

**Bitter White Lupine (*Lupinus albus* L.) Production Guideline for
the Highland Areas of Ethiopia**

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1. Introduction

The Amhara Region had 3 main ecological zones categorized as areas that receive adequate moisture, western lowlands conducive to agricultural investment, and eastern areas of the region where their average annual rainfall does not exceed 700 mm. In the region, the majority of the areas receive an average yearly rainfall of 700 -1500 mm. On the other hand, the soil fertility of the areas receiving high rain fall is decreasing over time and the problem of soil acidification is high, and the productivity is low.

Soil acidity affects a significant portion of agricultural land and around 1.5 million hectares of land in the Amhara region of Ethiopia are impacted by soil acidity. This represents a substantial challenge for farmers, as acidic soils can reduce crop yields and soil fertility. Efforts are being made to address this issue through soil management practices, such as liming and the use of acid-tolerant crop varieties. The Amhara Region Agricultural office has prepared crop development and protection packages for areas that receive adequate rainfall in the region in 2007 E.C. However, one of the important legume crops, bitter white lupine (BWL), which is adaptable in acidic soil and marginal lands is not included in the crop development and protection packages.

Bitter white lupine (*Lupinus albus*) (BWL) is a neglected but essential leguminous crop known for its high protein content and ability to fix atmospheric nitrogen, improving soil fertility. It plays a vital role in food security, especially in regions like the Amhara region of Ethiopia, where agricultural productivity is crucial for livelihoods. The BWL in Ethiopia is produced by smallholder subsistent farmers in Amhara and Benishangul-Gumuz regions having an elevation ranging between 1500-3000 masl with the mean annual rainfall ranging from 1100 to 2300 mm.

According to the CSA (Ethiopian Central Statistics Agency, 2021) report, the BWL crop area coverage and production in 2019/2020 and 2020/2021 shows a reduction trend of 19.05% (19,248.83 to 15,580.99 hectares) and 18.67% (36,045,653 to 29,314,363 ton) with the productivity of 1.873 and 1.881 ton, respectively as compared with 2019/2020 main (*meher*) cropping season. The agency report also displays that almost all BWL is produced in the Amhara region in Awi and West Gojjam zones. In this regard, Habtemariam et al. (2019) reported that about 95.85% of land coverage and 99.29% of BWL total productions in Ethiopia accounted for the Amhara region in the 2017/18 cropping season, and the authors

concluded that BWL harvested area, production, and productivity show inconsistencies in Ethiopia

In north-western Ethiopia, smallholder subsistence farmers cultivate BWL on marginal lands as one of the best practices for improving soil fertility and enhancing the productivity of their land. In the region, it can contribute to sustainable agriculture and food security. BWL is preferred by farmers, involved in crop rotation and intercropping systems as compared with the common food legumes, because of its ability for better nitrogen fixation, drought adaptation, and its ability to offer considerable human food in marginal lands with limited water availability.

However, BWL is mostly produced with minimum agronomic practices, and the lack of improved varieties, diseases, insect pests, and limited technological support are the main causes for the low and inconsistent productivity status. Technological support is crucial for enhancing production. This includes the development and dissemination of improved varieties, appropriate agronomic practices, and effective pest and disease management strategies. Extension services and farmer training are also essential to bridge the knowledge gap.

So far, there is no production package for BWL production the region and nation that functions as reference material for extension agents. The first ever study made by the HFA (HealthyFoodAfrica) project highlights the potential of BWL as an alternative source of protein for poor households, source of income, export commodity, break crop for cereal based farming system, reclaiming soil acidity, soil nutrients, particularly in areas where chemical fertilizers are scarce or expensive. The findings help to develop appropriate management plans for the conservation of threatened soil health and the design of future scale-ups for soil health improvement and regenerative agriculture. Therefore, based on the study, it is recommended that agricultural extension agents and researchers should work with smallholder subsistence farmers to promote the integration of BWL into their farming systems for soil health improvement and regenerative agriculture (Mulugeta et al 2024).

To achieve the plan and recommendation, it has been necessary to develop a BWL crop production and protection package which will help to enhance the capacity of the agricultural development agents, professionals, and farmers. Hence, this package has been organized for areas that grow BWL in the Amhara region, combining the farmer's indigenous knowledge and perception of the importance of BWL in the farming systems, focussing on the local BWL varieties obtained in the hands of farmers, local agronomic practices, production methodologies and valuable experiences from the experienced farmers.

There are opportunities to achieve production and productivity of BWL in the Amhara region and also in the entire region. In addition to having a common understanding of the farmers regarding the benefit of BWL, farmers have been growing now and have an interest in producing the crop in the future, there are kebele professionals, researchers who are interested to get involved in the area, the farmers have benefited more from increasing their productivity and getting a reliable market and better price for their produce. The increasing interest in improving crop productivity, the acquisition of valuable experiences from the production and productivity enhancement efforts carried out, and the relative improvement in the understanding and ability of farmers to perform through skill training and exchange of experiences, are the main reasons, that encourage the professionals and farmers to be more motivated and diligent.

2. Bases of this production guideline

White bitter lupine is an orphan crop with significant untapped potential for improving soil health and supporting sustainable agriculture in areas with acidified soils. Despite its contribution, there has been little research or extension work carried out to improve its productivity and ecosystem services.

During the recent workshop organized by Bahir Dar Food System Lab, representatives from the regional Bureau of Agriculture requested the need for a production guideline based which extension agents can provide advices to farmers. This is essential because farmers lack formal guidance on how to best cultivate this crop, and agricultural extension agents have limited resources to advise them. As a result, farmers continue to rely on indigenous knowledge passed down through generations, which, while valuable, does not always incorporate modern agronomic advances that could enhance BWL's potential.

In response to this need, the production guideline is prepared based on the research assessments carried out by a PhD student to document and assess current BWL cultivation practices in the Amhara region. The students' research provided a unique opportunity to capture farmers' indigenous knowledge and experiences of cultivating BWL. Based on these insights, and recognizing the absence of comprehensive research on BWL, the guideline is intended to serve as a temporary yet practical tool for improving BWL production until sufficient research evidences are generated.

Although more research is needed to develop advanced agronomic recommendations, this guideline offers immediate, actionable advice to enhance current farming practices, particularly in the face of the challenges posed by soil acidity and low-input farming systems.

3. Recommendation Domains

3.1. Applicable Areas

The production guideline outlined in this package applies to the Highlands of Amhara region, where the agroecological conditions are suitable for BWL cultivation. It can also be applicable to other areas where BWL is growing. These areas typically have altitudes ranging from 1,500 to 3000 meters, well-drained acidic soils, and moderate rainfall.

3.2. Target Audience

This guideline is intended for:

- **Farmers:** To improve and expand their BWL production practices.
- **Agricultural Extension Agents:** To assist in disseminating knowledge and best practices to farmers and other stakeholders.
- **Researchers and Experts:** To guide research and development efforts in BWL cultivation and its agroecological values.

4. Suitable Agroecology and Cropping Systems for BWL Production

4.1. Geographic Areas in Ethiopia and the Amhara Region

BWL is predominantly produced in the highland areas of Ethiopia, with significant cultivation in the Amhara region. Areas like East Gojjam, West Gojjam, and Awi zones of Amhara region are known for their BWL production due to favourable climatic and soil conditions.

4.2. Integration into Cropping Systems

BWL is often integrated into existing cropping systems as a rotation/sole cropping and/or intercropping crop. It can be also grown as a relay cropping system. It is commonly rotated

with common cereal crops. It can be intercropped with cereals like teff, common oat (*Engido*), maize, finger millet, and wheat to improve soil fertility and break pest and disease cycles. BWL is sown during the main rainy season (June-August) depending on the agroecological variation and harvested in January-March. In addition, BWL can be cultivated by residual moisture after the harvest of some crops like barley, wheat and potato in a sequential cropping pattern.

4.3. Seasons and Modalities of Production

BWL is typically grown as a rain-fed crop during the main growing season. Additionally, BWL can be grown at the end of the main rainy season as a relay crop with residual moisture. However, in some areas, it should also be cultivated or intercropped under irrigation conditions, especially for seed production and for increasing the productivity of irrigated component crops like wheat.

5. Land Preparation and Use of Inputs

5.1. Land Preparation

- ✚ **Time and Frequency of Ploughing:** The land should be plowed only 0-2 times to achieve a fine seedbed, and reduce harvest loss. If plowing is required, the first plowing should be done at the onset of the rains.
- ✚ **Preferred Soils:** BWL thrives in well-drained loamy or sandy-loam slight to moderate acidic soils. Farmers should avoid heavy clay soils prone to water logging.

5.2. Sowing Date and Inputs Required

- ✚ **Local varieties:** Varieties that are traditionally grown and well-adapted to local conditions can be used as seeds. However, since they may have lower yields and be more susceptible to diseases and pests, improved varieties developed through breeding programs may be required.
- ✚ **Sowing Date:** BWL should be sown at the beginning of the main rainy season (June-August). It can also be sown as sequential cropping after harvesting of early maturing crops such as barely, wheat, potato and others.

- ✚ **Use of Rhizobial Strains:** the BWL seed should be inoculated with suitable *Bradyrhizobium* strains to enhance nitrogen fixation and improve yields and soil health, particularly when BWL is grown in new areas. However, there is no tested strains so far in the country.
- ✚ **Fertilizer Application:** At the planting stage 60-80 kg of P_2O_5 per hectare may require and in a low fertile soil starter nitrogen (10-20 kg N/ha) may be applied to increase the efficiency of inoculants.
- ✚ **Sowing Method:** BWL seeds should be sown in rows, with a spacing of 30-40 cm between rows and 10-15 cm between plants within rows. The seeding rate should be 80-100 kg per hectare, and seeds should be planted at the top 2-4 cm depth.

6. Agronomic Management of BWL

- ✚ **Weeding Frequency:** Weed control is required during the first 4-6 weeks after sowing. Manual weeding or the use of selective herbicides may be necessary.
- ✚ **Pest and Disease Management:**
 - **Pests:** The traditionally known “*black and green tile*” (Aphids or Leafhoppers) are mostly occur during the dry season and at the pod establishment stage and damages the leaves of BWL. In addition, the Australian native budworm which is locally known as *Kortm*, or “*Nech tle*”, is another pest that damages the root part of the crop. Therefore, biological insecticides like Neem oil or insecticide chemicals can be used for control.
 - **Diseases:** the locally known “*Michi*” or “*Atewlg*” (Fusarium wilt and Anthracnose) are the common BWL disease that causes root rot and dries parts or the whole plant. Use resistant varieties and implement crop rotation to manage these diseases.

7. Harvesting, Threshing, and Post-Harvest Management

- ✚ **Time of Harvesting:** Harvesting should be done when the pods turn brown, and the seeds are hard, usually after 120-150 days of sowing.
- ✚ **Threshing Techniques:** Before threshing, the harvested plants should be dried thoroughly. Traditional methods of mechanical threshers can be used.

- ✚ **Storage Requirements:** The cleaned seeds should be stored in cool, dry conditions, ideally in sound containers.
- ✚ **Post-Harvest Handling and Marketing:** After threshing, ensure proper cleaning, grading of seeds, and processing (if required) to meet market standards. Establish market linkages to ensure profitable sales.

8. Profitability of Cultivating BWL

As BWL is cultivated with zero or minimum tillage, less weeding, and without or minimal use of both organic and chemical fertilizers, it is an important commodity produced by extensive farming systems with low inputs, labour, and herbicide costs. It contributes to soil health regeneration and sustainable agriculture, reduce the cost of production, dependence on external inputs, chemical contamination through runoff and leaching, and environmental pollution, and promote the growth of beneficial native plant species, enhance biodiversity, and contribute to the development of a more ecologically balanced agroecosystem. However, a detailed cost-benefit analysis and the marginal rate of return assessment are required as input efficiency, market access, and price stability play a crucial role.

This working package may serve as a guide for BWL cultivation in the Amhara region highlands, providing essential information for farmers, extension agents, agricultural experts, and researchers.

9. Extension Services and Farmer Training

- ✚ **Capacity Building:** Farmers should be trained on best practices for BWL cultivation, pest management, and post-harvest handling.
- ✚ **Field Demonstrations:** Establish demonstration plots to showcase successful BWL cultivation.
- ✚ **Further research works:** Research, education, and extension on the BWL breeding, protection, agronomy, nutrition, and other aspects should be studied.

10. Sustainability and Environmental Impact

- ✚ **Soil Fertility:** BWL cultivation as part of a crop rotation, inter-cropping, relay cropping, and green manuring system should be promoted to improve soil fertility.
- ✚ **Biodiversity and food security:** By integrating BWL into existing farming systems, crop diversity and food security should be maintained.

11. Reference

- CSA (Ethiopia Central Statistical Agency), 2021. Report On Area And Production Of Major Crops: Private Peasant Holdings, Meher Season. Agricultural Sample Survey 2020/21 Report, Addis Ababa.
- Habtemariam A., Woldetsadik A. and Belay A., 2019. Analyze Production, Utilization and Its Future Trends of Lupin in Ethiopia. *American Journal of Plant Sciences*, **10**, 1797-1812. doi: 10.4236/ajps.2019.1010127.
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