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Current status and future strategy in breeding grasspea (*Lathyrus sativus*)

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Abstract

Efforts in grasspea (*Lathyrus sativus*) improvement have increased since the development of lines that are very low in the neurotoxin Beta-N-oxalyl-L-alpha-beta-diamino propionic acid (ODAP); also referred to as Beta-N oxalyl-amino-L-alanine (BOAA). Many programs now address several related aspects of improvement simultaneously. These include reduced ODAP concentrations, insect and disease resistance, nitrogen fixation, agronomic practices, fodder and forage production, and components for increased yielding ability. The coordinated, multidisciplinary approach now being applied to the genetic improvement of grasspea should allow the potential of this largely neglected grain legume to be fully realized.

Introduction

Grasspea (*Lathyrus sativus* L.), also called chickling pea, khesari or sabberi, is produced as a major crop in Bangladesh, China, India, Nepal, and Pakistan, and to a lesser extent in many countries of Europe, the Middle East, northern Africa, and in Chile and Brazil in South America. It is extensively cultivated and naturalized in the Middle East countries of Iraq, Iran, Afghanistan, Syria, and Lebanon, in France and Spain in southern Europe, and in Ethiopia, Egypt, Morocco, Algeria, and Libya in northern Africa.

The origin of *L. sativus* is unknown but it is thought that the natural distribution has been completely obscured by cultivation even in southwest and central Asia, its presumed center of origin (Smartt, 1984). It shows great morphological variation, especially in vegetative characters such as leaf length, while floral characters are much less variable (Jackson & Yunus, 1983). They postulated that the forms with blue flowers and speckled seeds are more primitive. The pattern of variation was not unlike that found in lentils and faba beans where primitive forms with small seeds have a distribution to the east of the Mediterranean, while larger seeded forms have been selected in the Mediterranean region. The development of forms with larger leaves may have resulted from selection of forage types. It would appear that there is a large base of germplasm present in many countries that can be utilized by plant breeders in the production of adapted lines for specific or dual purpose requirements.

Grasspea is very tolerant of drought conditions and has been grown successfully in areas with an average annual precipitation of 380 to 650 mm. Despite its tolerance to drought, grasspea is not affected by excessive rainfall and can be grown on land subject to flooding (Sinha, 1977). In India, Bangladesh, Nepal, and Pakistan it is often broadcast into a standing rice crop one to two weeks before the rice is ready for harvest where it flourishes on the residual moisture left after the rice has been harvested. It has a very hardy and penetrating root system and can be grown on a wide range of soil types, including very poor soils and heavy clays. This hardiness and its ability to fix atmospheric nitrogen make the crop one that seems designed to grow under adverse conditions.

Despite its obvious advantages, relatively little effort until recently has been extended in the improvement of this very hardy pulse crop. Indeed, the history of grasspea has been one where it has been banned by many countries due to it containing the neurotoxin Beta-N-oxalyl-L-alpha-beta-diamino propionic acid (ODAP) also referred to as Beta-N-oxalyl-ammo-L-alanine (BOAA). The neurotoxin in grasspea causes irreversible crippling when it is consumed as a major portion of the diet over a 3 to 4 month period. In spite of this, grasspea is still produced in significant quantities in many parts of the world. Improvement of the crop is now being addressed in many countries through germplasm collection and evaluation, as well as in crop improvement programs, many of which include a breeding component.

Crop improvement by conventional breeding methods

Evaluation

Local and introduced germplasm has been evaluated both for seed and for fodder purposes and to determine their adaptability to various climates. In the littoral zone of Morocco, "Favetta" performed well in comparison to cultivars introduced from Greece, Libya, and Portugal (Villax, 1963). In Cyprus, in comparisons of four local cultivars with 23 introductions from Algeria, Australia, Egypt, Greece, Libya, Portugal, and Turkey of *L. sativus*, *L. cicera*, and *L. ochrus*, an accession of *L. sativus* from Greece outyielded other introductions and was more leafy (Soadou, 1959). In Turkey, nine ecotypes of *L. sativus* were collected from different regions of Turkey from 1965 to 1969 and are now maintained on the west coast of Izmir (Hertzsche, 1970). In Jordan, a cultivar of *L. sativus* from Cyprus performed well (Hopkinson, 1975), while in Syria Van der Veen (1967) stated that two cultivars from Cyprus have proven to be well adapted. In northern Iraq, a local cultivar of *L. sativus* was cultivated extensively in some areas, while a cultivar introduced from Turkey proved to be more productive and cold tolerant than the local cultivar in small adaptability tests at Mosul (Kernick, 1976). In Nepal, a local germplasm collection of 87 accessions was evaluated and compared to 10 exotic lines. The local accessions were higher in yield, had more seeds per pod and were earlier to mature when compared to the imported lines (Yadov, personal communication). Early and final stand counts were also found to be higher in the local material. The exotic lines had larger seed sizes of 10.2 to 11.0 grams per 100 seeds as compared to 4.7 to 5.3 in the local material. A summary of the agronomic characteristics examined has shown a wide range of variability especially in plant height and pods per plant (Table 1).

Table 1. Summary of agronomic characteristics of a collection of *Lathyrus sativus* germplasm evaluated at Rampur, Nepal

Character	Mean	Range
Days to flower	85	68-94
Days to maturity	135	125-139
Plant height (cm)	71	46-106
Pods per plant	36	13-59
Seeds per pd	3.5	2.4-5.0
1000 seed weight (g)	42	30-60

Insect resistance

There has been little work reported on the resistance of grasspea to various insect pests. The lines JRL 6 and JRL 41 have been found to be tolerant to thrips at Raipur, India (Chitale, personal communication). In Syria, lines resistant to cyst nematodes (*Heterodera cicer*) and root-knot nematode (*Meloidogyne artiella*) have been identified (Abd El Moneim, personal communication). Certainly more effort is required in this area in the improvement of this very hardy pulse crop.

Disease resistance

Powdery mildew (*Erysiphe polygoni* DC) and downy mildew (*Peronospora lathi-pulustris* Gaumann) are the two major diseases which infect grasspea. Losses due to these diseases as well as cultivar reaction have not been critically studied. However, lines showing moderate resistance to powdery mildew have been identified in India (Lal *et al.*, 1985). At Raipur, the lines RPLK 26 and RL 41 have been found to be tolerant to powdery mildew. In addition, 86 lines from a local germplasm collection from around Raipur, India have shown resistance to downy mildew (Agrawal, unpublished). Efforts are underway in India to transfer the powdery mildew resistance to higher yielding, more adapted lines. In Syria, *L. sativus* lines that were moderately resistant to powdery mildew (*Ersiphe pisi*) have been identified. Lines in India have also been identified that were free from infection by downy mildew in a three year evaluation under conditions of heavy natural infection (Narsinghani & Kumar, 1979).

Decreased neurotoxin (ODAP) concentrations

Most of the reported work on grasspea improvement has involved reducing ODAP concentrations in the seeds. Although lines with reduced ODAP concentrations were identified almost 20 years ago, no concerted effort was placed on this problem until after 1985. The Lathyrus Collogue held that year at Pau, France served as a catalyst in many ways to focus research on many of the different aspects of grasspea improvement.

The ODAP concentrations of grasspea differ widely among accessions and environments (Dahiya & Jeswani, 1975; Ramanujam *et al.*, 1980). The distribution of ODAP concentrations in landraces in several countries was quite similar (Table 2). Although many attempts have been made to find a correlation between ODAP concentration and seedcoat color or flower color the results have either conflicted (Dahiya, 1985; Quader *et al.*, 1985) or have been unsuccessful (Roy & Rao, 1978). A high correlation to a readily identifiable plant characteristic would allow the characteristic to be used as a rapid selection technique for reduced ODAP concentrations. However, a rapid and fairly inexpensive method capable of analyzing over 100 samples per day has been developed for a breeding program for identification of segregants with reduced ODAP concentrations (Campbell, unpublished). This method is a variation of the method of Briggs *et al.* (1983).

In China, the major result in the past two decades has been the selection of four lines with relatively low toxin concentrations and with good agronomic characteristics. These were selected from 73 lines with ODAP concentrations ranging from 0.075 to 0.993%. Protein content of these lines averaged from 23 to 25%. These low toxin lines have been stable over several years. Toxicological tests of lines from the Wuwei District of Gansu Province have shown that they were safe when fed to animals. Neither acute nor chronic lathyrism was found when donkeys, pigs, and sheep were fed

Table 2. Distribution of ODAP content in landraces of *Lathyrus sativus* collected at Raipur, India and Adhet, Ethiopia

Percent ODAP	Number of land races	
	Raipur	Adhet
< 0.200	10	0
0.201-0.300	104	0
0.301-0.400	391	4
0.401-0.600	606	29
0.601-1.00	91	5
> 1.01	21	1
Total	1223	39

Table 3. Distribution of ODAP in different tissues of *Lathyrus sativus*

Plant part	ODAP content
	mg 100 g^{-1}
Root	14
Stem	64
Leaf	60
Pod	24
Seed coat	81
Embryo	400
Cotyledon	126

with seeds of these lines constituting 50 to 80% of the daily intake for 180 to 250 days (Chen, unpublished).

Genetic improvement work of *L. sativus* commenced in 1966 at the Jawaharlal Nehru Agricultural University, Jabalpur (M.P.), India with the collection, maintenance and evaluation of 503 germplasm accessions (Lal *et al.*, 1985). In 1970, over 1500 samples of *Lathyrus* maintained at the Indian Agricultural Research Institute (IARI) at New Delhi were screened for ODAP concentration, with a few lines having concentrations which ranged from 0.15 to 0.30% (Jeswani *et al.*, 1970). In 1971, 1000 samples were screened for ODAP concentration in a research program at IARI and were found to vary from 0.2 to 2.0% (Leakey, 1979). The distribution of ODAP in different plant tissues was also determined (Mehta *et al.*, 1991) (Table 3). A breeding and selection program using recurrent mutagenic treatment was started to produce high-yielding, low-toxin lines of *Lathyrus* (Swaminathan *et al.*, 1971).

The *Lathyrus* improvement program in India was transferred to the Indira Gandhi Agricultural University at Raipur where work is continuing on screening lines for low ODAP concentration as well as developing lines with specific morphological characters. Also, they are using lines from Canada that have been selected for reduced ODAP concentrations in a hybridization and selection program designed to develop adapted high-yielding material with reduced concentrations of the neurotoxin. Recently, the *Lathyrus* breeding program at IARI has been reactivated with emphasis being placed on reducing the ODAP concentration through the use of both hybridization and somaclonal variation.

In Bangladesh, a screening program was initiated in 1979 to explore the possibility of isolating toxin-free lines from germplasm systematically collected from ten districts (Kaul *et al.*, 1985). The screening of the germplasm continued for over 5 years. Lines having as little as 450 mg ODAP per 100 g of sample to as much as 1400 mg were found indicating large variation in ODAP content. Line 3968 was selected as being significantly low in ODAP, as well as the earliest to mature and the largest yielder (Anon, 1980). An ongoing *Lathyrus* improvement program at the Bangladesh Agricultural Research Institute at Joydepur has recently produced a number of lines having ODAP concentrations, ranging as low as 0.03% (M.P. Quader, personal communication). These lines, however, are not as high yielding as some of the local accessions.

Canadian evaluation of *Lathyrus* germplasm began in 1967 at the Agriculture Canada Research Station, Morden, Manitoba. A breeding and improvement program was established in 1982 and has resulted in the release of the germplasm LS 8246 (LS82046) having a ODAP concentration of 0.03% in the seed (Campbell, 1987). An additional two lines containing a factor for low ODAP content have been developed. These lines, L900239 and L920278, have been shown to produce low ODAP content in the seeds when used as parents in crosses. They also appear to differ in the content of ODAP in the cotyledons and in the seedlings (Table 4). It is possible that the amount of ODAP found in the seed of grasspea is dependent not only on the amount produced in the plant but also on the amount transferred into the developing seeds. Studies are underway to determine the inheritance and mode of action of the three sources of low ODAP concentration. The present objectives of the program are to transfer the genes for reduced ODAP concentration into high-yielding, adapted lines having good agronomic potential. Some of these lines have been selected for increased seeds per pod and for double pods per node. This involves hybridization of selected lines with screening and evaluation of the resulting progenies.

Table 4. ODAP analysis of seedlings, cotyledons, dry seeds and the ratio of seedling concentration to dry seed concentration in selected lines of *Lathyrus sativus*

Line	Seedling	Cotyledons	Dry seeds	Ratio*
	mg g^{-1}	mg g^{-1}	mg g^{-1}	
Jamalpur	48.04	8.10	2.37	20.3
LS82046	9.32	0.57	0.29	32.1
LS90239	1.52	0.19	0.40	3.8
LS90278	57.18	1.19	0.34	168.2

Data from Lambien, unpublished
* Ratio of the concentration of ODAP in the seedlings to the ODAP concentration in the dry seeds

Grasspea improvement in Nepal commenced with the collection of 17 lines in 1986 and an additional 89 lines in 1987. These are presently being evaluated for agronomic characteristics under the Grain Legumes Improvement Program and are being screened for ODAP concentration at the Morden Research Station. High yielding accessions have been selected as parental material for a hybridization program to develop high yielding, adapted types with very low or zero ODAP concentration in the seed.

Collection and evaluation of grasspea has also taken place in Ethiopia, with 252 lines of locally collected material being maintained at the Plant Genetic Resource Centre in Addis Ababa. At least 127 of these lines have been evaluated for agronomic characteristics at the Adhet Research Station and genotypes with reasonable yield and lower ODAP levels have been selected.

Male sterility

Male sterility, due to a condition whereby the plants have short filaments and anthers which are much below the stigmas, has been reported in *L. sativus*. Male fertility was thought to be restored by a pair of complementary genes (Srivastava & Somayajulu, 1981) or possibly by both single and double restorer genes (Quader, 1987). It is possible that male sterility can be useful in population improvement programs and be used to possibly exploit some of the non-additive gene action on characters affecting production.

General and specific combining abilities have been estimated in grasspea for pods per plant, 100 seed-weight, seeds per pod, grain yield per plant and ODAP concentration (Dahiya & Jeswani, 1974). It was generally found that non-additive gene action was predominant in both the F_1 and the F_2.

Improved lines

Attempts to provide growers with cultivars with low ODAP concentrations led to the selection and release in 1973–74 of "Pusa–24" by IARI (Lal *et al.*, 1985). This cultivar had comparable yields to some local collections in most years. Pusa–24 was a very important breakthrough as it clearly demonstrated that the concentration of ODAP in the seeds could be selected against and that lines reduced in or lacking in ODAP were indeed possible.

In Chile, the cultivar "Quila-blanco" was developed in 1983 (Tay *et al.*, unpublished). It was a bulk of six plants selected from the locally grown heterogeneous population. The principle characteristics of this cultivar are uniform maturity, large white seeds (100 seeds weigh 28.7 g), and a protein concentration of 24.3%.

Cytogenetics

Chromosomal and cytogenetic studies have shown the genus *Lathyrus* to be predominantly diploid with $2n = 2x = 14$ chromosomes. The chromosome number of more than 60 species have been reported with only three species having been shown to have more than 14 somatic chromosomes. Two species *L. pratensis* and *L. venosus* are tetraploid with $2n = 28$ chromosomes and one species *L. palustris* is hexaploid with $2n = 42$ chromosomes. These species have been studied cytologically and have been shown to be autopolyploids. The occurrence of an autohexaploid is among the very few examples of it occurring in the plant kingdom (Khawaja, unpublished). These autopolyploids are, in reality, cytotypes as diploid forms also occur in nature.

Interest in experimental interspecific hybridization in the genus was shown in sweet pea (*L. odoratus*) as early as 1916. Burpee (1916) and others were interested in trying to introduce yellow flower color genes into the cultivated species from wild relatives in the same genus. Successful interspecific hybridization in the genus has been shown to be exceedingly rare as has been found in other genera of the Leguminosae.

Interspecific hybridization between other species in the genus *Lathyrus* has been attempted by many researchers since the report of the successful crossing of *L. hirsutus* × *L. odoratus* by Barker (1916). Most attempts have been failures and even though many thousand cross combinations are theoretically possible, only 16 have been reported as successful. Interspecific hybridization involving *L. sativus* has only been reported as successful in two instances. In 1956, Lwin (1956) succeeded in crossing *L. cicera* with *L. sativus*, however this cross has been unsuccessful in subsequent attempts (Davies 1958; Khawaja 1988). Khawaja (1988) reported that *L. sativus* crosses readily with *L. amphicarpos* when the latter is used as the female. It has also been noted that in certain cross combinations fertilization is successful but the embryo aborts during development. The stage of development at which abortion takes place differs with the cross combination. Cytological studies of the F_1 hybrids between *L. amphicarpos* × *L. sativus*, *L. amphicarpos* × *L. cicera* and *L. odoratus* × *L. chloranthus* were carried out by Khawaja (1988) and showed 50% to 70% chromosome homology and pollen fertility in conformity with the meiotic pairing.

From the information available on crossing, fertility, and chromosome behavior of the hybrids, it may be concluded that breeding strategies involving alien genetic transfer for the improvement of grasspea is possible through the readily crossable species *L. amphicarpos*. There also appears to be a high probability of success in obtaining interspecific crosses between some species that do not cross due to embryo abortion after fertilization through the utilization of embryo rescue techniques.

Plant regeneration techniques have been successful in regenerating plants from explants derived from stem, leaf, and root tissue (Mehta *et al.*, 1991). The resulting plants showed a high amount of somaclonal variation in plant habit. This technique may be successfully exploited in the production of agronomically desirable types in low ODAP lines and thus provide a faster means of improvement than allowed by conventional crossing and backcrossing methods.

Crop improvement by mutation breeding

Genetic evaluation

Mutation breeding can be a valuable supplement to conventional plant breeding methods. It can be used to create additional genetic variability that may be utilized by the plant breeder in the development of cultivars for specific purposes or with specific adaptabilities. Mutation studies on *L. sativus* have shown that the chemical mutagens EMS (ethyl methane sulphonate) and NMU (N-nitroso-N-methyl urea) are more efficient than radiation in the production of chlorophyll mutations (Nerkar, 1974). However, cultivars have been found to respond differently to exposure to gamma irradiation (Prassad and Das, 1980a). A wide spectrum of morphological mutations have been found affecting plant habit, maturity, branching, stem shape, leaf size, stipule shape, flower color and structure, pod size, and seed size and color (Nerkar, 1976). Plant habit mutants such as dwarf and erect, as well as giant forms, have also been induced (Prassad & Das, 1980b). There thus appears to be a large selection of both naturally occurring as well as induced morphological characteristics that are available to the plant breeder.

Studies by Singh & Chaturvedi (1987) have shown that at biological comparable doses the mutagenic effectiveness was in the order of N-nitroso-N-methyl urea (NMU), ethyl methane sulphonate (EMS) and gamma-rays and efficiency in the order of Gamma-rays, EMS and NMU.

Decreased neurotoxin content

An indication that ODAP content might exhibit simple mendelian inheritance has been reported from variation induced in grasspea through both physical and chemical mutagens (Nerkar, 1972). In the segregating M2 generation in all treatments, the distribution curves showed three distinct peaks which are characteristic of monogenic F_2 segregation. If this proves to indeed be the case, rapid improvement of locally adapted germplasm is feasible through a hybridization and backcrossing program.

Genetic resources

Characterizing material with descriptors

The Germplasm Resources, Crop Improvement and Agronomy Committee of the International Network for the Improvement of *Lathyrus sativus* and the Elimination of Lathyrism (INILSEL) has agreed to use the following descriptors:

1) Days from seeding to 50% plants with flowers.
2) Anthocyanin present in stem.
3) Flower color.
4) Leaf width (narrow = 0.5 cm, medium = 1.0 cm, wide = 1.5 cm).
5) Seedcoat color.
6) Maturity (days from seeding to 90% pods turned brown).
7) Plant height in centimeters.
8) Downy mildew severity (0 = none, 10 = severe).
9) Pod shattering at maturity (0 = none, 9 = 90–100%).
10) Plant type (indeterminant or determinant).
11) Plant habit (1 = erect, 5 = prostrate).
12) 1000 seed weight in grams.
13) Seed density (kg hl^{-1}).
14) Seeds per pod.
15) Insect resistance.
16) ODAP concentration of the seeds.

Dr. D. Combes, University of Pau, Pau, France coordinates lists of accessions, passport data, and descriptors for all members of the network.

Collections

The collections of grasspea that have taken place in the past have involved large numbers of lines. As an example, the Indian Agricultural Research Institute, New Delhi, India analyzed 1500 lines in 1970 and 1000 in 1971. Although these collections have taken place in many different countries and have been accomplished for many different reasons most of them now have one thing in common. The germplasm that was collected has been lost or destroyed and is no longer available to grasspea improvement programs. While this problem area is now starting to be addressed, an organized system of long term storage with backup storage at other locations is desperately needed in the areas where grasspea is now being cultivated. The large amount of variability that has been found in local germplasm must be sampled, described, and stored for future use.

Storage

Collections of *Lathyrus* germplasm are presently being stored in Bangladesh, Chile, China, Canada, Ethiopia, France, Germany, India, Nepal, Pakistan, Russia, Syria, United States, and the United Kingdom. While many of these are relatively small collections and do not represent a true sampling of the possible genetic variability existing in local germplasm, they are a very valuable component of any grasspea improvement program. Coordination of *Lathyrus* germplasm storage for INILSEL has been undertaken by Dr. D. Combes, Pau, France as an initial attempt at a more organized storage system.

Present crop improvement programs

Many crop improvement programs are presently addressing research on the different aspects of grasspea production. Several of these are programs that contain a number of different, but interrelated, fields of specialization. These developments along with increased "networking" and collaboration with other programs has provided a good base for rapid improvement in this formerly badly neglected crop. The various facets that are contained in different programs include not only crop improvement aspects but also those of a nutritional, medical, socio-economic and biotechnical nature.

Some of the major crop improvement programs and their major emphasis on present research are listed below:

The Lathyrus Improvement program at the Indira Gandhi Agricultural University, Raipur, India includes selection and hybridization of low ODAP lines, insect and disease resistance, and plant regeneration techniques.

At the Indian Agricultural Research Institute, New Delhi, India the program includes aspects of selection and hybridization of lines, development of lines with reduced concentrations of ODAP and the study of protein components for quantity and quality.

The *Lathyrus* Improvement program at the National Agricultural Research Institute, Islamabad, Pakistan, is studying forage and fodder aspects of grasspea, nitrogen fixation, inter-specific hybridization through cytogenetical procedures and analytical aspects, as well as the development of high yielding and reduced ODAP adapted lines. A study of the incidence and severity of Lathyrism is also being addressed.

In Bangladesh, the Bangladesh Agricultural Research Institute has emphasized development of lines with reduced concentrations of ODAP combined with disease and insect resistance. At Mymensingh University, drought tolerance and agronomic traits are being studied.

In Chile, grasspea is a minor crop and presently no research is underway on breeding aspects. Research is being conducted on production practices including planting dates and fertilization.

The grasspea improvement project at Lanzhou University, Lanzhou, China is emphasizing agronomic aspects of production, the development of reduced ODAP lines, and mutational breeding.

The Grain legumes Research Program in Nepal is evaluating and selecting grasspea lines for agronomic characteristics. They are also selecting within segregating progenies from crosses made in Canada between reduced ODAP lines and selected local material.

In Ethiopia, grasspea improvement work at the Institute for Agricultural Research includes agronomic studies and the development of reduced ODAP lines together with processing techniques for the removal of ODAP. Nutritional, medical, and socio-economic aspects are also being addressed in a comprehensive study.

Grasspea research in Canada has developed germplasm with very small concentrations of ODAP. Research underway includes the inheritance of reduced ODAP concentration, nutritional aspects both for human consumption and animal feed, and agronomic studies including competition with weeds. Development of components for increased yield are also being addressed.

In addition to the above mentioned programs, many of them also contain a collaborative component. This allows complementation of the strengths of different programs and should result in efficient research. Many of these collaborative agreements encompass two or more countries and several different aspects that are essential to improvement of this hardy pulse crop.

Future research areas

Breeding and evaluation

Many of the crop improvement programs will continue with the main emphasis being on the development of high yielding, adapted cultivars containing very little or zero amounts of the neurotoxin ODAP. Attempts will be made to completely remove the neurotoxin ODAP. Complete elimination of the neurotoxin content is presently being addressed by two main approaches. Identification and elimination of the enzyme responsible for ODAP production, and by transfer of genetic characters through inter-specific hybridization utilizing both cytogenetics and tissue culture techniques. The feasibility of introgression of desirable characteristics from other closely related species will be also be addressed. The emphasis on seed yield will probably remain, and forage aspects of this crop are starting to demand more attention. Enhancing the nutritional value of the crop by reducing antinutritional factors will also recieve more emphasis. Many of the crop improvement programs will add another dimension or direction to their present programs.

In future research at Lanzhou, China, for example, investigations will be conducted along two directions. Breeding of reduced neurotoxin lines with good agronomic characteristics will continue as well as crop improvement by mutational breeding. Special emphasis will be paid to induced mutation caused by Cobalt 64 heavy ion irradiation.

The forage aspects of grasspea production has always been important to producers. In many areas, the fodder value of the crop for grazing or the feed value of the straw is the main reason for production of this crop. These aspects are now increasingly being addressed by several programs.

For example, the long term goals of ICARDA are as follows:

1) Select genotypes with increased herbage production, seed yield, and harvest index.
2) Assess the selected genotypes for tolerance to production constraints (foliar and root diseases, drought, and cold).
3) Develop other important traits (earliness, leaf-retention, erect plant habit, and non-shattering pods).
4) Assist in replacement of fallow with *Lathyrus* species to increase animal production and improve soil fertility.
5) Develop high yielding but low neurotoxin (ODAP) content *Lathyrus* species.
6) Target suitable *Lathyrus* species to specific farming systems.
7) Identify potential insect pests.
8) Develop control measures for *Orobanche* species (broomrape).

Molecular genetics has emerged as an applied research discipline during the past decade and promises to assist in the solution of many agricultural problems. Genetic engineering holds promise for development of specific genotypes since it is based on identification, characterization, and transfer of specific genes into the recipient plant as compared to the mixing of two complete genomes of two parental lines followed by backcrossing for several generations to remove undesirable genes.

Molecular genetic techniques can be employed to characterize the genes and identify important linkages which could facilitate gene transfer to suitable agronomic types, genes for disease or insect resistance, reduced ODAP concentration, increased protein content, and other characters of agronomic importance seem to be adaptable to this approach.

Interdisciplinary research efforts, now underway at several research establishments together with collaboration between institutes, promises to produce needed improvements in grasspea in the near future.

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