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Review Article

Refining Agronomic Practices for Major Lowlands and Midlands Pulses Crops in Southwestern Ethiopia; a Review

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Abstract

Haricot bean and soybean are among the most important warm season food legumes cultivated in rotation with cereal crops in the low and midlands of southwestern Ethiopia. Poor agronomic practices are among the major constraints limiting the production and productivity of both crops. Improving agronomic practices such as seedbed preparation, sowing date, plant density, fertilizer rates, weed control and pest management will enhance the production and productivity of Haricot bean and soybean. In general, early July until the end of July and second weeks of June to end of June, are the recommended time to plant haricot bean and soybean in Ethiopia's midlands respectively. However, this depends on the climate, soil type, and maturity duration of the particular crop cultivar. In south-western Ethiopia, applying 46 kg/ha N and 46 kg/ha P2O5 significantly increased the production of soybeans and haricot beans by 70%. Inter and intra row spacing 30*10 cm (333, 333) plants ha-1 and (30 *5 cm) 666, 667 plants ha-1 of soybeans and haricot beans taken as optimal for Jimma areas. Twice hand weeding sessions boosted soybeans and haricot beans production by 60%. It has a significant role in the socioeconomic circumstances of southwest Ethiopia; nevertheless, there is little and inadequate documentation regarding the agronomic practices of soybeans and haricot beans production in this area. Hence, recording and disseminating such crucial crop information can assist producers in gaining greater knowledge about agronomic practices. Therefore, this review advances our understanding of recommended agronomic practices for haricot bean and soybean production in southwestern Ethiopia's and will encourage more use of recommended agronomic practices.

Keywords

Pulse Crops, Haricot Beans, Soybeans, Nitrogen Fixation, Agronomic Practices

1. Introduction

Pulses are the crops which meet the major protein requirement of human beings. Average protein available in pulses is 20-30%. Pulses provide biologically fixed nitrogen directly and indirectly through manure-based nitrogen inputs that preserve soil productivity, legumes are essential for sustainable agriculture [22, 36]. Pulses increases the organic carbon content in soil which in turn increases the organic matter. According to Powell et al. [49], using legume crop residues as fodder has been proposed as a crucial technical option for enhancing the quality of livestock feed while guaranteeing farmers receive sufficient returns based on the dual use of legumes as a food or income crop and as a source of fodder. Pulses also multiplies microorganisms in the soil. Microorganisms will actively lives in soil and performs their

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daily activities which makes soil loose and fragile, improves water holding capacity, nutrient holding capacity and nutrient use efficiency of crops.

In Ethiopia, pulse crops rank second as food after cereals and occupy about 15.2% of the total cultivated areas and contribute about 11.9% of the total production [12]. Due to improper recommended agronomic practices yields of pulses are reducing drastically which leads to reduction of per capital availability of pulses. To increase the productivity of pulses use of improved and high yielding varieties, fertilization, irrigation and crop protection remain are more likely to combat the challenge. Haricot bean and soybean are the major pulses growing in Southwestern Ethiopia contributing 53,221.10 ha of area under pulses [12]. Haricot bean and soybean are the two main lowland food legume crops and predominantly grown in the warmer and low land parts of the country [10, 29, 47].

According to Hailu and Kelemu, [27], a ten year (2002 to 2012) soybean data showed that the land coverage and total production increased by 10 and 21 fold, respectively; with average productivity of 1.06 ton/ha. However, the amount of land allotted for the production of soybean is very low compared to land allocated for other oil crops ([27]. It is one of pre-eminent crops in providing cheap protein (40%) and oil (20%) which determines the economic worth of the crop on the globe [43]. Soybean is known for its wide adaptability coupled with its higher productivity per unit area than other grain legumes. Soybean grows in altitudes ranging from 1250-2200 m.a.s.l but performs well between 1300-1700 m.a.s.l. and can also be grown in an area receiving 450 to 1500 mm annual rainfall [26]. In southwestern part of Ethiopia has huge potential for soybean production although the current production status is not comparable to the existing potential [41]. This might be due to improper recommended agronomic practices.

In Ethiopia, haricot beans are grown extensively in low and mid-altitude regions and are produced in nearly all regional states to varied degrees. Additionally, some regions with elevations as low as 500 m and as high as 1900 m a.s.l. that receive evenly distributed average rainfall of 500 to 1500 mm during the growing season are favorable for the crop [42]. Additionally, farmers favored it since it matured faster than any other crop for human use, provided fresh monetary flow for the local market, and could be interplant with maize.

Haricot beans and soybean are an important crop in southwestern Ethiopia, although poor productivity and production are partly caused by farmers employing agronomic techniques that are not advised. Thus, by employing these advanced agronomic techniques, farmers in southwest Ethiopia may greatly increase the yield and profitability of their pulse crops, improving the region's food security and standard of living [19].

In Southwestern Ethiopia, where maize is the major staple food crop, and grown in mono crop condition, the importance of soybean and haricot beans for crop rotation is paramount. This is mainly because of the fact that mono crop system causes depleted soil fertility, and unbalanced diet to the maize feeders over time [40]. The pulses are generally grown in rotation with cereals to break cereal disease cycles and to fix atmospheric nitrogen, thus reducing the demand of other cereal crops for nitrogen fertilizers. Therefore, the objective of this paper is to review recommended agronomic practices for major low and midlands pulses crop in Southwestern Ethiopia.

2. Literature Review

2.1. Haricot Beans

Haricot bean is the main cash crop and the least expensive protein source for farmers in many of the lowlands and midlands of Ethiopia. It is also exported to earn foreign exchange [9, 20, 48]. The crop is grown either as a sole crop and/or intercropped with either cereal or perennial crops [33]. Almost all haricot beans were produced by smallholder farmers. The average farm size for smallholder farmers is between 0.25 to 0.5 hectare. Haricot bean is the most widely cultivated in Ethiopia which covered 18.6% of land with 17.3% of grain production from pulse crops produced in 2021 [12]. In Ethiopia, haricot bean covered about 339,350.34 hectares of land and 584,157.99 tons of grain was produced per annum in 2022 with average productivity of 1.72 tons per hectare [13]. As the demand of haricot bean production is increasing in alarming rate, the area of production increasing from 280,834.99 ha in 2020 to 339,350.34 ha in 2022 [13]. According to the 2014/15 agricultural sample survey result, Oromia took the lion share (51%) of haricot bean production in the country, followed by SNNPR (27%), Amhara (20%) Benishangul-Gumuz 1.4% and the other regions contributing rest to the country total production [7]. Despite of the production area of haricot bean has been steadily expanding, the demand increasing and agronomic constraints contribute to the low national productivity of the crop, which is nearly 1.7 t ha^{-1} [13]. Hence, there are an experience from experimental plots indicates that 2.5-3.0 tones per hectare can be obtained [17]. This might be due to use of appropriate technologies (fertilizer, improved seed, and herbicide) with the recommended rate and time. The national agricultural research system has generated a number of improved agricultural technologies and recommendations such as crop variety, agronomic practices, crop protection measures as well as other technical advices and practices.

Ethiopia grows a variety of haricot bean types, such as black, white, red, and mottled variants [18]. Pure red and pure white bean cultivars are the most often farmed and are becoming the most popular due to rising market demand [20]. The Ethiopian Institute of Agricultural Research [18] has created a number of high-yielding, multi-disease resistant bean varieties to help the expansion of the domestic and export bean markets [2]. In order to serve the commercial sector, this genetic enhancement initiative has concentrated on pure red and white beans [2]. Red Melka, a medium-sized red bean with a mottled appearance; Red Wolaita, a medium-sized pure light red bean; and Nasser, a little pure dark red bean, are the most popular and widely recognized red bean varieties [20]. According to Merga [31], the Nasir and Goberesha varieties often fared better in southwest Ethiopia. Haricot beans are very significant crops that are primarily planted in house yards, especially on fences, as an intercropping with maize and climbers.

The haricot bean is one of Ethiopia's most important pulse crops in terms of commerce. Its average yield, as reported at the national level, is still significantly less than what could be produced. This is caused in part by poor management of soil fertility, improper agronomic packages, pest and disease issues, and a dearth of improved cultivars. The use of improved bean varieties that are suited to the local conditions, appropriate seed selection and planting rates, fertilizer application particularly phosphorus intercropping with other crops, irrigation management when available, and pest and disease control are all important agronomic practices for haricot bean cultivation in Ethiopia. These practices are all done while taking into account the average land size and resource availability of smallholder farmers in the area.

2.1.1. Land Preparation

The ideal soil conditions for haricot beans include well-drained soil with a pH between 6.5 and 7.5, and sufficient water and phosphorus, just fine enough to allow the seed to come into contact with the soil. Before seeding, the land should be thoroughly ploughed three to four times, increasing yield up to 2.5-3.0 tons/ha [32, 38].

2.1.2. Sowing Date

Sowing at the appropriate time is vital. It's crucial to plant when the earth is still moist. Timely sowing, which costs the farmer little or nothing, is the cheapest and most effective step towards ensuring satisfactory haricot bean yields. When beans are sown too early, they are impacted by ongoing rainfall. Once seeds are fully grown, they may start to sprout inside their pods if the rain persists. Rainfall is reduced when seeds are sown too late. Sowing should be done 2-5 cm deep in moist soil. In the midland regions of southwest Ethiopia, haricot beans are typically sown from early July until the end of July, increasing production by 2.5–3.0 tons/ha [32, 38]. This suggestion had been as proved on trial plots.

2.1.3. Plant Density

The final plant population density is determined by the seed rate for a given crop, which should take into account the germination percentage and its establishment potential. The seed rate is dependent on the number of plants to be grown in one hectare. Farmers will either choose less or more than the recommended seed rate, which is a crucial production factor that ultimately determines the yield of crop per unit area. In the Nitsols Jimma area, haricot bean cultivars were primarily planted; production was boosted by using an ideal seed rate of 60–80 kg/ha [38]. The experiment conducted in south western Ethiopia indicated that optimum plant density varied from 200,000 plants ha^{-1} to 250,000 plants ha^{-1} [38]. However, Muhidin et al. [5] concluded based on their research results that the intra and inter row spacing 30*10cm or equivalent (333,333) plants ha^{-1} taken as optimal for study areas and similar agroecology.

2.1.4. Fertilizer Rate

The limited use of chemical fertilizers on legumes is due to the lack of awareness of the benefits of fertilizer for pulses, as well as the limited access to credit and a lack of imported phosphate fertilizers. The groups haricot bean exhibit morphological and physiological variation, and also revealed different requirements for nitrogen and phosphates. The amount of fertilizer to be applied depends mainly on haricot bean yield and the fertility level of the soil as determined by soil tests. In the experiment conducted at Jimma, south western Ethiopia, the result indicated that the application of 46/23 NP fertilizer rate on haricot bean responded to higher nitrogen and lower phosphate rate and thus 46/23 kg/ha N/P2O5 appeared optimum [39]. Additionally, a field experiment conducted at the effects of NP fertilizer and plant density on haricot beans was conducted in the Jimma Zone for three consecutive main cropping seasons from 2018 to 2020. The results showed that, depending on the soil fertility, 46 kg/ha N and 46 P_2O_5 kg/ha should be applied for production [32]. In most cases, applying 46 kg/ha N and 46 P2O5 kg/ha in south-western Ethiopia greatly enhanced haricot bean yield by 70% [32, 38]. The whole NPS is applied at the time of sowing and Urea should be applied in split i.e. 1/2 at the time of sowing, 1/2 after seedling emergence 25-30 days [32].

2.1.5. Cropping System

In cereals producing districts of Jimma area where red soils (nitisols) predominate, the fertility has reached near state of complete depletion, that has been believed to be consequence of long years continuous farming and cropping intensitie [4]. Continuous farming forces a decline in the physical characteristics and organic matter of the soil. However, fallow periods has been the mainstay for increasing soil fertility in crop production, while nowadays contrasting effect of higher population pressures led to shortages of land and aggravated mono cropping of maize and cereals. In these areas it has been noticed that legumes inclusions in crop rotation has been rarely practiced [37]. Eventually, there may be alternatives in agriculture to upgrade soil fertility status, including crop rotation, intercropping and composting. Cereal and legume crop rotation improves soil fertility and yield, lowers disease rates, and controls pests and weeds. Crop rotation is the most popular and traditional agronomic technique for maintaining the water and nutrient balance, preventing disease, managing weeds, insects, and pests, and boosting crop yield [3].

The intercropping strategy boosts yield and makes adequate use of resources [34]. Higher productivity per unit area and production stability are two benefits of intercropping. The results of an experiment on maize and haricot bean intercropping at Jimma showed that higher land equivalent proportion (LER) for row intercropping had a 36% advantage over sole cropping at Jimma [44]. Tesfa [38] and Sisay et al [23] concluded based on his research results that maize and common bean intercropping in south-western Ethiopia, 1:2 maize to common bean ratios intercropping cropping increased 50% more nitrogen in the soil, while intercropping crops with common beans offered 40% more benefits than sole cropping.

2.1.6. Weed Control

Weeds cause significant yield and quality loss in haricot bean. It suffer significant losses ranging from 58 to 98% when they become infested with a variety of weeds and subjected to intense weed competition because they are a weak competitor to weeds [1, 15, 30]. For haricot bean production to be both profitable and sustainable, weed control is crucial. To boost haricot bean growers' competitiveness in local and international markets, broad range, efficient weed control techniques must be consistently found. Based on his research findings, Tesfa [38] concluded that twice hand weeding sessions boosted haricot bean production by 60%. Hand weeding is better than herbicide, according to this scholar.

2.2. Soybean

Soybean (*Glycine max. L.*) is one of the most important and widely grown legume crops worldwide due to its multipurpose use particularly in the animal feed industries and human nutrition. Its high quality protein and balanced amino acid profile in ration formulation and human diets are the driving forces of soybean production [35]. Ethiopia is producing more soybeans than ever before in order to satisfy the country's growing food and market demands. Additionally, for Ethiopia's various agro-ecological zones, certain soybean varieties that fall into three maturity groups early, medium, and late maturing varieties are recommended [45]. It is a multipurpose crop that can be used for a number of things, such as making various soybean foods, animal feed, soy milk, and raw materials for the processing industry. It also helps to increase soil fertility by counteracting the depletion of plant nutrients caused by the ongoing monoculture of cereals, particularly maize and sorghum [25].

One of the key subsectors now receiving help from governmental and nongovernmental organizations is soybeans. Ethiopia has several locations where soybeans can be produced, most notably in the western and southwestern regions (Benishangul Gumuz, Gambela, and portions of the Oromia area). These regions offer an abundance of rich land and an agro climatic environment that is ideal for soybean cultivation. In Ethiopia records obtained from 2019 data indicated that area production and yield of soybean from 64,720.12 ha of land was 149,454.6 tones with national average yield of 2.309 tons ha^{-1} [11]. The demand of soybean is increasing from time to time. Currently soybean is one of the focus subsectors supported by government and nongovernmental organization. Soybean can be grown in different parts of Ethiopia notably in the western and south western parts of the country (Benishangul Gumuz, Gambela and parts of Oromia region). These areas have vast fertile land and a favorable agro- climate suited to growing soybean.

Soybean production in Ethiopia has increased in recent years, but the country's average productivity is still lower than the global average. The main reasons for low productivity is the farmers use non recommended agronomic practices. Soybeans are grown in a variety of agro-ecologies, especially in low to mid altitude areas with moderate annual rainfall. Agronomic research on soybeans has thus far been recommended cropping density, cropping pattern, cropping system, nutrient management etc have significantly contributed to the crop systems.

2.2.1. Land Preparation

Land preparation for soybeans involves selecting a suitable site, clearing vegetation, and preparing the soil for planting. Soybeans seed needs soils that are moist, well aerated, Loamy, loose soils that drain well are best. To maximize soybean yields, farmers need to pay close attention to field drainage. Well-drained soil is essential as it enhances soybean yields. Loose, aerated soil facilitates air reaching the roots and nitrogen-fixing nodules, increases water-holding capacity, and ultimately reduces erosion [14]. In study conducted at Jimma research center to evaluate the effect of plowing on the grain yield soybeans, three to four times gave highest yield 7-8 tons/ha [38].

2.2.2. Planting Date

Since it's difficult to predict the weather, it's also difficult to predict when to plant soybeans. Still, researchers suggest planting full-season soybeans as early as possible in your given area and season. Soybeans planted extremely early have not shown consistent yield gains to offset the risk of cool-weather diseases that may occur in cold, damp soils and frost that may occur after leaf emergence. Delays in planting may result in fewer pods per acre. According to research at the Jimma Research Center, soybeans with better yields can be harvested between the second weeks of June to end of June, with yields reaching 2.5 to 3.5 tons/ha [38]. This argument supported by Eshetu et al. [46] on evaluation of soybean varieties and plant density at Karsa and Omonada Woredas for three cropping seasons.

2.2.3. Plant Density

The ideal plant population density for various locations should be determined because plant density plays a significant role in soybean yield. This is because different areas have varying potentials for soybean growth, with some areas being able to support high plant densities without sacrificing yield. Since a high plant density depletes soil moisture and nutrients before crop maturity and a low plant density leaves nutrients unused, determining an ideal plant density is crucial to achieving a maximum yield [8]. In study conducted at Jimma research center to evaluate the effect of effect of plant density on the grain yield soybeans, 200,000 to 250,000 plants/ha gave highest yield 2.5-3.0 tons/ha [38]. Eshetu et al.'s [46] evaluation of the effect of soy bean varieties and plant density in Karsa and Omonada Woredas yielded a maximum yield of 3.7 tons/ha, which is in contrast to this previous recommendation. It is economically possible and increases grain yield to utilize the Clark-63k or Nyala varieties with a plant density of 666,667 plants ha-1 (30 *5 cm) for soybean cultivation in the southwestern Ethiopia. Additionally, the optimum seed rate of soybean, 80-100 kg/ha based on seed size, moisture available, soil fertility status and other factors [46].

2.2.4. Fertilizer Rate

In certain agro ecologies, farmers usually do not use nitrogen fertilizers when growing soybeans. This is a result of soybeans' ability to fix atmospheric nitrogen. However, the southwestern region of Ethiopia has substantial nitrogen leaching due to excessive rainfall. Therefore, soybeans do not have enough atmospheric nitrogen in their soil, or a tiny amount of starter-nitrogen fertilizer (20 kg) may not increase crop productivity and nodulation. Soybean responds to nitrogen and phosphorus in complex ways, including changes in growth, root architecture, and nitrogen fixation at different agroecology. Hence, soybean production and soil fertility as assessed by soil testing are the primary determinants of fertilizer application amount. The whole NPS is applied at the time of sowing and Urea should be applied in split i. e. 1/2 at the time of sowing, 1/2 after seedling emergence 25-30 days. In the experiment conducted at Jimma, south western Ethiopia, the result indicated that the application of 46/46 NP fertilizer rate significantly increased soybean yield by 50-100% [24, 38]. Seed treatment with the Rhizobium strain will increase the Nitrogen fixing ability of the plant and thereby yield will be enhanced by 20-30% [38].

2.2.5. Cropping System

Soybean can be grown using a variety of cropping systems, including monoculture, multi-canopy, intercropping, and rotation. These systems can help improve yield and crop health, and reduce the need for synthetic fertilizers. Research has shown that intercropping generally yields higher yields than mono cropping [21]. Using light energy and other growth resources effectively could be one way to do this. As plant population density increases and crops are cultivated under intercropping, land resource use optimization may also be accomplished. In crop production, intercropping may have benefits for resource efficiency, reduced input costs, and enhanced sustainability [16]. In an earlier experiment at the Jimma Agriculture Research Center, it was shown that intercropping maize and soybeans at a 1:2 ratio could result in lower grain yields for both crops but higher income per unit area [28]. Soybean rotation is a farming practice that alternates the growth of soybeans with other crops, such as corn or wheat. This practice can improve soil health, reduce pest and disease pressure, and increase yields [3]. It also soybeans can pull nitrogen from the air and store it in their roots, which can help replenish the soil for corn and other cereals crops. In the experiment conducted at Jimma, south western Ethiopia, the result indicated that soy bean rotating and intercropping with maize reduced fertilizer cost by 40-60% [38]. It also the results confirmed maize rotated with soybean on farmers' fields gave up to a 46% grain yield advantage, and further it was found that soybean contributed 46 kg N ha^{-1} to succeeding maize, and thus, it could offset the cost of 46 kg N ha^{-1} (reduce maize fertilizer requirement by 50%) from commercial urea for smallholder farmers [6].

2.2.6. Weed Control

Initially pulses cannot compete with weeds because of their inherent slow growth rate. So weed infestation will be higher during initial stages. Depending upon the duration of the crop, the critical period for weed competition in the pulses varies from 20-45 DAS. Using an integrated weed management program that incorporates crop rotation, herbicides, and cultural approaches can help control soybean weeds. Since soybean is sown in rows, bullock drawn harrows can be used for controlling the weeds. Two inter cultivations, first at 20-30 DAS and the second around 45 DAS along with manual weeding can maintain the soybean field weed free for economic yield. Based on his research findings, Tesfa [38] and Muhidin et al [32] concluded that twice hand weeding sessions boosted soybean productivity by 60%. Hand weeding is better than herbicide, according to this scholar.

2.2.7. Diseases and Insects Pests Soybean

Pulses are generally susceptible to a wide range of diseases and insect pests that cause large losses. Crop rotation, plant spacing, and other agronomic techniques can be used to control soybean diseases and pests. Rotate soybeans with other crops to minimize the accumulation of pests and pathogens. Plant spacing: Provide sufficient plant spacing and plant in narrow rows to promote biological control. For yield stability and wider adaptability of phenotype, it is essential to select varieties with multiple resistance to major diseases and insect pest are identified.

2.2.8. Harvesting

Harvesting is done when plant reaches 90% maturity either by uprooting the entire plant or cutting the entire plant at ground level for the varieties with synchronous maturity. Harvested produce should be sun dried on threshing floor and threshed by trampling either by animals or tractor and winnowed. If the varieties does not have synchronous maturity pods have to be harvested manually.

3. Conclusion

Based on the review above, I came to the conclusion that agronomic practices played an equal role in genotype potential of major pulse crops in the low and midland environment of southwestern Ethiopia. To increase the production and productivity of pulses crops farmers maintain and strengthen the development of new, well-adapted crop cultivars with high yield potential and the genetic capacity to withstand major biotic and abiotic stresses, proper planting dates, using appropriate fertilization strategies, using appropriate plant density, using integrated pest management (IPM) to control pests and diseases, encouraging crop rotations and intercropping systems that capitalize on the benefits of diverse crops in this climate change issue. All of these agronomic practices technology boost productivity and efficiency while taking into account the unique requirements of the primary pulses grown in the area, such as soybean and haricot beans. Poor agronomic practices are among the major constraints limiting the production and productivity of this crop. Proper land preparation, sowing date, seed rate, weeding, and diseases and pests control are important agronomic variables that help to optimize soybean and haricot beans crops production and productivity. Proper planning and management of resources, focusing agricultural investment on the small holders, creating favorable linkages between farmers, governments, researchers and other agents of agriculture.

Abbreviations

LER	Land Equivalent Ration
DAS	Days After Sowing
IPM	Integrated Pest Management

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Conflicts of Interest

The author declares no conflicts of interest.

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