

Advances and Future Prospects of Climate-Resilient *Crop Grasspea* Research and Development in Nepal

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10 July 2025: Received | 08 August 2025: Revised | 05 September 2025: Accepted | 02 October 2025: Available Online

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Citation: Rajendra Darai, Shiv Kumar, and Padam Poudel (2025). Advances and Future Prospects of Climate-Resilient *Crop Grasspea* Research and Development in Nepal. *Plant Science Review*.

DOI: <https://doi.org/10.51470/PSR.2025.06.02.36>

Abstract

Grass pea (*Lathyrus sativus* L.) is a nutritionally important, climate-resilient crop cultivated under stress-prone conditions in Nepal. From two decades of research, significant achievements have been made for the development of low β -ODAP (β -N-oxalyl-L- α , β -diaminopropionic acid), high-yielding new varieties suitable under drought and poor soil conditions. These new varieties have already demonstrated their excellence in terms of yield, biomass, nutritional quality, low ODAP content, and adaptability to changing climatic scenarios. Furthermore, efforts need to be made to raise awareness among the stakeholders about the benefits of growing low-ODAP-content, high-yielding grass pea varieties for their deployment across the country. Continued research, development activities, capacity enhancement, extension services, and collaboration of the research system with stakeholders are essential for advancing the cultivation of grass pea, grass pea can be considered an alternative to lentils and a potential future climate-resilient crop in Nepal. Besides this, changes in government priorities and policies are required for support and investment in grass pea in the coming days so that the crop can play a significant role in ensuring food security and sustainable agriculture.

Keywords: ODAP, grasspea, climate change, nutritional security.

Introduction

Grass pea (*Lathyrus sativus* L.) is a nutritionally important, climate-resilient crop cultivated under stress-prone conditions in Nepal. It is a diploid species ($2n = 14$; genome size of approximately 8.2 GB with a great potential for expansion in dry areas [10]. Grasspea, also known as Khashari, Latara, Latari, or Matara in local languages, is well adapted to extreme drought and abnormal rains, which are negatively impacted by climate change [11]. In Nepal, grasspea is cultivated after late maturing rice as a sole crop or relay in rice-rice/grasspea or rice/grasspea system one to two weeks prior to rice harvest. Sometimes it is mixed with linseed, chickpea, and lentils in rice /grasspea + linseed+chickpea + lentils cropping pattern. Most importantly, grasspea uses the residual moisture and does not need to apply extra fertilizer, and it uses rice straw for traveling. Owing to its extremely strong root system and ability to penetrate thick clay, it has the ability to adapt to a wide range of soil and climatic regimes. This crop is exceptionally well-suited for challenging environments due to its remarkable resilience and ability to fix atmospheric nitrogen.

Its adaptation mechanisms allow it to thrive in conditions that may be detrimental to other species, making it a valuable asset for sustainable agriculture in areas with poor soil quality or limited water availability. By harnessing atmospheric nitrogen, this crop not only promotes its own growth but also enriches the soil, fostering a healthier ecosystem and enhancing overall agricultural productivity. Its unique attributes position it as a key player in addressing food security and promoting ecological balance in the face of climate change. *Lathyrus* has also been recognized as a potential source of resistance to several important diseases in legumes [8]. It is most commonly used in the preparation of Dal (aqueous slurry cooked with spices), Atta (flour boiled in water), and Satu (roasted flour mixed with water). It is frequently added as an adulterant to flour, pigeon pea dal, and chickpea dal [5]. The young plant is consumed with rice meal as a leafy vegetable. In addition, they are dried and rolled to be used as a vegetable in the off-season [5]. It is also used as a valuable livestock fodder. Grass pea area was 51170 ha in 1984/85, but now its area is limited to 10407 ha with production of 12072 mt, representing 3% of total legumes in

the country [1]. As a result, Nepal lost huge numbers of valuable landraces forever. The major grass pea-growing districts in Nepal were Kapilbastu, Sarlahi, Parsa, Rupendehi, Morang, Bajhang, Rauthat, Banke, Jhapa, Surkhet, Salyan, and Dang. Abiding peoples are simultaneously conscious of the importance of grass peas for human, livestock, and soil health, which has led to an increasing consumption rate. Likely province-wise area and production trends in Nepal during the year 2021 indicated that Lumbini shared the significant areas nearly 40%, followed by Madesh (23%), Sudurpaschim (12%), and Koshi (10%), while Gandaki had negligible shares (1%). The main lathyrus growing areas (2711 ha) and production (3321 mt) were shared by Kapilbastu, followed by the areas (885 ha) and production (955 mt) of Sarlahi, and the area (631 ha) and production (711 mt) of Parsa district. Out of the top ten districts that grow grasspeas, Salyan district deserves the highest yield (1302 kg/ha), followed by Rupendehi (1252 kg/ha) and Kapilbastu (1225 kg/ha). Over the past two decades, the cultivation and productivity of grass pea (*Lathyrus sativus* L.) have shown remarkable improvement in several countries. Compared with the year 2000, the cultivated area has increased by approximately 19%, while production and productivity have risen by 78% and 49%, respectively. These gains are primarily attributed to the development and dissemination of high-yielding, stress-resilient, and low-ODAP-containing grass pea varieties. Despite this progress, the expansion of grass pea cultivation has been somewhat constrained due to concerns about neurolathyrism, a neurological disorder that causes paralysis of the lower limbs. This condition results from prolonged consumption of large quantities of grass pea containing the neurotoxic compound β -N-oxalyl-L- α , β -diaminopropionic acid (ODAP), also known as β -ODAP or BOAA, which is present in all parts of the plant. Historically, outbreaks of neurolathyrism have been documented in regions where grass pea serves as a staple food during droughts and food shortages. For instance, during the 1980s drought-induced famine in Bangladesh, many rural families relied heavily on grass pea as a survival food, leading to a well-documented epidemic of neurolathyrism. This event raised significant health concerns and led to increased public awareness across South Asian markets. As a precautionary measure, the Government of Nepal imposed a ban on the marketing of grass pea in 1991–92 to prevent similar health crises.

The presence of ODAP in *Lathyrus* species was first identified by researchers who detected *ninhydrin-reacting compounds* in *L. sativus* and other related species [15]. Subsequent biochemical studies demonstrated that β -ODAP is biosynthesized from its precursor, β -(isoxazolin-5-on-2-yl)-alanine (BIA), particularly in young pods of the plant [16]. In local cultivars, ODAP concentrations typically range between 0.6–0.8%, levels that are generally considered safe for occasional consumption by humans and livestock.

Notably, sheep and other ruminants appear to tolerate these concentrations without adverse effects. To mitigate the risks associated with ODAP while retaining the crop's resilience and nutritional benefits, breeding and selection programs have been initiated. These efforts, which employ recurrent mutagenesis and selection techniques, aim to produce high-yielding, low-toxin lines of grass pea. Collaborative initiatives involving organizations such as Australian Centre for International Agricultural Research (ACIAR) and the International Center for Agricultural Research in the Dry Areas (ICARDA) have played a key role in developing and promoting these improved varieties. Such advancements are expected to re-establish grass pea as a safe, climate-resilient, and nutritionally valuable legume suitable for sustainable agricultural systems in drought-prone regions. Over the past two decades, remarkable progress has been achieved in the development of low β -ODAP (β -N-oxalyl-L- α , β -diaminopropionic acid), high-yielding varieties of grass pea (*Lathyrus sativus* L.) suitable for cultivation under drought and poor soil conditions. Traditional landraces of grass pea have been found to contain high levels of ODAP, the neurotoxic compound responsible for neurolathyrism, which has limited the crop's wider adoption despite its resilience and nutritional value. To address this challenge, several low-ODAP grass pea lines—including 19-A, 20-A, CLIMA Pink, CLIMA-2, and BARI-2—were introduced from CLIMA, Australia, as part of collaborative research initiatives. Among these, CLIMA Pink, 19-A, and 20-A demonstrated superior adaptability to local agro-climatic conditions and were subsequently introduced in key grass pea-growing regions to replace traditional high-ODAP landraces [13].

Field evaluations and farmer participatory trials have confirmed the success and acceptance of CLIMA Pink, particularly in Padharia village of Siraha district and Baijapur village of Banke district, Nepal, where farmers have adopted the variety due to its low ODAP content, higher yield potential, and better drought tolerance. These achievements mark a significant milestone toward the safe and sustainable cultivation of grass pea, a crop with immense potential to enhance food security, nutritional resilience, and income generation for smallholder farmers, especially under climate change-induced stress conditions.

Moving forward, raising awareness among farmers, policymakers, and agricultural stakeholders about the advantages of cultivating low-ODAP, high-yielding grass pea varieties is critical to ensuring their widespread adoption. This requires continued investment in research and breeding programs, strengthened extension and capacity-building efforts, and enhanced collaboration between national and international research organizations. With supportive government policies and institutional commitment, grass pea can emerge as a climate-resilient alternative to lentil, contributing substantially to sustainable agriculture, rural livelihoods, and national food security in Nepal.

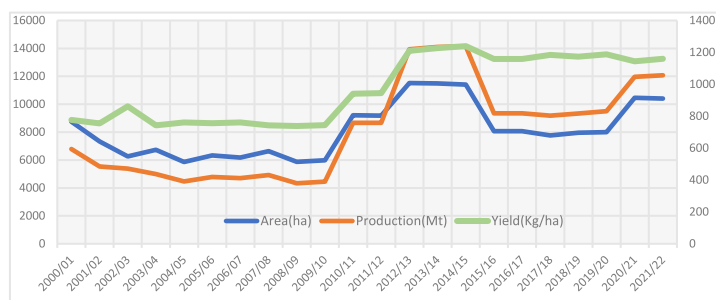


Fig. 1 Area, production, and yield trends over the years (2000-2021)

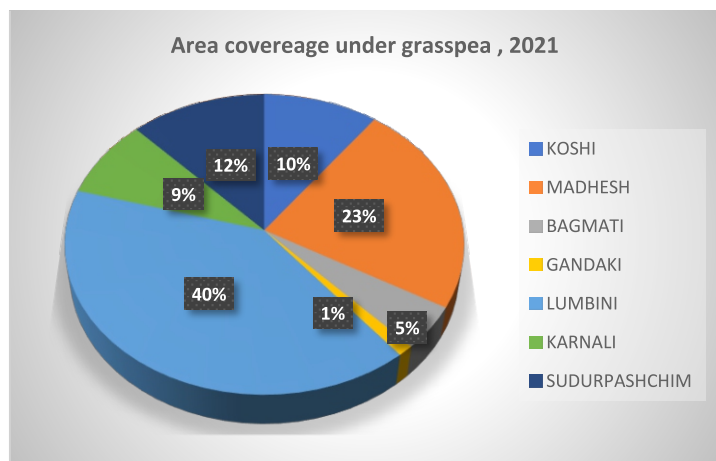


Fig. 2 Area shared by grasspea, 2021

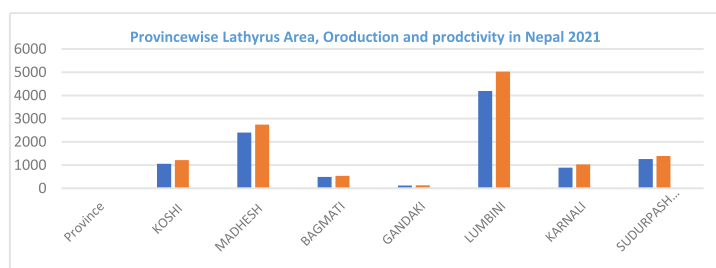


Fig. 3 Province wise grasspea area. Production and productivity in Nepal 2021

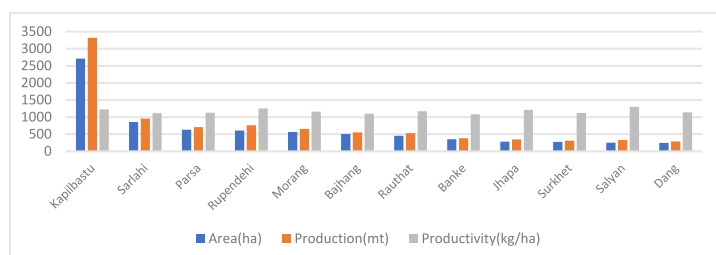


Fig. 4. Major grasspea growing districts in Nepal, 2021

Importance of climate-resilient crops in Nepal

Climate-resilient crops like grass pea play a crucial role in addressing food security and environmental challenges in Nepal.

- **Food and Nutritional Security:** As a nutrient-dense crop, grass pea contributes to food security by providing essential proteins, dietary fibers, and micronutrients, such as iron, calcium, and phosphorus, to the diet of millions of Nepalese people. It is also rich in antioxidants and has been found to have potential health benefits.

- **Climate Resilience:** Grass pea's resilience to drought, flooding, and temperature fluctuations allows it to thrive in various climatic conditions, reducing the vulnerability of farmers to climate-related risks.
- **Soil Health:** Grass pea's capacity to fix atmospheric nitrogen enhances soil fertility, reducing the need for chemical fertilizers and promoting sustainable agricultural practices.
- **Economic Benefits:** Grass pea can be used to produce various products, such as Dal, green vegetables, flour, and animal feed. This diversification of uses can create new income-generating opportunities for farmers and contribute to rural economies.
- **Employment opportunities:** Grasspea production and processing create employment opportunities for rural communities, particularly women and youth.
- **Conservation:** Grasspea is an important crop for conservation efforts in Nepal. It helps to maintain soil health, reduce erosion, and promote biodiversity.

Limitations and challenges

- **Lathrogenic risk:** Grass pea contains a toxin called ODAP (β -N-oxalyl-L- α , β -diaminopropionic acid), which can cause a neurological disorder known as lathyrism if consumed in large quantities. This is a major concern in Nepal, where traditional cooking methods may not effectively remove the toxin.
- **Limited availability of high-quality seeds:** In Nepal, there is a shortage of high-quality seeds of grasspea, which can affect the crop's yield and quality. This is due to the lack of organized seed production and marketing systems.
- **Climate and soil limitations:** Grasspea is sensitive to extreme temperatures, humidity, and soil conditions. In Nepal, its growth is often limited by poor soil fertility, waterlogging, and frost damage.
- **Enhance the pest and disease management:** Grasspea is susceptible to pests and diseases such as aphids, whiteflies, and powdery mildew, which can reduce its yield and quality. In Nepal, the lack of effective pest and disease management practices can exacerbate these problems.
- **Low market demand:** Despite its nutritional benefits, grasspea has low market demand in Nepal due to its relatively low yield and perceived lower quality compared to other crops.

- **Limited knowledge and adoption:** Many farmers in Nepal are not aware of the benefits and potential of grasspea, which limits its adoption. Additionally, there is a lack of technical guidance and support for farmers who want to grow grasspea.
- **Develop the post-harvest management practices:** Grasspea is a sensitive crop that requires proper post-harvest management to maintain its quality. In Nepal, the lack of facilities for drying, storage, and processing can lead to losses and reduced quality.
- **Compatibility with other crops:** Grasspea is a legume that requires specific soil conditions and may not be compatible with other crops that require different soil conditions. In Nepal, this can limit its integration into existing cropping systems.
- **Scalability:** Grasspea is a labor-intensive crop that requires manual harvesting and processing. In Nepal, the lack of mechanized harvesting and processing technologies can limit its scalability.
- **Regulatory framework:** There is a need for a regulatory framework to ensure the quality and safety of grasspea products in Nepal. This includes establishing standards for seed production, processing, and trade.
- Lower priority has been given to the pulse research and development at the national policy level.
- Ban to grow grasspea (Oxalyl diamine Propionic Acid) - which is regarded as Hardy, Climate resilient, Future food crop To overcome these challenges, the government and non-governmental organizations (NGOs) in Nepal must play a crucial role in promoting grasspea cultivation through
- Organize awareness campaigns to educate farmers about the health benefits and potential of grasspea cultivation.
- Provide training and capacity-building programs for farmers on grasspea cultivation practices, post-harvest management, and the market chain.
- Produce the high-quality seed varieties of grasspea to farmers and support the development of local seed systems.
- Support the development of markets for grasspea food products profile and promote value-added products like flour and snacks.
- Conduct further research and development on grasspea to develop low ODAP varieties that help to improve yields and reduce risks.

Prospects of grasspea in Nepal

- Grass pea has the potential to play a key role in sustainable agriculture and food security in Nepal, particularly in the face of a changing climate context.
- There is a growing interest in promoting the cultivation of the grass pea among farmers and policymakers in Nepal.
- Still about 0.39 million ha rice-fallow area, which has ample scope for increasing grasspea areas in the rice-based cropping system
- Grasspea is a rich source of protein, with a protein content of up to 31%, carbohydrates 41%, fiber 17%, and micronutrients such as iron, zinc, and calcium, making it an excellent alternative source of lentils along with staple foods like rice and wheat.
- **Climate change adaptation:** It is relatively heat and drought-tolerant, which makes it an attractive option for farmers in rainfed agriculture
- **Soil conservation:** It can grow well in a variety of soils, including poor soil conditions, and since its deep root system helps to reduce erosion, which makes it is an ideal crop for small-scale farmers
- It requires minimal labor inputs, making it a suitable option for farmers who may not have access to large tracts of land or labor resources.
- It contains a range of essential nutrients, including vitamins, minerals, and antioxidants, making it a valuable addition to the Nepalese diet.
- It can provide an additional income stream for farmers by selling the grain or value-added products like flour and snacks.
- Supports sustainable agriculture: It is a low-input crop that requires minimal fertilizers and pesticides, making it an attractive option for sustainable agriculture.
- Market potential: Grasspea has a potential market in Nepal, particularly in urban areas where there is a growing demand for healthy and nutritious food.
- Diversification of cropping systems: Grasspea can be integrated into existing cropping systems to provide a diversification of crops and reduce reliance on a single crop.
- Research and development: Continued research, development, and investment in the crop could lead to further improvements in yield, nutritional quality, and climate resilience

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- **Export opportunities:** Grasspea has potential export opportunities to countries with high demand for legumes, such as India, China, and the Middle East.

Research Achievements

Pre-breeding

Significant progress has been made in the pre-breeding research and genetic improvement of grass pea (*Lathyrus sativus* L.) in Nepal, focusing on the exploration, characterization, and conservation of germplasm resources for future breeding programs. To date, five wild relatives of grass pea have been reported in the country, each contributing to the genetic diversity and potential breeding pool of the species. *Lathyrus aphaca* L. (locally known as *Pili Matri*) is an annual herb bearing yellow flowers, commonly found in the Terai region, and used primarily as fodder. *Lathyrus odoratus* L., popularly known as sweet pea (*Kerauphul*), is a wild ornamental form cultivated in home gardens [2]. Other species, including *Lathyrus pratensis* L., *Lathyrus sphericus* Retz., and *Lathyrus humilis* (Ser.) (Fischer ex. Spreng.), have also been identified in various ecological zones, reflecting the wide adaptability of the genus *Lathyrus* in Nepal's diverse agro-climatic conditions.

At present, the Grain Legumes Research Program (GLRP) under the Nepal Agricultural Research Council (NARC) is engaged in the evaluation of approximately 200 grass pea lines, including low-ODAP accessions, to identify promising genotypes for yield, adaptability, and toxin content. These efforts are complemented by on-farm promotional trials in major grass pea-growing districts to encourage farmer adoption of improved lines. Furthermore, a total of 441 local landraces have been safely conserved in the National Agriculture Genetic Resources Centre (NAGRC, Gene Bank), ensuring the long-term preservation of Nepal's valuable grass pea genetic diversity.

The systematic collection and documentation of grass pea germplasm in Nepal date back to 1987, when the Grain Legumes Research Program (GLRP) and the Nepal Agricultural Association (NAA), with financial support from the International Development Research Centre (IDRC), Canada, initiated extensive surveys across the Terai and inner Terai regions. This collaborative effort successfully collected 76 landraces from 18 districts, forming the foundation for subsequent genetic improvement programs [11].

The first systematic characterization of legume germplasm using International Board for Plant Genetic Resources (IBPGR) descriptors was conducted during 1987–88 at NARC research centers [6]. Subsequently, 87 accessions of grass pea germplasm were characterized by GLRP, while an additional 171 accessions were evaluated at the National Plant Genetic Resources Centre (NPGRC), Khumaltar, using standardized IBPGR descriptors [14]. These characterization studies revealed a wide range of genetic variability in important agronomic traits such as plant height, number of pods per plant, seeds per pod, 100-seed weight, and grain yield.

Interestingly, the results demonstrated that local landraces were better adapted to local conditions, exhibited earlier maturity and stable yield performance, but had smaller seed sizes compared to the exotic germplasm, which generally displayed larger seeds and greater yield potential under favorable conditions [5]. This variation highlights the potential for hybridization and pre-breeding between local and exotic lines to combine desirable traits such as early maturity, drought tolerance, and reduced ODAP content for future varietal development. Collectively, these pre-breeding achievements have established a strong genetic foundation for the improvement of grass pea in Nepal, enabling targeted breeding efforts to develop climate-resilient, high-yielding, and nutritionally safe varieties suited to the nation's diverse agro-ecological environments.

Breeding improvement

- Improved varieties of grass pea have been developed through breeding programs, resulting in higher yields and better nutritional quality.
- Development of new low toxin *Lathyrus* germplasm: The new lines involve a cross between Nepal landraces, Sarlahi, and CLIMA low ODAP selection 20B (Ceora), resulting in the development of low ODAP (<0.2%) containing lines 19-A, 20-A, CLIMA Pink, CLIMA-2, BARI-2, 31.4, 36.3, 38.2, 59.1, promising in terms of high grain yield
- ICARDA Yield Trial: High biomass fodder varieties Sel-1959, Sel-290, Sel-2119, Sel-2177, Sel-387, Sel-299, Sel-449 and Sel-1942
- International Grass pea Screening Nursery (IGSN): High-yielding and early maturity genotypes 45.3, 2.3, LHH-0066
- Regional Elites Varietal Trial (REVT) : Low ODAP Lines LHH-0012(2715 kg/ha), 26.2(2501 kg/ha), DL7-1(2483 kg/ha) and 38.1(2415 kg/ha) selected for
- Multi-Environment Trial: Low ODAP and high-yielding grass pea genotypes Indian origin Ratan (1866 kgha-1), local check Nepalese landrace (1662 kgha-1), Indian origin Bidhan-1(1323 kg/ha), Greece origin Acc # 190 (1293 kgha-1), and Syrian origin Acc # 554(1160 kgha-1)
- Large Plot Demonstration and Seed production: ~15 hectares areas occupied under large plot demonstration and 3 ha areas covered for seed production of CLIMA PINK, Ratan, Bidhan-1 at the station and on-farm.

Agronomic Research

Grass pea (*Lathyrus sativus* L.) has been widely recognized for its resilience to abiotic stresses, particularly drought and salinity, making it a highly suitable crop for farmers in Nepal's diverse agro-ecological conditions. Studies indicate that relay sowing of grass pea prior to rice harvest—ideally 1–2 weeks before the harvest in November—is the most effective practice. Seeds can be broadcasted or sown in lines, with one to two harrowings under post-rice conditions to ensure proper soil-seed contact and uniform establishment. In areas experiencing moisture stress, a simple pre-sowing technique has been widely adopted by farmers: overnight soaking of seeds in plain water, followed by mixing with fresh cow dung before broadcasting. This approach not only protects seeds from birds and insects but also enhances germination and seedling vigor under suboptimal conditions. Notably, grass pea cultivation generally does not require chemical fertilizers or insecticide applications, highlighting its low-input nature and suitability for sustainable farming systems. Intercropping practices have also gained traction, particularly in the Terai and inner Terai regions. Farmers commonly mix grass pea seeds with linseed, mustard, lentils, or chickpeas during relay sowing. Additionally, grass pea is often grown after maize under minimum land preparation or conservation tillage systems, providing soil cover, improving soil fertility, and enhancing overall system productivity. These agronomic strategies not only optimize resource use but also contribute to resilient and diversified cropping systems.

Areas for Future Research

Despite notable progress, several knowledge gaps and opportunities for future research remain in grass pea agronomy and breeding:

- 1. Germplasm Exploration and Conservation:** Large-scale collection, characterization, and conservation of grass pea germplasm from unexplored or marginal regions to broaden the genetic base.
- 2. Low-ODAP Genotypes:** Accelerated development of low- or near-zero ODAP varieties to ensure nutritional safety for human consumption.
- 3. Forage and Fodder Enhancement:** Breeding for increased biomass, forage, and fodder production to support livestock systems.
- 4. Abiotic Stress Tolerance:** Improved understanding of drought- and salinity-tolerance mechanisms at physiological, molecular, and genomic levels.
- 5. Biotic Stress Resistance:** Identification of resistant sources and development of genotypes resilient to insect pests and diseases.

6. ODAP Biosynthesis and Detoxification: Identification and genetic manipulation of enzymes responsible for ODAP production and refinement of high-throughput ODAP detoxification methods.

7. Utera Cultivation Practices: Optimization and refinement of production technologies for relay or utera cultivation systems.

8. Genomic Tools: Generation of saturated linkage maps, genome-wide markers, and other cost-effective genomic resources.

Integration of Genomic Resources: Application of newly developed molecular and genomic tools within existing breeding protocols to accelerate the development of High-Yielding, Low-ODAP Varieties: Research Strategy

The development of high-yielding, low-ODAP grass pea (*Lathyrus sativus* L.) varieties is critical for enhancing food security, nutrition, and climate resilience in Nepal. A comprehensive research strategy has been designed to address germplasm improvement, agronomic optimization, and policy support, focusing on both biotic and abiotic challenges. The key strategic approaches are outlined below:

1. Germplasm Collection and Evaluation:

- Systematic collection of local landraces, crop wild relatives (CWRs), and segregating materials from International Agricultural Research Centers (IARCs) for evaluation and selection.
- Assessment and recommendation of promising grass pea varieties adapted to diverse agro-climatic conditions.

2. Selection and Breeding:

- Identification of the best-adapted grass pea lines through International Elite Nurseries, focusing on stress tolerance and yield potential.
- Initiation of breeding programs targeting abiotic (drought, cold) and biotic (diseases, pests, nematodes) stress tolerance.
- Development of low-toxin (ODAP) varieties to improve nutritional quality and human health.
- Focus on early-maturing varieties suitable for intercropping, relay cropping, and sole cropping systems.

3. Seed Production and Delivery Systems:

- Ensure adequate quality source seed production at NARC stations and through farm cooperatives or seed growers.

- Strengthen the seed delivery chain, ensuring availability of breeder seed, foundation seed, and quality-certified improved seeds to farmers.

4. Methodological and Technological Advancements:

- Incorporate improved methodologies for genetic improvement, including pre-breeding, advanced biometry, and crop information systems.
- Initiate fast-track breeding approaches using molecular tools, genomics, and Genome-Wide Association Studies (GWAS).
- Strengthen laboratory facilities and human resource capacity to accelerate breeding outcomes.

5. Agronomic Optimization and Crop Management:

- Development of enhanced agronomic practices for grass pea, including optimized production systems, soil fertility management, and postharvest technologies.
- Promote rice-fallow and maize-based cropping systems by integrating grass pea as a main or catch crop.

6. Policy Support and Market Development:

- Formulate government policies to facilitate grass pea production, marketing, and import/export.
- Implement programs for food and nutritional security to increase domestic consumption of grass pea.
- Develop long-term strategies for the pulse sector, covering production, processing, consumption, and trade, supported by adequate research and investment.

7. Collaborations and Capacity Building:

- Establish strong collaborations with international centers such as ICARDA, USAID, Crop Trust, and IBPGR for genetic enhancement, germplasm sharing, and scientist capacity building.
- Encourage partnerships among research institutions, universities, and farmer organizations to accelerate adoption of improved varieties.

Conclusion

Grass pea's climate resilience, nutritional benefits, and ability to improve soil health make it a potential solution to food security and climate change in Nepal. Continued research and investment in grass pea can result in low ODAP climate-resilient varieties by promoting the cultivation and utilization of this hardy legume. Nepal can enhance its agricultural productivity, promote sustainable practices, and contribute to a more resilient agricultural sector in the country and the well-being of its people.

Acknowledgements

The authors would like to highly acknowledge all sorts of support from the CROPTRUST under the BOLD Project and ICARDA.

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