

Production Status, Adoption of Improved Common Bean (*Phaseolus vulgaris* L.) Varieties and Associated Agronomic Practices in Ethiopia

Review Article

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Abstract

Common bean (*Phaseolus vulgaris* L.) is one of the most important food legumes of Ethiopia and it is considered as the main cash crop and the least expensive source of protein for the farmers in many lowlands and mid altitude of the country. Low production and productivity, which are mainly associated with poor adoption of improved technologies, poor agronomic practice and poor marketing system, was among the major problems. Adoption of improved technologies is one of the most promising ways to reduce food insecurity in Ethiopia. However, the adoption and dissemination of these technologies is constrained by various factors. To this end the aim of this paper was to review adoption of improved common bean varieties and associated agronomic practices in Ethiopia. Various authors indicated that household head's attitude towards common bean production technology package, participation in extension event (participation in training and field visit) and access to credit were important variables which had positively and significantly influenced adoption and intensity of adoption of improved common bean production package. Whereas, perceived relative is advantage of technology attributes of the household head had shown negative relationship with adoption and intensity of adoption. Some farmers who previously adopted improved common bean varieties have discontinued planting the varieties mainly due to market problem and poor management practice. The overall finding of this review underlined the high importance of institutional support; credit and market to enhance adoption of improved common bean production package. Therefore, policy and development interventions should give emphasis to improvement of such institutional support system so as to achieve wider adoption, good management practice increased productivity and income to small scale farmers.

Keywords: Adoption; Agronomic practice; Haricot bean; Varieties

Introduction

Common bean (*Phaseolus vulgaris* L.) ($2n=2x=22$) belongs to the order Rosales, family Fabaceae, subfamily Papilionoideae, tribe Phaseoleae [1]. Among the pulse crops, common bean is the second in area of production in the country [2]. The total production, household consumption and sale of common bean in 2014/2015 cropping season in Ethiopia were 343, 448 tons, 67% and 20%, respectively [2]. High

in nutrients and commercial potential, common bean holds great promise for fighting hunger, increasing income and improving soil fertility in Sub Saharan Africa. It is an important source of protein, source of cash, and emergency crop.

Common bean is a major grain legume consumed worldwide for its edible seeds and pods. In Ethiopia, it is one of the most important cash crops and source of protein in many lowlands and mid land area

areas. It is high in starch, dietary fiber and is an excellent source of potassium, selenium, molybdenum, thiamine, vitamin B6 and folic acid [3]. It is used as food in different form the green unripe pods are cooked or conserved as vegetable and the ripe seeds cooked for “*nifro*” or boiled with mixed with sorghum or maize and can be consumed as “*woti*” using powder form [4]. More than 85% of the Ethiopian population, which resides in the rural area, is engaged in agricultural production as a major means of livelihood [5]. The agricultural production system is mainly rain fed and traditional, which is characterized by low input of improved seeds, fertilizer, pesticides and other technologies [6]. Moreover, the ever increasing population pressure led to decline in land holding per household that eventually resulted in low level of production to meet even the consumption requirement of the households [7].

Increasing agricultural production at the household level is vital to achieve food security [8]. As one of the approaches to ensure households food security, the Ethiopian rural development policy and strategy document has given weight to follow diversification and specializations in production systems along with improved access and use of agricultural technologies [9]. In general, raising agricultural output and productivity on a sustainable basis necessitates large scale adoption and diffusion of new technologies [10].

The national average yield of common beans is low ranging from 1.6 tone ha⁻¹, which is far below the corresponding yield recorded at research sites (2.5-3 tones ha⁻¹) using improved varieties [2]. This could be attributed to various constraints related to low adoption of improved agricultural technologies, drought and poor cultural practices, disease and environmental degradation [6]. In essence of things, the generation and transfer of technologies is not an end in itself. Therefore, increasing productivity and production of common bean will be realized if and only if the farmers adopt the technologies that are developed by research. So the objective of this paper is to review adoption of improved common bean varieties in Ethiopia.

Common bean production

Almost all haricot beans were produced by smallholder farmers [2]. The average farm size for smallholder farmers is between 0.25-0.5 hectares. There is a wide range of common bean types grown in Ethiopia including mottled, red, white and black varieties [11]. The most commercial varieties are pure red and pure white colored beans and these are becoming the most commonly grown types with increasing market demand [12]. To support both the growth in domestic and export bean markets, Ethiopian Institute of Agricultural Research (EIAR, 2014) has developed a range of high yielding, multi-disease resistant bean varieties. The focus of this genetic improvement program has been on the pure red and white beans to support the commercial sector [13]. Within the red bean types, the most favored and most commercially accepted varieties include Red Melka, a mottled medium sized red; Red Wolayita, a medium sized pure light red; and Nasser, a small pure dark red variety [12]. Among the country pulse crops common bean is the second both cultivated area and in volume of production accounting 21% and 19% respectively [2].

Productivity

Common beans productivity depends on good weather

condition and 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. The technologies promoted include improved varieties, recommended fertilizer rates and types, improved agronomic and weed control practices. The average common bean productivity was about 1.6 tons ha⁻¹ [2]. However, the experience from experimental plots indicates that 2.5-3.0 tons ha⁻¹ can be obtained (EIAR, 2014).

Economic importance of common bean in Ethiopia

Common bean is one of the most important cash crops and source of protein for farmers in many lowlands and mid-altitude. The country's export earnings is estimated to be over 85% of export earnings from pulses, exceeding that of other pulses such as lentils, horse (faba) bean and chickpea [14]. According to FAOSTAT, (2010) report overall, common bean ranks third as an export commodity in Ethiopia, contributing about 9.5% of total export value from agriculture. Gabre-Madhin reported that common bean is also highly preferred by Ethiopian farmers because of its fast maturing characteristics that enables households to get cash income required to purchase food and other household needs when other crops have not yet matured [15]. Ethiopia has a geographic comparative advantage over other competitive countries. It takes nine weeks for sea shipments of beans from China to reach EU markets, whereas it only takes three weeks from Ethiopia [12]. ERCA report shows that common bean exports increased in total value from 19 million \$ in 2005 to 134 million \$ in 2014, quantity of 43 thousand MT in 2005 to 171 thousand MT in 2014, exhibiting a growth of more than threefold [16].

Overview of technology adoption

Varietal adaptation under the Ethiopian Institute of Agricultural Research (EIAR) and Regional Agricultural Institutes (RARIs) with the support from the International Center of Tropical Agriculture (CIAT) under the umbrella of the Pan Africa Bean Research Alliance (PABRA) resulted into higher yielding improved common bean varieties that are potentially suitable for a range of ecologies (from lowlands to highlands). These improved varieties were also highly appreciated by consumers and market but farmers continued to grow low yielding old varieties instead [17]. The analysis of constraints hindering use of improved varieties with stakeholders revealed that the main constraint to adoption of bean improved varieties was associated with limited accessibility to seed [18].

In 2004, the Ethiopian National Bean Research Program (ENBRP) with technical support from the International Center for Tropical Agriculture (CIAT) under the PABRA frame work initiated a partnership with a broader range of organizations from government, non-governmental and farmers' organizations and individual farmers aiming to overcome these seed bottlenecks. The intervention encompassed both the production and distribution of seeds and enhancing the skills and knowledge of service providers to backstop a growing seed supply sector. As a result of the intervention, a longer-lasting partnership on bean technology transfer was developed among the participating agencies (including bean exporters and

traders), and farmers in impressive numbers have gained access to new bean varieties [18].

Rubyogo, et al. reported that to sustain the productivity and keep the momentum will depend on the availability and accessibility of demand driven research products through a combination of service providers from private sector and producer organizations such Farmer Cooperative Unions. This arrangement should be supported by small holder farm centered extension services and continuous bean market development (market infrastructure development, identification of new emerging markets). Therefore, more involvement of reliable private sector in the production of basic seeds will improve on seed availability and accessibility to sustain the momentum as the demand increases. This will ease the burden on research institutes. Furthermore, diversified sources of other agricultural inputs such as fertilizers will bring efficiency and expand the use of these inputs to more farmers.

Farmers are sometimes unable to adopt an innovation, even though they have mentally accepted it, because of economic and situational constraints [19]. According to Alemitu, et al. [20], there is variation among the grower households in the level of adoption. Variation in adoption among the sample households was assessed in view of various factors categorized as household personal and demographic, economic and institutional. The rate of adoption is defined as the percentage of farmers who have adopted a given technology. Most of the variables assumed to influence the adoption behavior were significantly associated with the adoption and intensity of adoption of improved common bean production [20]. On the other hand, the intensity of adoption is defined as the level of adoption of a given technological package. Put it in a different way, the number of hectares planted with improved seed also tested as (the percentage of each farm planted to improved seed) or the amount of input applied per hectare represent the intensity of adoption of the respective technologies [21]. According to Augustine, et al. [22], the importance of adoption study is to quantify the number of technology users over time and to assess impacts or determine extension requirements that would help us in monitoring and feedback in technology generation. It also provides further insights into the effectiveness of technology transfer.

Seeding rate

Ethiopian farmers, in general, use lower seed rate than research recommendations which result in lower grain yields [13]. The seed yield of bean is the result of many plant growth processes which ultimately influence the yield components such as pods/plant, seeds/pod and unit weight of seed. The highest seed yields were obtained when all the above got maximized [23]. The spatial distribution of plants in a crop community is an important determinant of yield and many experiments have been conducted to determine the spacing between rows and between plants that maximizes yield [24]. Two general concepts are frequently used to explain the relationship between spacing, plant density, and yield. First, maximum yield could be only if the plant community produced enough leaf area to provide maximum light interception during reproductive growth [23]. Secondly, equidistant spacing between plants affected interplant competition [25]. Hence, it will be very important to adjust the spatial distribution of the recommended population in order to have maximum yield.

Use of fertilizer on common bean production

Application of fertilizer in a recommended amount is essential for high yield and quality of grains [26]. The use of fertilizer is considered to be one of the most important factors to increase crop yield per unit area basis, however the response to the type of fertilizer and rate of application vary widely with location, climate and soil type [27]. Nitrogen deficiency occurs almost everywhere unless Nitrogen is applied as a fertilizer or manure [28]. It has been reported that there was increased yield responses of pulse for nitrogen fertilizer [26].

Phosphorus is classified as a major nutrient, meaning that it is required by crops in relatively large amounts. Generally, P is vital to plant growth and is found in every living plant cell. Phosphorus is the second most critical plant nutrient over all, but for legumes it assumes primary importance [29]. Plants need phosphorus for growth throughout their life cycle, especially during the early stages of growth and development. The primary role of phosphorus compounds in plants is to store and transfer energy produced by photosynthesis to be used for growth and reproduction [30]. On the other hand, Lambers, et al. pointed out that [31], phosphorus is required in large quantities in young cells particularly shoots tips where metabolism is high and cell division is rapid. Tesfaye, et al. also indicated that number of primary branch increased in acid soil as application of P increased [32]. Sufficient phosphorus is also required to enhance plant growth, promote nodulation, early maturity and grain formation in legumes [33]. Apart from growth, Gangasuresh, et al. noted that phosphorus is a crucial element in legume crop production which plays an important role for many characteristics such as sugar and starch utilization [34], photosynthesis, cell division and organization and nodule formation [35]. Beside, farmers resist using fertilizer for production of common bean because application of fertilizer is not cost effective as cost benefit analysis. Because, most farmers consider common bean have capacity to improve soil fertility; some of them think it as minor crops [20].

Weed control practices

Weeds are major constraints in pulse production in Ethiopia, particularly in the low lands, where competition between crops and weeds is high due to the prevalent problem of moisture stress [13]. Common bean, being a weak competitor to weeds, gets infested with a variety of weeds and subjected to heavy weed competition, which often inflicts huge losses ranging from 58 to 98% [36]. Weeds also interfere with harvest operations and may stain common bean, resulting in reduced market value [37]. Therefore, weed management is very important for profitable and sustainable common bean production.

Proper weed controls crucial to ensure optimum crop performance but in pulse either the operation is not done at all or employed too late to provide any benefit to the crop [38]. In common bean production 2-3 times weeding is necessary for getting good yield. The first weeding is done after two weeks of the plant emergence and the second is 21-25 days after emergence [39]. Abdel latif reported that the integrated use of herbicides with hand weeding might have helped in producing more vigorous leaves under low weed infestation that improved the photosynthetic efficiency of the faba bean (*Vicia faba* L.) and supported a large number of pods [40]. Similarly, Amoabeng, et al. showed more

Pods with integrated use of herbicides with hand weeding in soybean than herbicides application alone [41]. Likewise, Peer, et al. also reported that fluchloralin and pendimethalin at lower rates (1.0 kg ha⁻¹ each) in combination with hand weeding resulted in higher number of pods plant⁻¹ which was at par with weed-free in soybean [42].

Pest control practices

Insect pest constitute a major constraints to sustainable production of common bean. The key pests in food legume crops in Ethiopia are aphids and bean stem maggot [41]. The bean stem maggot and bean bruchids are the most important pest of common bean in the field and in storage respectively [43]. According to common bean production manual 2003, control measure for pests are, intercropping and dressing the seed with 25gm premirrol methyl for 10kg seed of haricot bean.

Disease control practice

Fungal and bacterial diseases are among the main production constraints in the major bean growing areas of the country [44]. The effect of diseases may be restricted to certain production systems, locations and cropping seasons [45]. Among the listed disease of beans in Ethiopia, common bacterial blight, rust, anthracnose and angular leaf spot are economically important [44]. Using disease resistance varieties, clean seed and intercropping are some of the control measure for common bean diseases [46].

Harvesting

Timely harvest is important to reduce mold, bird and insect damage and also to decrease losses due to shattering [13]. Crops may be harvested when they are physiologically mature. Common bean is harvested when the foliage of the crop is turned to yellow and before starting shattering to reduce yield loss 40% [39].

Conclusion

In conclusion, the review pointed out that adoption of common bean varieties are one of serious problems on production and productivity of beans. And agronomic practices are also main problems on adoption of common bean production.

Recommendation

Amongst the factors affecting adoption of improved Common beans varieties, low extension service and also lack of financial capacity of farmers to apply the necessary inputs as recommended. Improved common bean production involves the use of different practices which require knowledge and skill of application and management. Extension service on improved common bean production was found to have a strong relation with adoption of improved common bean production package as it enhances ability to acquire and use information required for production.

Therefore, extension service provision has to be strengthened so as to improve farmers' access to information and extension advices. Moreover, improving credit access to farmers within these localities is also paramount. In addition to that Use of proper seed rates, recommended fertilizer, pest control, disease control, weed control and proper harvest and post-harvest handling are also in considerations.

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