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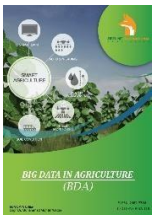


RESEARCH ARTICLE

# INDEX OF SOYBEAN TECHNOLOGY ADOPTION AND MULTIVARIATE CORRELATIONS IN SMALLHOLDER SYSTEMS

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**ABSTRACT**

This study aims to critically highlight appropriate soybean production techniques that enhance levels of agricultural productivity. Therefore, it analyzed soybean production technologies and multivariate correlations in smallholder systems at Jos East, Plateau State, Nigeria. The respondents (120) were selected via multistage techniques. Descriptive statistics, adoption index and multivariate correlation techniques were used to analyze data collected via questionnaires. Soybean production technologies mainly applied by farmers in the area include planting on ridge (81%), improved varieties (80%) and appropriate harvest date (51%); most (67.5%) have a low adoption index of ≤0.36. The correlation coefficients of the multivariate factors (farm output, adoption cost, and adoption index) were significant at $r_{xz}$ (-0.64,), $r_{yz}$ (0.79) and $r_{xy}$ (-0.75), respectively. The identified constraints are barriers to technology adoption. Therefore, the study recommends improved input supply and subsidies, improved advisory services, credit access and market linkages.

**KEYWORDS**

Adoption Constraints, Cost of Adoption, Agricultural Practices/Technologies, Correlation Analysis, Index of Adoption, Soybean Productivity.

## 1. INTRODUCTION

Soybean (Glycine max) has long been considered suitable for commercial-scale cultivation for seed production; further used in animal feed formulation. United States, Brazil, China, India, Argentina, Nigeria, South Africa and Uganda have been identified as major soybean producers (Onuwa et al., 2021; International Institute of Tropical Agriculture (IITA), 2009). In Nigeria soybean production begins from May-June and harvest usually occurs from October-November. Harvesting takes place three to four months after sowing; the planting date and cultivar used are determinants of harvest date. Soybean production improves sustainability of soil fertility in cropping systems through nitrogen fixation, extending soil coverage in series cropping and the supply of crop residues for livestock feed formulation (Onuwa et al., 2021; Rahmianna and Nikkuni, 2002).

For the past 20 years, the International Institute of Tropical Agriculture (IITA) has improved crop productivity by developing high-yielding, early-maturing varieties that can be tailored in combination with local rhizome fungi and additional desirable traits. Nigeria seeks to improve farm technology by initiating several activities and programs. In spite of activities to improve yield and farmers welfare status; farm output and returns to scale continue to decline. This may be due to the many restrictions farmers encounter; hence, creating barriers to the use of modern production technologies. Thus, quantitative techniques investigating the uptake of agricultural techniques by soybean producers in Nigeria is grossly inadequate (Ani *et al*., 2008). There are insufficient quantitative data on adoption and utilization of modern agricultural technologies that improves farm yields and facilitates sustainable livelihoods in agrarian societies. Also, there's a dearth of information on empirical variables influencing the uptake of modern agricultural techniques (Ani et al., 2008; Okunola, 2003).

Smallholders are constantly looking for alternatives to complement and enhance their technical capacity and poverty reduction, including risk management strategies, but this is poorly documented. The goal of improving farm output that ensures food sufficiency remains improbable (Agbaje et al., 2005). This is especially true for soybean cultivation. In fact, according to available statistics, soybean supply is lagging demand. Nigeria's estimated annual mean population growth is between 2.5% to 3.0%, while annual food production remains at <2%; resulting to food deficits (Agbaje et al., 2005). A group researchers cited high planting material costs, high labor costs, high labor demand requirements, low farm capital and exorbitant cost of farm inputs as contributing variables to the decline in farm output (Komolafe et al., 2010). Moreover, technical knowledge of rural farmers can help improve agricultural productivity in Nigeria is less well understood.

A group researchers posited that seed varieties and labor input requirements were critical barriers to improve farm output (Omotugba et al., 2008). Declining agricultural yields were attributable to deviations from modern agricultural techniques and sub-optimal resource utilization; resulting to production inefficiencies (Onuwa et al., 2021; Omotugba et al., 2008; Coelli and Battese, 1996). Therefore, it was necessary to analyze the uptake of modern soybean production techniques by smallholders in the study area; and as such, formulate effective policies that facilitates improved yield in soybean production among smallholders in the area. Thus, the study aims to analyze the index of soybean technology adoption and multivariate correlations in smallholder systems. Also, it highlights the merits of modern agricultural techniques, suitable techniques to enhance levels of agricultural yields and contributions of soybean cultivation to household food security in the area. The findings will aid to determine soybean technology adoption indices and correlations of multivariate factors. The study attempts to proffer solutions to the under-listed research questions.

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1. What are they soybean production technologies available?
2. What is the adoption index of soybean production technologies?
3. Are there correlations between multivariate factors?
4. What barriers mitigate soybean technology adoption?

### 1.1 Research Hypothesis

$H_o$: There are no significant multivariate factor correlations.

## 2. METHODOLOGY

### 2.1 Study Area (Site)

The study was conducted at Jos-East Local Government Area (LGA); comprising over 622,682 inhabitants, covering an area of 1,037 square kilometers. It has coordinates within latitude 9.6⁰-9.9⁰N and longitude of 9.06⁰-9.1⁰E (Onuwa et al., 2021; https://en.m.wikipedia.org /wiki/jos _east). The average temperature in the study area is about 26°C and annual precipitation is about 100 mm (NBS, 2012). Jos East comprises Federe, Fursum, Fobur, Shere and Maigemu districts. The LGA has a rural economy characterized by low agricultural output in arable crops, vegetables, cattle, sheep and goats, poultry and very low forestry output except for artisanal extraction of forestry products. Government and private services in terms of education, health, transport; are generally very poor (Onuwa et al., 2021; https://en.m.wikipedia.org/wiki/jos_east). Regarding trade transactions, agricultural produce like cereal, tubers, vegetable, potatoes, groundnuts, legumes, fruits, cattle, sheep and goats are been traded in the LGA (NBS, 2012). There are seven active markets in the LGA, which deal majorly on agro commodities; all these markets are characterized by poor infrastructures. They LGA are widely known for their agricultural and economic activities.

### 2.2 Sampling Procedure

The study employed multistage techniques; in the initial phase, Jos-East LGA was purposively selected; attributable to a high presence of soybean producers in the area. In stage two, five districts (Fobur, Fursum, Shere, Maigemu and Federu) were selected systematically based on a high prevalence of soybean production. The third step involves purposive selection of a few villages from the selected districts because of the prevalence of soybean farmers in these areas. The survey framework was used to estimate the sample size (number of respondents) based on a proportionate sampling rate. finally, respondents were randomly selected from the sample frame of 3,420 soybean producers compiled by Agricultural Development Project (ADP) unit at the LGA secretariat in synergy with local enumerators, hence at constant sampling proportion of 3.5% (0.035) a sample size of 120 soybean farmers was derived and validated at 95% level of confidence and 5% error margin with raosoft sample size calculator as adapted (Onuwa et al., 2022). Table 1 presents the distribution of the sampling frame and size.

**Table 1:** Sample Frame and Size

| District | Villages | Sample frame | Sample size (0.035) |
|---|---|---|---|
| Fobur | 5 | 683 | 24 |
| Fursum | 5 | 667 | 23 |
| Shere | 3 | 308 | 11 |
| Maigemu | 7 | 922 | 32 |
| Federe | 5 | 840 | 30 |
| Total | 35 | 3420 | 120 |

Source: Field Survey (2018).

### 2.3 Collection of Data

Structured questionnaires were used to collect primary data from the respondents.

### 2.4 Analysis of Data

Descriptive statistics was used to identify the available soybean production technologies and constraints of technology adoption. The adoption index was used to estimate the level of adoption for agricultural practices/technologies and multivariate correlation techniques was used to evaluate the relationships between factors (i.e., yield, cost of adoption and index of adoption)

#### *2.4.1 Index of Adoption*

The index of adoption for Soybean technologies per smallholder was estimated and presented in equation (1) as adapted from (Saka and Lawal, 2009):

$$B_i = \sum (R_i/R_T) \quad (1)$$

Where:

$B_i$ = Adoption index of soybean technologies by $i_{th}$ smallholder; $R_i$ = adopted soybean technologies by $i_{th}$ smallholder; and $R_T$ = soybean technologies available to $i_{th}$ smallholders; and i = (1……..n).

**Decision rule:** ≤0.36 represents a low index of adoption, while ≥0.45 represents a high index of adoption.

Available soybean technologies in the study area include: (i) planting on ridges; (ii) improved varieties; (iii) appropriate harvest date; (iv) treatment method; (v) weeding interval; (vi) pest control; (vii) recommended spacing; (viii) herbicide application; (ix) planting date; and (x) disease prevention.

#### *2.4.2 Correlation Analysis*

Correlation techniques were employed to analyze multivariate factor [cost of adoption (x) (₦), index of adoption (y) (ratio/index) and yield (z) (kg)] relationships; (R, r) represent the coefficients of correlation, presented in equation (2) as adapted from (Wikipedia, 2018; Gujarat, 2004).

$$Rz, xy = \sqrt{r^2_{xz} + r^2_{yz} - 2r_{xz}.r_{yz}.r_{xy} / 1 - r^2_{xy}} \quad (2)$$

Where:

Rz, xy= multiple coefficient of correlation for the dependent and independent factors; z = dependent variable z; x = independent variable x; y = independent variable y; $r^2$ = coefficient of determination; $r^2_{xz}$ = coefficient of determination for x and z; $r^2_{yz}$ = coefficient of determination for y and z; $r^2_{xy}$ = coefficient of determination for x and y; $r_{xz}$= coefficient of correlation for x and z; $r_{yz}$= coefficient of correlation for y and z; and $r_{xy}$= coefficient of correlation for x and y.

**Decision Rule**: The level of significance of the coefficient of correlation (r) is presented as follows: ≥+/-0.7 (indicating an intense linear correlation); +/- 0.4 - 0.69 (indicating an average linear correlation); and ≤+/-0.39 (indicating a poor linear correlation).

## 3. RESULTS AND DISCUSSION

### 3.1 Soybean Production Technologies

Table 2 and Figure 1show the different soybean technologies adopted by respondents in the area. The adopted techniques include planting on ridges (81%), improved varieties (80%), appropriate harvest date (51%), seed treatment (49.2%), weed management (47.5%), spacing intervals (44.2%), herbicide use (38.3%), sowing date (35%), pest management (28.3%) and disease prevention (19.2%). These modern practices adopted critically affected soybean output and improved yields at farm level. However, low uptake of these modern practices by respondents in the area was observed (Onuwa et al., 2021; Komolafe et al., 2010; Okunade, 2006; Rahmianna and Nikkuni, 2002).

**Table 2:** Distribution according to Soybean Technologies Adopted

| Practices/Technology | Frequency* | % |
|---|---|---|
| Improved variety | 96 | 80 |
| Sowing date | 42 | 35 |
| Planting on ridges | 97 | 81 |
| Herbicide use | 46 | 38.3 |
| Appropriate harvest date | 61 | 51 |
| Spacing intervals | 53 | 44.2 |
| Weed management | 57 | 47.5 |
| Pest management | 34 | 28.3 |
| Seed treatment | 59 | 49.2 |
| Disease prevention | 23 | 19.2 |

Source: Field Survey (2018); *Multiple Responses.

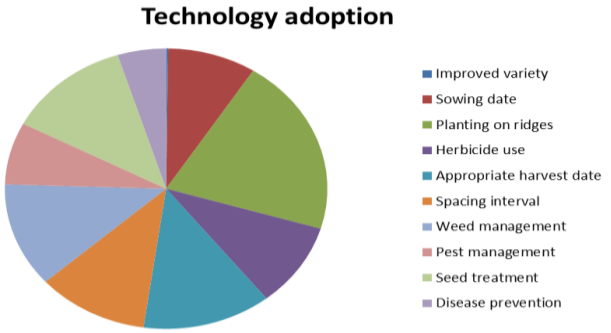


**Figure 1:** Distribution according to Soybean Technology Adoption

### 3.2 Adoption Index of Soybean Technologies

Figure 2 reveals that most (67.5%) of the respondents have low adoption indexes of 0.36 or less. On the other hand, 32.5% have the adoption index of or above 0.45. In addition, it was clear that multiple technologies are available in the area to improve agricultural techniques for growing soybeans. However, the adoption index for these techniques has been inadequate and unsatisfactory; low agricultural yield for this crop in the area was attributable to this trend. Oladele and Kareem posited that low agricultural productivity among smallholder farmers in sub-Saharan Africa is due to insufficient adoption of improved agricultural techniques (Oladele and Kareem, 2003). Therefore, identifying factors that impede adoption/uptake of improved agricultural techniques is of particular relevance and importance for agricultural communities (Onuwa et al., 2021; Adesope et al., 2012; Bonabana-Wabbi, 2002).

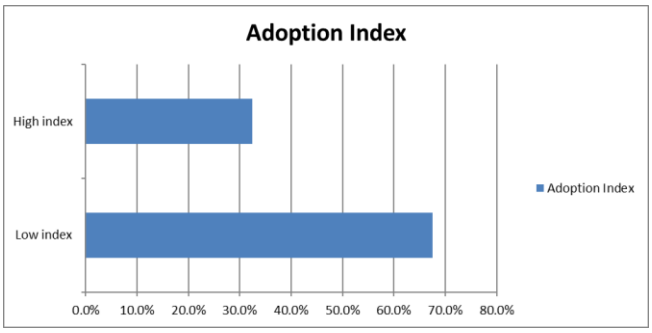


**Figure 2:** Distribution based on the Index of Soybean Technology Adoption

### 3.3 Correlation of Multivariate Factors

Table 3 shows that the analysis of correlation was significant at probability level of 5%; implying that multivariate factor correlations were significant and as such, the null hypothesis is rejected. The coefficient of correlation for x and z ($r_{xz}$) is -0.64; implying an average and reverse linear correlation of the variables. Thus, as the cost of adoption surges adoption of technology declines and as a result gross yield contract. The coefficient of correlation for y and z ($r_{yz}$) is 0.79; implying an intense linear correlation of the variables. This result suggests that a surge in the index of adoption tends to improve agricultural yield. The coefficient of correlation for x and y ($r_{xy}$) is -0.75; implying an intense and reverse linear correlation of the variables. Thus, as the cost of adoption surges the adoption index for Soybean technologies among respondents diminishes. Therefore, soybean technology adoption improves yield and agricultural sustainability across different smallholder farm units in the area. Further, the monetary value of agricultural innovations was a determinant of technology adoption by smallholders. This conforms to who reported similar outcomes in their respective studies on adoption of production practices and technology among farmers (Matata et al., 2010; Yasin, 2003).

**Table 3:** Coefficients of Correlation Matrix

| Variables | Yield (z) | Cost of Adoption (x) | Index of Adoption (y) |
|---|---|---|---|
| Yield (z) | 1.00 | | |
| Cost of Adoption (x) | -0.64* | 1.00 | |
| Index of Adoption (y) | 0.79* | -0.75* | 1.00 |

Source: Field Survey (2018); * Coefficient of correlation (r) (at 5% level significance) (2-tailed).

### 3.4 Constraints of Soybean Technology Adoption

Table 4 and Figure 3 show the barriers of soybean technology adoption by respondents in the area. Important obstacles to adoption for soybean growers include technology cost (68.3%), inadequate technical expertise (50.8%), insufficient funds (40.8%), deficient market linkage (40.0%), poor credit access (39.1%), poor extension services (30%), and poor technology access (8.3%). These limitations were critical for soybean technology adoption by respondents in the area. This conforms to who posited related outcomes in their respective studies on adoption of agricultural technology (Onuwa et al., 2021; Enitan, 2010; Ume and Okpukpara, 2006; Akpoko, 2004).

**Table 4:** Distribution according to the Barriers of Technology Adoption

| Barriers | Frequency* | % |
|---|---|---|
| Technology cost | 82 | 68.3 |
| Inadequate technical expertise | 61 | 50.8 |
| Insufficient funds | 49 | 40.8 |
| Deficient market linkage | 48 | 40.0 |
| Poor credit access | 47 | 39.1 |
| Poor extension services | 36 | 30 |
| Poor technology access | 10 | 8.3 |

Source: Field Survey (2018); *Multiple Responses.

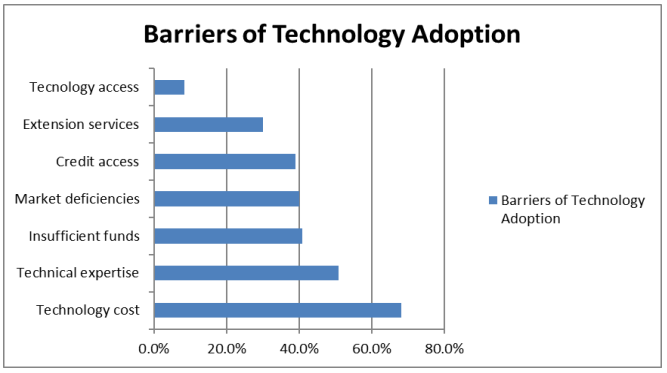


**Figure 3:** Distribution according to the Barriers of Soybean Technology Adoption

## 4. CONCLUSION

The study estimated the index of soybean technology adoption and multivariate correlations in smallholder systems. The study identified the various soybean technologies in the study area; howbeit, technology adoption by the respondents was insufficient, leading to decreased agricultural productivity. Furthermore, the multivariate variables (yield, cost of adoption and index of adoption) have significant linear correlations; hence, positive correlations promote sustainable agriculture. All identified limitations affected soybean technology adoption critically. Conclusively, several soybean practices/ technologies are available in the area, with relatively low adoption level, significant relationship between multivariable factors exists and the identified constraints affected technology adoption; however, a study on the comparative analysis of soybean productivity will be required to ascertain the level of farm productivity and profitability among soybean farmers including both adopters and non-adopters of modern agricultural practices/ technologies to validate the economic potentials of agricultural technology adoption. Based on the above, these recommendations are proposed:

i. More investments to improve extension services, through public-private sector partnerships; and as such, promote the consciousness and sensitivity about agricultural technology among smallholders.

ii. Agricultural technology subsidies, through public-private sector partnerships; to reduce the cost of technology adoption.

iii. Develop and implement policies that mitigate barriers to agricultural technology adoption by smallholders.

iv. Adoption of policies to promote full linkage with commodity markets.

v. Develop and implement policies to promote full access to financial services and farm capital.

vi. Develop and implement policies that provide technical support to smallholders in the process of technology adoption.

## AUTHORS CONTRIBUTIONS

The Authors designed the study and produced the initial draft for the manuscript; in addition to data processing, analysis and literature searches. Also, the manuscript was proofed by the authors.

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