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Review on Adoption of Improved Soya Bean Technologies: Empirical Evidence from Ethiopia

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Abstract
Soybean is a legume crop grown in the tropical, subtropical, and temperate climates which are used for food and animal feed. However, the production and productivity of soybean is low and improvement in production and productivity depends on the extent to which a household has applied the recommended production technologies. The review was aimed to identify the determinants of adoption and intensity of improved soybean varieties to generate information that helps to understand and evaluate the key challenges in Ethiopia. The review showed that sex of household, age of household head, education, farm experience, participation in training, and extension service affect the adoption of improved soya bean varieties positively and significantly while the distance to the nearest market affects adoption of improved soya bean varieties negatively and significantly. On the other hand, the intensity of adoption was affected by age, soya bean farm experience, participation in training, and size of livestock holding. Most of the studies reviewed in this paper indicated that sex has a significant positive impact on the adoption of improved soya bean varieties. However, the participation of female households in the adoption process indicated that 15% of female-headed households and dominated by 85% of male household heads. Therefore, to improve the adoption of modern agricultural technologies like improved soya beans the following recommendations are forwarded. Female-headed households should get emphasis in all activities of the promotion of new technologies. On the other hand, evidences showed that the huge oil factories in Ethiopia like W. A and BK are using soya bean as a major input to their production. Consequently, those industries demanding a higher amount of soya bean as an input and they are creating a backward linkage to smallholder soya bean producer farmers. For instance, W.A's edible oil factory alone needs 20,000 hectares of land to run the business and 500,000 quintals of soya bean requires per year. Therefore, it can improve smallholder farmers' livelihood by creating market opportunities to supply their products directly to factories. Thus, the promotion of new soya bean varieties, strong linkage between farmers and factories and comprehensive studies on the adoption and impact of soya bean should get attention from the regional and federal government of Ethiopia.
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1. INTRODUCTION

The Ethiopian economy is dominated by the agricultural sector, which contributes significantly to the GDP, employment, and foreign exchange revenues. It is still thought that this industry will continue to play a significant part in boosting the nation's overall economic growth throughout time. However, rain-fed, low input/poor yield subsistence farming dominates Ethiopian agriculture. Poor land management practices that have resulted in significant land degradation, limited access to agricultural inputs by smallholder farmers, financial services, improved production technology, irrigation, and agricultural markets are all factors that contribute to low agricultural productivity [1].

As a result of these facts, Ethiopian governments have prioritized encouraging technology-led initiatives on agricultural production to increase productivity, particularly in smallholder agriculture [13]. The government is currently working on a plan to raise agricultural production, particularly through agricultural intensification, which involves using more inputs, such as seeds from better crop kinds [16]. Growing crops for food and fiber is a common agricultural practice used by farmers in Ethiopia. Crop production is one of the agricultural sub-sectors that improve farmers' livelihoods through the use of improved inputs like improved crop varieties, fertilizer,

pesticides, etc. This method uses all the feed materials needed to grow and maintain crops.

When it comes to new high-value, lucrative, and versatile crops, soybeans fall under the category of pulse crops. They are used to make a variety of soy-based foods, animal feed, and raw materials for the processing sector [2]. It was brought to Ethiopia in the early 1950s, became one of the most important low-land crops, and was suited to low to medium agro ecologies, with smallholder farmers producing the majority of its output [15]. Production of this crop is vital in Ethiopia to overcome food insecurity and malnutrition the crop can substitute the relative expensive of animal protein.

The country's western and south-western regions, particularly Benishangul-Gumuz, Gambela, and portions of the Oromia Region, are currently the primary soybean-growing regions. The country's highest soy bean output is split between the Oromia and Benishangul-Gumuz areas at 51% and 40%, respectively [20]. However, in some potential soybean-producing regions, farmers' willingness to produce the crop has decreased, and production growth has stagnated as a result of low or nonexistent soybean demand for marketing and direct consumption, monopolistic soybean trade, high transaction costs for district market sales, inadequate infrastructure, and high transport costs. Additionally, the newly released enhanced high-yielding soybean varieties were not widely embraced by smallholder farmers, who instead chose local soybean types that lower productivity and production.

The factors that affect the acceptance and intensity of enhanced soybean varieties have been studied by several scientists. In order to produce information that aids in understanding and assessing the major difficulties in Ethiopia, this review sought to determine the factors that influence the acceptance and intensity of enhanced soybean varieties.

2. Research Method

This review was adopted reviewing of different journal articles as well as governmental organization annual reported at different times. In addition to this, some physical observation was taken from field day. As much as possible summarized and rewritten on the authors view and perspectives'

3. Literature Review

3.1. Soybean Product and Its Application

Providing oil and stable food with high nutritional value, soybeans are a significant crop on a global scale. Vegetable oil and compressed soy meal are produced mostly by solvent extraction of the crop. Only a small fraction of the crop is eaten by people. You can combine wheat flour and soybean meal-made flour. Additionally, it is employed in the production of ice cream and candies. You can also make soy milk, curds, and cheese from mature seeds. Soybean also contains a number of benefits for your health. It is thought to have an equal amount of protein as animal products. It is fantastic for a wide range of ailments, including high blood pressure, disorders linked to diabetes, and many more. It is excellent for enhancing the diet of undernourished children, energizing those with heart and breast cancer, and contains no cholesterol [10].

Over 60% of the world's total meal production—vegetable and animal meal is made up of soymeal, which also ranks highly among the protein feedstuffs used to make feed concentrates. With 25% of the world's use of vegetable/animal oils and fats, soybean oil ranks second in importance only to palm oil. Due to its consistent and reliable availability, affordable price, neutral flavor, and stability in both hybridized and partially hydrogenated forms, soybean oil is very widely used as food oil. Moreover, the rapid rise in the demand for compound feed has contributed considerably to the rise in soya oil production. Because soya meal is in high demand and soy oil is a very profitable byproduct, soybean's position is anticipated to be stable [2].

3.2. Present Demand and Supply of Soya bean

According to [9], there are about 22,190.76 hectares of land covered by smallholders and produced 548,052.95 quintals of soybean. The average national productivity of the crop is 24.70 quintals per hectare. At present, the use of soybean in Ethiopia is limited to baby foods production. These baby food-processing plants such as the Faffa food factory mainly cover their demand totally from imports, as there is no ample and sustainable supply of soybean required by the factories.

According to the Faffa food plant, it produces faffa baby food with 18% deflated soy flour, Dube with 13% soy protein, and Meten containing soy flour with 14% protein. This implies that about 15% of the factory's whole product is soy flour and this percentage share can be used to estimate the present annual demand for soy flour by the baby food-producing plants. In this connection, the report of [7], pointed out that about 16,550 tons of Fafa, Dube, Edget, and Meten have been produced in 2006/07 alone which, therefore, implies that about 2,483 tons of soy flour have been imported into the country in 2006/07 alone. This by itself indicates the presence of huge demand for the product.

Additionally, given the wide range of health benefits of soybean stated earlier, flour mill factories are likely to blend their products with soy flour if it is available domestically at an affordable price. This will increase the nutritional value of the milled flour thereby increasing the demand in the market. According to [8], about 173,991

tons of wheat and other flour has been produced in 2005/06 alone. Since the minimum requirement of soy flour being blended by flour mill plants in many developing countries is 3%, the potential demand by the flour mill plants in the country is estimated at 5,220 tons.

In general, based on the foregoing analysis, the present annual potential demand for soy flour is estimated to be about 7,703 ton, where 2,483 ton (32%) emanates from the baby food-producing plants while the remaining 5220 ton (68%) is the demand of flour milling plants. In general, the above presentation divulges that there is substantial potential demand for the product. As indicated by [8] the average per hectare yield of soybean in commercial farming is about 1.5ton per hectare. The current annual potential demand for the soybean in Ethiopia is estimated to be 7,703 tons. The level of demand will increase in the future as more and more families become aware of the diet and health advantages of the grain.

3.3. Production and Productivity Gaps of Soybean in Ethiopia

There are favorable climatic and soil conditions for soybean production in South and Western Ethiopia, which is essential both for subsistence farming as well as for commercial purposes. The problems of producing soybean are not only limited to market access but also low productivity and production, lack of processing facilities, lack of capital to increase production, and no market information system for effective agricultural marketing.

Soybean is a high-value and profitable crop. The economic viability of soy production is determined by the commercial utilization of its sub-products meal and oil respectively, which account for about two-thirds and one-third of the crop's economic value. Soy oil and meal are consumed worldwide as food and animal feedstuff respectively.

Figure 1: Soybean as Bread, Seed and Oil Respectively

Figure 2: Soybean Dabo Kollo and Bread with Wheat

Source: own source from Field day at Pawe district, Benishangul Gumuz Region

Soybean varieties selected for drought tolerance have the potential of improving agricultural productivity and hence livelihoods if adopted by farmers. Soybean grows in areas where maize and common beans are grown. It is drought tolerant and grows to a height of 60–120 cm, maturing in 3 to 6 months depending on variety, climate, and location. Depending on the variety, the crop can be grown from 0-2200m altitude and under rainfall ranging from 300 to 1200mm. Altitude influences temperature that in turn affects the initiation of flowering and maturity. At very high altitudes, flowering may not occur and the crop remains vegetative. Therefore, a crop that requires warm climates is suitable for low to medium altitudes. It grows best when planted in pure stands.

Table 1.Soybean production, productivity, and area coverage of Ethiopia (2012/13-2019/20)

Production Year	Area coverage (Hectare)	Total Production (Ton)	Productivity (Qt/ha)
2012/13	31,854.75	636,53.101	19.90
2013/14	30,517.38	61024.916	19.90
2014/15	35,259.76	72183.745	20.50
2015/16	38,166.04	81241.833	21.30
2016/17	36,635.79	81234.659	22.20
2017/18	37,078.70	864,678.69	22.71
2018/19	64,720.12	1,494,546.13	23.09
2019/20	54,543.26	1,256,232.03	23.03

Source: CSA of Ethiopia

Despite the importance of the crop and the efforts made to increase its production, the productivity of soybeans in farmers' fields was low, therefore, 19.9 to 23.03 quintals/hectare. According to the above table, Table 1, 1,494,546.13 tons of soybeans were produced from 64,720.12 hectares of land in the 2018/19 production period. This was the largest production recorded from 2012/13 to 2019/20. The average production is therefore 21.57875 quintals per hectare. The yield increased from 19.9 quintals per hectare in the 2012/13 production season to 23.03 quintals per hectare in 2019/20

Soybean Production, Yield and Areal Coverage

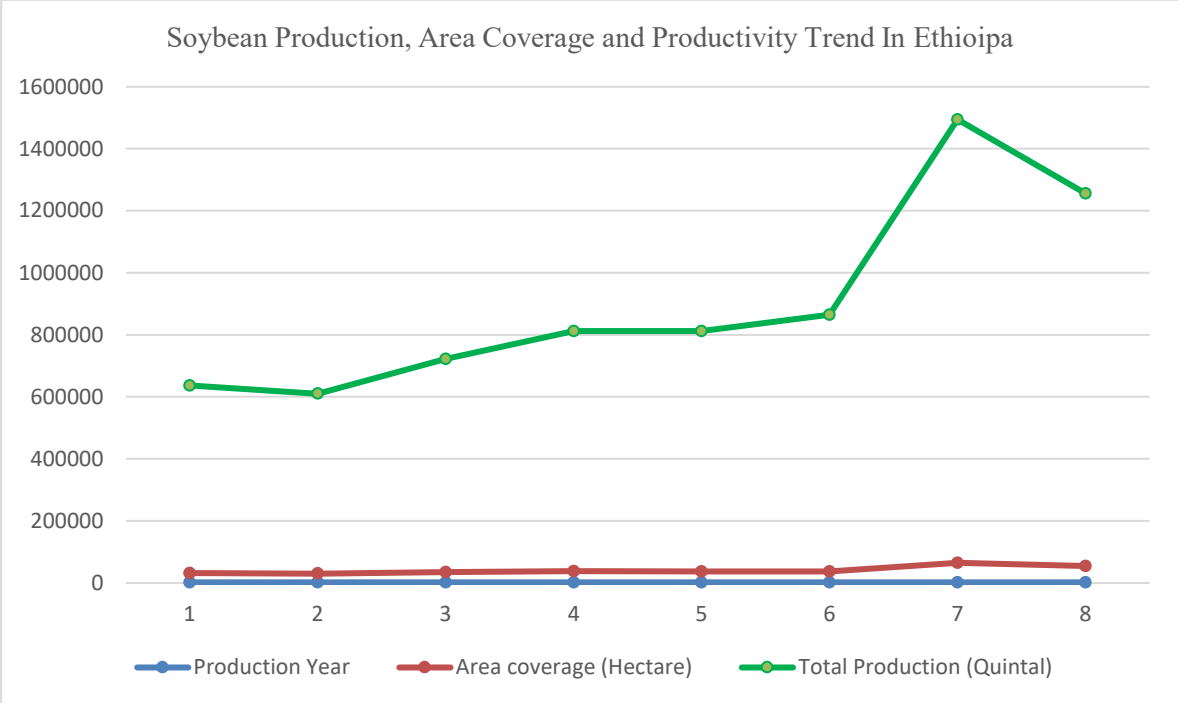

Figure 3: Soybean Production, Yield, Area Coverage Trend in Ethiopia

3.4. Empirical Studies on Soya bean Technology Adoption

The study was performed by [16] on Factors Affecting Adoption of Soybean Production Technologies in Tiro Afeta District, Ethiopia. The study was based on cross-sectional data of 188 smallholder farmers (97non-adopter and 91 adopters of soybean production technology) who were randomly selected from total households. The data were collected using the schedule, focus group discussion, and key informant interview and analyzed using descriptive statistics and Hackman selection model for the factors affecting household's soybean production technology. The result from Heckman's two-step model indicated that education level of household, total livestock holding, improved seed availability, frequency of extension contact, credit use, and farm income were positively and significantly influenced whereas market distance negatively and significantly affected the adoption of soybean production technologies. In addition, the result indicated that age, landholding size, and farm income determine the intensity of soybean technologies adoption positively and significantly whereas distance from the market affects negatively and significantly.

Astudy by [17] measured the Impact of Improved Soybean (Belessa-95) Variety on Income among Smallholder Farmers in Bambasi Woreda, Benishangul Gumuz Regional State. The response of the farmers to the demonstration of improved soybean varieties was collected from 18 randomly selected farmers. In this study, a multi-stage sampling technique was employed to select rural kebeles and households. A structured interview schedule was developed, pre-tested, and used for collecting the essential quantitative data for the study from 134 randomly selected households. Descriptive statistics and propensity score machining (PSM) models were employed to analyze data. The estimation of the impact of improved soybean variety on farm income showed that the sex of household head, the religion of household head, distance to the nearest market, and cooperative membership of household head have been the major factors of group difference.

Another study was undertaken to analyze the determinants of adoption and intensity of adoption of improved soya bean varieties [14]. The study was based on cross-sectional data collected from 146 (adopters=48 and non-adopters =98) randomly selected soya bean-producing farmers. Among the sample respondents from the chewaka district, 78.72% were male-headed and the remaining 21.28% were female-headed while in Gobusayo 90.38% and 9.62% were male and female-headed producers, respectively. Descriptive and econometric analyses were used to analyze data. Based on the analysis result sex, education, farm experience, training, and size of livestock owned

has a significant and positive impact on adoption and intensity of improved soya bean. On the other hand, distance to the nearest market was statistically significant and negatively affected influenced the adoption and intensity of improved soya bean varieties.

Analysis of factors determines the rate and level of improved soybean variety adoption under smallholder farmers in North-Western Ethiopia was undertaken by [22]. A total of 167 soybean producers (67 improved and 100 local soybean producers) were taking using systematic and random sampling methods. The data were collected through face-to-face interviews and analyzed the descriptive and Tobit model. The majority of the sample households were male heads (91%) and (9%) of them were female-headed households. The Tobit analysis showed that participation in the demonstration, cooperative membership, Training, soybean output, seed cost, and distance to the nearest market was the main factors that determining improved soybean varieties adoption and adoption level in the study area. The four former variables have statistical significance and positive effect whereas the latter two variables have statistical significance and negative effect on the adoption and adoption level of improved soybean variety respectively.

Further study by [20], performed the study to answer the general objective of determinants of Adoption of Soybean and its Impact on the Livelihood of Smallholder Farmers in Jimma Zone. A total of 106 households were randomly selected from the member list of each Kebele from 43 villages using a structured questionnaire and analyzed using a logistic model. The majority (90%) of the sampled households were male-headed and having an average experience of 23.9 years. The logit model result revealed that education level, training access, access to extension service, are significant and positive determinants of Soya bean adoption. Although age, distance to the market, and family size are significant and negative has effects on the adoption of Soya bean.

A study was done on "Factors affecting adoption and degree of adoption of soybean in Ilu-Ababora Zone; South-Western Ethiopia". The data were collected using a cross-sectional survey from 185 households (146 adapters and 39 non-adopters) and selected using multi-stage sampling procedures. The logistic regression model was implemented to analyze those factors that affect the adoption of soybean in the study area. The result of this study showed that 92% were male-headed households and the remaining 8% were female-headed households. The result of this study revealed that the overall adoption rate of soybean in the study area was 78.9% that was very high. The analysis result implies that sex, farm size, training access were statistically significant and positive determinants of Soya bean adoption [10].

Another the study was undertaken to answer the general objective to assess the level of adoption of improved soybean production technology and to identify the major factors affecting the adoption of improved soybean production technology in Pawi district, Ethiopia. A multi-stage sampling procedure was employed to selecting123 farm households. The primary data were collected from the households by using the structured questionnaire survey and focus group discussions analyzed by descriptive statistical analysis, inferential statistical, and Tobit model to determine the relative influence of explanatory variables on the dependent variable. The majority 80.5% were male household heads and the rest 19.5% were female household heads. The majority of the female household heads were found in the low adoption category. The number of livestock owned by household in TLU affects positively and significantly the level of adoption of soybean production technology less than 1% significant level. In addition, there was a positive and significant relationship between extension contact and adoption of soybean production technology [19]

3.5. Factors Affecting Adoption and Intensity on other New Crop Technologies in Ethiopia

Different scholars in the smallholders' agricultural sector of Ethiopia have undertaken different adoption studies. Some of the studies are discussed as follows:

Study was carried out on the determinants of adoption of improved maize varieties for male-headed and female-headed households in the West Harerghe zone [24]. From the total sampled households 44.3% of households and 15.2% of female households farmers used improved maize varieties and 92 (55.7% of male households and 84.8% of female households) farmers did not use during the main cropping season. Correctly, predicted figures for adopters were about 84.3% and 93.9%; while correctly predicted sample sizes for non-adopters were 89.1% and 80% for male households and females, respectively. Cultivated farm size, number of tropical livestock units, extension contact affects positively and significantly adoption of improved maize varieties while age and distance to the nearest input market had a negative and significant on the probability of adoption of improved maize varieties.

A study was conducted on the determinants of improved rice varieties adoption in the Fogera district of Ethiopia [5]. The study was based on cross-sectional data and selected 151 rice-producing farmers. The study used the univariate probit model to address factors that influence the decision to participate in improved rice varieties adoption. The descriptive statistics result showed that, out of the total randomly selected households, 57% were adopters and 43% were non-adopters of improved rice seed. The univarite model result showed that, household size, education of the household head, land, rice farming experience, access to new cultivars of rice, off-farm income, and institutions affected positively and significantly improved rice varieties while the distance to the

nearest village market, access to the main market, distance to access agricultural extension office explain negatively and significantly the probability of participation in improved rice cultivation.

Another study was conducted on the impact of improved maize varieties adoption on smallholder farmers' marketed maize surplus in Oromia regional state, Ethiopia. The study used cross-sectional data of 300 maize-producing farmers. Logit model was applied to analyze the collected data and to investigate the determinants of adoption. Out of 300 households, about 26% were adopters while74% are non-adopters. The logit model result showed that age, family size, marital status, adult-literacy, average livestock holding, access to output markets, access to credit for new verities affects positively and significantly while access to credit for other input and distance to the main market affects a negatively and significantly adoption of improved maize verities [4].

Astudy by [12], assessed the adoption of improved sorghum varieties and farmers' varietal trait preference in the kobo district, north Wolo zone, Ethiopia. The study used cross-sectional data of 150 sorghum-producing farmers. To answer the study objective, the study applied logit and Tobit model to identify the important determinants of adoption and intensity of use of improved sorghum varieties among the sample households. Based on the study results, out of 150 households, about 35.3% of households were adopters while 64.7% are non-adopters. The model results indicated that Tropical Livestock Unit, participation in off-farm, perception on taste, quality of improved seed, irrigated farm size, Striga infested land, and perception on yield capacity of improved sorghum affects positively and significantly improved sorghum varieties adoption. Moreover, farm size proportion of sorghum area from total cropland, distance from FTC to home, and active labor ratio had a negative and significant effect on adoption of improved sorghum verities.

The study conducted by [23], examined the determinants adoption of malt-barley technology: Evidence from North Gondar Ethiopia. This study also used cross-sectional data from 120 malt-barley producing farmers. The probit model was used to estimating the probability of adoption. Out of 120 households, about 32.5% of households were adopters while 67.5% are non-adopters. Educational status, access to improved seed varieties, and training affected the adoption of malt-barley technology positively and significantly while the social status of the household head had negative and significant impact on the adoption of improved malt barley technology.

Factors influencing adoption of improved maize varieties in Gorogutu Woreda of Eastern Hararghe, was studied by [18]. The study used cross-sectional data from 130 improved maize producers and the Tobit model was applied to analyze factors affecting the probability and intensity of adoption of improved maize seed. Out of 130 households, about 43.8% of households were adopters while 56.2 % are non-adopters. According to this study, educational level of household head, size of own cultivated land, off-farm employment, access to credit, contact with extension agent, membership in a cooperative, income from chat and land size had a positive and significant impact while cosmopolitan affect negatively and significantly adoption of improved maize varieties.

Another study was undertaken on the adoption and impact of agricultural technologies on farm income: evidence from southern Tigray, northern Ethiopia [6]. The study was based on cross-sectional data of 270 randomly selected smallholder farmers. The data were analyzed using the Probit model. About 27% and 34% of the sample respondents were respectively chemical fertilizer and hybrid variety adopters while 73% and 66% of the sample respondents were respectively chemical fertilizer and hybrid variety non-adopters. Age, land ownership, irrigation use, and access to credit affect positively and significantly while the distance to the nearest market and Tropical Livestock Unit (TLU) affects negatively and significantly agricultural technology adoption

4. Summary and Conclusion

The objectives of this review were to identify the determinants of adoption and intensity of improved soybean varieties to generate information that helps to understand and evaluate the key challenges in Ethiopia. The review showed that sex of household, age of household head, education, farm experience, participation in training, and extension service affect the adoption of improved soya bean varieties positively and significantly while the distance to the nearest market affects adoption of improved soya bean varieties negatively and significantly. On the other hand, the intensity of adoption was affected by age, soya bean farm experience, participation in training, and size of livestock holding. Most of the studies reviewed in this paper indicated that sex has a significant positive impact on the adoption of improved soya bean varieties. However, the participation of female households in the adoption process was only 15% and dominated by 85% of male household heads. On the other hand, the huge oil factories in Ethiopia like W. A and BK are using soya bean as a major input to their production. Consequently, those industries demanding a higher amount of soya bean as an input. These factories are creating a backward linkage to smallholder soya bean producer farmers in the area. Therefore, it can improve smallholder farmers' livelihood by creating market opportunities to supply their products directly to factories. In addition, W.A's edible oil factory alone needs 20,000 hectares of land to run the business and 500,000 quintals of soya bean requires per year.

4.1. Recommendations

To improve the adoption of modern agricultural technologies like improved soya beans the following recommendations are forwarded. Female-headed households should get emphasis in all activities of the promotion

of new technologies. On the other hand, evidences showed that the huge oil factories in Ethiopia like W. A and BK using soya bean as a major input to their production. Fruthermore, they are creating a backward linkage to smallholder soya bean producer farmers in the area. Thus, the promotion of new soya bean varieties, strong linkage between farmers and factories and comprehensive studies on the adoption and impact of soya bean should get attention from the regional and central government.

Figure 4: Improved Soybean Variety Seed Multiplication at pawi District, Benshagul Gumuz Region

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