. No.242. pp. 180-181.

Zohary, D. 1970. Centers of Diversity and Centers of Origins. *In* Genetic Resources in Plants—Their Exploration and Conservation O.H. Frankel and E. Bennett (eds.). Blackwell Sci. Pub., Oxford and Edinburgh.

Appendix I. *In situ* Conservation of Genetic Diversity in Turkey

The flora of Turkey is very rich in diversity consisting of some 9000 taxa, 30% of them being endemic. Such an abundance in biodiversity can be attributed to having three major floristic regions, namely, Euro-Siberian (Black Sea coast), Mediterranean (Aegean and Mediterranean coasts), and Irano-Turanian (Middle, East and Southest Anatolia).

Plants studied in this project were wild and weedy relatives, and landraces of cultivated crops, such as cereals, forages, food legumes, industrial crops, vegetables, ornamentals, fruits, nuts and grapes, medicinal and aromatic plants, endemic species.

In situ project is an important part of the National Plant Genetic Resources Research Project, and will be applied for both agricultural and forest tree species in collaboration with the Ministry of Agricultural and Rural Affairs, Ministry of Forestry, and Ministry of Environment.

The objective of the project are to identify and establish *in situ* conservation areas in Turkey for the protection of wild genetic resources that originated in Turkey, to test and develop a new approach for conservation of genetic diversity, and to provide sustainable *in situ* conservation of wild genetic resources.

Project components : 1. Site surveys and inventories, 2. Gene management zones, 3. Data management, 4. National plan for *in situ* conservation.

Survey and inventory sites and proposed gene management zones :

1. Kazdag in north-west represents Euro-Siberian, Mediterranean and Irano-Turanian elements.

2. Ceylanpinar State Farm in Southern represents Mediterranean and Irano-Turanian elements.

3. Anatolian Diagonal in South and Central Turkey represents Mediterranean, Irano-Turanian and Euro-Siberian elements.

Aegean Agricultural Research Institute has responsibility for performing the project in Kazdag, and partly in Anatolian Diagonal. From agricultural point of view, chestnut and plum have been specified as target species for Kazdag, and nine potential sites having the possibility of becoming gene management zones have been selected. Inventory studies were performed to make clear ecogeographic ranges and environmental heterogeneity for target species. Field Crops Central Research Institute in Ankara has been conducting the studies in Ceylanpinar where *Triticum* species have been clarified as target species. Initial survey studies have already started in Anatolian Diagonal, where *Vicia* and some other forage legumes will probably be target species.

A database will be created for data management using Geographic Information System(GIS).

The national plan for *in situ* conservation will provide the foundation for review of the project, facilitate coordination and cooperation of gene management zones into other nature conservation strategies, and outline an implementation plan for continuing *in situ* conservation activities.

Networking in Plant Genetic Resources: WANANET

YAWOOZ ADHAM

Introduction

West Asia and North Africa Plant Genetic Resources Network (WANANET) was established during a workshop sponsored by IBPGR (now IPGRI), ICARDA and FAO. Representative from 13 countries (Algeria, Cyprus, Egypt, Iran, Jordan, Lebanon, Libya, Morocco, Pakistan, Syria, Tunisia, Turkey and Yemen) met at ICARDA's Headquarters from 4 - 7 May 1992 for the purpose of establishing this network. The overall objectives, as recognized by the organizers of this workshop were to :

a) Establish a regional network and formulate the type, mode of operation and management structure of the network.

b) Identify common problems and constraints hampering effective conservation and utilization of plant genetic resources in member countries and in the region.

c) Assist National Agricultural Research Systems (NARS's) in developing national plant genetic resources programmes.

d) Formulate and prioritise collaborative research work and strategies in collecting, conservation, documentation, germplasm exchange and training.

e) Formulate recommendations for regional cooperative programmes in plant genetic resources.

Structure of WANANET

The network is governed by WANA Plant Genetic Resources Committee (WANA PGRC), which is composed of national plant genetic resources coordinators in member countries, and representatives of IPGRI, ICARDA, FAO, nominated to serve for the duration of Phase I of WANANET (1992-1994), and will coordinate and facilitate the implementation of recommendations of the Workshop (Fig. 1). A steering committee was elected to serve during Phase I of WANANET. The steering committe will assist the WANA Groups to:

a) Develop plans for plant genetic resources work in the region, and

b) Formulate and monitor projects in plant genetic resources activities at the country and regional levels, assess priorities, and identify potential donors.

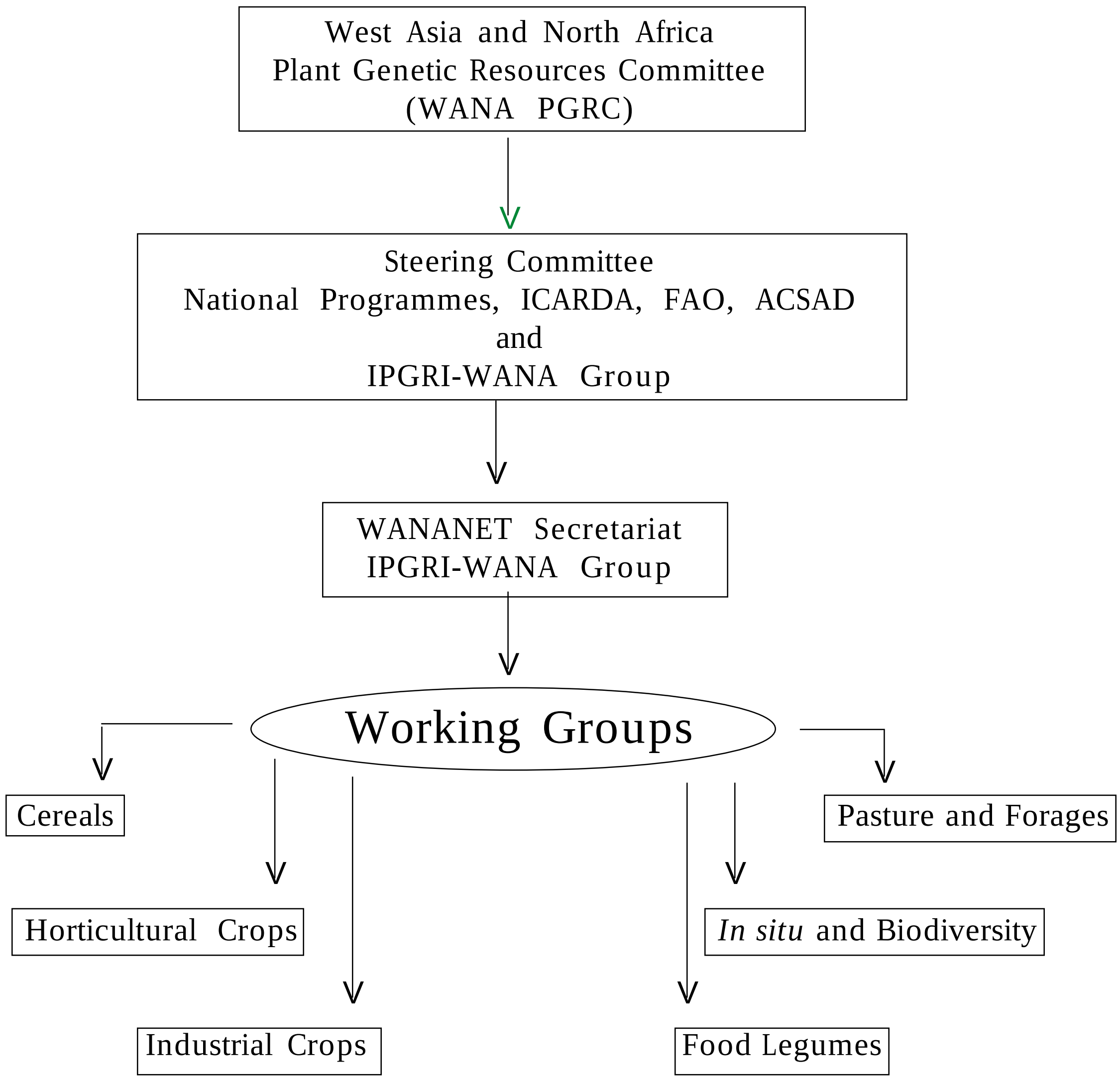


Fig. 1. Structure of West Asia and North Africa Plant Genetic Resources Network (WANANET)

Working groups have been formed, based on importance of plant genetic resources and availability of expertise within WANA. Country membership in these working groups reflect the importance of the country as a source of a particular plant genetic resources and the availability of expertise within that country. The tasks of the working groups include:

a) Specify priorities in plant genetic resources,
b) Identify and implement collaborative projects, and
c) Implement regional activities agreed by the WANA PGRC.

Six specialized working groups have been formed and these were able to meet during Phase I of WANANET (see later), discuss specific problems and initiate activities in plant genetic resources of cereals, food legumes, horticultural crops, pasture and forage plants, industrial crops, and *in situ* conservation and biodiversity.

Activities of WANANET during Phase I

All six working groups of WANANET met during Phase I at different locations throughout the region. The working group on cereal genetic resources met in Islamabad at the Pakistan Plant Genetic Resources Institute. Members of this working group noted that genetic erosion of landraces and primitive cultivars is a serious problem in parts of the region, especially in the Fertile Cresent. They recommended that national programmes should update or create their own database on cereal genetic resources as a pre-requisite for building a regional database, and as a contribution towards the establishment of Global Information System on plant genetic resources led by FAO. A few countries, including Syria, Pakistan and Iran, already started updating their databases on cereal genetic resources using a software programme provided by IPGRI. Moreover, both IPGRI WANA Regional Office and ICARDA, in cooperation with national programmes in Syria, Jordan, Lebanon and Iran, are formulating a project proposal for on-farm conservation of wheat and barley landraces. National programmes in Turkey and Iran expressed interest in joining such a collaborative programme.

The Working Group on Horticultural Crops met at the Headquarters of the Arab Center for Studies of the Arid Zones and Dry Lands (ACSAD) in Damascus, Syria. A regional project for the collection, conservation and utilization of fruit and nut trees of WANA was presented to the Working Group. It was possible to identify fruit tree species and countries to be covered by this project which is carried out by IPGRI Regional Office in collaboration with national programmes. The Working Group identified the lack of guidelines for the safe movement of fruit and nut tree genetic resources, limiting the use of these genetic resources within WANA. The Germplasm Maintenance and Use (GMU) Group of IPGRI was requested to develop such guidelines.

ICARDA's office for West Asia in Amman, Jordan was the venue for the meeting of the Working Group on Forage and Pasture. These genetic resources, being more subjected to environmental hazards and human intervention, are more prone to genetic erosion.

Therefore, the Working Group considered their collection, conservation and utilization as priority activities in the region. However, need for specialists in the region was felt to take the imbalances between forage legumes and grasses, annuals and perennial, and between Mediterranean and tropical/subtropical regions into account when planning or conducting activities related to these genetic resources. A major information gap was identified by the Working Group concerning the need for a generalized descriptor lists for major forage, pasture and shrub species in the region. A group of scientists in the region took the responsibility of developing an in-depth list for the purpose of evaluation of pasture and forage species.

The *in situ* and Biodiversity Working Group met at the Turkish Plant Genetic Resources Research Institute, near Izmir and close to a major site of the GEF - funded project on *in situ* conservation of biodiversity in Turkey. As a regional initiative, *in situ* conservation of plant genetic resources was considered by the working group as complementary to *ex situ* conservation. Moreover, the Working Group recognized the need for a close cooperation with national authorities responsible for, or interested in, environmental issues, and the need for a legal back up for *in situ* conservation of plant genetic resources. The Non-Governmental Organizations (NGOs) were called upon to participate in national or regional *in situ* initatives, especially for public awareness purposes. Two initiatives are underway in the region, one for the *in situ* conservation of endangered wild progenitors of major crops that originated in WANA and the other for on-farm conservation of landraces of field crops in the Fertile Crescent.

The Egyptian Field Crops Research Institute, Giza hosted the Food Legumes Working Group meeting. The meeting agreed on launching a regional activity on ‘Biodiversity of Food Legumes in WANA’. National programmes will participate in this 5-year programme in order to assess problems, document existing collections and identify gaps in collections, collect, characterize and evaluate germplasm, and promote exchange of germplasm and information on genetic resources of food legumes.

The Industrial Crops Working Group was the last one to meet at IPGRI Regional Office in Aleppo, Syria. Members of this working group met with a formidable task while chosing from a large number of industrial crops to be included in their list. Cultivated and wild relatives of *Saccharum* and *Beta* species, sesame, safflower, sunflower and flax were the ones of immediate importace within WANA, and were included as priority genetic resources of industrial crops to work with. Flow of information and germplasm of these crops is apparently limited to WANA. National programmes were requested to contribute towards building a database on these and other potential genetic resources; the experience of the *Beta* Network could be helpful in implementing projects and cooperation in the field.

Conservation and Use of Underutilized Crops in Asia

M. ZHOU AND R.K. ARORA

Introduction

In the region of Asia, the Pacific and Oceania, there are a number of underutilized/neglected crop species. The maximum diversity of lesser known cultivated food plants in the world occurs in the Chinese-Japanese, Indo-Chinese, Indonesian, South American and African Centres. It was estimated that about 900 lesser known food plants in the world occur in Asia (Arora 1985). These are important locally and often of value under the rural subsistence agricultural pattern. For many such crops like buckwheat, taro, grasspea, etc., not much importance has been given to improving the conservation and use of plant genetic resources. However, these food-cum-multipurpose crops deserve more concern regionally and need to be fully exploited. This paper summarizes such activities undertaken by IPGRI and focuses concern on research and development efforts required on underutilized crops for which South, South-east and East Asia hold rich diversity.

IPGRI-APO Project on Underutilized Crops

The APO project on underutilized crops addresses these concerns and involves activities relating to improved conservation and use of buckwheat, sesame, safflower, grasspea, taro and other potential crops. This also emphasizes the methodologies for linking conservation and use of underutilized crops. The primary objectives are: (a) assess the genetic diversity of such crops and help organize strategies for their conservation and use, (b) improve their utilization, (c) lay emphasis on methodologies for linking use and conservation, and (d) improving strategies and technologies for conservation. This activity is further promoted through the German-aided 3-year project at IPGRI Headquarters dealing with neglected crops, which also includes *Lathyrus* species.

Information gathering on buckwheat genetic resources and studies on genetic diversity

In collaboration with national programmes in South Asia, South-east Asia and East Asia, many activities have been undertaken. Much headway has been made in information gathering on buckwheat. Comprehensive information on buckwheat genetic resources diversity in Asia has been gathered and synthesized by IPGRI-APO staff and consultants from China, Nepal and India. Work on a book entitled 'Buckwheat Genetic Resources in Asia' is in progress. Directory of Buckwheat and Buckwheat Bibliography have been published.

IPGRI-supported studies on genetic diversity of buckwheat in China were undertaken by the Shaanxi Academy of Agricultural Sciences, Shaanxi University and Shaanxi Agricultural University. Great diversity in morphological characters, light reaction and isozyme pattern was found. Variations were found in plant height (24.3-126.7 cm), number of main stems (8.6-15.5), number of primary branches (0-62), seed weight (0.04-4.08 g/plant), 1000-grain weight (11.0-49.5g) and days to maturity (60-78 days) in common buckwheat. Differences among varieties of common buckwheat in photoperiod sensitivity were also revealed. Regression analysis showed that 22 buckwheat accessions studied could be classified into three types, viz., strongly sensitive, sensitive and weakly sensitive. Electrophoretic analysis of two enzymes were carried out using polyacrylamide gel eletrophoresis. For superoxide dismutase (SOD) four bands were found in tartary buckwheat (S_1, S_2, S_4 and S_6). Similarly, four bands were observed in common buckweat (S_2, S_5, S_6 and S_7) but a small difference in location of the bands was found between common and tartary buckwheat. The results of easterase analysis showed three identical bands(E_1, E_2 and E_3). Some populations from Yunan, Guizhou and Hunan provinces showed strong E_4 bands. This study provided information data to buckwheat breeders for use in buckwheat improvement and research work.

Sesame genetic resources : Diversity and improvement

On sesame, a joint study on interaction between genotype and environment at selected locations was supported by IPGRI, and implemented in Republic of Korea and India in 1994 and 1995. The results of this study provided scientific basis for effective use of sesame germplasm. An IPGRI-supported project on characterization and evaluation of world sesame collection carried out in Republic of Korea will promote use of genetic resources and further contribute to sesame improvement. Studies on establishment of sesame core collection in China are being carried out in Oil Crops Research Institute, Chinese Academy of Agricultural Sciences (CAAS) with IPGRI support. Experience in development of core collection improves collecting, conservation, characterization and evaluation activities in genebanks and increases germplasm enhancement (Hodgkin 1994). The establishment of a sesame core collection involves the collation of existing data on the accessions within a collection, the grouping of accessions with characteristics in common and the selection of an appropriate sample from each group. It is expected that this study will not only result in establishing a sesame core collection but also play a leading role for developing core collections for other crops in China.

Safflower conservation and utilization

Information on medicinal use of safflower is available in Chinese. Translation of selected papers from Chinese to English would promote dissemination of knowledge on medicinal uses of safflower.

Collaborative activities on safflower between Yunnan Academy of Agricultural Sciences (YAAS) and the Indian Council of Agricultural Research (ICAR)/Directorate of Oil Seeds Research have been planned for better utilization of diversity. The focus of the activities will be on studies on the ecotypes of safflower at selected locations in China and India.

Lathyrus (grasspea) — A neglected crop : *Conservation and use of diversity*

Lathyrus sativus is one of the target crops under IPGRI-APO Project on underutilized crops. It is an important legume crop in South and West Asia. The cultivated area under this crop is declining and landraces diversity is in danger of being lost. In China, about 20 000 hectares of grasspea were grown in North Shaanxi province in recent years. The farmers like this crop because of its high yield potential (20% higher than pea) and wide adaptability. It has strong tolerance to drought and impoverished soil. As a legume, it has ability in nitrogen fixing. The crop is used as animal feed and a supplement in food processing. Therefore, grasspea was grown widely in China. However, the cultivated area is decreasing because grasspea contains a neurotoxic compound ODAP (β-N-oxalyl diaminopropionic acid) causing lathyrism in human beings. During the 1970s, there was serious lathyrism toxin in Shaanxi province, so the cultivation of grasspea was restricted by the Ministry of Agriculture. Now, the cultivation is mainly concentrated in the North Shaanxi Province. The elimination of the toxic constituent is of concern, and is necessary for better utilization of *Lathyrus* as a pulse. Further genetic elimination of the toxic constituent is needed. According to Yu (1994), the same variety showed same ODAP content when it was cultivated in different locations under different climates. For example, variety Pusa 24 contained 0.2% ODAP when it was grown in India and 0.195% when it was grown in Yangling, Shaanxi, China. The ODAP content varies with different species, 0.15 - 0.87% in *Lathyrus sativus*, 0.12 - 0.13% in *L. odoratus*, 0.07 - 0.10% in *L. cicera*, 0.105% in *L. sylvestris*, and 0.230 - 0.348% in *L. latifolius* (Yu 1994). These studies indicated that ODAP content is mainly genetically controlled rather than affected by the environment. Based on this fact, breeding programmes on selecting toxin-free strains have been carried out in the Soil and Fertilizer Institute of Shaanxi Academy of Agricultural Sciences. Six accessions with ODAP < 0.2% have been selected from local varieties. A toxin-free gene has been identified in *Lathyrus tingitanus*. An effort is made at the Institute to obtain toxin-free variety through crossing grasspea and *L. tingitanus*. Toxin-free grasspea varieties have great potential development in Northwest China, which is an arid area. Therefore, further studies on elimination of ODAP are very important in *Lathyrus* improvement. Similar studies have also been carried out in India under the national coordinated project and 12 accessions with ODAP < 0.2% have been identified (Pandey *et al.* 1995).

Ethnobotanical studies on taro and yams

IPGRI - supported studies to collect ethnobotanical information on taro and yams are under progress in collaboration with Central Tuber Crops Research Institute, Trivandrum, India and Kunming Institute of Botany, Chinese Academy of Sciences. Also similar studies have been undertaken in the Philippines and Sri Lanka where they are well cultivated. Genetic analysis on taro is supported by IPGRI and implemented by the Biological Research Centre and Vegetable Institute of CAAS.

Promoting Regional Collaboration

In order to increase public awareness and promote activities on underutilized crops, IPGRI not only actively participated in conferences and workshops on underutilized crops but also supported international, regional conferences/symposia and workshops in the region. Through these workshops and conferences, information exchange and collaboration among plant genetic resources workers was further promoted.

In collaboration with National Institute of Agrobiological Resources, Japan and CAAS, China, IBPGR(now IPGRI) organized a workshop on Buckwheat Genetic Resources in Tsukuba, Japan in 1991 and a workshop on Less-Utilized Crop Genetic Resources of East Asia in Beijing, China in the same year. IBPGR was one of the organizers of the 5th International Symposium on Buckwheat held in Taiyuan, China in 1992 and the Third International Safflower Conference held in Beijing in 1993. In 1993, in collaboration with NBPGR, a Regional Workshop on Sesame Genetic Resources and Utilization was organized. IPGRI was actively involved with the preparations and organization of these conferences and symposia, which its staff attended. The proceedings of these conferences and symposia have already been published by IPGRI or partners (IBPGR 1991a; IBPGR 1991b; Lin 1992; Arora and Riley 1994, Li Dajue and Han Yuanzhou 1993).

Future Concern

IPGRI lays emphasis on studies directed towards germplasm collecting, evaluation, documentation and conservation of genetic resources in *Lathyrus* vis-a-vis their utilization, keeping the research needs/overall priorities in view, both for its use as a pulse and as a forage crop. This collaborative workshop will address many of these topics and open avenues for current and future measures to promote further work on this crop. Collaboration in the concerned priorities identified by this workshop should be strengthened, possibly through a network mechanism involving national programmes engaged in Research and Development efforts directed towards conservation, improvement and use of *Lathyrus* diversity.

References

Arora, R.K. 1985. Genetic Resources of Less Known Cultivated Food Plants. 126 p. NBPGR Sci. Monograph 9, National Bureau of Plant Genetic Resources, New Delhi.

Arora, R.K. and K.W. Riley. 1994. Sesame Biodiverstiy in Asia: Conservation , Evaluation and Improvement. IPGRI, New Delhi, India.

Hodgkin, T. 1994. Core collection and conservation of genetic resources. Pp. 41-51. *In* Sesame Biodiversity in Asia: Conservation, Evaluation and Improvement. R.K.Arora and K.W. Riley (eds.). IPGRI Office for South Asia, New Delhi.

IBPGR. 1991a. Papers of the IBPGR Workshop on Buckwheat Genetic Resources in East Asia, held at Tsukuba, Ibaraki, Japan, 18-20 Sept. 1991. IBPGR Intl. Crop Network Series No.6, IBPGR, Rome, Italy.

IBPGR. 1991b. Less Utilized Crop Genetic Resources of East Asia. Proceedings of the IBPGR Workshop on Less Utilized Crop Genetic Resources of East Asia, held at Beijing, China, 25-26 April 1991, IBPGR Office for East Asia, Beijing.

Lin Rufa, Z. Ming-De, T. Vongru, L. Jianying and Z. Zongwen. 1992. Proc. 5th Intl. Symp. Buckwheat, Taiyuan, China. Agriculture Publishing House, Beijing.

Li Dajue and Han Yuanzhou. 1993. Proceedings of the Third International Safflower Conference, held at Beijing, China, 14-18 January 1993.

Pandey, R.L., M.W. Chitale, R.N. Sharma, O.P. Kashap, S.K. Agrawal, A.K. Geda, H.K. Chandrakar and K.K. Agrawal. 1995. Catalogue on Grasspea (*Lathyrus sativus* L.) Germplasm. 60 p. Department of Plant Breeding & Genetics, Indira Gandhi Agricultural University, Raipur (M.P.), India.

Yu, J.Z. 1994. Cultivation of Grasspea and Selection of Lower Toxin Varieties and Species of *Lathyrus* in China. Pp. 145-151. *In Lathyrus sativus* and Human Lathyrism, Progress and Prospects. H.K.M. Yusuf and F. Lambein (eds.). Proc. 2nd Intl. Colloq. *Lathyrus* / Lathyrism, Dhaka, 10-12 December 1993. University of Dhaka.

Lathyrus Germplasm Collection, Conservation and Utilization for Crop Improvement at ICARDA

Larry D. Robertson and Ali M. Abd El Moneim

Introduction

The International Center for Agricultural Research in the Dry Areas (ICARDA) is concerned with collection, conservation, evaluation and crop improvement for *Lathyrus* species in the West Asia and North Africa (WANA) region and for Ethiopia. In WANA, *Lathyrus sativus* L., *Lathyrus cicera* L. and *Lathyrus ochrus* (L.) DC. are mainly used as feed legumes through direct grazing, and seed and straw production. *L. cicera* (n=96) is common in Cyprus, Greece, Iran, Iraq, Jordan, Spain and Syria; *L. sativus* (n=272) is used in Jordan; and *L. ochrus* (n=58) in Cyprus and Greece (Saxena *et al.* 1993). In Ethiopia, *L. sativus* is also used for pulse production.

L. sativus is valued because of its drought and waterlogging tolerance. In Ethiopia, *L. sativus* is grown on waterlogged soils where there is no possibility for production of any other alternative pulse. *L. cicera* is grown where there is need for cold tolerance and *L. ochrus* has the highest levels of resistance to broomrape (*Orobanche crenata* Forsk.), an obligate parasitic weed which often causes complete devastation of legume crops.

Status of Collections

ICARDA holds 'in-trust' *Lathyrus* germplasm from more than 45 countries under the auspices of the Food and Agriculture Organization (FAO). While the emphasis at ICARDA for genetic resources and crop improvement of *Lathyrus* is for three species (*L. sativus, L. cicera* and *L. achrus*), a sizeable collection is maintained of more than 40 other species of *Lathyrus* (Table 1). The majority of accessions of all species of *Lathyrus* held in the ICARDA genebank, except *L. sativus*, is from the WANA region. The collections of *Lathyrus* species from WANA are wild forms of naturally occurring populations, found mostly in crop fields and orchards. The *L. sativus* accessions from Ethiopia and the Indian subcontinent are local landraces. There is a sizable collection of *L. sativus* from Bangladesh.

Ecogeographical Evaluation

The WANA region is the center of origin and primary diversity for *Lathyrus* species (Zohary and Hopf 1988). The geographical distribution of *Lathyrus* collection in WANA region is shown in Fig. 1 for those accessions where passport data is available. The accessions are concentrated in Morocco, Algeria, Tunisia, Turkey, Syria and Jordan. Geographical

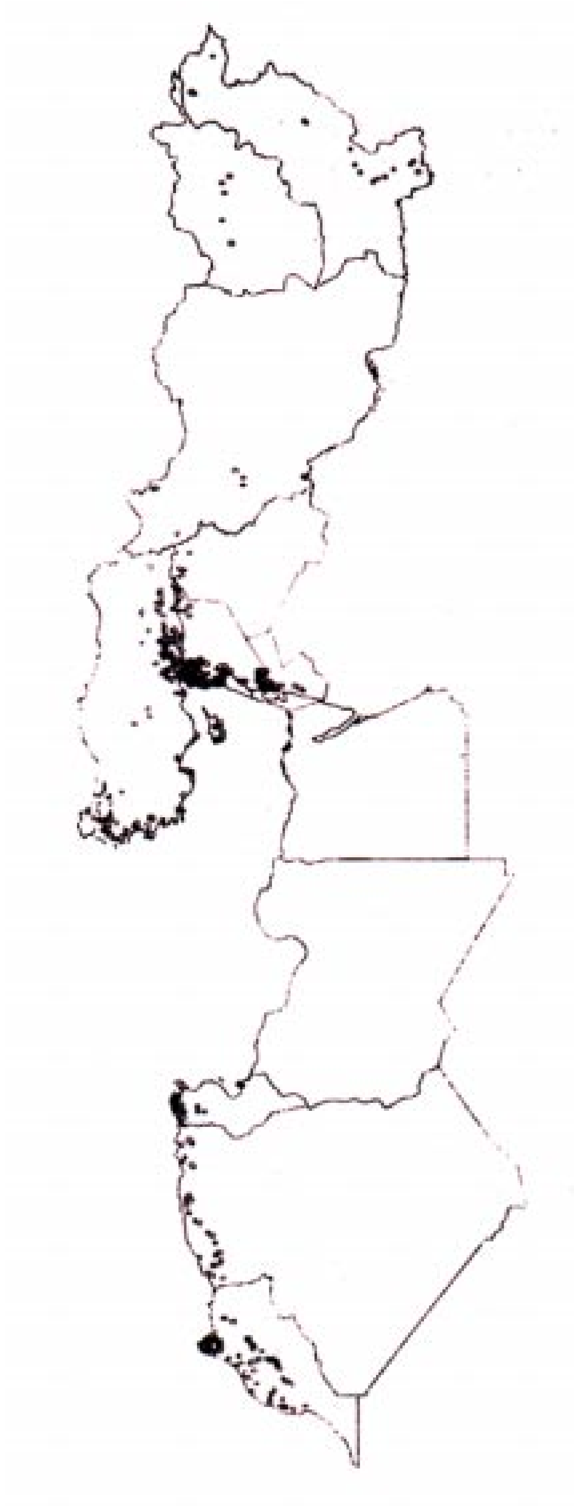


Fig. 1. Geographical distribution of ICARDA *Lathyrus* germplasm accessions from the WANA region

Fig. 2. Geographical distribution of ICARDA *Lathyrus sativus* germplasm accessions from the WANA region

Fig. 3. Geographical distribution of ICARDA *Lathyrus cicera* germplasm accessions from the WANA region

Fig. 4. Geographical distribution of ICARDA *Lathyrus ochrus* germplasm accessions from the WANA region

distributions for *L. sativus*, *L. cicera* and *L. ochrus* are shown in Figs. 2-4. It can be seen that *L. ochrus* and *L. sativus* are mostly distributed in coastal, lowland sites (Figs. 5 and 7), while *L. cicera* is the most common species in highland cold temperate sites (Fig. 6).

Direct Utilization

Crop improvement of *Lathyrus* at ICARDA is conducted mainly for three species, *L. sativus, L. cicera* and *L. ochrus*, with the objective of producing varieties with high yield of herbage, seed and straw and with abiotic and biotic stress tolerances. Another major objective is to produce varieties with improved quality by reducing the content of β-ODAP and improving the palatability, intake and nutritive value of herbage, seed and straw. The emphasis in the breeding programme is still concentrated on selection within germplasm accessions rather than hybridization, although the balance of selection within germplasm accessions versus hybridization will shift toward more emphasis on hybridization in the next five years.

Table 1. *Lathyrus* species germplasm accessions maintained at ICARDA

Regions/Countries	*L. sativus*	*L. cicera*	*L. ochrus*	Others
North Africa	17	45	45	117
Morocco	14	31	9	94
Algeria	-	12	6	18
Tunisia	3	2	30	4
Egypt	-	-	-	1
West Asia	70	79	39	810
Turkey	13	53	4	299
Syria	4	24	11	457
Cyprus	20	1	22	-
Jordan	1	1	-	33
Palestine	-	-	-	2
Iraq	-	-	-	10
Iran	13	-	1	8
Afghanistan	19	-	-	1
WANA	87	124	84	927
Ethiopia	110	-	-	-
South Asia	1 285	3	2	12
Pakistan	82	2	-	3
Nepal	81	-	-	9
Bangladesh	1 115	-	-	-
India	7	1	2	-
Others	78	58	52	117
Total	1 560	185	138	1 056

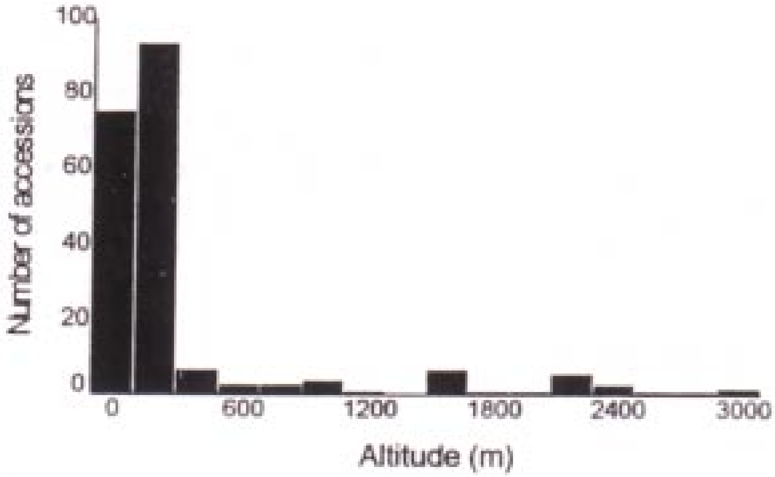


Fig. 5. Distribution of altitude of collection sites for *Lathyrus sativus* in the ICARDA germplasm collection

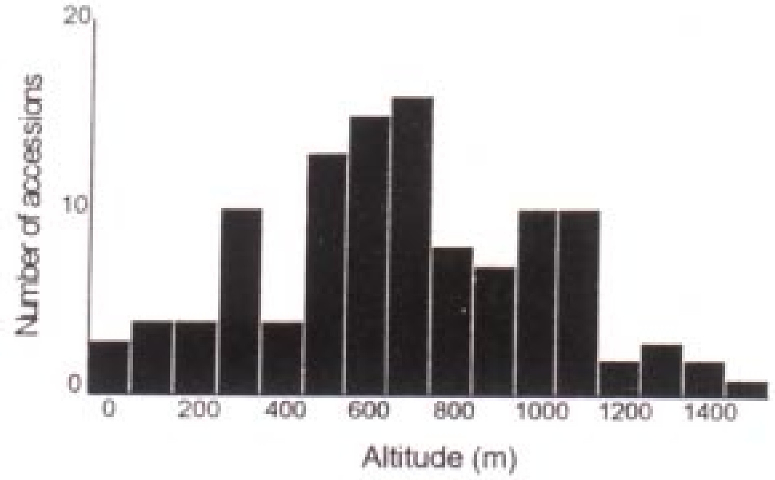


Fig. 6. Distribution of altitude of collection sites for *Lathyrus cicera* in the ICARDA germplasm collection

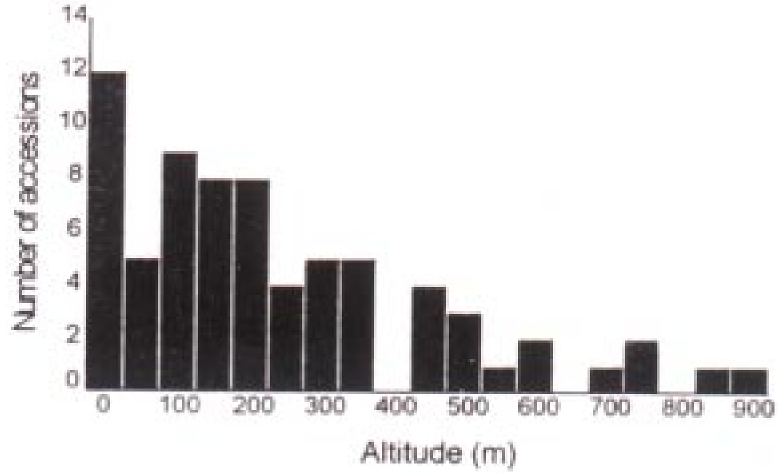


Fig. 7. Distribution of altitude of collection sites for *Lathyrus ochrus* in the ICARDA germplasm collection

The selections are distributed using the International Legumes Nursery Network developed for this purpose, first through adaptation trials and then through yield trials and screening nurseries. This programme was successful in identifying cultivars for release, because of the efforts of breeders and agronomists of national programmes in testing the provided material for adaptation to local conditions. The national programme of Jordan has released two cultivars, one of *L. ochrus* (IFLAO 101/185) and one of *L. sativus* (IFLAS 311).

Stress Resistance and Tolerance

Resistance to major stem and leaf diseases is necessary to develop productive forage legumes with stable performance. Host-plant screening in *Lathyrus* species for resistances to powdery mildew (*Erysiphe pisi*), Botrytis blight (*Botrytis cinerea* Pers. ex Fr) and Ascochyta blight (*Ascochyta pisi* Lib.) have recently started. Several resistance sources in *L. sativus* for powdery mildew and Ascochyta blight (dual resistance) have been found (Table 2). Resistance sources for other diseases and species have also been found but are to be reconfirmed.

Table 2. Resistant sources of chickling (*Lathyrus*) to cold, *Orobanche crenata*, downy mildew and Ascochyta blight

Stress/Species	Resistant sources
Orobanche crenata	
L. ochrus	IFLAO 84, 94, 95, 101
Cold	
L. ochrus	IFLAO 109
L. cicera	Most accessions
Downy mildew and Ascochyta blight	
L. sativus	Sel. 553, 555, 563, 529, 504

Orobanche crenata can cause major yield losses in forage legumes. There are accessions of *L. ochrus* that remain free of emerged *O. crenata* shoots (Linke *et al.* 1993). On the other hand, accessions of *L. sativus* and *L. cicera* were found highly susceptible to *O. crenata*. Resistant lines to *O. crenata* for *Lathyrus* species are listed in Table 2.

Most accessions of *L. cicera* are resistant to cold, whereas *L. ochrus* and *L. sativus* are generally very susceptible to cold (Table 2). Screening has not resulted in identification of any cold tolerant line of *L. sativus*. One accession of *L. ochrus*, IFLAO 109, from Portugal, has a high level of cold tolerance. This is explainable from the previous discussion on the ecology of these species, where most *L. sativus* and *L. ochrus* accessions are from low altitude, mild winter environments, whereas many *L. cicera* accessions are from high altitude, continental environments with severe winter.

Quality Factors

Lathyrus sativus represents the major component of human diet and animal feed in time of drought induced famine in Asia and Africa. One of the drawbacks of *L. sativus*, however, is that its excessive consumption can cause Lathyrism, a nervous disorder resulting in an incurable paralysis of the lower limbs of human beings or domestic animals, which is caused by the presence of a free amino acid known as β-*N*-oxalyl-L-α,β-diaminopropionic acid (β-ODAP) in seed. Therefore, special attention has been given in *Lathyrus* species to evaluate for low neurotoxin content in the germplasm collection. One of the main objectives in breeding chicklings at ICARDA is developing lines with low or no neurotoxin (β-ODAP) adapted to marginal low rainfall areas.

Results from preliminary screening indicated that none of the *Lathyrus* species lines was β-ODAP free, although in several lines the β-ODAP content was very low (Aletor *et al*. 1994). This seems to be species related, since samples of *L. cicera* ranged from 0.03 to 0.22% with a mean of 0.16%. *L. sativus* showed the biggest range from 0.02 to 0.74% with a mean of 0.48%, while *L. ochrus* lines were highest in ODAP ranging from 0.46 to 0.67% with a mean of 0.57%. Four lines of *L. sativus*, viz., IFLLS 521 (Syria), IFLLS 588 (Cyprus), IFLLS 516 (Turkey) and IFLLS 563 (Turkey) were found with low β-ODAP content ranging from 0.02 to 0.07%. Similar results have been found in screening an additional 110 breeding lines of the three species (Table 3).

Table 3. β-ODAP content (%) for three *Lathyrus* species grown at Tel Hadya in 1994

Species	No of accessions	Mean	Range	SEM
L. sativus	70	0.492	0.070 - 0.750	0.12
L. cicera	24	0.159	0.096 - 0.220	0.03
L. ochrus	16	0.615	0.400 - 0.710	0.06

The low neurotoxin lines have undesirable agronomic traits such as late flowering and lower yield. Therefore, a hybridization programme was initiated in 1991 to overcome these difficulties using the low neurotoxin lines and 21 high yielding *L. sativus* lines with β-ODAP ranging from 0.2 to 0.75%. The segregating populations showed transgressive segregation or partial dominance for earliness. Three families (19, 80 and 85) had low β-ODAP content (0.02 to 0.017%) and had large, white or cream coloured seeds and white flowers with seed yield ranging from 0.9 to 1.5 t/ha. Lighter seed coloured lines were found to have lower values of β-ODAP, while the black seeded families had the highest β-ODAP levels.

Agronomic Evaluation

Lathyrus germplasm from the ICARDA collection (1082 accessions belonging to 30 species) were evaluated in 1992-93. The experimental design used was a series of augmented nurseries (one per species) using one systematic check of *L. sativus* (IFLA 347) and two random checks of *L. ochrus* (IFLA 101) and *L. cicera* (IFLA 536).

The 21 descriptors observed were growth habit (GRH), flower colour (FLCO), anthocyanin (ANTH), leaf shape (LFSH), days to 50% flowering (DFLR), days to 90% maturity (DMAT), days to 90% podding (DPOD), plant height in cm (PTHT), height to the first flower in cm (HTFF), leaf length in cm (LFL), leaf width in cm (LFW), pod length in cm (LPD), pod width in cm (WPD), peduncle length in cm (PEDL), internode length in cm (LINT), seeds per pod (SPD), 1000 seed weight in g (W1000), seed yield in kg/ha (SYLD), biomass in kg/ha (BYLD), straw yield in kg/ha (STYLD) and harvest index in % (HI).

Results are presented only for the three economically important species, viz., *L. cicera*, *L. ochrus* and *L. sativus*. Most accessions of *L. cicera* were from Greece, Syria and Turkey. The accessions of *L. ochrus* were mostly from Greece, Cyprus and Syria, and those of *L. sativus* from Ethiopia, Afghanistan, Cyprus, Pakistan, Iran and Turkey.

Table 4. Frequency distributions for GRH, FLCO, ANTH, and LFSH for *L. cicera*, *L. ochrus* and *L. sativus* germplasm evaluated at Tel Hadya, Syria during 1992-93

Descriptors/score	*L. cicera*	*L. ochrus*	*L. sativus*
GRH			
Prostrate	24.0	3.4	0.7
Semi-erect	51.0	96.6	96.0
Erect	25.0	0.0	3.3
FLCO			
White	0.0	53.4	1.5
Cream	1.0	12.1	2.2
Brick	11.5	0.0	0.4
Pink	5.2	0.0	0.0
Violet	4.2	13.8	95.6
Yellow	2.1	0.0	0.0
Blue	0.0	0.0	0.0
Red	76.0	20.7	0.4
ANTH			
Weak	83.3	100.0	83.8
Fair	8.3	0.0	9.9
Strong	7.3	0.0	6.2
Very strong	1.0	0.0	0.0
LFSH			
Narrow	99.0	8.6	99.6
Medium	1.0	91.4	0.0
Oval	0.0	0.0	0.4

GRH = Growth habit, FLCO = Flower colour, ANTH = Anthocyanin, LFSH = Leaf shape.

Most of the accessions of *L. ochrus* and *L. sativus* had semi-erect GRH, while accessions of *L. cicera* also had erect and prostrate plant types (Table 4). Most accessions of *L. cicera* had red FLCO while most *L. ochrus* accessions had white FLCO and almost all *L. sativus* accessions had violet FLCO. All accessions had weak anthocyanin pigmentation. *L. cicera* and *L. sativus* had mostly narrow LFSH and *L. ochrus* mostly medium LFSH. These descriptors are used for taxonomic identification in *Lathyrus.*

The accessions of *L. cicera* were earlier than the *L. cicera* check, IFLA 536, by up to 11 days (Table 5). The SPD was higher for the tested accessions, but the W1000 was smaller and the HI was similar to the check. The BYLD was reduced, which resulted in a lower SYLD and STYLD for the tested accessions. The *L. ochrus* accessions were also earlier than the *L. ochrus* check (Table 6). The vegetative descriptors were similar to the check for *L. ochrus*. The W1000 was smaller for the tested entries as was the SPD. However, for *L. ochrus*, the mean of the tested accessions for BYLD was the same as the check, which resulted in similar values for STYLD and SYLD. The HI, BYLD, SYLD and STYLD were much lower for the tested *L. sativus* germplasm accessions than the *L. sativus* check (Table 7 and Figs. 8 and 9). Unlike the other two species, the tested accessions of *L. sativus* were later than the *L. sativus* check (Table 7 and Fig. 10). Overall, the *L. cicera* germplasm was the best performing in this year as indicated by the checks and the germplasm accessions.

Correlations among phenological traits (DFLR, DMAT and DPOD) were high and positive for all three species. All three species had significant positive correlations of HI and STYLD with SYLD (Table 8). *L. cicera* had significant negative correlations of phenological

Table 5. Summary statistics for 96 *Lathyrus cicera* germplasm accessions evaluated at Tel Hadya, Syria during 1992-93

Descriptors		Check mean (IFLA 536)	Accessions Mean	Min.	Max.	C.V. (%)
DFLR	(days)	126.2	123.9	115.0	136.0	3.3
DMAT	(days)	161.7	163.9	156.0	181.0	2.8
DPOD	(days)	133.7	128.3	122.0	148.0	4.5
PTHT	(cm)	36.7	35.4	24.1	49.8	12.5
HTFF	(cm)	10.7	8.1	2.4	13.2	18.5
SPD		3.61	3.8	2.3	9.62	24.2
HI	(%)	36.6	33.8	12.7	52.0	26.1
W1000	(g)	91.8	83.1	13.9	116.7	24.2
SYLD	(kg/ha)	1 237.0	1 120.0	117.0	2 030.0	52.5
BYLD	(kg/ha)	3 350.0	3 101.0	635.0	4 972.0	37.7
STYLD	(kg/ha)	2 113.0	2 578.0	488.0	3 067.0	26.1

DFLR = Days to 50%. flowering, DMAT = Days to 90% maturity, DPOD Days to 90% podding, PTHT = Plant height, HTFF = Height to the first flower, SPD = Seeds per pod, HI = Harvest index, W1000 = 1000 Seed weight, SYLD = Seed yield, BYLD = Biomass yield, STYLD = Straw yield.

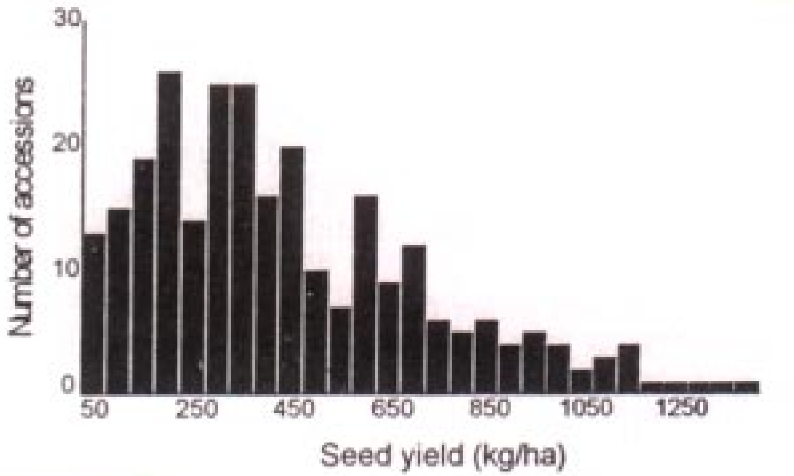


Fig. 8. Distribution of seed yield (kg/ha) for *Lathyrus sativus* germplasm evaluated at Tel Hadya, Syria 1992/93

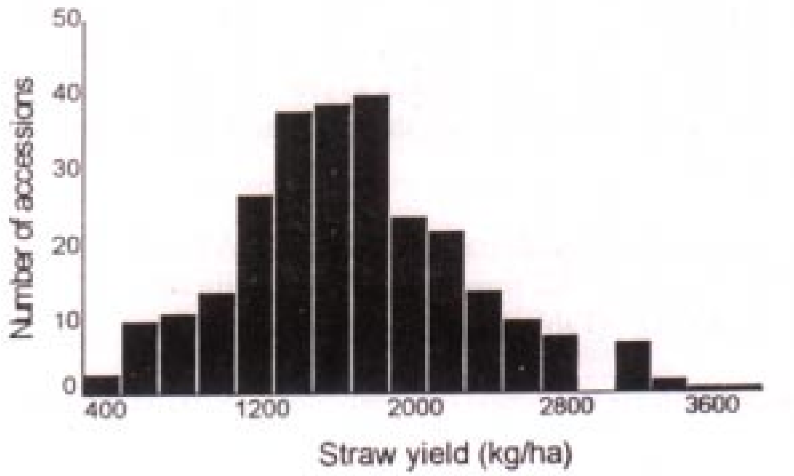


Fig. 9. Distribution of straw yield (kg/ha) for *Lathyrus sativus* germplasm evaluated at Tel Hadya, Syria in 1992/93

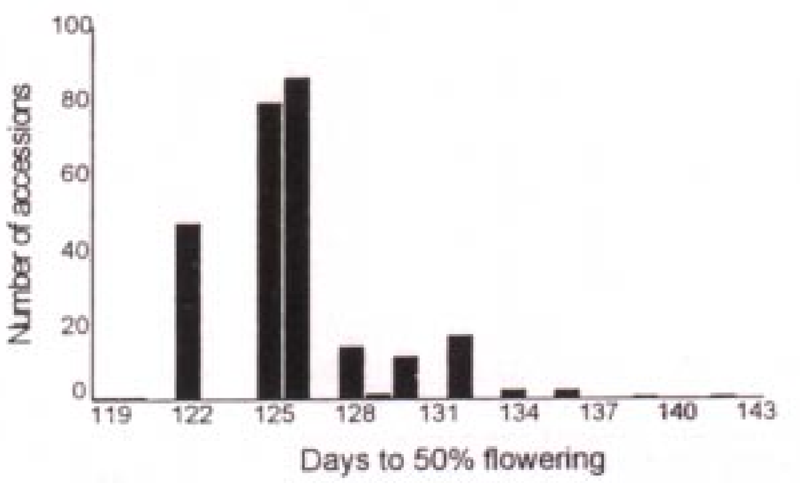


Fig. 10. Distribution of days to 50% flowering for *Lathyrus sativus* germplasm evaluated at Tel Hadya, Syria in 1992/93

traits with SYLD (earlier accessions yielded highest). Only *L. sativus* had significant correlations (positive) of plant size descriptors with SYLD and *L. cicera*.

Breeding for yield and adaptation

The ICARDA breeding programme has made significant progress in selecting high yielding

Table 6. Summary statistics for 58 *Lathyrus ochrus* germplasm accessions evaluated at Tel Hadya, Syria during 1992-93

Descriptors*		Check mean	Accessions			
		(IFLA 101)	Mean	Min.	Max.	C.V. (%)
DFLR	(days)	124.3	120.4	115.0	145.0	4.1
DMAT	(days)	160.0	157.0	149.0	184.0	3.2
DPOD	(days)	128.0	124.0	118.0	154.0	4.6
PTHT	(cm)	33.1	34.7	23.8	48.6	15.4
HTFF	(cm)	15.8	13.0	7.6	19.2	15.5
SPD		4.8	4.6	3.32	5.7	11.9
HI	(%)	38.5	36.2	12.7	48.6	20.1
W1000	(g)	130.2	121.3	57.2	156.3	17.7
SYLD	(kg/ha)	853.0	815.0	105.0	1 454.0	38.0
BYLD	(kg/ha)	2 214.0	2 221.0	726.0	3 741.0	32.0
STYLD	(kg/ha)	1 362.0	1 406.0	564.0	2 499.0	32.5

*Descriptor abbreviations as per Table 5.

Table 7. Summary statistics for 272 *Lathyrus sativus* germplasm accessions evaluated at Tel Hadya, Syria during 1992-93

Descriptors*		Check mean	Accessions			
		(IFLA 347)	Mean	Min.	Max.	C.V. (%)
DFLR	(days)	121.1	126.0	119.0	142.0	2.5
DMAT	(days)	163.3	173.8	145.0	189.0	3.9
DPOD	(days)	125.1	137.5	122.0	154.0	4.9
PTHT	(cm)	40.8	41.1	5.5	60.2	15.7
HTFF	(cm)	7.3	9.2	3.4	17.4	18.5
SPD		3.3	3.1	1.48	6.52	16.4
HI	(%)	26.6	19.5	1.9	54.7	43.8
W1000	(g)	104.1	86.8	34.5	225.9	34.3
SYLD	(kg/ha)	729.0	445.0	29.0	1 406.0	65.9
BYLD	(kg/ha)	2 682.0	2 167.0	516.0	5 200.0	38.2
STYLD	(kg/ha)	1 953.0	1 722.0	440.0	3 861.0	36.2

*Descriptor abbreviations as per Table 5.

Table 8. Correlations of SYLD with DFLR, DMAT, DPOD, PTHT, HTFF, SPD, HI, W1000 and STYLD for *Lathyrus cicera*, *L. ochrus* and *L. sativus*

Descriptors*		*L. cicera*	*L. ochrus*	*L. sativus*
DFLR	(days)	-0.45**	0.20	-0.06
DMAT	(days)	-0.26**	0.23	-0.01
DPOD	(days)	-0.45**	0.19	-0.07
PTHT	(cm)	0.21*	0.22	0.25**
HTFF	(cm)	0.03	0.07	0.14*
SPD		0.16	0.23	0.13*
HI	(%)	0.85**	0.60**	0.78**
W1000	(g)	0.50**	0.25	0.01
STYLD	(kg/ha)	0.85**	0.71**	0.58**

*Descriptor abbreviations as per Table 5.
*,**Significant at P=0.05 and P=0.01, respectively.

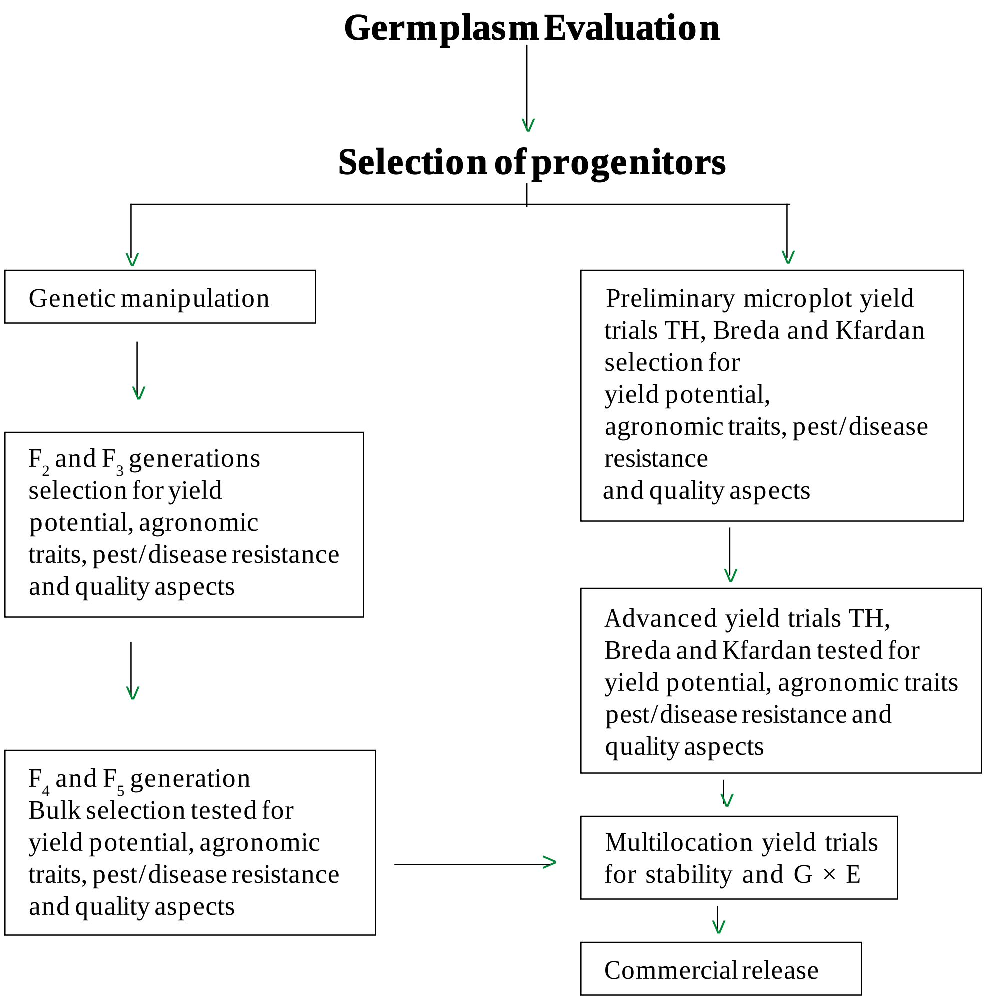
Table 9. Herbage, seed and straw yield (kg/ha) and days to flowering of the nine top advanced lines of *Lathyrus sativus* grown at Breda in 1994

Sel. No.	Herbage yield	Seed yield	Straw yield	Days to flowering
553	2 304	1 041	2 059	124
555	2 198	1 073	2 356	128
556	2 694	1 048	2 166	115
558	2 437	1 031	2 008	126
559	2 833	1 143	1 947	126
560	2 402	1 001	2 190	125
561	2335	1 111	2 041	118
562	2 665	1 051	1 943	117
566	2 519	1 211	1 865	117
Mean	2 440	1 026	1 834	115
SEM	144	114	212	0.3
CV (%)	11	20	20	2

(herbage, seed and straw) *Lathyrus* lines adapted to the WANA region. The programme target areas range between 250 and 400 mm rainfall in WANA. Two main approaches are used to develop improved lines of *Lathyrus* species. The first is to select within wild accessions to develop improved cultivars and the second is to use hybridization to combine selections from the wild types having useful traits (Fig. 11). This work is carried out by a multi-disciplinary team involving the breeder, physiologist, pathologist, entomologist, animal nutritionist and germplasm curator. The major avenue of dissemination for the lines developed by the breeding programme is through the ICARDA International Legumes Nursery Network.

There have been significant gains in improvement of yielding ability of *Lathyrus* species by using these methodologies. *L. sativus* lines have been selected which yield over one tonne/ha seed in an environment (Breda, Syria) with an average yearly rainfall of ca. 260 mm (Table 9). These also yield approximately 2.5 t/ha of herbage and 1.8 t/ha of straw.

L. cicera is a species with potential for low temperature, high altitude environments because of its cold tolerance (Table 2). Dwarf chickling (*L. cicera*) lines have also been selected with promise for low rainfall environments (Breda, Syria) and medium rainfall environments (Tel Hadya, Syria; ca. 335 mm average yearly rainfall) (Table 10). Lines



Structure of forage legumes breeding porgramme : (A) Hybridization, (B) Selection

Fig. 11. Breeding programme scheme for *Lathyrus* used at ICARDA

with promise for medium rainfall environments are IFLLC 494, 495, 497, 498, 473 and 569; lines with promise for low rainfall environments are IFLLC 487, 492, 496, 499, 573 and 574.

L. ochrus (*ochrus* chickling) is an important species in the WANA region because of its high levels of resistance to *Orobance crenata* (Table 2). Large areas of WANA are infested with this parasitic weed and production of most legume species including *Lathyrus* species in these areas is difficult to impossible. However, this species is susceptible to cold, though one accession has been found with moderate levels of cold tolerance. In moderate winter environment, selections from this species are significantly more productive than *L. sativus* or *L. cicera* (Table 11). Lines with seed yields up to 1.85 t/ha in low rainfall and up to 2.47 t/ha in moderate rainfall environments have been selected.

Distribution Supply of *Lathyrus* Germplasm

The Genetic Resources Unit of ICARDA distributes seed samples of all available accessions

Table 10. Herbage, seed and straw yield (kg/ha) of 25 advanced lines of dwarf chickling at two locations in Syria in 1994

Locations	Herbage yield	Seed yield	Straw yield
Tel Hadya			
Mean	3 776	1 968	4 642
SEM	249	135	309
Range	2 953 - 4 559	1 694 - 2 293	3 692 - 5 630
Breda			
Mean	2 241	844	1 454
SEM	183	117	170
Range	1 663 - 2 640	561 - 1 106	955 - 1 931

Table 11. Straw and seed yields (kg/ha) of 16 advanced lines of *L. ochrus* chickling at two locations in Syria in 1994

Locations	Straw yield	Seed yield
Tel Hadya		
Mean	5 811	2 091
SEM	401	200
Range	4 823 - 7 159	1 427 - 2 467
Breda		
Mean	4 358	1 568
SEM	360	160
Range	3 700 - 5 400	1 001 - 1 850

of *Lathyrus*. As a consequence of the agreement with the FAO, holding this collection 'in trust', ICARDA is in the process of implementing a policy that would require users to sign a seed order form which states that the recipient agrees: (a) not to claim ownership over the material received nor to seek intellectual property rights over that germplasm or related information without prior negotiation and permission of the country of origin, and (b) to ensure that all subsequent persons or institutions to whom they make samples of the germplasm available is bound by the same provision. ICARDA distributes a large number of accessions of its *Lathyrus* germplasm collection. Approximately 500-1000 accessions of *L. sativus*, *L. cicera* and *L. ochrus* are distributed per year.

References

Aletor, V.A., A.M. Abd El Moneim and A.V. Goodchild. 1994. Evaluation of the seeds of selected lines of three *Lathyrus* spp. for BOAA, tannins, trypsin inhibitor activity and certain *in vitro* characteristics. *J. Sci. and Food Agric.*

Linke, K.H., A.M. Abd El Moneim and M.C. Saxena. 1993. Variation in resistance of some forage legumes species to *Orobanche crenata* Forsk. *Field Crops Research* 32 : 277-285.

Saxena, M.C., A.M. Abd El Moneim and M. Raninam. 1993. Vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.) in the farming systems in West Asia and North Africa and improvement of these crops at ICARDA. Pp. 2-9. *In* Potential for *Vicia* and *Lathyrus* Species as New Grain and Fodder Legumes for Southern Australia, CLIMA, Nedlands, Western Australia. J.R. Garlinge and M.W. Perry (eds.).

Zohary, D. and M. Hopf. 1988. Domestication of Plants in the Old World. Clarendon Press, Oxford. 249 p.

Lathyrus Germplasm Evaluation in a Mediterranean Type Environment of South-Western Australia

K.H.M. Siddique, C.D. Hanbury, A. Sarker, M.W. Perry and C.M. Francis

Introduction

With the increased emphasis on premium based payments for wheat protein content and a trend towards greater cropping in farming systems, growers in Western Australia are looking for grain legumes to include in their cropping rotations on soil types unsuitable for the production of narrow-leafed lupin (*Lupinus angustifolius* L.). A range of fully domesticated grain legumes being evaluated in Western Australia viz., field pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.), chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* M.) and lupin (*Lupinu albus* L.) are of immediate potential (Siddique *et al.* 1993). These crops are grown in many parts of the world and have well established human consumption or stockfeed markets. However, they may not be suitable for every region or soil type and farmers may also require a range of grain legumes for their cropping rotations to reduce build up of disease that may occur in a system based on one grain legume. *Lathyrus* spp., vetches (*Vicia* spp.) and narbon bean (*Vicia narbonensis* L.) are potential grain legumes for Australian farming systems.

Australian agriculture has drawn heavily on the genetic heritage of the Mediterranean basin, and many southern Australian farming systems are based on species of *Trifolium*, *Medicago* and *Lupinus* introduced from the region. In contrast, the genus *Lathyrus* has been the subject of only superficial evaluation in Australia (Bailey 1952; Riceman and Powrie 1952; Silsbury 1975; Laurence 1979) using only a limited range of germplasm. Whether *Lathyrus* will eventually find a significant role in Australian agriculture is uncertain, however, the wide distribution of *L. sativus* in temperate, Mediterranean and tropical environments, its varied role as a forage and grain crop, its large genetic diversity, and its reputed tolerance to drought and to waterlogging suggest its potential economic value to Australian farming systems. The results reported here are part of a project to evaluate *Lathyrus* with the intention of defining its potential to contribute to farming systems in southern Australia with the following specific objectives :

a) Introduce a wide range of *Lathyrus* germplasm with emphasis on *L. sativus*, *L. cicera* and *L. ochrus*, all of which are domesticated species and presently cultivated or are relic crops.

b) Evaluate *Lathyrus* germplasm in anticipation of providing lines adapted to Mediterranean type environments of southern Australia.

Materials and Methods

Sources of germplasm

Accessions of *Lathyrus* were obtained from a wide range of geographical origins including Afghanistan, Bangladesh, Bulgaria, Canada, Crete, Cyprus, Czechoslovakia, Ethiopia, Germany, Greece, Hungary, India, Iran, Iraq, Pakistan, Poland, Portugal, Syria, Tunisia and Turkey. The major sources of germplasm were the International Centre for Agricultural Research in Dry Areas (ICARDA) in Syria; Bangladesh Agricultural Research Institute (BARI), Bangladesh; and the National Agricultural Research Centre (NARC), Pakistan. Lines supplied by ICARDA were first grown in 1993 in small field plots at the University of Western Australia, Shenton Park Field Station, Perth W.A. for preliminary assessment and seed multiplication. All remaining lines were imported and first sown at the field site.

Site

All lines were evaluated at the Avon Districts Agricultural Centre, Northam Western Australia (31°53'S, 116°41'E). The soil was rocky, red-brown loamy sand over clay. The surface (0-10 cm) pH was 5.9 (measured in $CaCl_2$) and increased slightly down the soil profile to 6 at 30 cm. The site had been under a mixed grass/subterranean clover (*Trifolium subterraneum*) pasture for the previous 5 years.

Climatic conditions

Rainfall at Northam during 1994 was 284 mm, considerably lower than the long term average of 434 mm (Fig. 1). The distribution of rainfall varied considerably from normal, virtually no rainfall in the summer months and although the growing season opened with heavy rainfall (May), only 282 mm were received during the May-October growing season, lower than the long term average of 359 mm. The spring and early summer period received well below average rainfall. Monthly rainfall totals for 1994 and the long term monthly average rainfall are shown in Fig. 1, together with monthly average minimum and maximum temperatures for 1994.

Site management

The site was cultivated before sowing and weeds present were controlled using pre-sowing applications of cyanazine (Bladex at 2 l/ha) and paraquat/diquat (Sprayseed at 2 l/ha). After crop emergence, grass weeds were controlled by spraying with fluiazifop-p-butyl (Fusilade at 400 ml/ha) and broadleafed weeds were controlled by a combination of hand weeding and inter-row application of glyphosphate. Red-legged earth mite (*Halotydeus destructor*) and aphids (*Aphis craccivora*) were controlled as required. No fertiliser was applied in 1994, however, the site was fertile and 60 kg/ha of triple superphosphate (12 kg/ha P) had been applied to the pasture in 1993.

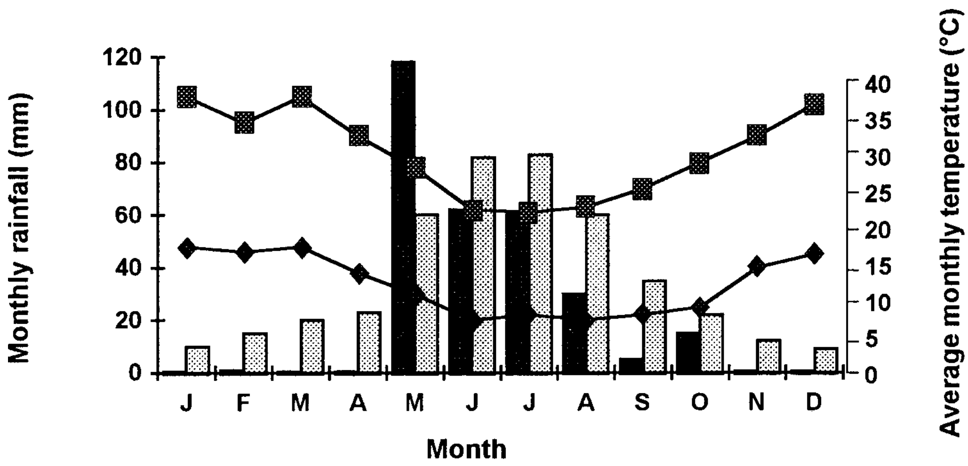


Fig. 1. Monthly average rainfall in 1994 (shaded), long term average rainfall (non-shaded); monthly average minimum (■) and maximum (◆) temperatures for 1994, Northern W.A.

Seeds were sown by hand into furrows prepared with a rake or single row planter to 5 cm depth, and seeds were placed 10 cm apart within the row. In two-row plots, the row spacing was 20 cm. A rhizobial inoculant (Group E) was applied to the seed as a slurry poured along the furrow before closure. Australian Temperate Field Crops Collection (ATC) numbers were used whenever possible for identification, although some recently received lines did not have an ATC number. A total of 639 accessions of *Lathyrus* which include *L. sativus* (451), *L. cicera* (130) and *L. ochrus* (58) were grown for characterization and evaluation. Field pea (*Pisum sativum* cv. Dundale) or common vetch (*Vicia sativa* cv. Languedoc) were grown alternately in every tenth plot for comparison purposes. These species have similar growth habit to the *Lathyrus* species, but are more widely grown and adapted in Western Australia and South Australia. The seeds were sown in early June 1994 and the majority of plots were harvested in November 1994. Seeds were harvested by machine for most lines using a Wintersteiger open front harvester fitted with crop lifters, some prostrate lines or early maturing lines were harvested by hand and fed through the harvester manually as they matured.

Observations and measurements

All plots were scored for vigour, start and finish of flowering, pod formation, plant habit and flower colour. Harvested seeds were dried, cleaned and weighed, and subsamples analysed for ODAP concentration.

1. *Vigour* : Plant vigour was scored at 46 and 73 days after sowing (DAS). The score was based on a 1 (least vigorous) to 5 (most vigorous) scale.

2. *Days to flowering commencement and finishing* : Time to flowering (DAS) was recorded when 50% of all plants within a plot had at least one open flower. Time of finishing of flowering (DAS) was recorded as the date when there were no longer any visible open flowers on the plot.

3. *Days to podding* : Time to podding (DAS) was recorded when 50% of plants within the plot had at least one visible pod.

4. *Days to maturity* : Physiological maturity was recorded when all pods were golden yellow in colour. At this stage, plants within the plot were dry but were not shedding leaves.

5. *Plant habit* : Plant growth habit of all lines was recorded at 50% flowering and was scored as 1 (erect), 2 (semi-erect), 3 (semi-prostrate) and 4 (prostrate).

6. *Flower colour* : Any lines with a wide variation in flower colour were recorded as mixed. If only a small amount of one colour was present within a plot, the plants of the minority colour were removed from the plot.

7. *Seed yield* : Seed was weighed and yield per plot was expressed as a percentage of the yield of the nearest control plot, thus two yield estimates were obtained, one as percentage of Languedoc and one as percentage of Dundale. 100 seed weight was also calculated from weighing and counting at least 200 seeds. Hereafter, yield refers to seed yield as percentage of controls.

8. *ODAP* : *L. cicera*, *L. ochrus* and *L. sativus* were analysed for whole seed ODAP concentration on a 10 to 20 g sample. ODAP analysis was performed using the capillary zone electrophoresis method of Arentoft and Grierson (1995). Whole seed was ground in a Tecator Cyclotec 1093 sample mill with a 1 mm screen. Samples of 0.5 g of the flour were extracted using two volumes of 10 ml of ethanol-water (6:4) by tumbling for 45 minutes per time. The two extracts were then combined and centrifuged, filtered through a 0.45 mm filter before analysis by capillary electrophoresis. Hippuric acid was used for an internal standard. The analysis was performed using a capillary of uncoated fused silica 48.5 cm by 50 mm i.d. at 515 V/cm and 40°C in 20 mM Na_2HPO_4 buffer at pH 7.8 with direct UV detection at 195 nm. Quantification was based on the peak area relative to a pure standard of ODAP obtained from Sigma Chemical Company.

Results

Morphological and phenological characters

Lathyrus sativus : A summary of observations for *L. sativus* germplasm evaluation is given in Table 1. This species exhibited the greatest variation in most characteristics, at least in part due to the greater numbers of lines and diversity of geographical origin compared to the other two species.

Table 1. Mean values of characteristics of *L. sativus* grown at Northam, W.A. in 1994

Characteristics	Mean	Accession Number	Range
Yield (% of Languedoc)	43 (± 1)	381	3 to 186
Yield (% of Dundale)	40 (± 1)	381	3 to 108
50% flowering (DAS)	98 (± 0)	441	76 to 123
50% podding (DAS)	118 (± 0)	220	105 to 126
Flowering finish (DAS)	132 (± 0)	441	111 to 150
Maturity (DAS)	152 (± 0)	441	130 to 167
Time from 50% flowering to podding (d)	16 (± 0)	220	-
Duration of flowering (d)	35 (± 0)	441	-
ODAP in seed (%)	0.39 (± 0.01)	437	0.04 to 0.76
Field pea yield (kg/ha)	1 340(± 40)	046	650 to 1 940
Common vetch yield (kg/ha)	1 320(± 50)	57	530 to 2 230

Large variation in flower colour was apparent for *L. sativus*, the most commonly recorded flower colours were pale blue, dark blue, white and white tinged with blue, but pink flowers and white flowers tinged with pink were also identified. Vigour varied widely, scoring between 1 and 4.

L. sativus was the earliest flowering species with a name of 98 DAS (Table 1) but still substantially later than the controls for which 50% flowering occurred at 78 days for Dundale and 86 days for Languedoc vetch (Table 4). The time interval between flowering and the observation of visible pods was greatest in *L. sativus* (16 days), and the duration of flowering was also longest at 35 days. Podding, finish of flowering and maturity were latest in *L. sativus* at 118, 132 and 152 DAS, respectively.

The *L. sativus* germplasm had the lowest yields averaging only 40% of Dundale and 43% of Languedoc. The 200 lines received from Bangladesh were, as a group, clearly less vigorous and lower yielding overall, however, even excluding these, the yield of *L. sativus* was only 51 (± 2) % Dundale and 57 (± 2) % Languedoc. Two lines exceeded the yield of the highest yielding control (Dundale).

Lathyrus cicera : All lines of *L. cicera* had red flowers with only minor variation in the depth of colouration. On an average, *L. cicera* flowered 103 DAS (Table 2), the latest to flower among the three species. The duration between flowering and initiation of podding was short in *L. cicera* (8 days) compared to controls Languedoc (16 days) and Dundale (17 days). The duration of flowering was shortest of the *Lathyrus* species (19 days), and was very short in comparison with controls Languedoc (30 days) and Dundale (45 days). Pod formation, however, was rapid in *L. cicera* (110 DAS) and was followed by early maturity (144 DAS).

Table 2. Mean values of characteristics of *L. cicera* grown at Northam, W.A. in 1994

Characteristics	Mean ± SEM	Accession Number	Range
Yield (% of Languedoc)	102 (± 4)	83	22 to 264
Yield (% of Dundale)	89 (± 2)	83	20 to 118
50% flowering (DAS)	103 (± 1)	96	95 to 138
50% podding (DAS)	110 (± 1)	83	103 to 138
Flowering finish (DAS)	123 (± 1)	96	110 to 144
Maturity (DAS)	144 (± 1)	83	136 to 167
Time from 50% flowering to 50% podding (d)	8 (± 0)	83	-
Duration of flowering (d)	19 (± 0)	96	-
ODAP in seed (%)	0.18 (± 0.02)	88	0.08 to 0.34
Field pea yield (kg/ha)	1 340 (± 40)	46	650 to 1 940
Common vetch yield (kg/ha)	1 320 (± 50)	57	530 to 2 230

In general, *L. cicera* was the highest yielding of the three *Lathyrus* species. For the 83 lines for which observations are available, the mean yield was 89% of Dundale and 102 % of Languedoc, however, 25 of the lines were equal or greater in yield than the highest yielding (Dundale) control.

Lathyrus ochrus : Flower colour in *L. ochrus* was cream with little or no apparent variation. On an average, *L. ochrus* flowered 102 DAS, podded 110 DAS and finished flowering 124 DAS (Table 3). The duration between flowering and initiation of podding

Table 3. Mean values of characteristics of *L. ochrus* grown at Northam, W.A. in 1994

Characteristics	Mean ± SEM	Accession Number	Range
Yield (% of Languedoc)	64 (± 4)	48	16 to 141
Yield (% of Dundale)	61 (± 4)	48	10 to 128
50% flowering (DAS)	102 (± 1)	49	95 to 115
50% podding (DAS)	110 (± 1)	33	105 to 124
Flowering finish (DAS)	124 (± 1)	49	114 to 132
Maturity (DAS)	143 (± 0)	49	137 to 148
Time from 50% flowering to podding (d)	8 (± 0)	33	-
Duration of flowering (d)	23 (± 1)	49	-
ODAP in seed (%)	1.01 (± 0.03)	32	0.64 to 1.35
Field pea yield (kg/ha)	1 340 (± 40)	46	650 to 1 940
Common vetch yield (kg/ha)	1 320 (± 50)	57	530 to 2 230

was short in *L. ochrus* (8 days), and the duration of flowering (23 days) was intermediate between that for *L. sativus* and *L. cicera*, but still shorter than the controls Dundale (45 days) and Languedoc (30 days). Podding occurred early in *L. ochrus* (110 DAS), and it was earliest to mature (143 DAS). In general, all lines of *L. ochrus* had yields intermediate between *L. sativus* and *L. cicera*, averaging 61% of Dundale and 64% of Languedoc.

Table 4. Mean values of phenological characteristics and yield of common vetch (cv Languedoc) and field pea (cv Dundale) used as controls

Characteristics	Languedoc		Dundale	
	Mean ± SEM	Accession Number	Mean ± SEM	Accession Number
50% flowering (DAS)	86 (± 0.3)	60	78 (± 0.5)	47
50% podding (DAS)	100 (± 0.6)	39	95 (± 0.7)	26
Flowering finish (DAS)	113 (± 0.5)	60	125 (± 0.7)	47
Maturity (DAS)	139 (± 0.7)	60	141 (± 0.6)	47
Seed yield (kg/ha)	1 320 (± 50)	57	1 340 (± 40)	46

ODAP concentration

ODAP concentration in the seeds of the three species varied widely from 0.08% in some lines of *L. cicera* to a maximum of 1.35% in lines of *L. ochrus* (Table 5).

Table 5. Concentration of ODAP measured in whole seeds of *L. sativus, L. cicera* and *L. ochrus*

Characteristics	*L. sativus*	*L. cicera*	*L. ochrus*
ODAP (%)	0.39 (± 0.01)	0.18 (± 0.02)	1.01 (± 0.03)
Number of accessions	437	88	32
Range	0.04 to 0.76	0.08 to 0.34	0.64 to 1.35

L. sativus was intermediate in ODAP content (average 0.39%), but there was a range from 0.04 to 0.76% (Tables 1 and 5) between lines. Most of the low ODAP lines originated from Bangladesh, however, in general, these lines exhibited low vigour and low seed yield in this environment. Two lines obtained from Canada and two from Pakistan also gave low values (< 0.20%) when analysed for ODAP. Comparing the three species (Table 5), concentration of ODAP in the seed were lowest in *L. cicera* (average 0.18%, range 0.08 to 0.34%) and greatest in *L. ochrus* (average 1.01%, range 0.64 to 1.35%).

Environmental variation in ODAP levels

For a limited number of lines, seed samples were analysed for ODAP before sowing and for these lines there are two sets of ODAP analyses (Fig. 2). These lines were obtained from ICARDA in 1993, grown at Shenton Park in 1993 and at Northam in 1994, ODAP analysis was performed after each season. Correlation coefficients between the 1993 and 1994 results are 0.85 using all *Lathyrus* species and 0.46 using *L. sativus* only (Fig. 2), indicating good correlation between the two sites and seasons.

Correlation between seed yield and other characters

Lathyrus sativus : There was a positive correlation between vigour at both 46 DAS and 73 DAS, and yield expressed relative to the controls, the more vigorous lines producing greater yield. There were also positive correlations between 100 seed weight and yield, between the two measures of vigour (46 and 73 DAS), and between the various phenological characteristics. Yield was negatively correlated with the measures of phenology (flowering time, podding time, finish of flowering and maturity), suggesting that in this environment early reproductive development and maturity favoured greater yield. ODAP concentration was negatively correlated with all phenological characteristics of *L. sativus* indicating that the later developing lines were lower in ODAP.

Lathyrus cicera : In contrast to *L. sativus*, there was a negative correlation between yield and vigour in *L. cicera*, although the correlation coefficients were low. *L. cicera* also showed non-significant correlations between 100 seed weight and any other characteristics, and there was no consistent relationship between yield and phenological characteristics. However, yield (% Languedoc) was negatively correlated with finish of flowering and maturity. ODAP concentration in *L. cicera* showed significant negative correlation with yield and weak negative correlations with the phenological characteristics of flowering and podding.

Lathyrus ochrus : *L. ochrus* exhibited a positive correlation between yield (% Languedoc) and vigour only at 46 DAS. There was a positive correlation between vigour 46 DAS and 100 seed weight in *L. ochrus*, and also between yield and 100 seed weight. 100 seed weight was negatively correlated with all phenological characters. *L. ochrus* gave high negative correlations between yield and the four measures of phenology indicating that phenologically earlier lines produced greater yields. ODAP concentration in *L. ochrus* was also negatively correlated with all phenological characteristics. However, it was positively correlated with vigour at 43 DAS with yield (% Languedoc) and 100 seed weight.

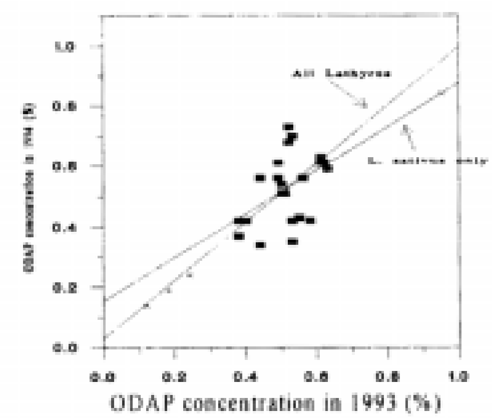


Fig. 2. ODAP concentration (%) in the seed of individual lines grown at Shenton Park, 1993 versus ODAP concentration in seed following growth of the same individual lines at Northam, 1994

Discussion

The three *Lathyrus* species examined in this study and other studies in this environment (Siddique *et al*. 1996) showed considerable potential as grain and forage legumes for mediterranean-type environments in Western Australia. In most cases, dry matter production near flowering of the best lines of *L. cicera* was equivalent to field pea and grain yields were similar to field pea at Northam and other environments (Siddique *et al*. 1995). The low grain yields of the *L. sativus* lines in our study are probably a reflection of their poor early vigour or late flowering times relative to the other two *Lathyrus* species.

Phenological development and yield

The phenological behaviour of *L. sativus* was markedly different from that of *L. cicera* and *L. ochrus*. It flowered earlier (98 DAS) but the duration between flowering and pod formation was much longer for *L. sativus* (16 days compared to 8 days for *L. cicera* and *L. ochrus*); and maturity was also substantially later for *L. sativus* (152 DAS) compared to *L. cicera* (144 DAS) and *L. ochrus* (143 DAS). The duration of flowering and seed formation was thus much longer in *L. sativus* (35 days) than *L. cicera* (19 days) or *L. ochrus* (23 days).

The ability to flower early in the life cycle and to mature rapidly have generally been key characteristics in improving the adaptation of both crop and pasture species to the Mediterranean lands of southern Australia (Loss and Siddique 1994). Although a range of maturities may be required for different environments, the mean flowering dates in this experiment for *L. sativus* (98 DAS), *L. cicera* (103 DAS) and *L. ochrus* (102 DAS) are relatively late compared to the well adapted Dundale field pea (78 DAS) and Languedoc vetch (86 DAS) included as controls; and compared to the flowering dates observed for other adapted grain legumes such as 70-90 DAS for field pea and faba bean (Siddique *et al*. 1993). It is, therefore, likely that selection for earlier maturity will be important in improving the adaptation of *Lathyrus* in southern Australia.

The yield of *L. sativus* lines included in this study were disappointingly low compared to the yield of Dundale field pea which can be considered well adapted to the environment used for the study. Using the 381 lines for which reliable yield were obtained, the average was only 40% of Dundale field pea and even when the lines from Bangladesh (which in general were low in vigour and yield) are excluded, the average over 181 lines was still only 51% of Dundale. Results from a multi-site comparison of *L. sativus* with other grain legumes confirm these results (Siddique *et al*. 1993). Reasons for the low average yield are probably in part the relatively late flowering and maturity, and the fact that the set of lines have not been the subject of any selection in Australia. Two lines, however, exceeded the field pea yield and indicate that crossing and subsequent selection should allow substantial yield improvement.

Yield of *L. cicera* was generally much higher than that of either *L. sativus* or *L. ochrus* and lines of *L. cicera* with both high yield and low ODAP have been identified. *L. cicera* shows promising adaptation to low rainfall conditions, given that little selection has taken place and yet yields were frequently greater than the adapted controls. Since flowering was relatively late (95 to 138 DAS) over 96 accessions, the yield advantage must come from some other aspect of its physiology, possibly related to its more determinate habit and very rapid progress from flowering to maturity. Seed yield of *L. ochrus* was greater than for *L. sativus*, but on average substantially below that of *L. cicera*.

Correlation analysis

The correlation analysis undertaken on the observations must be considered as a preliminary study only due to differences in the size of the populations, the dominance of a few sources of material and the differing plot types from which the observations were taken. They nevertheless give some clues to characteristics which may be important in improving the adaptation of the species. As would be expected, the phenological characteristics i.e. flowering time, podding time, finish of flowering and maturity were highly positively correlated.

For all three *Lathyrus* species, the relationship of yield and phenological characters were overall negative, indicating that lines flowered earlier and matured earlier tended to yield best. The relationship was strong for *L. sativus* and *L. ochrus* but was much weaker in *L. cicera*. As discussed earlier, this matches the common experience with annual crop and pasture species in southern Australia; however, it is the opposite of that found for *L. sativus* in Bangladesh with a similar harsh finish to the season, but where yield tends to be positively related to maturity (Kaul *et al.* 1986).

L. sativus showed large variation in many characters and this is consistent with the large selection effort that has been carried out over a long period, it is also consistent with the large number of lines examined in this study. The strong positive relationship between vigour (particularly at 46 DAS) and yield indicates that early vigour is probably a good criteria to select high yielding *L. sativus* lines. 100-seed weight was also consistently and positively correlated with vigour and yield, possibly indicating that large seed size gave an early advantage in establishment and growth which led to higher yield. The negative correlations obtained between measures of flowering and maturity, and yield tend to support earlier conclusions that selection for earlier flowering would improve the adaptation of this species.

L. cicera germplasm was dominated by lines originating in Greece and thus the correlations obtained may not truly represent the species. Nevertheless, the negative relationships obtained between yield and vigour, and lack of correlation between yield and measures of reproductive development suggest a very different physiology to that of *L. sativus.*

Clearly the early lines of *L. ochrus* yielded better than late lines, but they also had highest ODAP levels. 100-seed weight was positively related to yield and negatively correlated with phenological characters, so selection for larger seeded lines may also be productive, in conjunction with selection for early maturity.

ODAP concentration

In any future development of *Lathyrus* as a crop for human consumption, zero or very low levels of the neurotoxin (ODAP) will be essential. Selections with reputed low levels of ODAP have been made in India where the first low ODAP variety of *L. sativus* (P24) was selected with an ODAP concentration of 0.24%, other low ODAP lines have been selected in Ethiopia, Bangladesh, Pakistan and Canada (Campbell *et al.* 1994). In Bangladesh, selection within the *L. sativus* breeding programme is for lines with less than 0.1% ODAP (A. Sarker, personal communication), a level selected as persumed safe for human consumption.

The lines of *L. sativus* low in ODAP are predominantly from Bangladesh and generally did not yield well in this environment. Although these lines are poorly adapted to local conditions, some have already been used as low ODAP parents in our crossing programme. *L. cicera* provided seven lines that, in addition to having low ODAP concentration, had greater yield than the control, however, there were no lines of *L. ochrus* in the current collection with low ODAP concentrations.

ODAP concentration showed negative correlation with phenological characteristics, most strongly in *L. sativus* and least in *L. cicera*, indicating that ODAP concentration in the seed is highest in the earlier developing lines. Siddique *et al.* (1993) came to a similar conclusion using a more limited range of germplasm but grown in three agroclimatically different locations within western Australia.

The significance of ODAP level for the development of *Lathyrus* in Australia is still unclear. Domestic consumption is unlikely except as a novelty food, and the prospects for export are uncertain. Although substantial human consumption occurs in India, Bangladesh, Pakistan and Ethiopia, other pulses are generally preferred and prices are likely to be lower than for alternative pulse crops. Export of common vetch (*Vicia sativa*) from Australia was halted due to the presence of β-cyanoalanine, a neurotoxin, in the seed; and clear evidence of the acceptability of *Lathyrus* by an importing country would be required before export could be contemplated. However, until marketable quantities of seed low in neurotoxin are available, it is unlikely that market potential can be realistically defined. For *L. cicera* and *L. ochrus*, no realistic prospect is seen for developing human consumption markets despite reports of consumption of the latter in Morroco (Francis, personal communication). Other uses for *Lathyrus* in southern Australia include production as a high protein stockfeed grain and use as a green manure/forage/utility crop. For these purposes, the importance of ODAP levels are less clear as production for stockfeed purposes will inevitably mean consumption by monogastric animals.

Whether *L. sativus* and/or other *Lathyrus* species will find a role in southern Australian farming systems is still uncertain. To do so, they must either fit a unique niche for which no other species is available (for example as a reliable low rainfall legume crop), or must displace an existing legume by providing greater overall value in the farming system. Thus yield, unit price and system considerations (ease of harvest, pest and disease susceptibility, rotational benefits etc.) will all contribute to a decision to adopt *Lathyrus* in preference to another crop or pasture legume.

We suggest that initial selection or breeding effort in *Lathyrus* species should emphasize early flowering, early vigour and high dry matter production, combined with high HI, increased seed size and ODAP concentration below 1.0 mg/g. The potential for *Lathyrus* within Australia is as a stockfeed both on and off the farm, however, its value requires further quantification before it will be accepted by growers or stockfeed companies. If suitable export pulse markets were to emerge, there is also scope for developing *L. sativus* as a food legume. Before releasing the crop to commercial growers, agronomic packages such as time of sowing, seeding rate and fertiliser requirements should be developed.

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References

Arentoft, A.M. and B.N. Grierson. 1995. Analysis of β-N-oxalyl-L-α, β -diaminopropanoic acid and its isomer in grasspea (*Lathyrus sativus*) by capillary zone electrophoresis. Journal of Agricultural and Food Chemistry 43 : 942-945.

Bailey, E.T. 1952. Agronomic studies of vetches and other large seeded legumes in southern Western Australia. CSIRO Division of Plant Industries Technical Paper No.1.

Campbell, C.G., R.B. Mehra, S.K. Agrawal, Y.Z. Chen, A.M. Moneim Abd El, H.I.T. Khawaja, C.R. Yadav, J.U. Tay and W.A. Araya. 1994. Current status and future research strategy in breeding grasspea (*Lathyrus sativus*). Euphytica 73 : 167-175.

Kaul, A.K., M.Q. Islam and A. Hamid. 1986. Screening of *Lathyrus* germplasm of Bangladesh for BOAA content and some agronomic characters. Pp. 130-141. *In Lathyrus* and Lathyrism. A.K. Kaul and D. Combes (eds.). New York. Third World Medical Research Foundation.

Laurence, R.C.N. 1979. A comparison of the grain and protein yield potential of some annual grain legume species in South Australia. Australian Journal of Experimental Agriculture and Animal Husbandry 19 : 495-503.

Loss, S.P. and K.H.M. Siddique. 1994. Morphological and physiological traits associated with wheat yield increases in Mediterrranean environments. Advances in Agronomy 52 : 229-276.

Riceman, D.S. and J.K. Powrie. 1952. A comparitive study of *Pisum*, *Vicia*, *Lathyrus* and *Lupinus* varieties grown in Buckingham sand in the Coonalpyn Downs, South Australia. CSIRO Bulletin No. 269.

Siddique, K.H.M., S.P. Loss, S. Herwig and J. Wilson. 1995. Growth, yield and neurotoxin (ODAP) concentration of three *Lathyrus* species in Mediterranean-type environments of Western Australia. Australian Journal of Experimental Agriculture 36(2) (in press).

Siddique, K.H.M., G.H. Walton and M. Seymour. 1993. A comparison of seed yields of winter grain legumes in Western Australia. Australian Journal of Experimental Agriculture 33 : 915-922.

Silsbury, J.H. 1975. Grain yield and flowering of some introduced grain legumes in South Australia. Australian Journal of Experimental Agriculture and Animal Husbandry 15 : 556-560.

Lathyrus Germplasm Enhancement

JAGDISH KUMAR

Introduction

Lathyrus sativus L. is a legume crop of remarkable adaptation to extremes of drought and excess moisture. Its acceptability as a food, feed and fodder is well known. It is mainly cultivated as a relay crop following rainy season rice. The land otherwise remains fallow as usually no other crop is able to establish well in those conditions. One major negative factor is its neurotoxin which needs to be reduced or eliminated. This is generally a major topic for discussion in many meetings including this workshop. I shall discuss some other important aspects which may be considered in the improvement of this crop. These include its wide adaptation, marker aided selection, breeding behavior and a possible ideal ideotype. The purpose is to improve the productivity and enhance the sustainability of some of the most difficult agricultural production systems, where this crop is the main hope for diversification.

Wide Adaptation

1. Root characteristcs - strong tap root and fibrous side roots.
2. Low disease and insect damage - stability of performance.
3. Capacity to regenerate - fodder potential.

Often there is an apprehension in genetic enhancement programmes that because of improvement in crop productivity and reduction in its neurotoxin, *Lathyrus* may lose its wide adaptation. Therefore, it will be necessary that the new varieties developed in various programmes retain the above mentioned characteristics.

Marker Aided Selection

Morphological, genetic and molecular markers have been identified in this species (Gutierrez and Vences 1995). These should be utilized to aid selection of improved germplasm and varieties.

Breeding Methodology

A major factor which determines the breeding methodology for a crop is its breeding behavior. *Lathyrus* is considered a self-pollinated crop. However, Rahman *et al.* (1995) reported upto 30% cross pollination at Ishurdi in Bangladesh. Also male sterility has been reported (Quader 1987). These open up the possibility of utilization of breeding methods used for cross pollinated crops. These include population improvement methods such as recurrent selection and development of hybrid varieties.

It will be necessary to work out seed production technology including isolation distances to produce and maintain the purity of seed of low toxin varieties which are being produced in several countries. Thus more care will be needed in handling the seed of elite varieties than before when this was considered as only a self-pollinated crop.

An Ideal Ideotype

A possible ideal ideotype may be a combination of stability of *Lathyrus* and productivity of chickpea. Can we tailor such a plant type through wide hybridization? This is a challenge to pulse breeders.

References

Gutierrez, J.F. and F.J. Vences. 1995. Genetic and physiological studies in *Lathyrus sativus* L. Pp. 189-199. *In Lathyrus sativus* and Human Lathyrism: Progress and Prospectus. Yusuf H.K.M. and F. Lambein, (eds.). Proc. 2nd Int. Colloq. *Lathyrus*/Lathyrism. Dhaka, 10-12 December, 1993. University of Dhaka, Dhaka, Bangladesh.

Quader, M. 1987. Male sterility in *Lathyrus sativus*. Bangladesh J. Bot. 16 : 913.

Rahman, M.M., J. Kumar, M.A Rahman, and M.A. Afzal. 1995. Natural outcrossing in *Lathyrus sativus* L. Indian J. Genet. 55 : 204-207.

Plant Biotechnology for Development of Non-toxic Strains of *Lathyrus sativus*

S.L. Mehta and I.M. Santha

Introduction

Lathyrus sativus, commonly known as grasspea, chickling vetch, *khesari*, is a grain legume grown in various parts of India, namely, Madhya Pradesh, Eastern Uttar Pradesh, Bihar and West Bengal. It is also an important crop for Bangladesh and Nepal. The Government of India had banned the cultivation of this crop because of the presence of a neurotoxin in it. Despite the ban, farmers grow this crop because its cultivation does not require any major inputs and the crop is resistant to extreme conditions of drought and waterlogging. This crop is also used as fodder in some areas.

The disease caused by the consumption of this crop was prevalent in early sixties in areas of Madhya Pradesh because people were consuming this crop as staple food for prolonged period due to famine or drought conditions. The causative agent has been identified as β-N-oxalyl amino alanine (BOAA) or β-N-oxalyl diaminopropionic acid (ODAP) (Sarma and Padmanaban 1969). The disease caused is known as neurolathyrism and was found to be associated only with prolonged consumption of *Lathyrus* as staple food.

Plant breeding efforts during the last 2-3 decades have led to the development of lines like P 24, LSD 1 and LSD 3 which have ODAP content of 0.2 - 0.3% as compared to commercially available cultivars having 0.6 - 0.7% (Somayajulu *et al.* 1975). With the development of newer and powerful techniques of plant biotechnology, it is now possible to develop transgenic plants by cloning of genes and silencing of genes.

Considering the importance of this crop and the fact that it is highly rich in protein with better nutritional quality, plant biotechnological techniques were used by authors for removal of ODAP from *Lathyrus sativus*. For this purpose the strategies planned were:

(i) Exploitation of somaclonal variation,

(ii) Isolation of a microbe that can degrade ODAP and cloning of ODAP degrading gene in *Lathyrus sativus*, and

(iii) Application of antisense/ribozyme technology to silence the genes involved in biosynthesis of ODAP.

ODAP is synthesized by the involvement of two terminal enzymes, namely, oxalyl CoA synthetase and ODAP synthase. Silencing of any of these two enzymes by antisense/ribozyme engineering could lead to lowering of ODAP synthesis.

Exploitation of Somaclonal Variation

Various researchers had tried to regenerate *Lathyrus sativus* through tissue culture methods, but none of them were able to regenerate plants bearing viable seeds. With our persuasive effort, we could successfully regenerate *Lathyrus sativus* plants from leaf, root and internode explants from variety P 24 (Roy *et al.* 1991, 1992, 1993). A total of over 300 plants developed by tissue culture were taken to field of which 102 survived. These plants set viable seeds and were analysed for ODAP content. Seeds from low ODAP containing plants were grown in subsequent generations. The somaclones generated showed tremendous variability with respect to leaf size, internodal length, flower colour, seed colour, seed weight and pod morphology (Mehta *et al.* 1944). The parent P 24 has blue coloured flower. Somaclones with white, pink and red flower colour, white red and varying shade of grey seed coat colour were observed. Some of the variability is shown in Fig. 1 - 3 (Mehta *et al.* 1994).

Some of these characteristics can be used as markers. Individual plants were analysed for ODAP content and the seeds of low ODAP content were grown individually and also in subsequent generation. They are now in the R_5 generation. The physical characteristics observed as well as the ODAP content have remained unchanged over generations. In R_1 generation, the ODAP content varied from 0.03 - 0.08%. The low ODAP containing lines when analysed for ODAP in R_2 generation showed segregation. Majority of plants had ODAP content less than 0.1% but in some cases it was more than 0.1% and as high as 0.6%. The segregation for ODAP content was because of cross pollination caused by honey bees. This was discovered mainly because some of the white flowered and white seeded somaclones during subsequent generation showed some blue flowered plants as white colour is recessive. Continuous selection for low ODAP content helped in obtaining and maintaining extremely low ODAP nature. Some of the low ODAP somaclones also yielded very high. Low ODAP somaclones under Delhi conditions yielded 19 to 45 q/ha as compared to 17.0 q/ha by parent P 24 in the 1994-95 winter *(Rabi)* season. The ODAP content in the low ODAP lines varied from 0.03 to 0.075% and that of parent is 0.320% (Table 1).

Trials conducted at various centres like Kanpur and Raipur have also indicated the stable nature of somaclones. During 1994-95, five of our somaclones, viz., L 208, Bio R 231, Bio R 202, Bio L 212 and Bio 203 entered the Advance Varietal Trial (AVT) - 1 conducted by the Indian Institute for Pulses Research (IIPR), Kanpur and seeds from various locations were analysed for toxin content. They all had lower ODAP content as compared to all other entries and check P 24. In yield also, the somaclones developed by us fared better than others as the first four positions out of first five were by these somaclones. At one location, Bharari, one of our somaclone Bio L 212 yielded as high as 35 q/ha. This year two somaclones Bio L 212 and Bio I 222 have entered the Mini Kit trials. But Bio I 227 has other attribute of early flowering by two weeks. Bio L 208 is white flowered and white seeded. Bio L 212 has broad leaf and is bold seeded. All these are extremely low in ODAP content and high yielding somaclones. Analysis of these somaclones at CLIMA, Australia by very sensitive techniques like capillary zone electrophoresis have also shown the ODAP content to be very low (Table 2).

1

2

3

Fig. 1-3. Somaclonal variation observed with respect to leaf size and morphology, flower and seed colour.

Table 1. ODAP and yield/10 sqm in different somaclones of *Lathyrus sativus*

Somaclones	ODAP(%) (1994)	ODAP (%) 1995	Yield/10 sqm 1994-95(kg)	Yield (q/ha)
Bio 15-8	0.044	0.056	2.47	24.7
Bio 16-4	0.034	0.031	2.45	24.5
Bio L 03	0.063	0.065	2.42	24.2
Bio L 07	0.050	0.044	2.01	20.1
Bio L 08	0.028	0.047	4.50	45.0
Bio L 12	0.037	0.038	2.34	23.4
Bio L 54	0.046	0.062	2.75	27.5
Bio L 56	0.065	0.050	2.25	22.5
Bio L 57	0.063	0.059	1.96	19.6
Bio R 02	0.034	0.056	2.90	29.0
Bio R 15	0.041	0.100	3.12	31.2
Bio R 24	0.046	0.056	2.19	21.9
Bio R 29	0.063	0.068	2.66	26.6
Bio R 31	0.050	0.046	2.91	29.1
Bio R 33	0.069	0.075	3.62	36.2
Bio I 18	0.059	0.056	2.30	23.0
Bio I 22	0.031	0.040	3.90	39.0
Bio I 30	0.044	0.050	1.96	19.6
P 24	0.321	0.320	1.70	17.0

Molecular analysis of somaclones

Molecular analysis including isozyme patterns, southern hybridization pattern with cDNA probes, southern hybridization pattern and RAPD analysis of few of the somaclones varying in different characteristics were carried out alongwith parent P 24. The somaclones studied in detail with their characteristics are listed as follows:

Parent P 24	High ODAP, grey seed, blue flower.
Bio I 22	Extremely low ODAP, early maturing.
Bio 15-8	Extremely low ODAP.
Bio R 27	Fairly low ODAP, white flower, white seed coat.
Bio R 02	Low ODAP, broad leaf, highest plant height.
Bio L 08	Low ODAP, white flower, white seed coat.
Bio 16-4	Low ODAP, narrow leaves.
Bio L 19	High ODAP, pink flower.

Table 2. ODAP content (%) in *Lathyrus sativus* somaclones analyzed at the Chemistry Centre, University of Western Australia, Perth

Somaclones	ODAP(%)
Bio 164	<0.01
Bio R 202 (Ratan)	0.06
Bio L 208 (Moti)	0.03
Bio R 209	0.02
Bio L 212	0.01
Bio I 222	0.06
Bio R 231	<0.01
Bio L 254	<0.01
P 24	0.34

Seeds from single plants of each of these somaclones were analyzed for their esterase isozyme pattern as well as ODAP content. Seeds from plants having same esterase pattern and ODAP content were pooled and used for further analysis.

Isozyme pattern

Isozyme pattern of esterase, GDH, MDH, ADH and peroxidase were studied. Seven days old seedlings were used for studying the isozyme pattern. The peroxide, MDH and GDH isozyme patterns did not show any difference between different somaclones and their parent P 24. ADH isozyme pattern showed some differences. One extra band was present at Rm 0.51 in Bio I 22 and Bio 15-8 and one band was missing at Rm 0.56 in Bio R 02 which was present in all other somaclones and in parent P 24. Esterase pattern showed differences among the somaclones (Fig. 4). Bands with Rm 0.37, 0.55 and 0.73 were

Lane

1. Bio L 19
2. Bio R 02
3. Bio I 22
4. Bio R 27
5. Bio 15-8
6. Bio L 08
7. Bio 16-4
8. P 24

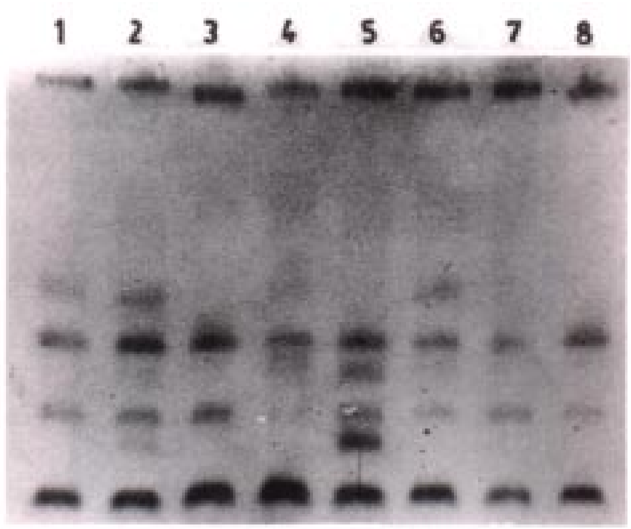


Fig. 4. Esterase pattern of 6-day old etiolated shoots from the seeds of R_2 generation plants in different somaclones and parent cultivars

common to all somaclones and parent in P 24. In Bio. L 19, Bio R 02, Bio R 27 and Bio L 08, an extra band with Rm 0.30 was present. Bio 15-8 had two extra prominent bands at Rm 0.40 and 0.48. Bio R 27 and Bio L 08 also showed the extra band at Rm 0.40 but with less intensity and Bio R 02 had a faint band at Rm 0.48. One distinguishable feature of R 27 was that one band at Rm value 0.45 which was present in all other somaclones as well in parent P 24 was missing in it. Esterase pattern has been found to be stable in subsequent generation also.

Southern analysis of genomic DNA

Genomic DNA was isolated from the seven somaclones described above and parent P 24 was restricted with restriction enzymes Eco R1, PstI, Bam HI, Xba I, KpnI, Hae III, Msp I and Hpa II were separately hybridized with a random cDNA clone (clone 29) of *Lathurus sativus*. In eco RI digested DNA, one single band was observed at 4.0 kb, but the intensity of the band was very high in Bio R 02 and Bio L 08. Bam HI and Pst I hybridized with a 4.3 kb fragment in all somaclones and P 24 and with an extra 5.0 kb band in Bio R 02 and Bio L 08 whose intensity was comparatively less in Pst I restricted DNA. In Xba I restricted DNA also, 4.3 kb hybridizing band was seen in all somaclones and P 24 with more intensity in Bio R 02 and Bio L 08 (Fig. 5).

In Bio R 02, additional 3 more bands of size 6kb, 9kb and 21kb were found to hybridize and amongst these the intensity of the band was highest with the 6 kb band. The hybridization pattern with Kpnl enzyme was similar to that of Xba I except that the faint common band present in Xba I restricted DNA of somaclones P 24, and was absent in P 24 and all somaclones except Bio RD2 and Bio L 08. With Hae III, which is a four nucleotide recognizing enzyme, gave hybridizing bands only in Bio R 02 and Bio L 08 somaclones, which were similar in both.

Mspl and Hpall combination is normally used for detecting methylation in DNA. Mspl

Lane
1. Bio 16-4
2. Bio L 08
3. Bio 15-8
4. Bio R 27
5. Bio I 22
6. Bio R 02
7. Bio L 19
8. P 24

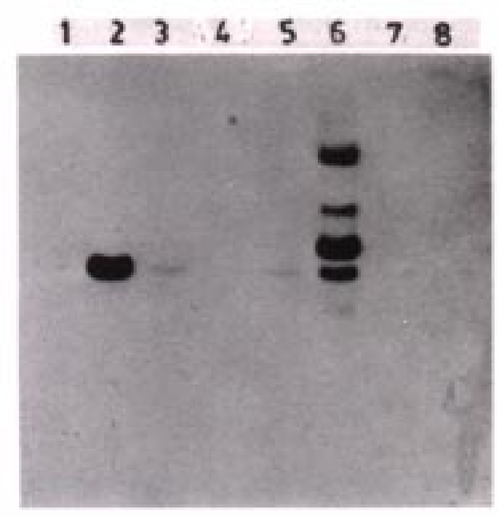


Fig. 5. Southern hybridization pattern of Xba I restricted genomic DNA with cDNA clone - 29 of different somaclones and parent cultivar P 24

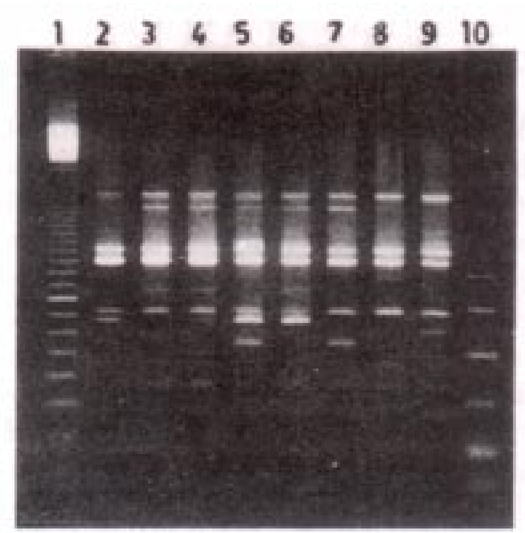
restricted DNA hybridized with a 4.3 kb of same intensity in all somaclones and P 24, and in Bio R 02 and Bio L 08 there were 3 extra bands of 0.6, 0.8 and 1.2 kb, respectively. Hpa II isochizomer of Msp II showed hybridization with 4.3 kb band in all as in the case of Hpa II but Bio L 08 and Bio R 02 showed a different banding pattern as compared to that of Mspl. In Bio R 02, it hybridized with 3 bands of 5.0 kb, ~ 10 kb and ~ 15 kb which were absent in all other somaclones and in parent P 24.

RAPD pattern

RAPD analysis were conducted mainly to see the similarity among different somaclones and the parent as well as to get finger print of the somaclones at DNA level, which could be used further for identifying a particular somaclones. RAPD pattern was studied with 81 oligodecaprimers in 7 somaclones mentioned above and parent P 24. Maximum number of primers did not show polymorphic band. Only 24 out of 81 primers showed polymorphism. Figure 6 shows the RAPD pattern of different somaclones and P 24 with a decamer OPB-16. Similarly, matrix calculated on the basis of total number of bands and number of shared bands showed more than 90% similarity between any two somaclones, and between any somaclones and parent P 24. RAPD analysis also showed that with a single primer, it was not possible to identify a particular somaclone and would require any two, three or more primers for this purpose.

Isolation of ODAP Degrading Genes from Soil Microbe

Three strains of soil microorganisms have been isolated from drain near the IARI Campus and have been designated as BYA1, BYK1 and BYT1 depending upon their resistance towards antibiotics ampicillin, kanamycin and tetracycline, respectively . BYA1 has been identified as *Enterobacter cloacae* (Yadav *et al.* 1992) and BYT1 and BYK1 as *Pseudomonas stutzeri* (Shelly Praveen *et al.* 1994; Sachdev *et al.* 1995). These microbes were able to grow



Lane
1. 100 bp ladder
2. P 24
3. Bio 16-4
4. Bio L 08
5. Bio 15-8
6. Bio R 27
7. Bio I 22
8. Bio R 02
9. Bio L 19
19. PCR marker

Fig. 6. RAPD pattern of different somaclones and parent cultivar P 24 using primer OPB-16

on media containing ODAP as sole source of carbon and nitrogen. The property of degradation of ODAP in all these strains is borne on plasmid present in them.

The plasmid from BYA1 has been studied in more detail which has a size of over 50 kb. An overlapping circular map of this plasmid with respect to enzyme NotI, PstI, KpnI and HindIII have been prepared. In order to isolate the gene responsible for degradation of ODAP, a partial Sau3A library of the plasmid was prepared in a vector pUC18. The recombinant clones, selected by growing recombinants on minimal agar plate containing ODAP as sole source of carbon and nitrogen were isolated. One of the recombinant clone BM1 could utilize ODAP as sole source of carbon and nitrogen had an insert of ~ 1.8 kb. DNA sequencing of this 1.8 kb fragment was carried out after generating deletions using Bal31 exonuclease and recloning in pUC18 (Sukanya *et al.* 1993).

Analysis of the sequences showed the largest open reading frame of 630 nucleotides in one frame. It had at 5' end sequences similar to other *E. coli* promoters representing the ‘43’, ‘35’ and ‘10’ sequences and a start codon. The proposed start codon in this case is GUG in place of normal AUG. The gene coded for a polypeptide contained 199 amino acids. Sequence homology of this sequence did not show any sequence homology with any of *E. coli* decarboxylase or deaminase. This fragment has been cloned to an *E. coli* expression vector $pMALC_2$ and got expressed in *E. coli* host TB15. The polypeptide coded by the ODAP degrading gene is expressed as fusion protein with maltose binding protein and has been cleaved with endoprotease Xa factor and purified. The molecular weight determined by SDS-PAGE was found to be ~20.9 kd which corresponds to that revealed from sequence analysis. The gene is expressed as a single polypeptide (Nair *et al.* 1994).

Further studies using this purified protein will reveal the metabolic pathway of ODAP utilization. This 1.8 kb fragment has been cloned into *Agrobacterium tumefaciens* strain. Methods of transformation of *Lathyrus sativus Agrobacterium* vectors as well as using projectile gene bombardment have been standardized (Barua and Mehta 1995).

Transformation of *Lathyrus sativus*

For introducing the ODAP degrading gene to *Lathyrus*, efficient transformation protocols need to be developed. The most used method of transformation is using *Agrobacterium tumefaciens* vector. Recently transformation using microprojectile gun has also been widely used. Indirect embryogenesis has been reported in *Lathyrus* earlier by Gharyal and Maheswari (1983), but there is no report on direct embryogenesis in *Lathyrus*. Direct embryogenesis has importance in gene transfer work, protocols were developed for direct embryogenesis. Somatic embryos were observed to form both on leaf and internode explants. 98% of individual embryos upon transfer to hormone-free medium germinated to form root with slight elongation of hypocotyl and 2% of the embryos germinated to form shoots. Transformation using *Agrobacterium* vectors had only 9 to 20% frequency and also the embryos/callus formed were unable to form plantlets. Hence, the biolistic method of transformation was standardized. The frequency of transformation by this method was much better than that of *A. tumefaciens* method. The transformation of tissue was determined by assaying for GUS expression as well as resistance to kanamycin. Shoot and root were also regenerated of these transformed calli to form transgenic plantlet

(Barna and Mehta 1995). This work will be further extended to develop transgenic *Lathyrus* carrying ODAP degrading gene.

Isolation of oxalyl CoA synthetase

Application of antisense RNA technology/ribozyme technology to silence/block the biosynthetic pathway of ODAP synthesis is another approach to develop ODAP-free cultivar of *Lathyrus sativus*. Two terminal steps involving two different enzymes oxalyl CoA synthetase and ODAP synthase are proposed for the biosynthesis of ODAP. Hence, blocking of expression of any one of these enzymes will indirectly reduce the ODAP synthesis. This can be achieved by applying antisense RNA technology or by ribozyme technology. A foremost need for application of these technologies is to isolate the genes responsible for either of these two enzymes described earlier. The method followed was to purify the enzyme oxalyl CoA synthetase, raise antibodies against it and use the antibody developed to screen a cDNA library of *L. sativus* prepared in an expression vector. Studies in this regard are being initiated in our laboratory and we have been able to isolate and purify the enzyme oxalyl CoA synthetase and raise antibody (Sehgal *et al.* 1992). cDNA library of mRNA isolated from *L. sativus* seedling have been prepared and will further be used for analysis and isolation of gene.

Summary and Conclusions

Attempts have been made to apply plant biotechnological methods to develop toxin-free cultivar of *L. sativus*. Exploitation of somaclonal variation has helped in isolating various somaclones differing in various characteristics with respect to leaf size and morphology, flower colour, seed colour, etc. Somaclones with low ODAP combined with high yield have been developed. They have also fared well in various location trials and had the lowest ODAP content among the entries. Two of the somaclones have also entered the mini kit trials. Molecular markers have been developed for some of the somaclones.

An ODAP degrading gene has been isolated from a soil microbe, sequenced and introduced into *A. tumefaciens*. Methods have been developed for development of transgenic *L. sativus* plants using biolistic methods. The enzyme oxalyl CoA synthetase have been purified and antibodies raised.

References

Mehta, S.L., K. Ali and K.S. Barna. 1994. Somaclonal variation in a food legume *Lathyrus sativus*. J Plant Biochem Biotech. 3 : 7377.

Nair, A.J., G.S. Khatri, I.M. Santha and S.L. Mehta. 1994. Cloning of ODAP degrading gene and its expression as fusion protein in *Escherichia coli*. J Plant Biochem Biotech. 3 : 103-106.

Roy, P.K., B. Singh, S.L. Mehta, G.K. Barat, A. Gupta, P.B. Kirti and V.L. Chopra. 1991. Plant regeneration from leaf disc of *Lathyrus sativus*. Indian J Expt Biol. 29 : 327-330.

Roy, P.K., G.K. Barat and S.L. Mehta. 1992. *In vitro* regeneration from callus derived from root explants of *Lathyrus sativus*. Plant Cell Tissue and Organ Culture 29 : 135-138.

Roy, P.K., K. Ali, A. Gupta, G.K. Barat and S.L. Mehta. 1993. b-N-oxalyl-L-a,b diaminopropionic acid in somaclones derived from internode explants of *Lathyrus sativus.* J Plant Biochem Biotech. 2 : 9-13.

Sachdev, A., M. Sharma, R.P. Johari and S.L. Mehta. 1995. Characterization and cloning of ODAP degrading gene from a soil microbe. J Plant Biochem Biotech. 4 : 33-36.

Sarma, P.S. and G. Padmanaban. 1969. Lathyrogens. Pp. 267-291. *In* Toxic Constitutents of Plant Food-stuffs. I.E. Liener (ed.). Academic Press, New York.

Sehgal, D., I.M. Santha and S.L. Mehta. 1992. Purification of oxalyl CoA synthetase enzyme from *Lathyrus sativus* and raising of antibodies. J Plant Biochem Biotech. 1 : 97-100.

Shelly Praveen, R.P. Johari and S.L. Mehta. 1994. Cloning and expression of OXDAPRO degrading genes from soil microbe. J Plant Biochem Biotech. 3 : 25-29.

Somayajulu, P.L.N., G.K. Barat, Shiv Prakash, B.K. Misra and Y.C. Srivastava. 1975. Breeding of low toxin containing varieties of *L. sativus.* Proc. Nutr. Sci. (India) 19 : 35-39.

Sukanya, R., I.M. Santha and S.L. Mehta. 1993. Cloning and characterization of a gene responsible for the *Lathyrus sativus* neurotoxin degradation. J Plant Biochem Biotech. 2 : 77-82.

Yadav, V.K., I.M. Santha, M.P. Timko and S.L. Mehta. 1992. Metabolism of the *Lathyrus sativus* L. neurotoxin b-N-oxalyl-L-a,b-diaminopropionic acid by a pure culture of a soilborne microbe. J Plant Biochem Biotech. 1 : 8792.

Lathyrus Cultivation in Chhattisgarh Region of Central India: Problems and Prospects

S.S. Baghel, A.S.R.A.S. Sastri and A.K. Geda

Introduction

Lathyrus is the most important pulse crop of Chhattisgarh region, Madhya Pradesh (Table 1), covering an area of about 600 000 ha and accounting for nearly two-third of the total reported area under this crop in India. Its area fluctuates from year to year depending upon the distribution of rainfall. It is predominantly grown as a relay crop, popularly known as *utera*, in rice fields purely under rainfed conditions. Wide fluctuations in its productivity are observed depending upon the occurrence of winter rains. It is a rich source of protein and is used as a pulse by the poor sections of the society. It is widely used as an adulterant in varying proportions in chickpea and pigeonpea and in a large number of Indian recipes made out of gram (chickpea) flour. It is commonly believed that the receipes become tastier with the blending of gram flour with *Lathyrus* flour. It is also preferred for its good straw quality. Farmers in the region feed their animals on paddy straw and the *Lathyrus* straw, which being rich in nutritive value, serves as a good supplement to nutritionally poor paddy straw, since under rainfed situation growing of other quality fodder is not feasible.

Diversity Grown

There are two cultivated forms of *Lathyrus* grown in the region. The bold seeded type, popularly known as *lakh*, is cultivated as a post rainy season (*rabi*) crop in unbunded vertisols (locally called *bharri*) left fallow during rainy season. The other type, popularly known as *lakhadi*, is small seeded and is largely sown as a relay crop (*utera*) in standing paddy fields. This classification is arbitrarily based on seed size and its genetics is not properly understood. The karyotypic, protein profile and peroxidase and esterase isozyme studies did not reveal any clear differences among genotypes belonging to these two broad categories.

Production and Cultivation practices

Lathyrus has an important place in the economy of the region, since in terms of area, it is the second most important crop, next only to rice among all food crops grown in the region. The important *Lathyrus* growing districts are Raipur, Durg, Bilaspur and Rajnandgaon. It is also grown in sizable area in Balaghat. In Raigarh, Surguja and Bastar, its area is very small due to occurrence of light textured soils (Table 1.)

Table 1. Area and productivity of *Lathyrus* in different districts of Chhattisgarh region (1994-95)

District	Area ('000 ha)	Productivity (kg/ha)
Raipur	144.10	461
Durg	198.70	457
Rajnandgaon	74.90	330
Bilaspur	166.80	571
Balaghat*	15.00	383
Raigarh	4.60	478
Surguja	0.80	478
Bastar	2.90	586

* figures for 1990 - 91

As mentioned earlier, it is commonly grown as a relay crop in paddy fields. In this practice the seeds of *Lathyrus* are broadcasted in standing paddy fields 2-3 weeks before the harvest of paddy. The excess water is drained of about 12-24 hours after the sowing of *Lathyrus*. No other operation is performed between sowing and harvesting. The crop, being very hardy, grows on residual moisture. This practice is followed in relatively heavy soils like vertisols and to some extent in alfisols having good moisture holding capacity. The vast majority of fields belonging to other soil types with less moisture retention capacity remain fallow after paddy.

Problems

The productivity of *Lathyrus* in this region is quite low (Table 1). The main reasons are:

1. Inadequate plant stand
2. Lack of suitable varieties
3. Losses due to insect pests, particularly thrips
4. Losses due to diseases like powdery mildew and downy mildew
5. Losses due to weeds
6. Moisture stress
7. Non use of fertilizers

Inadequate plant stand

The *utera* system of cultivation, evolved over years as an insurance against aberrant weather conditions, results in poor plant stand, although very high seed rate (75-80 kg/ha) is used. It is because the moisture status in the field is not uniform and the harvested paddy is left in the field for several days for drying. The poor seed quality is another factor responsible for inadequate plant stand.

Lack of suitable varieties

The farmers are growing their traditional varieties, which have evolved over the years to suit the poor growing environment. The breeders have been trying to select varieties from local landraces and systematic introduction and introgression of diverse germplasm have not been undertaken. The varietal improvement could not progress because of the restrictions imposed on the release of new varieties regarding the BOAA (ODAP) content. The recent improvement in technique requiring low sample size is likely to help in the development of varieties having high yield and low ODAP content. Low ODAP containing lines have been developed by Indira Gandhi Agricultural University, Raipur by conventional breeding method and at Indian Agricultural Research Institute, New Delhi using tissues culture technique. These lines are currently under evaluation.

Losses due to insect-pests

Thrips are the major pest limiting *Lathyrus* production. There is no known source of resistance. The newly bred low ODAP containing lines are extremely susceptible to thrips.

Losses due to diseases

Powdery mildew causes extensive damage to *Lathyrus*. The available germplasm does not have resistant donors. The downy mildew becomes a problem only if water stagnation occurs due to winter rains.

Losses due to weeds

Since the *Lathyrus* seeds are broadcasted in standing paddy fields, weeds are a serious problem. Hand weeding, although effective, is very expensive.

Moisture stress

Although *Lathyrus* is drought resistant and most of the germplasm has typical drought resistance characteristics like low leaf area index (LAI), less chlorophyll content in order to increase the short wave radiation reflectivity (albedo) etc., still the crop suffers moisture stress and is benefitted, if winter rains are received.

Non use of monetary inputs, particularly fertilizers

The farmers do not use any fertilizers, since the available varieties give poor response to fertilizer application. The variability in plant stand under *utera* system makes it difficult to realize the effect of added fertilizers.

Prospects

Area

The *Lathyrus* area is declining in almost all the districts of the region. It is decreasing rapidly in district like Rajnandgaon, where soybean is coming up on a large scale as a more renumerative crop in unbunded vertisols. The area is also decreasing in those regions where irrigation facilities are developing, since better alternative crops are available. The *Lathyrus* area under upland is likely to be replaced unless high yielding better varieties of *Lathyrus* are evolved.

However, most of the *Lathyrus* is grown as *utera* in paddy fields under rainfed condition. This is a well established paddy based cropping system and the farmers do not have better alternative under such a harsh crop growing environment. The University in early eighties developed the technology of chickpea replacing *Lathyrus* as an *utera* crop. It worked well in relatively favourable environment in a limited area. However, during the past few years there is no perceptible replacement of *Lathyrus* with chickpea under *utera*. Thus, *Lathyrus* is going to be an important pulse crop in future too in the region.

Productivity

The productivity of *Lathyrus* is showing an increasing trend in almost all the districts. Since there has been no genetic improvement or change in growing technology, the increase in productivity could be attributed to increased use of phosphorus fertilizer in paddy and the *Lathyrus* crop benefitting from its residual effect.

The productivity is expected to increase further and at a faster rate, if some of the low ODAP containing lines are found suitable for *utera* cultivation. They are having high yield potential under upland conditions with protection against thrips and supplemental irrigation. However, the conditions under *utera* are entirely different and it is to be seen whether low ODAP containing lines will perform better under *utera* also.

Low ODAP vs. high yield

During the past few years with the easy availability of wheat and rice, the food habits of the people have undergone considerable change. Moreover, the prices of *Lathyrus*, which used to be low earlier, are now comparable to wheat and rice and thus *Lathyrus* is no more the staple food. Its intake is too low to cause lathyrism. Also *Lathyrus* as a causative factor of crippling diseases is not established beyond doubt. The experimental evidence indicates that ODAP, being water soluable, its large proportion is lost during traditional method of *dal* (decorticated split cotyledons) making. Cheaper methods of detoxification of *Lathyrus* seed are also available. As indicated earlier, it is being largely used as an adulterant with common pulses like chickpea and pigeonpea and in chickpea flour for making various recipes. Therefore, while every effort should be made to evolve high yielding varieties with low ODAP content, the straints having desirable attributes like high yield, disease and pests resistance and containing ODAP comparable to the level of local cultivars should also be considered for release and popularization to ensure the supply of cheaper source of protein and better returns to the farmers in a less favourable environment.

Grasspea Cultivation in Problem Areas : Present Approaches

A.N. ASTHANA

Introduction

Grasspea (*Lathyrus sativus*), also called chickling pea, *khesari* or *teora*, is cultivated as a major crop in India, Bangladesh, Nepal, China and Pakistan. It is also grown in many countries of Europe, the Middle East, Northern Africa, Chile and Brazil. The crop can be grown under very high (1500 mm) to low rainfall (300 mm) conditions. Being a drought tolerant crop, it requires low inputs for its cultivation. It is a rich source of protein (28%) and has become a mainstay of Indian diets under famine conditions in some areas.

In India, grasspea is occupying an area of about 0.8 million hectares and is mainly cultivated in parts of Madhya Pradesh, Bihar, Maharasthra, Orissa, West Bengal and Eastern Uttar Pradesh. The maximum hectarage of the crop is under *utera* system where the seed of grasspea is broadcasted in the paddy field about 10-15 days before the paddy is ready for harvest. The crop can be grown on the types and conditions of soil which can hardly sustain any other crop, but the average productivity is hardly 2-3 q/ha.

During early 1960s, some cases of neurolathyrism characterized by lower limb paralysis were reported from various parts of India. The compound has been identified as β-N-oxalyl-L-α-β-diaminopropionic acid (ODAP) (Adiga *et al.* 1963; Murti *et al.* 1964; Mani *et al.* 1971). Lathyrism may strike any one whose diet contains about 25 per cent of grasspea as staple food for 3-4 months. In view of this, the sale of grasspea has been banned in many states in India, however, there has not been an effective ban on its cultivation. Unless low toxin varieties are developed, work on other improvement aspects is considered as of secondary importance.

Detoxification and Varietal Development

The removal of toxic compound of the grasspea grains before consumption was suggested as a measure to prevent lathyrism. Such a detoxification can be done by boiling, roasting (140°C) or by soaking overnight and draining out the supernatant (Mohan *et al.* 1966; Bell 1964). The other method suggested was of genetic detoxification. This method involves selection and breeding for low toxin lines. Screening of germplasm has resulted in identifying several lines that have low toxin content. The first phase in the crop improvement between 1940 and 1960 included the collection of local cultivars and isolation of single plant progenies superior in yield. As a result, a number of lines were isolated and recommended for cultivation by various state departments of agriculture, like BR 13, LC 76 (Bihar), No. 11 and No. 91 (M.P.), B 19 (West Bengal) (Singh and Mishra 1988).

In the second phase, improved varieties relatively low in neurotoxin were developed. The extensive testing and evaluation resulted in the identification and recommendation of a variety Pusa 24 by the Pulse Research Workshop in 1974 with relatively lower amount of ODAP (0.2%) and suitable for upland cultivation (Jain *et al.* 1974). Another variety Nirmal (B_1) developed by single plant selection from local material with low ODAP content (0.2%) was released in 1980 in West Bengal. Both these varieties have the yield potential of 7 - 8 q/ha. Further research work at Indian Agricultural Research Institute (IARI), New Delhi helped in identifying 3 varieties, viz., LSD 1, LSD 3 and LSD 6 with low ODAP ranging from 0.15 to 0.2%. While LSD 6 was recommended for upland cultivation, LSD 1 and LSD 3 were suitable for *utera* cultivation in rice fallows (Sethi *et al.* 1981). Later on, some other lines like Pusa 505 for upland, Sel 1276 for *utera* and upland were developed with ODAP content of about 0.2%.

Certain lines developed by Indria Gandhi Agricultural University (IGAU), Raipur like RLS 6, RLS 8 and LS 157-14 are reported to have good yield potential with comparatively lower ODAP content. Recently, certain lines with almost negligible amount of toxin level have been developed at IARI, New Delhi using biotechnological techniques (Table 1). Some of these lines are Bio R 202, Bio L 203, Bio L 212, Bio R 231 and Bio L 208. These lines are now utilized in the grasspea improvement programme at various centres. Some of these lines also have good grain yield potential and high harvest index. Certain donors for low ODAP suggested by ICARDA (Sel 521, Sel 443, Sel 519 and Sel 536) and Canada (LS 8246 and LS 8545) are also being used in the improvement programme with an aim to develop low ODAP varieties with good yield potential.

Selection for Disease and Pest Resistance

Grasspea is highly susceptible to thrips, particularly in the central zone of India. Certain lines like JRL 41 and JRL 6 are reported by IGAU, Raipur as tolerant to thrips. Powdery mildew and downy mildew are the two major diseases which infect grasspea. Lines reported by IGAU, Raipur centre to be tolerant to powdery mildew are RPLK 26, RLS 2 and JRL 41. Also, a number of lines have been reported to have resistance to downy mildew.

Constraints

Socio-economic constraints

a) *Inputs* : Generally the crop is grown by marginal and sub-marginal farmers who are unable to provide any input.

b) *Lack of certified seeds* : The seeds of improved varieties have not yet reached to the farmers.

Table 1. Performance of grasspea genotypes in respect of grain yield (kg/ha) and ODAP content (figures in parenthesis indicate no. of locations)

Genotypes	Zones	Grain yield (kg/ha)						ODAP (%)
		1991-92	1992-93	1993-94	1994-95	Average	Average over zones & years	
P 24	NWPZ	2 313(1)	903(1)	849(1)	556(1)	1 155	1 059	0.299(7)
	NEPZ	1 103(2)	953(2)	701(1)	950(3)	927		
	CZ	1 183(3)	974(4)	-	1 126(4)	1 094		
LSD 3	NWPZ	2 000(1)	1 007(1)	1 299(1)	347(1)	1 163	1 209	0.294(4)
	NEPZ	916(2)	1 147(2)	885(2)	2 308(1)	1 314		
	CZ	1 129(3)	790(3)	1 307(3)	1 378(1)	1151		
P 28	NWPZ	1 823(1)	-	951(1)	521(1)	1 098	1 055	0.207(6)
	NEPZ	872(2)	-	1 042(2)	1 114(3)	1 009		
	CZ	1 268(3)	645(3)	1 195(2)	1 118(3)	1 057		
P 90-2	NWPZ	-	-	816(1)	556(1)	686	722	0.193(6)
	NEPZ	-	660(1)	929(2)	-	795		
	CZ	-	509(3)	858(2)	-	684		
Bio R 202	NWPZ	-	-	-	503(1)	503	1 063	0.059(1)
	NEPZ	-	1 508(1)	1 582(1)	1 572(3)	1 554		
	CZ	-	641(1)	1 340(2)	1 414(4)	1 132		
Bio L 203	NWPZ	-	-	-	434(1)	434	906	0.069(6)
	NEPZ	-	1 190(1)	895(1)	1 186(3)	1 090		
	CZ	-	506(1)	1 627(2)	1 446(3)	1 193		
Bio R 231	NWPZ	-	-	-	503(1)	503	1 015	0.087(6)
	NEPZ	-	1 508(1)	1 261(1)	1 356(3)	1 375		
	CZ	-	641(1)	1 297(2)	1 566(4)	1 168		

(Contd. ...)

Table 1. contd.

Bio L 212	NWPZ	-	-	-	764(1)	764	1 267	0.093(7)
	NEPZ	-	-	1 301(1)	1 751(3)	1 526		
	CZ	-	-	1 281(1)	1 741(4)	1 511		
Bio L 208	NWPZ	-	-	-	486(1)	486	960	0.097(7)
	NEPZ	-	-	1 357(1)	1 278(3)	1 318		
	CZ	-	-	622(1)	1 410(4)	1 016		
P 94-1	NWPZ	-	-	-	347(1)	347	1 018	0.329(5)
	NEPZ	-	-	-	1 221(3)	1 221		
	CZ	-	-	-	1 487(2)	1 487		
P 94-2	NWPZ	-	-	-	417(1)	417	1 043	0.311(5)
	NEPZ	-	-	-	908(3)	908		
	CZ	-	-	-	1 803(2)	1 803		
P 94-3	NWPZ	-	-	-	487(1)	487	1 152	0.131(6)
	NEPZ	-	-	-	1 403(3)	1 403		
	CZ	-	-	-	1 566(3)	1 566		

NWPZ = North West Zone, NEPZ = North East Zone, CZ = Central Zone.

Plant based constraints

a) Widely adaptable varieties have not been developed, varieties suitable for upland planting do not survive well in *utera* system.

b) Varieties are highly susceptible to thrips, powdery mildew and downy mildew.

c) Most of the released varieties are with high and unstable ODAP.

Marketing constraints

The ban imposed on the sale of this crop is a major constraint for its further development.

Future Programme/Needs

In order to strengthen the National *Lathyrus* Improvement Programme, emphasis on both basic as well as applied research has been given at IARI, New Delhi (Mehra 1991; Mehta and Santha in these proceedings); IGAU, Raipur and at the Indian Institute of Pulses Research (IIPR), Kanpur on the various aspects of grasspea production. Research underway includes inheritance of reduced ODAP concentration, selection and hybridization of low ODAP lines, insect (thrips) and disease (powdery mildew and downy mildew) resistance, and elimination of ODAP through biotechnological techniques.

Low ODAP donors which are being used in the hybridization programme are Bio R 202, Bio L 203, Bio R 231, Bio L 212, Bio L 208, P 28, P 90-2, P 94-3, P 505 etc. Certain donors suggested by IGAU, Raipur for tolerance to thrips (JRL 41, JRL 6) and powdery mildew (RPLK 26, RLS 2, RL 41) are also being used in the improvement programme to develop low ODAP genotypes tolerant to these biotic factors.

References

Adiga, P.R., S.L.N. Rao, and P.S. Sarma. 1963. Current Science 32 : 153-155.

Bell, E.A. 1964. Nature (London) 203 : 378-380.

Jain, H.K., Somagajula and G.K. Barat. 1974. Final technical report on investigation in *Lathyrus sativus*. Indian Agricultural Research Institute, New Delhi.

Laxman Singh. 1965. *Lathyrus* Cultivation in Madhya Pradesh and Prevention of Lathyrism. Director of Research Services, J.N.K.V.V., Jabalpur.

Mani, K.S., S. Sriramachari, S.L.N. Rao and P.S. Sarma. 1971. Indian J. Med. Res. 59 : 880.

Mehra, R.B. 1991. Genetic improvement of *Lathyrus sativus* - Problems and potentialities. Pp. 205-216. *In* Genetic Improvement of Pulse Crops, vol.2. Khan and Farook (eds.). Premier Publishing House, Hyderabad, India.

Mohan, V.S., V. Nagarajan and C. Gopalan. 1966. Indian J. Med. Res. 54 : 410-414.

Murti, V.V.S., T.R. Seshadri and T.A. Venkatesubramanian. 1964. Phytochemistry 3 : 73-78.

Sethi, K.L., R.B. Mehra and B.M. Lal. 1981. Science and Culture 47 (7) : 263-264.

Singh, S.P and B.K. Mishra. 1988. Grasspea. Pp. 108-113. *In* Bhag Mal: Underutilized Grain Legume and Proceedings — Their Potentials in Asia (1994). RAPA/FAO, Bangkok, Thailand.

A Network Approach for the Conservation and Use of *Lathyrus sativus* Genetic Resources

K.W. Riley

Past International Collaboration on *Lathyrus*

Lathyrus sativus is grown in India, Nepal, Bangladesh and Ethiopia where it is a major legume used for fodder and grain for human consumption. The crop is also grown in parts of Pakistan, West Asia and China. *Lathyrus*, also known as the grasspea, is a hardy crop, able to withstand both drought and prolonged flooding, and can produce a crop where other legumes fail (Campbell 1995). Until recently, crop improvement efforts were constrained by the presence of a water soluble, non-protein amino acid ODAP (β-N-oxalyl-α, β-diaminoproprionic acid), which acts as a neurotoxin crippling the lower limbs when consumed in large amounts causing the disease lathyrism. This has lead to the crop being excluded from agricultural improvement efforts. In fact, growing of *Lathyrus* has been officially banned in some countries.

Initial international interest in the *Lathyrus* gene pool was largely based on genetic studies of the species relationship among *L. sativus* and its related species (all diploid with 2n = 14) which form primary, secondary, tertiary and quaternary gene pools, depending upon ease of hybridization (Campbell 1995). In the past decade, a number of international meetings have been held on *Lathyrus*. Partially as a result of these meetings and the scientific interest generated, advances have been rapid.

- In 1985, in Pau, France, a *Lathyrus* Colloquia was convened. A multi-disciplinary group of scientists discussed the biochemical and medical basis for Lathyrism as well as genetic and agronomic information confirming the potential importance of the crop (Kaul and Combes 1986).

- In 1988, a consultation meeting in London resulted in the formation of INILSEL [International Network for the Improvement of *Lathyrus sativus* and the Eradication of Lathyrism (Spencer 1989)]. INILSEL was set up with 4 technical teams: Chemistry, Medical and Toxicology, Nutritional and Processing, and Crop Improvement. Although, INILSEL has not been as active as planned, many research activities were started.

- In 1993, the Second *Lathyrus* Colloquium was convened in Dhaka, Bangladesh. At this meeting, reports of virtual elimination of ODAP from *Lathyrus* lines through conventional breeding, attempts to use recombinant DNA to develop transgenic *Lathyrus* lines with low neurotoxin levels, and advances in the knowledge of the biochemical pathway of ODAP metabolism were reported (Yusuf and Lambien 1995).

- During this period, donor support from the European Commission was obtained for biochemical studies of ODAP in Belgium and Bangladesh.

- In 1993, Dr S.L. Mehta and his group at the Indian Agricultural Research Institute in Delhi reported very low ODAP levels in selected somaclonal lines of *L. sativus* grown from *in vitro* produced explants. These lines, when tested in the field in Western Asutralia, retained their very low neurotoxin levels (K.H.M. Siddique-see these proceedings). Some of these selections produced top yields in the *Lathyrus* growing areas of India (Roy 1993).

- In November 1995, a conference in Addis-Ababa, Ethiopia focused on the toxicity and biochemistry of ODAP and methods of removing it from *L. sativus*. An International *Lathyrus* and Lathyrism Research Association (ILLRA) was formed to follow up on these questions. As confirmed by the organizers, the Ethiopia meeting did not directly address resources of *Lathyrus* (F. Lambien, personal communication).

Lathyrus sativus and Genetic Resources

The flurry of activities during the past decade to elucidate the biosynthetic pathway and ODAP develop varieties of *L. sativus* with very low levels of the neurotoxin has resulted in rapid progress in this area. As participants in this workshop were able to observe for themselves, low neurotoxin levels are being quickly combined with high yield in India and elsewhere. Along with this rapid progress, it is wise to gain a better understanding of the extent of genetic diversity available in the *L. sativus* gene pool, and how it might be best conserved and used in improved *Lathyrus* varieties.

Campbell (1989) reviewed literature, and evaluated germplasm accessions from around the world and reported that the species showed great morphological variation, especially in vegetative characteristics such as leaf length, while floral characteristics are much less variable. A pattern of variation similar to that of lentil was found with more primitive forms possessing small seed occurring east of the Mediterranean, while larger-seeded forms have developed in Europe. As earlier indicated, variants with low neurotoxin levels have been identified as well as variation for protein, insect and disease resistance and many other useful traits.

Collections of germplasm are presently held in most of the *Lathyrus* producing countries as well as in Canada, France and Belgium.

Why is collaboration on conservation and use of *Lathyrus* genetic resources important?

- The *ex situ* collections as well as the diversity in the gene pool of *Lathyrus sativus* occurs mainly in countries in South and West Asia and Ethiopia. Producing countries need to collaborate with one another to document, conserve and use this diversity as effectively as possible.

- Much of the technology development in the areas of biochemistry, molecular genetics and genetic improvement have taken place outside this region (in Canada, Belgium, France and UK). Close collaboration between genetic resources and other activities will be necessary to balance conservation and use by means of new technologies.

- Under the Convention on Biological Diversity, countries have accepted the responsibility for conservation, sustainable use and sharing of their genetic resouces. Countries holding collections of *Lathyrus* diversity need to examine methods by which this can be done most effectively and inexpensively. Various tools including new methods and technologies for conserving and using genetic resources of *Lathyrus* may need to be carefully examined. Collaboration to share this task including information, technology and genetic resources is, therefore, needed.

- Networks have been recognized as effective tools to enable countries to carry out their responsibilities to conserve, use and share genetic resources, information and technology. In the Global Plan of Action for Conservation and Use of Plant Genetic Resources, networks are included as an important activity (Post-meeting note: Crop and Regional Networks are one of the 20 priority activities approved in the Global Plan of Action at the International Technical Conference on Plant Genetic Resources held in Leipzig, June 1996).

- A collection of available diversity of *Lathyrus* is necessary for the use of breeders as breeding parents in developing improved varieties of *Lathyrus*. As only part of the gene pool exists in any one country, germplasm exchange is essential if breeders are to select among lines containing maximum diversity and to maximize genetic improvement.

What is Network?

One useful definition of a network is : ‘A network can be defined as a group of people or organizations that agree to share information or other resources in such a way that greater benefit is derived than had the resources been used in any other way’. This definition makes it clear that a network can function at many different levels, among different partners provided that benefits are derived by the partners. In general, there can be either informal or formal networking.

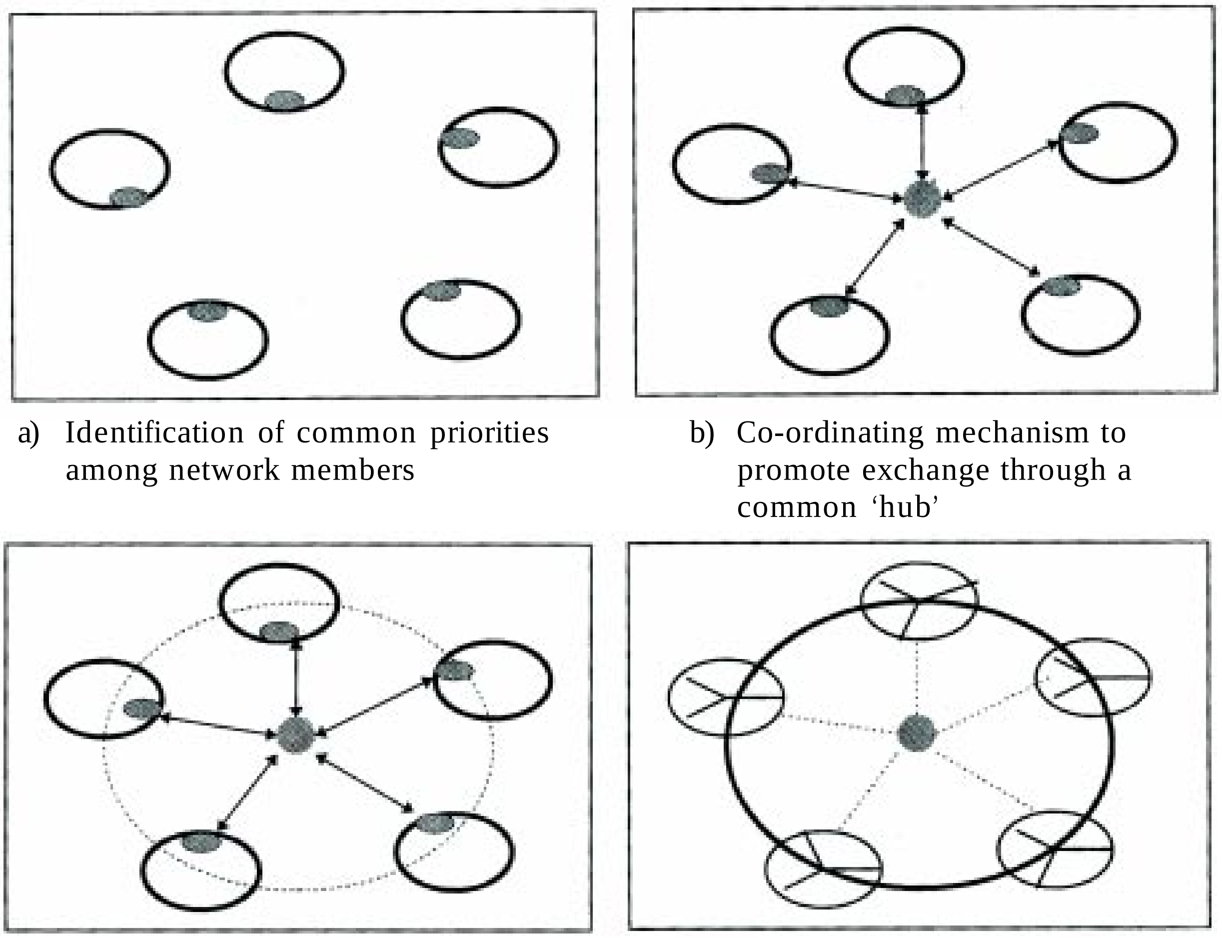
- *Informal networks* can share information, germplasm, work on common problems, and even share research or technology among informal group of interested people or scientists.

- *Formal networks* often have a defined work programme, a budget, an executive or steering committee and working groups, and take on an institutional function.

Formal networks make the commitment and collaboration among members more visible and defined.

How Do Networks Develop?

Networks can take on many forms, but we can see a progression towards increased formalization and complexity in the phases of network development as shown in Fig. 1.



a) Identification of common priorities among network members

b) Co-ordinating mechanism to promote exchange through a common 'hub'

c) Increased collaboration among members (the rim effect)

d) Within country networking, stronger rim and hub role may be reduced

Fig. 1. Different phases of network development.

Figure 1 also shows that networks can evolve towards increased collaboration among members, rather than entirely rely on inputs from a hub. Also linkages with a country, coordinated in turn by a country coordinator, can strengthen collaboration and increase the benefits from a network derived by each country. Greater benefits and sharing lead to more sustainable and effective networks.

IPGRI and Networks

IPGRI's broad mandate is to 'Advance the Conservation and Use of Plant Genetic Resources for Present and Future Generations'. In carrying out this mandate, IPGRI pursues 4 objectives to:

1) Assist countries, particularly developing countries, to assess and meet their needs for conservation of PGR and to strengthen links with the users of PGR;

2) Build international collaboration in the conservation and use of PGR;

3) Develop and promote improved strategies and technologies for PGR and integrated methods of conservation; and

4) Provide an information service to inform the world's genetic resources community of both practical and scientific developments in the field.

Perhaps surprisingly to some, IPGRI does not conserve germplasm itself, nor do we have our own laboratory or field facilities. Therefore, to carry out its programme, IPGRI depends on forging strong linkages and collaboration with individuals, institutions and countries around the world. IPGRI has assisted or taken the leadership to develop or maintain a number of networks that include or focus on plant genetic resources, conservation and use. A review of IPGRI's involvement in networks (Riley *et al.* 1995) showed that networks could be effective in advancing all of IPGRI's objectives in strengthening national programmes, collaboration, developing conservation technologies, and in exchanging and disseminating information on PGR. This review showed that IPGRI was involved in 18 PGR related networks. These were divided into two types: regional PGR networks and crop networks.

Regional PGR networks focus on the national PGR committees in each member country of a region and attempt to strengthen common activites carried out through these national committees. Regional PGR networks include the Mesoamerican, Andean and Amazonian Lowland Networks in Latin America, and regional networks in West Africa and North Africa, Europe, South East Asia, South Asia and East Asia. The primary purpose of most regional networks is to strengthen national programmes and encourage collaboration so that the member countries can better conserve their own plant genetic resources. The WANA-NET in West Africa is a good example of a regional network (see presentation by Y. Adham in these proceedings).

Crop Networks focus on the conservation and use of single crop gene pool. Members can include those countries around the world where the crop is important or institutes where collections are stored. Since 1989, IBPGR has implemented the idea of crop networks (IBPGR 1991). Crop networks operate by commitments from members who look after all or parts of the collection of a particular gene pool. Central databasing of the collections is seen as being essential. Each crop network is to include a variety of specialists who will study the gene pool to understand its genetic structure and taxonomy, to identify the need and locations for further collecting. Perret (1991) described 11 crop networks which had been established with support from IBPGR/IPGRI such as Beta, Musa, rice, barley, coconut, cassava, sweet potato and okra. IPGRI's involvement in these networks varies greatly ranging from simply monitoring through a focal point within IPGRI to the development and maintenance of a major network as part of IPGRI's core programme. A number of crop networks have focused in the Asia, the Pacific and Oceania region with

IPGRI's involvement. These inlcude COGENT, a larger Coconut Genetic Resources Network, executed by IPGRI which is now expanding to become a global network. For bamboo and rattan, IPGRI also leads and works in the biodiversity working group which is one of the 5 working groups in the International Network for Bamboo and Rattan (INBAR). A number of smaller networks focus on conservation and use of minor crop gene pools in the region including sesame, safflower, sweet potatoes with increased interest in the region for networking on *taro* and tropical fruit species. IPGRI works in close collaboration with others in supporting these networks.

Networks must be developed in close partnership with the countries and organization concerned. This often requires extensive consultation in order to ensure that all parties are committed to the objective and the plan of the network. Funding commitment, at least to maintain a secretariat, and preferably funding for specific network activities is required if a network is to be sustainable. Additional funding for specific activities should come either from the member countries or network activities are funded by external donors. Other donors (such as IDRC in the case of INBAR) and international organizations (such as CIP in the case of sweet potatoes) take a lead role in supporting many of these networks.

Sharing of information is an essential component of all these networks. As many countries have already developed databases of accessions of germplasm of the crop in question, which are often in different formats, the Asia, the Pacific and Oceania Regional Office of IPGRI has developed a Data Interchange Protocol (DIP) that allows different databases to exchange such information and compile it in a given format (Quek 1996).

A number of principles for the organization of regional and crop networks have been formulated by IPGRI (See Box below).

Principles for the Organization of Regional and Crop Networks

1. A network must have quantifiable objectives.
2. Concrete action plan with agreed activities, time table and mechanism to measure progress is required.
3. Participating countries/organizations must accept the agreed commitments.
4. Participants must be willing to share agreed/designated germplasm and information.
5. A realistic plan for sustained funding is needed.
6. A steering/governing body(ies) with members having a representational role should be established.
7. A coordinator must be empowered with a clear responsibility and with the resources (time and funds) to carry out a facilitator role to serve the network.
8. The development of a database of germplasm holdings to serve the network is very important.

Questions and Suggestions for Networking for the Conservation and Use of *Lathyrus* Diversity

a) *What are the priority activities for collaboration?*

- Secure the existing collections in each country.
- Develop a shared database (possibly using DIP) containing passport data and descriptor data (with a minimum core set of descriptors).
- Establish a safety duplicate collection.
- Identify what diversity is located in which countries or regions.
- Identify the priority areas for more collecting of *Lathyrus* diversity or where this diversity may be threatened.
- Develop different types of collections including active collections (frequently used lines), working collections (breeding lines) and base collections (all available lines). This can help in more effective use and conservation. Develop a core collection containing selecting types representing the diversity in the larger collection.
- Consider complementary conservation such as some of the diversity countries to be used by the farmers in their landraces, while another part of the crop gene pool is retained in *ex situ* seed genebank.
- Develop and publish a Germplasm Directory of the address and the amount of *ex situ* collections held in different genebanks.
- Develop and publish a descriptor list for *Lathyrus* [Appendix 1 contains a draft list of a minimal descriptor set originally developed by C.G. Campbell (1989)].

b) *Possible collaborative research studies*

- Adaptation studies (G×E).
- Regional or collaborative nurseries.
- Collaborative breeding for wide or specific adaptation.
- Outcrossing studies.
- Taxonomy/systematics.
- On-farm management and enhancement of diversity.

c) *Encourage the following activities to be undertaken by other groups such as INILSEL and ILLRA*

- Establishing a safe/threshold level for ODAP.
- Surveys on the extent of human lathyrism disease (any recent cases).
- Increase public awareness of the advantages of *Lathyrus* with safe neurotoxin levels.
- Agronomy research.
- Nitrogen fixation research.

What Should be the Structure of a Network ?

- Priority species for collaboration
  - only *L. sativus*?
  - the primary gene pool species?
  - include secondary and tertiary gene pool species?

- While the focus of the network will be on conservation and use of *Lathyrus* germplasm, should breeding activities be included in the network?

- Which countries and organizations should be included in the network?

- Should a country coordinator be appointed to handle collaboration among the member institutions within each country?

- Steering committees can provide an oversight, monitoring, technical or follow-up role. Is a steering committee needed? How to choose a representative steering committee and what is its role?

- How to share different responsibilities among members?

- Are sub-networks needed in different regions?

- Who should coordinate?

- Will the network be centralized or decentralized?

- Task forces are sometimes created within a network to follow up on specific issues. Possible priority issues for working groups may include:
  - information distribution, database management
  - wild species wide crosses
  - multilocation trials
  - pasture improvement
  - grain improvement
  - on-farm research/farmer participatory research
  - standardized toxin analysis methods for breeders

- Strenthening of human resources is also necessary to effectively conserve and use *Lathyrus* genetic resources in the collaborating countries. IPGRI aims to strengthen the training of trainers, provide regional training at the M.Sc. level on plant genetic resources and provide specific short course training for those involved in conserving PGR. Short courses on specialized topics such as genebank management are also offered. Finally, other organizations may offer training on relevant technologies for the improvement of *Lathyrus*.

- Locating funding is necessary for ensuring that planned activities can be carried out. Commitment from countries themselves for supporting the within-country activities is highly desirable. In addition, some funds for complementary funding to support specific collaborative projects in the network could be proposed to donors.

Conclusions

It would appear that there is good potential forming on effective networks for the conservation and use of *Lathyrus* diversity in Asia. A number of questions need to be discussed to define network objectives, linkages and details of what needs to be done, and what is the best way to do it? It is hoped that these suggestions will prove useful during the discussions in the workshop.

References

Campbell, C.G. 1995. The Grasspea. *In* Evolution of crop plants. Second edition, Smartt, J. and Simmonds, N.W. (eds.). Longman Scientific and Technical, UK. Pp 266-270.

Campbell, C.G. 1989. Improvement of *Lathyrus sativus. In* The Grasspea: Threat and Promise. Spencer, P.S. (ed.). Pp 139-146. Proceedings of the International Network for Improvement of *Lathyrus sativus* and the Eradication of Lathyrism. Third World Medical Research Foundation, New York.

IBPGR. 1991. International Crop Network Series 4 - Crop Networks (Searching for New Concepts for Collaborative Genetic Resources Management). Papers of the EUCARPIA/IBPGR Symposium held at Wageningen, The Netherlands, December 3-6, 1990.

Kaul, A.K. and D. Combes (eds.). 1986. *Lathyrus* and Lathyrism. Third World Medical Research Foundation, New York. 350 p.

Perret, P.M. 1991. Actual and future concepts for crop genetic resources. *In* Crop Networks - New Concept for Genetic Resources Management. Pp 13-22. International Crop Network Series 4. IBPGR, Rome, Italy.

Quek, P. 1996. Sustainable Information Networking and Data Interchange Protocol (DIP). Paper prepared for the DIP meeting, October 14-16, 1996, CAAS, Beijing, China.

Riley, K.W., M. Zhou and R. Rao. 1995. Regional and crop networks for effective management and use of plant genetic resources in Asia, the Pacific and Oceania. XVIII Pacific Science Congress on Population, Resources and Environment: Prospects and Initiatives, June 5-12, Beijing, China.

Roy, P.K., K. Ali, A. Gupta, G.K. Barat and S.L. Mehta. 1993. B-N-Oxalyl-α, β diaminopropionic acid in somaclones derived from internode explants of *Lathyrus sativus.* J. Biochemistry and Biotechnology. 2 : 9-13.

Spencer, P.S. 1989. The Grasspea: Threat and Promise. Proceedings of the International Network for Improvement of *Lathyrus sativus* and the Eradication of Lathyrism. Third World Medical Research Foundation, New York. 244 p.

Yusuf, K.M. and F. Lambien. 1995. *Lathyrus sativus* and human lathyrism — Progress and prospects. Proceedings of the Second International *Lathyrus* Colloquium, Dhaka, December 10-12, 1993. University of Dhaka. 288 p.

Appendix I

Minimal Descriptors for Working and Long-Term *Lathyrus* Collections

(Adapted from C.G. Campbell 1989).

- Days from seeding to 50% plants with flowers
- Anthocyanin present in stem
- Flower colour
- Leaf width (narrow = 0.5 cm; medium = 1 cm; wide = 1.5 cm)
- Seed coat colour
- Maturity (days from seeding to 90% pods turned brown)
- Plant height (cm)
- Downy mildew severity (0 = none; 9 = severe)
- Pod shattering at maturity (0 = none; 10 = 90-100%)
- Plant type (indeterminant or determinant)
- Plant habit (1 = erect; 5 = determinant)
- 1000 seed weight (gram)
- Seed density (kg/hl)
- Seeds/pod
- Insect resistance
- BOAA content of seed

Annexure I

IPGRI-ICAR/IGAU Regional Workshop on *Lathyrus* Genetic Resources in Asia

27-29 December 1995

[Venue : Indira Gandhi Agricultural University, Raipur (M.P.), India]

Technical Programme

26.12.1995 (Tuesday)	Arrival of participants—Hotel Piccadily	
27.12.1995 (Wednesday)		
09.00-10.00	Registration/Distribution of Workshop Material, Administrative Arrangements.	

Inaugural Session

10.00-11.00	Welcome	Dr S.S. Baghel
	Introduction to participants	Dr R.K. Arora
	Chairman's remarks	Dr A. Alam
	Remarks by IPGRI	Dr Ken Riley
	Inaugural address (Chief Guest)	Dr E.A. Siddiq
	Vote of thanks	Professor Zhou Ming-De
11.00-11.30	Tea/Coffee break	
Session I	Workshop Agenda and Country Reports	
	Chairman : Dr E.A. Siddiq	
	Rapporteur : Dr Ms. Q.A. Syouf	
11.30-13.15	Presentation of Country Reports	
	South Asia Region	
	Bangladesh Dr M.A. Malek, Mr M.S. Hassan — BARI	
	Nepal Dr R.K. Neupane, Mr C. Yadav — NARC	
13.15-14.30	Lunch break	
14.30-16.00	Chairman Dr A. Alam	
	India	
	Dr R.L. Pandey — IGAU	
	Dr R.B. Mehra — IARI	
16.00-16.30	Tea/Coffee break	
16.30-17.30	Discussion	
	[Dinner by IGAU]	

28.12.1995 (Thursday)	
Session II	Presentation of Country reports contd.
	Chairman : Dr M.A. Malek
	Co-chairman : Dr A.N. Asthana
	Rapporteur : Dr R.L. Pandey
09.00-11.00	WANA region
	Jordan
	Dr Q.A. Syouf, NCATT
	Turkey
	Dr C.O. Sabanci, AARI
11.00-11.15	Tea/Coffee break
11.15-12.15	Presentations by Observers (Special invitees)
	Dr J. Kumar, ICRISAT
12.15-13.00	Discussion
13.00-14.15	Lunch break
Session III	Global PGR Perspective on Conservation and Utilization
	Chairman : Dr K.P.S. Chandel
	Co-chairman : Dr S.S. Baghel
	Rapporteurs : Dr C.O. Sabanci
14.15-14.45	ICARDA
	Dr L. Robertson
14.45-15.15	CLIMA
	Dr K.H.M. Siddique
15.15-16.00	IPGRI
	Professor Zhou Ming-De
16.00-16.30	Tea/Coffee break
16.30-17.30	Discussion
	[Dinner by IPGRI]
29.12.1995 (Friday)	
Session IV	Biotechnology and Other Approaches to PGR Utilization, Management and Conservation
	Chairman : Dr S.L. Mehta
	Co-chairman : Dr L. Robertson
	Rapporteurs : Dr R.K. Neupane
09.00-10.30	Dr. S.L. Mehta — Biotechnology and use

	Dr K.P.S. Chandel — Conservation and germplasm exchange
	Dr S.S. Baghel — Scope for problem areas
	Dr A.N. Asthana — Scope for problem areas
	Dr. K.W. Riley — Network approach
10.30-11.00	Discussion
11.00-11.30	Tea/Coffee break
Session V	Present Constraints and Proposed Action Programme
	Chairman : Dr K.H.M. Siddique
	Rapporteurs : Mr C. Yadav, Dr R.B. Mehra
11.30-13.00	IPGRI to initiate : Dr K.W. Riley
	— Rationalizing the collections of *Lathyrus* in Asia and their utilization and conservation
	— Coordination mechanism, exchange of information and material
	— Identification of gaps — Research thrusts
13.00-14.00	Lunch break
14.00-14.30	Discussion contd.
Session VI	Plenary/Concluding Session
	Chairman : Dr S.S. Baghel
	Rapporteurs : Professor Zhou Ming-De, Dr R.K. Arora
14.30-16.00	Recommendations — R.K. Arora
16.00-16.30	Tea/Coffee break
16.30-18.00	Visit to IGAU fields
30.12.1995 (Saturday)	
09.00-13.00	Visit to Farmer's fields
13.00-14.00	Lunch break

Annexure II

IPGRI-ICAR/IGAU Regional Workshop on *Lathyrus* Genetic Resources in Asia 27-29 December 1995

[Venue : Indira Gandhi Agricultural University, Raipur, M.P., India]

List of Participants

SOUTH ASIA

Bangladesh

1. Dr. Mohamed Adbul Malek
Director
Pulses Research Centre
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur 1701
Bangladesh
Phone: 406444
Telex: 642401 SHER BJ
Fax: 880-2-841678

2. Mr. Mian Sayeed Hassan
Scientific Officer
Pulses Research Centre
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur 1701
Bangladesh
Phone: 406444
Telex: 642401 SHER BJ
Fax: 880-2-841678

India

3. Dr. S.L. Mehta
Deputy Director General (Education)
Indian Council of Agricultural Research
Krishi Anusandhan Bhavan
Pusa
New Delhi 110 012
Phone: 5783725
Telex: 031-77161 IARI-IN
Fax: 91-11-5751719

4. Dr. R.B. Mehra
Principal Scientist
Division of Genetics
Indian Agricultural Research Institute
Pusa
New Delhi 110 012
Phone: 581481/583077
Telex: 031-77161 IARI-IN
Fax: 91-11-5732006

5. Dr. R.L. Pandey
Project Coordinator *Lathyrus*
Indira Gandhi Agricultural University
Raipur 492 012
Phone: 424481/424315
Telex: 775-332 IGKV-IN
Fax: 91-771-424532

Nepal

6. Mr. Chitranjan Yadav
Grain Legumes Research Programme
Nepal Agricultural Research Council
c/o. Mr. B.K. Baniya
Director (Plg. & Coordination)
NARC, Khumaltar, Lalitpur
Nepal
Phone: 525703/525704
Telex: 2262 Narani NP
Fax: 977-1-521197

7. Dr. Ram Krishna Neupane
Scientist-I (Pulses)
c/o. Mr.B.K. Baniya
Director (Plg. & Coordination)
NARC, Khumaltar, Lalitpur
Nepal
Phone: 525703/525704
Telex: 2262 Narani NP
Fax: 977-1-521197

Pakistan

8. Dr. A.M. Haqqani*
Senior Scientific Officer (Pulses)
National Agricultural Research Centre
PARC, National Park Road
Islamabad
Pakistan
Phone: 92-51-240468
Telex: 5604 PARC PK
Fax: 92-51-240909/812968

WANA

Jordan

9. Ms. Maha Q.A. Syouf
National Center for Agricultural Research
and Technology Transfer
PO Box 639,
Baga 19381
Jordan
Phone: 963-21-725411/725412
Fax: 963-21-726009

Turkey

10. Dr. Cafer Olcayto Sabanci
Aegean Agricultural Research Institute
PO Box 9, Menemen
Izmir 35661
Turkey
Phone: 90-232-8461331
Fax: 90-232-8461107

International Centres

CLIMA

11. Dr. K.H.M. Siddique
Senior Legume Physiologist/Agronomist
Department of Agriculture
CLIMA
Baron-Hay Court
South Perth WA 6151
Australia
Phone: 61-9-3683493
Telex: AA 93304
Fax: 61-9-3682165

ICARDA

12. Dr. Larry D. Robertson
Legume Germplasm Curator
ICARDA
Aleppo
Syria
Phone: 963-21-247485
Telex: 331263 ICARDA SY
Fax: 963-21-213490

13. Dr. Ali Mohd Abd El Moneim*
ICARDA
Aleppo
Syria

Phone: 963-21-247485
Telex: 331263 ICARDA SY
Fax: 963-21-213490

ICRISAT

14. Dr. Jagdish Kumar
Senior Scientist
ICRISAT
Patancheru 502 324 (A.P)
India

Phone: 596161
Telex: 422203 ICRI-IN
Fax: 91-040-241239

IPGRI-APO

15. Dr. K.W. Riley
Regional Director
IPGRI-APO
c/o Stesen Kuarantin Lepas Masuk
Jabatan Pertanian, Bangunan JKR(P) 1746
43400 Serdang, Selangor Darul Ehsan,
Malaysia

Phone: 65-7389611
Telex: RS 5598 RELC
Fax: 65-7389636

16. Dr. R.K. Arora
Coordinator
IPGRI Office for South Asia
c/o NBPGR
Pusa Campus
New Delhi 110 012

Phone: 5786112
Telex: 031-77257 NBGR-IN
Fax: 91-11-5731845

17. Prof. Zhou Ming-De
Coordinator
IPGRI Office for East Asia
c/o CAAS
30 Bai Shi Qiao Road
Beijing 100081
China

Phone: 86-10 62183744
Telex: 222720 CAASCN
Fax: 86-10-62174159

IPGRI-WANA

18. Dr. Yawooz Adham*
Regional Director
IPGRI-WANA
c/o ICARDA
PO Box 5466, Aleppo
Syria

Phone: 963-21-247485
Telex: 924-331208 ICARDASY
Fax: 963-21-225105/213490

Special Invitees from India (including the Organizing Committee)

19. Dr. A. Alam
Vice Chancellor
Indira Gandhi Agricultural University
Raipur 492 012 (M.P)
India

Phone: 424481/424315
Telex: 775-332 IGKV-IN
Fax: 91-771-424532

20. Dr. S.S. Baghel
Director Research
Indira Gandhi Agricultural University
Raipur 492 012 (M.P)
India
Phone: 424481/424315
Telex: 775-332 IGKV-IN
Fax: 91-771-424532

21. Dr. R.K. Misra
Head
Division of Plant Breeding
Indira Gandhi Agricultural University
Raipur 492 012 (M.P)
India
Phone: 424481/424315
Telex: 775-332 IGKV-IN
Fax: 91-771-424532

22. Dr. K.P.S. Chandel
Director
NBPGR
Pusa Campus
New Delhi 110 012
Phone: 5732365
Telex: 031-77257 NBGR-IN
Fax: 91-11-5731495

23. Dr. A.N. Asthana
Director
Indian Institute of Pulses Research (IIPR)
Kanpur 208 024 (U.P)
Phone: 250146/250264
Telex: 325-471 IIPR-IN
Fax: 91-512-250264

Others

24 Mr. W. Aind
Jr. Sci-cum-Asstt. Prof (Agro)
Regional Research Station, NARP
Dumka 814 101
Bihar
FAO trainee through CLIMA
Phone: 619-3683500/3683501
Fax: 619 474 2840

Chief Guest

25. Dr. E.A. Siddiq
Deputy Director General (Crop Sciences)
Indian Council of Agricultural Research
Krishi Bhavan
Dr. Rajendra Prasad Road
New Delhi 110 001
Phone: 3382545
Telex: 031-62249 ICAR-IN
Fax: 91-11-3387293

* Invitees who could not participate but have sent their articles.

Annexure III

ABBREVIATIONS

AARI	Aegean Agricultural Research Institute
ACIAR	Australian Centre for International Agricultural Research
ACSAD	Arab Centre for Studies in Arid Zones and Dry Land
ADB	Asian Development Bank
APO	Asia, the Pacific and Oceania
AWA	Agricutural Western Australia
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BINA	Bangladesh Institute of Nuclear Agriculture
BMZ	Federal Ministry of Economic Cooperation and Development (Bundesministerium für Wirtschaftliche Zusammenarbeit)
CDP	Crop Diversification Programme
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CLIMA	Centre for Legumes in Mediterranean Agriculture
DAE	Department of Agricultural Extension
DAM	Department of Agricultural Marketing
EFCRI	Egyptian Field Crops Research Institute
EU	European Union
FAO	Food and Agricultural Organisation of the United Nations
FCCRI	Field Crops Central Research Institute
GLRP	Grain Legumes Research Programme
GRDC	Grains Reseach and Development Corporation
IARI	Indian Agricultural Research Institute
IBPGR	International Board for Plant Genetic Resources
ICAR	Indian Council of Agricultural Research
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICMR	Indian Council of Medical Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IGAU	Indira Gandhi Agricultural University
IIPR	Indian Institute of Pulses Research

ILNN	International Legume Nursery Network
IPGRI	International Plant Genetic Resources Institute
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidhyalaya
NAA	Nepal Agricultural Association
NARC	Nepal Agricultural Research Council
NARC	National Agricultural Research Centre, Pakistan
NBPGR	National Bureau of Plant Genetic Resources
NCARTT	National Centre for Agricultural Research and Technology Transfer
NIN	National Institute of Nutrition
NPGRRP	National Plant Genetic Resources Research Project
PGRI	Plant Genetic Resources Institute
RIRDC	Rural Industries Research and Development Corporation
RRI	Rice Research Institute
RU	Rajshahi University
TPGRRI	Turkish Plant Genetic Resources Research Institute
UNDP	United Nations Development Programme
USAID	US Agency for International Development
WANA	West Asia and North Africa
WANANET	West Asia and North Africa Plant Genetic Resources Network
WANAPGRC	West Asia and North Africa Plant Genetic Resources Committee